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Psychological Factors Associated With Fruit and Vegetable Intake and With Biomarkers in Adults From a Low-Income Neighborhood

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Fruit and vegetable consumption is below recommended levels in the population, particularly in low-income groups. This study assessed factors associated with self-reported intake and 2 biomarkers (potassium excretion and plasma vitamin C) in 271 adults living in a low-income neighborhood. Attitudinal barriers to change were negatively related to reported intake and to potassium excretion. Poor knowledge of recommended consumption was associated with low reported intake, low potassium excretion, and low plasma vitamin C concentration. Self-efficacy was related to reported intake but not to biomarkers. The authors conclude that several of the psychological factors associated with self-reported intake were also related to biomarkers in this population and that these may therefore be particularly appropriate targets for intervention.

Key words: fruit, vegetables, attitudes, vitamin C, potassium excretion, dietary knowledge

Fruit and vegetable intake is thought to be protective against cancers and cardiovascular diseases (Joshipura et al., 2001; Ness & Powles, 1997; Peto, 2001). Increasing fruit and vegetable consumption is a central objective in health promotion programs, and specific targets such as "five a day" have been widely adopted (Department of Health, 2000; Krauss et al., 2001; U.S. Department of Health and Human Services, 2000). Fruit and vegetable intake is inversely related to socioeconomic status in both the United States and the United Kingdom (Bennett, Dodd, Flatley, Freeth, & Bolling, 1995; Krebs-Smith, Cook, Subar, Cleveland, & Friday, 1995). This has led to specific recommendations to increase consumption in low-income sectors of the population to help redress socioeconomic inequalities in health (Acheson, 1998).

Efforts to increase consumption depend on understanding the factors determining intake. Eating fruit and vegetables is influenced by processes at a number of levels, from cultural norms and habits; through practical issues of food distribution and accessibility and family and social influences; to individual characteristics such as habits, preferences, and attitudes. Research on psychological factors has focused more on fat consumption than on fruit and vegetables. Nevertheless, a number of social and cognitive factors have been associated with fruit and vegetable consumption in adults, including social participation and perceived social support (Havas et al., 1998; Lindstrom, Hanson, Wirfalt, & Ostergren, 2001), barriers to consumption and perceived health and nonhealth benefits (Anderson, Winett, & Wojcik, 2000; Glanz, Kristal, Tilley, & Hirst, 1998; Trudeau, Kristal, Li, & Patterson, 1998), and self-efficacy (Brug, Lechner, & De Vries, 1995; Havas et al., 1998). These associations have been observed both in cross-sectional and intervention studies, where changes in social cognitive variables have correlated with changes in reported fruit and vegetable consumption (Kristal, Glanz, Tilley, & Li, 2000; Langenberg et al., 2000). There is a substantial body of evidence documenting relationships between stage of change and fruit and vegetable intake and between stage of change and attitudinal factors (Brug, Hospers, & Kok, 1997; Campbell et al., 1998; Laforge, Greene, & Prochaska, 1994; Ma et al., 2002; Sorensen, Stoddard, & Macario, 1998). Nutrition knowledge has shown an inconsistent association with fruit and vegetable intake that is due in part to the use of unreliable and unvalidated measures of knowledge. Wardle, Parmenter, and Waller (2000) have shown that knowledge assessed with a validated instrument is associated with intake and is a partial mediator of socioeconomic differences in fruit and vegetable consumption. Substantial portions of the population in the United Kingdom and the United States are not aware of the five-a-day recommendation (Krebs-Smith, Heimendinger, et al., 1995; Parmenter, Waller, & Wardle, 2000).

