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A Multicenter Randomized Controlled Trial of a Nutrition Intervention Program in a Multiethnic Adult Population in the Corporate Setting Reduces Depression and Anxiety and Improves Quality of Life: The GEICO Study

Ulka Agarwal, MD; Suruchi Mishra, PhD; Jia Xu, PhD; Susan Levin, MS, RD; Joseph Gonzales, RD; Neal D. Barnard, MD

Abstract

Purpose. To determine whether a plant-based nutrition program in a multicenter, corporate setting improves depression, anxiety, and productivity.

Design. A quasi-experimental study examined the impact of diet on emotional well-being and productivity.

Setting. The study was conducted in 10 corporate sites of a major U.S. insurance company.

Subjects. There were 292 participants (79.8% women, 20.2% men), with body mass index ≥ 25 kg/m^2 and/or previous diagnosis of type 2 diabetes.

Intervention. Either weekly instruction in following a vegan diet or no instruction was given for 18 weeks.

Measures. Depression and anxiety were measured using the Short Form-36 questionnaire. Work productivity was measured using the Work Productivity and Activity Impairment questionnaire.

Analysis. Baseline characteristics were examined by t-test for continuous variables and χ^2 test for categorical variables. Analysis of covariance models were adjusted for baseline covariates. Paired t-tests were used to determine within-group changes and t-tests for between-group differences.

Results. In an intention-to-treat analysis, improvements in impairment because of health ($p < .001$), overall work impairment because of health ($p = .02$), non-work-related activity impairment because of health ($p < .001$), depression ($p = .02$), anxiety ($p = .04$), fatigue ($p < .001$), emotional well-being ($p = .01$), daily functioning because of physical health ($p = .01$), and general health ($p = 0.02$) in the intervention group were significantly greater than in the control group. Results were similar for study completers.

Conclusion. A dietary intervention improves depression, anxiety, and productivity in a multicenter, corporate setting. (Am J Health Promot 2015;29[4]:245–254.)

Key Words: Vegan, Vegetarian, Depression, Productivity, Nutrition, Worksite, Prevention Research. Manuscript format: research; Research purpose: intervention testing, program evaluation; Study design: quasi-experimental; Outcome measure: behavioral, productivity; Setting: workplace; Health focus: nutrition; Strategy: education, behavior change; Target population: adults; Target population circumstances: education, geographic location, race/ethnicity

PURPOSE

Health in the workplace is often thought of in its physical aspects, such as the presence or absence of injuries or illnesses than can diminish productivity. However, people in the workforce are often encumbered by problems in psychological adjustment, most notably depression, but anxiety as well. In a given year, roughly 19 million American adults (9.5% of the adult population) will suffer from a depressive illness.[1] Approximately 80% of people with depression report some functional impairment caused by depression, and 27% report serious difficulties in work and home life.[2] Depressive symptoms lead to work absences and impaired work performance, and work stressors can aggravate these problems.[3]

Depression causes the loss of an estimated 200 million workdays each year at a cost to employers of $17 to $44 billion.[4] People with depression miss an average of 19 workdays and have 46 days of reduced productivity each year.[1] Depression is the leading cause of medical disability for people aged 14 to 44 years.[5] The cost of

depression (lost productivity and increased medical expenses) is estimated at $83 billion each year.[6] In addition to its direct costs, depression also indirectly increases health care costs and lost productivity by aggravating other costly conditions such as heart disease, diabetes, and stroke.[7]

In theory, at least, a dietary intervention at the worksite could reduce employer health care costs. A 2005 meta-analysis found that employees participating in health and wellness programs at the workplace had an average 26% decrease in health care costs, 27% decrease in sick leave, and 32% decrease in workers' compensation costs.[8]