Much of the evidence relating fruit and vegetable consumption with psychological factors has been collected from general population surveys. It is not known whether similar factors are salient

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in low-income neighborhoods, where issues of accessibility and availability may be more prominent. The first aim of this study was therefore to assess psychological factors associated with fruit and vegetable consumption in adults from a deprived inner-city area. Research in this field has been underpinned by a number of theoretical perspectives, including the health belief model, the theory of planned behavior, self-regulation theory, and the transtheoretical model. Our selection of measures was influenced by the consensus approach adopted by a number of theorists, as outlined by Fishbein and coauthors (Fishbein et al., 1992, 2001). This proposes that the variables underlying behavioral performance include perceived benefits, barriers, social support, self-efficacy, and knowledge. We further hypothesized that barriers to consumption would be more consistently associated with intake than the positive influence of perceived benefits. This is because obstacles to eating more fruit and vegetables, such as the inaccessibility of supplies, cost, and storage problems, may be more prominent in the lives of people in this sector of the population than among individuals living in more prosperous circumstances. We also predicted that knowledge about recommended intake would be a particularly important determinant, and that self-efficacy for eating fruit and vegetables under difficult circumstances would be associated with greater consumption.

The second aim of this study was to assess associations between psychological factors and biomarkers of fruit and vegetable intake. The assessment of dietary intake is problematic, and none of the most convenient methods of measurement in practical settings are free from error and bias (Kaaks, 1997). Biomarkers are often used for the validation of dietary assessment methods (Hann, Rock, King, & Drewnowski, 2001; McKeown et al., 2001). The benefits of eating fruit and vegetables may be mediated by macronutrient balance and by various micronutrients, depending on the specific health outcome in question.

In this study, we assessed two biomarkers of fruit and vegetable consumption, namely urinary potassium excretion and plasma vitamin C concentration. Potassium excretion is commonly used to monitor the potassium intake derived from fruit and vegetables (Bingham et al., 1997). A high potassium intake has been associated with reduced stroke mortality (Khaw & Barrett-Connor, 1987), and potassium supplementation has been shown to lower blood pressure in randomized trials (Whelton et al., 1997). An increase in fruit and vegetable consumption can raise potassium intake and has been associated with significant reductions in blood pressure (Appel et al., 1997). Siani et al. (1991) showed that a 1-year intervention to increase fruit and vegetable intake produced a 60% increase in reported potassium intake, which translated into a 45% increase in potassium excretion. Similar effects have been observed in other investigations (Smith-Warner et al., 2000).

Plasma vitamin C is also positively associated with fruit and vegetable consumption (Wrieden et al., 2000). A recent prospective population study involving more than 19,000 participants demonstrated that plasma ascorbic acid concentration is inversely related to deaths from all causes and cardiovascular disease (Khaw et al., 2001). An inverse association with cancer mortality was observed in men but not women. Other studies have also shown associations between vitamin C and death from cardiovascular disease, cancer, and stroke (Gaziano et al., 1995; Gillman et al., 1995). A randomized trial over 8 weeks that increased fruit and vegetables from less than three to eight portions a day resulted in a doubling of vitamin C concentration (Zino, Skeaff, Williams, & Mann, 1997). A recent population study in Washington County, Maryland, showed that fruit and vegetable intake was correlated more closely with plasma ascorbic acid (vitamin C) than with beta-carotene or beta-cryptoxanthin (Block, Norkus, Hudes, Mandel, & Helzlsouer, 2001).

Little is known about the associations between psychological factors and these biomarkers. Although dietary reports correlate with biomarkers, the correspondence is far from perfect. If the purpose of increasing fruit and vegetable intake is to modify biological processes related to disease, then understanding these associations is important. In the present study, we therefore assessed the relationship between potassium excretion and plasma vitamin C concentration and perceived barriers, perceived benefits, self-efficacy, and knowledge of recommended intake, expecting to find similar associations as with reported intake.

Method

Participants

The participants in this study were 271 patients registered with a single primary health care center in South London who agreed to take part in a randomized trial of nutritional counseling. The health care center was located in a deprived inner-city area with a Jarman underprivileged area (UPA) score of 40.3. The Jarman UPA score is an index of social deprivation based on eight criteria, including the proportion in the community of single-parent families, elderly persons living alone, children under 5 years old, and ethnic minorities and the levels of unemployment, overcrowding, and population mobility. A high score indicates greater deprivation. For comparison, the mean Jarman index for the South West Thames region is 5.27, ranging from 40.3 for the health center in this study (which had the highest score in the region) to –39.6 for the health center in the most affluent neighborhood of the region.

The 271 participants were recruited by letter at random from the list of registered patients aged 18–70 years, excluding individuals with serious illness and women who were pregnant or planned to become pregnant within the next 12 months. A total of 459 patients had expressed interest in the study, but 188 were excluded on the above criteria or because they had high incomes. Only 1 person per household was recruited to avoid statistical clustering.

The sample consisted of 166 women and 105 men with an average age of 43.2 $\pm$ 13.9 years. Seventy-one percent were White, 26% were Black (African or African Caribbean), and 3% were of South Asian origin. The proportion of married or cohabiting participants was 40%, and 17% were divorced, separated, or widowed. The rate of employment was 70% (59% full time, 11% part time), and 35% were in receipt of state (welfare) benefits. Vitamin supplements were taken by 31%, and 34% were cigarette smokers.

Measures of Fruit and Vegetable Intake

Fruit and vegetable consumption was assessed with the questions "How many pieces of fruit—of any sort—do you eat on a typical day?" and "How many portions of vegetables—excluding potatoes—do you eat on a typical day?" Participants were given detailed information about portion sizes. Similar items have been shown in recent studies to document the effects of psychologically based interventions in the same fashion as more elaborate measures (Marcus et al., 2001; Resnicow et al., 2001). Reponses to these questions were also positively correlated ($r = .40$, $p < .0001$) with responses to the appropriate sections of the Dietary Instrument for Nutrition Education (DINE) in this sample. The DINE is a weighted food frequency questionnaire that accounts for the majority of fat and fiber in the typical United Kingdom diet (Roe, Strong, Whiteside, Neil, & Mant, 1994). The magnitude of this association is similar to that between other self-report instruments in the literature (Calfas, Zabinski, & Rupp, 2000; McKeown et al., 2001).

Measure of Biomarkers

Plasma ascorbic acid (vitamin C) was measured from blood taken by venipuncture and spun in a centrifuge after an interval of at least 45 min at 3,000 rpm at 4 °C for 15 min. Plasma (0.25 ml) was then placed into 1.5-ml microtubes containing 0.5 ml of 10% metaphosphoric acid to stabilize it and mixed in a rotamixor for 15 s. Samples were snap frozen in dry ice for transportation then stored at −70 °C until analysis. Vitamin C was assayed with a fluorometric method at the Department of Clinical Biochemistry, University of Cambridge, England. Potassium and creatinine excretion were measured in 24-hr urine samples by flame photometry.

Attitudinal Measures

All attitudinal and cognitive measures were assessed on 5-point scales and were based on measures previously used in the investigation of dietary fat consumption (Steptoe, Doherty, Kerry, Rink, & Hilton, 2000).

Belief in health benefit. Belief in the health benefit of eating fruit and vegetables was assessed using four items: “Eating fruit (vegetables) is not very important for my health,” and “Eating fruit (vegetables) will lower my chances of getting serious illnesses like heart disease or cancer.” Ratings were averaged to produce a single score, and the internal consistency (Cronbach’s alpha) was 0.78. Ratings were skewed toward the positive, so they were subsequently divided into low (<4) and high (>4) categories.

Perceived barriers and perceived benefits. Perceived barriers and perceived benefits of eating fruit and vegetables were assessed using a decisional balance measure (Steptoe, Wijetunge, Doherty, & Wardle, 1996). The Perceived Barriers scale consisted of 12 items (e.g., “Fruit is inconvenient to eat”; “My family do not like vegetables”), and 12 items contributed to the Perceived Benefits scale (e.g., “Eating more vegetables will improve the way I look”). Scores on each scale could range from 1 to 5, with higher scores indicating greater barriers and greater benefits. For perceived barriers, $\alpha = 0.78$, and for perceived benefits, $\alpha = 0.72$.