Medications have an important role in mental health, but are limited in effectiveness and can have frequent side effects. Lifestyle interventions have an increasingly apparent role in physical and mental health, and among the most effective of these is the use of plant-based diets. Compared with individuals following omnivorous diets, people following vegetarian and vegan diets tend to have a lower risk of chronic physical illnesses, particularly obesity;[9–12] type 2 diabetes;[13–16] heart disease;[17,18] hypertension;[19–21] and certain forms of cancer.[20–24] Some evidence suggests that a vegan diet may have a particularly helpful effect on medical outcomes (compared with other types of plant-based diets).[14] Although data on the effects of nutritional interventions on depression, anxiety, and work productivity[25] are very limited, some studies have suggested the possibility of benefits. Beezhold et al. found that individuals following vegetarian diets had significantly less negative emotion,[26] better mood, and coped better with mental stress than did those eating fish and meat.[27] A stay at a raw vegan institute was associated with improved anxiety, perceived stress, and depression after 12 weeks,[28] although the effect of diet cannot be separated from the effect of the residential stay in such a study.

In a previous study conducted at two Government Employees Insurance Company (GEICO) corporate sites, participants in an intervention program of weekly classes in how to follow a vegan diet had significantly more improvement in depression and anxiety compared with those who had no intervention.[29] The present study aimed to assess the effects of a similar intervention in a larger and more geographically diverse population.

Worksite interventions are attractive and effective tools for employers as they have been shown to improve the health and well-being of employees and reduce health care, workers' compensation, and disability costs.[8,30–33] The workplace is a fitting venue for nutrition education interventions because it is where many individuals spend much of their day, consume multiple meals, and receive nutrition and health information. In addition, employers have a financial interest in the health of their employees.

The aim of the present study was to evaluate the effects of a program of weekly instruction in a low-fat vegan diet on physical well-being, depression, anxiety, and work productivity in a large sample of employees in 10 corporate sites in multiple geographical regions throughout the United States.

METHODS

Sample

Participants 18 years and above with a body mass index (BMI) ≥ 25 kg/m^2 and/or a previous diagnosis of type 2 diabetes were recruited through advertisements and group meetings at 10 GEICO corporate offices located in Tucson, Arizona; San Diego, California; Lakeland, Florida; Macon, Georgia; Chevy Chase, Maryland; Buffalo, New York; Woodbury, New York; Dallas, Texas; Fredericksburg, Virginia; and Virginia Beach, Virginia. Exclusion criteria included current alcohol or drug abuse; pregnancy; history of severe mental illness (such as severe depression with suicidal ideation, bipolar affective disorder, or schizophrenia); unstable medical status; current adherence to a low-fat, vegetarian diet; participation in the previous two-site GEICO study;[25] and inability to attend weekly group meetings.

Sites were randomly assigned to an intervention group in which volunteers were asked to follow a low-fat plant-based diet (five sites) or to a control group in which volunteers made no diet changes (five sites). At the intervention sites, participants also participated in weekly group meetings that included instruction and group support. At the control sites, participants did not receive any instruction. Dietary recalls were used to assess nutrient intake over two 24-hour periods at baseline and two 24-hour periods at 18 weeks, using an online (Automated Self-Administered 24-Hour Recall [ASA24]) program developed by the National Cancer Institute, Bethesda, Maryland.[34] The format and design of the ASA24 are based on the interviewer-administered Automated Multiple Pass Method (AMPM) 24-hour recall developed by the U.S. Department of Agriculture. The online program has the advantages of ease of use and scoring and face validity; however, although the AMPM is a validated instrument, validation trials of ASA24 remained in progress at the time of this study.[35] Participants were asked to complete their diet records online as best they could. Participants were advised that ASA24 includes common plant-based items, such as vegan burgers, seitan, and tofu, but omits others, such as quinoa and tempeh. Participants were instructed not to skip any entries even if exact matches were not found in ASA24. Instead, they were coached on how to find a suitable alterative, such as substituting brown rice for quinoa or a vegetarian submarine sandwich for a vegan sandwich. Registered dietitians cross-checked data on ASA24 by taking participant nutrient data and entering it into the U.S. Department of Agriculture nutrient database to make sure nutrient intake numbers were relevant to ASA24.