Self-efficacy. Self-efficacy for eating fruit and vegetables was assessed with a three-item measure adapted from a more extensive schedule (Glynn & Ruderman, 1986). Participants were asked to rate their confidence in eating more fruit and vegetables under challenging conditions (e.g., “when other tempting foods are available”). Scores could range from 3 to 15, with higher scores indicating greater self-efficacy. Cronbach’s alpha in this sample was 0.81.

Knowledge of recommended intake. Knowledge of the recommended intake was assessed by asking participants how many portions of fruit and vegetables doctors recommend each day. Similar measures have been used in other investigations (Havas et al., 1998; Krebs-Smith, Heimendinger, et al., 1995). Responses were divided into *don’t know*, *less than 5 per day*, and *5 or more per day*.

Encouragement. Encouragement from close others was used to index social support for a diet rich in fruit and vegetables and was assessed with the single item, “Does the person most important to you encourage you to eat fruit and vegetables?” The possible responses were *never*, *hardly ever*, *occasionally*, and *frequently*.

Procedure

Participants were invited to take part in a study of nutrition counseling. They were assessed individually in the health center by a trained research nurse who took blood samples, anthropometric measures, and a medical history and who instructed the person in how to collect a 24-hr urine sample. The questionnaire containing attitudinal measures was completed by participants prior to the clinical assessment and was checked by the nurse for errors and omissions.

Statistical Analysis

Data were analyzed by ordered analysis of variance of linear trends for each predictor, with age and sex as covariates. Smoking was also included as a covariate, because it is well established that smoking is associated with low fruit and vegetable intake and low plasma vitamin C concentrations (Khaw et al., 2001; Li et al., 2000; Liu et al., 2000). The taking of vitamin supplements was a covariate in the analyses of vitamin C. Potassium excretion was indexed by potassium:creatinine ratio rather than total potassium excretion, because the former is not affected by variations in the precision with which 24-hr samples were obtained. Higher potassium: creatinine ratios indicate greater potassium excretion. The dependent variables in the analyses were therefore the total number of fruit and vegetables eaten per day, potassium:creatinine ratio, and plasma vitamin C concentration. Belief in health benefits, perceived barriers, perceived benefits, self-efficacy, knowledge of recommended intake, and encouragement were the independent predictors. Perceived barriers, perceived benefits, and self-efficacy were categorized into quartiles to aid comparisons along a common measurement metric. Factors that were significant in univariate analyses were entered into multiple regression analyses.

Results

The number of portions of fruit and vegetables eaten per day averaged 3.58 ($SD = 1.8$) in women and 3.74 ($SD = 2.1$) in men, with 24% of women and 25% of men eating five or more portions per day. Self-reported consumption did not differ with age or ethnic group but was lower in smokers than nonsmokers ($M = 3.19$, $SD = 1.4$ vs. $M = 3.92$, $SD = 2.0$), $F(1, 269) = 11.9$, $p < .001$. Positive associations between reported fruit and vegetable consumption and levels of potassium excretion and plasma vitamin C were observed and have been detailed elsewhere (Cappuccio et al., 2001).

Associations between attitudinal factors in fruit and vegetable consumption are summarized in Table 1. Intake was related to perceived barriers, being greater in those who reported lower barriers, $F(3, 264) = 4.91$, $p < .001$. High self-efficacy ratings were also associated with greater consumption, $F(3, 264) = 4.29$, $p = .004$. Half the sample (50%) knew that doctors recommended five or more portions of fruit and vegetables per day. A further 23% gave a value lower than five a day, and 27% did not know what the recommended level was. Reported fruit and vegetable intake was related to knowledge of recommended intake, $F(2, 65) = 3.24$, $p = .016$, being lower in participants who ventured no opinion about the recommended level. The association between perceived benefits and consumption approached significance, $F(3, 264) = 1.52$, $p = .057$, with more portions being eaten by those reporting greater benefits. No significant associations were found between intake and beliefs in health benefits or encouragement from close others to eat fruit and vegetables.

A multiple regression on the reported daily intake of fruit and vegetables, including all the significant univariate predictors together with age, sex, and smoking status, yielded independent effects for perceived barriers ($\beta = -0.163$, $SE = 0.106$, $p = .01$), Self-Efficacy ($\beta = 0.140$, $SE = 0.111$, $p = .027$), and knowledge of recommended intake ($\beta = 0.146$, $SE = 0.138$, $p = .018$). These variables in combination accounted for 13% of the variance in fruit and vegetable intake.

Table 1
Attitudinal and Social Factors Associated With Fruit and Vegetable Consumption

Scale and response categories	n	No. of portions/day, adjusted for age, sex, and smoking status M	SD
Belief in Health Benefit			
Low	78	3.29	1.7
High	193	3.75	1.9
Perceived Barriers[a]			
1 (*low*)	71	4.19	2.0***
2	72	3.76	2.0
3	62	3.55	1.7
4 (*high*)	66	2.99	1.7
Perceived Benefits[a]			
1	62	3.37	2.0
2	81	3.60	1.7
3	68	3.55	2.0
4	60	4.07	1.8
Self-Efficacy[a]			
1	54	3.35	2.0**
2	82	3.18	1.6
3	65	3.92	2.0
4	70	4.14	1.9
Knowledge of Recommended Intake			
Don't know	72	3.16	1.5*
Less than five/day	63	3.80	2.4
Five or more/day	136	3.85	1.8
Encouragement			
Never	57	3.49	1.8
Hardly ever	40	3.67	2.2
Occasionally	92	3.52	1.8
Frequently	74	3.91	2.0

[a] Numbers (1–4) refer to the four response options on each of the scales, with 1 being the lowest and 4 the highest.
* $p < .05$. ** $p < .01$. *** $p < .001$.

The urinary potassium:creatinine ratio was available for 225 participants and averaged 6.98 ($SD = 2.5$) and 5.83 ($SD = 1.8$) in women and men respectively, $F(1, 224) = 14.7$, $p < .001$. Potassium:creatinine ratio was positively correlated with age ($r = .159$, $p = .017$) and was highest in White participants ($M = 7.0$, $SD = 2.4$), intermediate in South Asian participants ($M = 6.22$, $SD = 1.7$) and lowest in Black participants ($M = 5.07$, $SD = 1.6$), $F(2, 222) = 16.5$, $p < .001$. Levels were not affected by smoking or by use of vitamin supplements.

Potassium:creatinine ratio was inversely associated with perceived barriers, and was lower in participants who reported higher barriers to fruit and vegetable consumption, $F(3, 218) = 2.85$, $p = .005$. Excretion levels were unrelated to beliefs in health benefits, perceived benefits, or self-efficacy (Table 2). However, knowledge of recommended intake was associated with this biomarker, with higher potassium excretion in participants with greater awareness of the recommended level of fruit and vegetable intake, $F(2, 219) = -8.55$, $p < .001$. In multiple regression analyses, both barriers ($\beta = -0.164$, $SE = 0.125$, $p = .007$) and knowledge ($\beta = .253$, $SE = 0.176$, $p < .001$) were independently associated with potassium:creatinine excretion ratio, and the final model accounted for 21% of the variance in potassium output.

Plasma vitamin C concentration was available from 267 participants, and averaged 82.5 ($SD = 35.2$) μmol/l in women, significantly higher than levels in men ($M = 71.8$, $SD = 35.4$), $F(1, 265) = 5.81$, $p = .017$. Vitamin C was negatively correlated with age ($r = -.23$, $p < .001$), and was higher in White ($M = 82.6$, $SD = 37.6$) than Black ($M = 68.9$, $SD = 28.1$) or South Asian ($M = 57.0$, $SD = 28.5$ μmol/l) participants, $F(2, 260) = 5.32$, $p < .005$. The concentration of vitamin C was lower in the blood of smokers than nonsmokers ($M = 82.3$, $SD = 34.4$ μmol/l vs. $M = 70.2$, $SD = 36.8$ μmol/l), $F(1, 265) = 7.07$, $p = .008$. Values were also influenced by the use of vitamin supplements. Participants who took supplements had higher levels than others ($M = 84.5$, $SD = 36.7$ μmol/l vs. $M = 73.2$, $SD = 33.4$ μmol/l), $F(1, 244)$, $= 5.66$, $p = .018$.

Few significant associations between vitamin C and attitudinal factors were observed (Table 3). Nevertheless, plasma vitamin C concentration was lower in respondents who had no knowledge of recommended intake of fruit and vegetables, $F(2, 239) = 2.41$, $p = .05$. The relationship with encouragement from close others was the reverse of prediction, with higher vitamin C levels in those who said that they were never encouraged to eat fruit and vegetables, $F(3, 230) = 3.25$, $p = .034$. Restricting analyses to partic-

Table 2
Attitudinal and Social Factors Associated With Potassium/Creatinine Ratio

Scale and response categories	n	Ratio adjusted for age, sex, and smoking status M	SD
Belief in Health Benefit			
Low	67	6.19	2.4
High	158	6.65	2.3
Perceived Barriers[a]			
1	60	7.14	2.5**
2	57	6.56	2.2
3	53	6.19	2.3
4	55	6.06	2.2
Perceived Benefits[a]			
1	57	6.34	1.9
2	57	6.24	2.2
3	51	6.51	2.6
4	60	6.96	2.3
Self-Efficacy[a]			
1	44	6.13	2.2
2	72	6.62	2.3
3	54	6.63	2.4
4	55	6.51	2.4
Knowledge of Recommended Intake			
Don't know	59	5.53	1.8***
Less than five/day	56	6.50	2.2
Five or more/day	110	7.02	2.5
Encouragement			
Never	46	6.98	2.2
Hardly ever	35	6.61	2.7
Occasionally	73	5.95	2.1
Frequently	64	6.58	2.2

[a] Numbers (1–4) refer to the four response options on each of the scales, with 1 being the lowest and 4 the highest.
** $p < .01$. *** $p < .001$.

Table 3
Attitudinal and Social Factors Associated With Vitamin C Concentration

Scale and response categories	*n*	Concentration in μmol/1, adjusted for age, sex, smoking status, and vitamin supplementation *M*	*SD*
Belief in Health Benefit			
Low	74	73.9	36.5
High	172	76.5	33.8
Perceived Barriers[a]			
1	63	78.4	31.9
2	63	78.1	34.6
3	59	78.5	33.1
4	61	71.8	39.1
Perceived Benefits[a]			
1	55	73.2	37.7
2	73	80.6	36.3
3	65	76.5	35.7
4	53	75.4	28.5
Self-Efficacy[a]			
1	46	77.4	42.0
2	78	72.2	32.3
3	62	78.1	34.6
4	60	80.5	32.6*
Knowledge of Recommended Intake			
Don't know	64	71.1	32.6*
Less than five/day	57	72.5	34.0
Five or more/day	125	81.5	35.2
Encouragement			
Never	53	89.5	42.4*
Hardly ever	39	70.7	32.8
Occasionally	80	73.9	34.1
Frequently	66	74.3	28.1

[a] Numbers (1–4) refer to the four response options on each of the scales, with 1 being the lowest and 4 the highest.
* $p < .05$.

ipants who did not take vitamin supplements did not alter this pattern of results.

Discussion

The data in these analyses were collected from people living in a low-income neighborhood who had volunteered to take part in a study of nutritional counseling. Cross-sectional data on the psychological correlates of fruit and vegetable consumption have been presented from similar samples in the past (Glanz et al., 1998; Havas et al., 1998). Nonetheless, the fact that participants were willing to be involved in such a trial may reflect their particular interest in health and nutrition. The average number of portions of fruit and vegetables per day (3.64) was lower than that reported in recent surveys in the United States (Krebs-Smith, Cook, et al., 1995; U.S. Department of Health and Human Services, 2000). The proportion of participants eating five or more servings per day was 24%, again lower than the 32%–35% reported in the United States. The National Food Survey in the United Kingdom reported a mean intake of 3.85 portions per day across all households in 1999, with an average of 3.31 and 3.28 servings per day in low- and very low-income households (Ministry of Agriculture, Food and Fisheries, 2000). It does not appear, therefore, that our participants were especially likely to be eating more fruit and vegetables than expected. The proportion of men taking vitamins (29%) was rather higher than the 23% reported in the 1998 Health Survey for England (Erens & Primatesta, 1999), and the rates in women were comparable (33%). The differences between ethnic groups in biomarkers were similar to those previously described in surveys in this population (Ness, Cappuccio, Atkinson, Khaw, & Cook, 1999).

The focus on people living in a low-income urban neighborhood has implications for these results. Such neighborhoods are subject to greater stress because of traffic noise, antisocial behavior, and lack of facilities than are more affluent areas (Steptoe & Feldman, 2001). A greater proportion of household income must be spent on food compared with the situation in higher income neighborhoods, so purchasing choices tend to emphasize value for money and energy-dense foods. There is evidence for differential costing of “healthy” food in better off and deprived neighborhoods (Donkin, Dowler, Stevenson, & Turner, 2000). The low-income population was rather different from those studied in recent U.S. studies of fruit and vegetables, which have focused on the congregations of Black churches (Resnicow et al., 2001), rural African Americans (Campbell et al., 1998), and women with young children (Havas et al., 1998). The current study involved predominantly White, middle-aged men and women living in London.

Nonetheless, the factors that were associated with fruit and vegetable consumption were the same as those identified in more general surveys. The factor that emerged as the most consistent psychological correlate of outcome was awareness of recommendations concerning fruit and vegetable consumption. Knowledge of recommended levels was associated with greater self-reported intake, higher potassium excretion, and higher plasma vitamin C concentration. In comparison with respondents who did not know the recommended level of intake, participants who knew that the recommendation was five or more a day ate 24% more fruit and vegetables and had 27% higher potassium excretion and 15% higher vitamin C, after adjusting for confounders. This result supports the role played by nutritional knowledge in determining healthy diet and suggests that in this population, awareness of official recommendations is important. Interestingly, the main difference we observed was between knowing about five or more portions per day and not knowing about recommendations at all. In post hoc analyses (not detailed here), no differences were found between respondents who indicated that the recommended intake was above or below five servings a day. It is possible that those individuals who stated that they did not know the recommended daily intake may have been unaware that there even are recommendations, and inaccurate knowledge may not have been a bar to consumption.

Beliefs in the health benefits of eating fruit and vegetables have been related to consumption in a number of cross-sectional studies (Anderson et al., 2000; Wardle et al., 1997). The association was not significant in the current study (Table 1). This may have been due in part to the relatively small sample size and the fact that beliefs in health benefits covaried with age, sex, and smoking; when these factors were not included in the analysis, fruit and vegetable intake was significantly greater in participants who had high compared with low beliefs in health benefits ($p = .032$).

However, an additional issue was that ratings on the measure of health benefits were generally high, so did not effectively distinguish groups. Because the participants had volunteered for an intervention program, they may have been especially oriented toward recognizing the benefits of dietary change.

As expected, perceived barriers proved to be more consistently associated both with self-reported fruit and vegetable intake and with biomarkers than were the measures of nonhealth benefits. The latter were not reliably related to any outcome, whereas reported intake and potassium excretion were both lower in people reporting strong barriers. It can be estimated from Tables 1 and 2 that fruit and vegetable intake was 40% greater among participants in the lowest than highest quartiles of barriers, and the potassium excretion was 18% greater. This confirmed our hypothesis that in low-income neighborhoods, barriers to consumption are more tangible than perceived benefits. Agreement with such sentiments as *eating fruit and vegetables makes people feel good* or *eating fruit and vegetables improves the way people look* may reflect general positive attitudes to consumption that have less influence on behavior than do specific affective, economic, and social barriers.

Self-efficacy showed a strong association with reported fruit and vegetable intake, comparable with the patterns reported by others (Brug et al., 1995; Havas et al., 1998). The reported intake of fruit and vegetables was 24% greater in the highest compared with the lowest self-efficacy quartile, but it is striking that no relationship with self-efficacy was recorded for either of the biomarkers. The self-efficacy measure assessed people's confidence in eating fruit and vegetables under difficult circumstances, such as being away from home or in socially demanding situations. Therefore, there may only be a limited association between self-efficacy and habitual consumption, and the concept may be more important when behavior change is being promoted. Our failure to observe associations between encouragement from others and fruit and vegetable consumption is consistent with previous studies (Brug et al., 1995; Krebs-Smith, Heimendinger, et al., 1995). However, it should also be noted that encouragement was assessed with a single item, in contrast to the other multi-item variables, and may therefore not have been measured as reliably as other constructs.

In this study, we showed moderate consistency between the psychological factors associated with self-reported consumption and the psychological factors associated with biomarkers. The psychological measures that yielded significant relationships with biomarkers were all variables that also showed associations with fruit and vegetable consumption, with the exception of the unpredicted reverse relationship between encouragement from others and plasma vitamin C concentration. There are a number of plausible explanations for the variability of associations between reported intake and biomarkers. There may be errors and bias in diet measures because of inaccurate recall, difficulties in assessing diet in a culturally sensitive fashion, and the wish of some participants to present themselves in a favorable light. The measure of fruit and vegetable intake was general in nature, and not all intake contributes directly to the two biomarkers selected. Error may also arise from the variability in biomarkers over time. It has been argued, for example, that eight 24-hr urine records (and a minimum of 16 days of weighed intake) are needed to accurately assess usual dietary intake (McKeown et al., 2001). There is variation in the bioavailability of micronutrients because of the diverse factors influencing digestion and absorption, so the same nutritional load may have different effects on biomarkers across individuals (van den Berg, van der Gaag, & Hendriks, 2002). Biomarkers reflect recent intake of nutrients, whereas the dietary measure was presumed to assess habitual consumption.

The discrepancies between results for plasma vitamin C and potassium excretion relate in part to variation in other factors that affect these measures and in part to the specific patterns of food choice. Fruit and vegetable consumption was assessed with a general measure, but different foods do not have the same impact on these biomarkers. For example, the vitamin C content of a portion of grapefruit is more than five times greater than that of an apple (U.S. Department of Agriculture, 2001). The potassium content of a banana is 10 times that of a serving of lettuce. The dietary measures used here did not have the sensitivity to detect these differences because they were restricted to counting the total number of servings.

The limitations of this study should be recognized. Results were based on cross-sectional analyses, and no conclusions about the causal sequence can be drawn. As noted above, the data were collected from adults who agreed to participate in an intervention trial, so results may not be representative of this sector of the population in general. Nevertheless, the results are encouraging in demonstrating that social cognition variables are not only associated with self-reported fruit and vegetable intake but also with biomarkers of consumption. This adds strength to the argument that attitudinal factors index genuine influences on dietary behavior that affect the beneficial biological consequences of eating fruit and vegetables.

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