Design

Individuals interested in joining the study were asked to attend a group meeting with research staff. Those who satisfied participation criteria were scheduled for in-person interviews to review the study procedures and confirm eligibility. Participation was completely voluntary, and all participants provided written informed consent. The study was approved by an external institutional review board.

Worksites were pair-matched based on the number of volunteers per site. Each pair of sites represented a cluster.

The sites within each pair (cluster) were randomly assigned to the intervention group (five sites) or control group (five sites). All participants at a given site were in the same assigned group because assignment was done by site rather than by individual.

Intervention

Participants at the intervention sites were asked to participate in a program of instruction in following a low-fat vegan diet. The purpose of the study was to evaluate the effects of the intervention program as a whole, not to attempt to isolate the effects of the diet.

The diet consisted of fruits, vegetables, whole grains, and legumes. Participants were asked to avoid all animal products (i.e., meat, poultry, fish, dairy products, and eggs) and to minimize added oils, with a target of less than 3 grams of fat per serving. Participants were encouraged to favor foods with a low glycemic index, such as beans, fruits (except watermelon and pineapple), pasta, sweet potatoes (rather than white potatoes), rye and pumpernickel bread (rather than typical wheat breads), and oatmeal or bran cereal (rather than typical cold cereals). Participants received an hour-long lecture on the basics of the glycemic index, including a list of foods to favor and foods to avoid, and received a handout detailing the same information. No restrictions were placed on portion sizes, energy, or carbohydrate intakes. Participants at intervention sites were also asked to take a daily multivitamin to meet vitamin B_{12} requirements. At intervention sites that had cafeterias, the cafeteria management included low-fat vegan menu options. Typical breakfast options included oatmeal with cinnamon and raisins, soy or rice milk, pumpernickel toast with jam and grapefruit, or a whole grain bagel with apple butter, vegetarian bacon, and cantaloupe. Lunch options included a whole wheat pita stuffed with hummus, sliced tomatoes, lettuce, and carrot sticks, or a bean burritos (black beans in corn tortillas, chopped lettuce, tomatoes) and a salsa spinach salad with low-fat dressing. Dinner options included baked beans, baked sweet potato, steamed collard greens with lemon

juice, and a baked apple, or Chinese stir-fry over brown rice (tofu, broccoli, pea pods, water chestnuts, bok choy) and cantaloupe chunks with fresh lime juice. Snacks included items such as dried figs, mixed fruit salad, and baked corn tortillas with salsa.

Participants at the intervention sites were asked to follow a low-fat vegan diet for 18 weeks. Group instruction and support were provided for the duration of the study in weekly lunch-hour classes held at the worksite and led by a registered dietician, physician, and/or a cooking instructor following a predetermined curriculum. Classes included nutrition education lectures on topics such as the role of nutrition in weight loss, diabetes, heart disease, and cancer, as well as cooking demonstrations and group discussion. Additional support was provided by an interactive online message board.

Individuals at control sites received no dietary instruction, and no additional foods were offered in the cafeterias at those sites.

Individuals at intervention sites were not compensated. Because participants in the control group received no intervention that might compensate them for their efforts in participating, they were given monetary compensation in the form of $50 gift certificates to Whole Foods Market or Target for completion of all aspects of the study. This was not deemed necessary for intervention-group participants.

All participants in both groups were asked not to alter their exercise patterns during the study period. Participants were asked to continue their preexisting medication regimens unless modified by their personal physicians. No restrictions were placed on use of medications during the study, but information regarding current medication use was collected at baseline and week 18.

Measures

Physical and emotional well-being was assessed using the 36-Item Short Form Health Survey (SF-36), which includes four physical subscales (physical functioning, physical role limitation or daily functioning because of physical health, pain, and general health) and four mental subscales (fatigue, social functioning, emotional
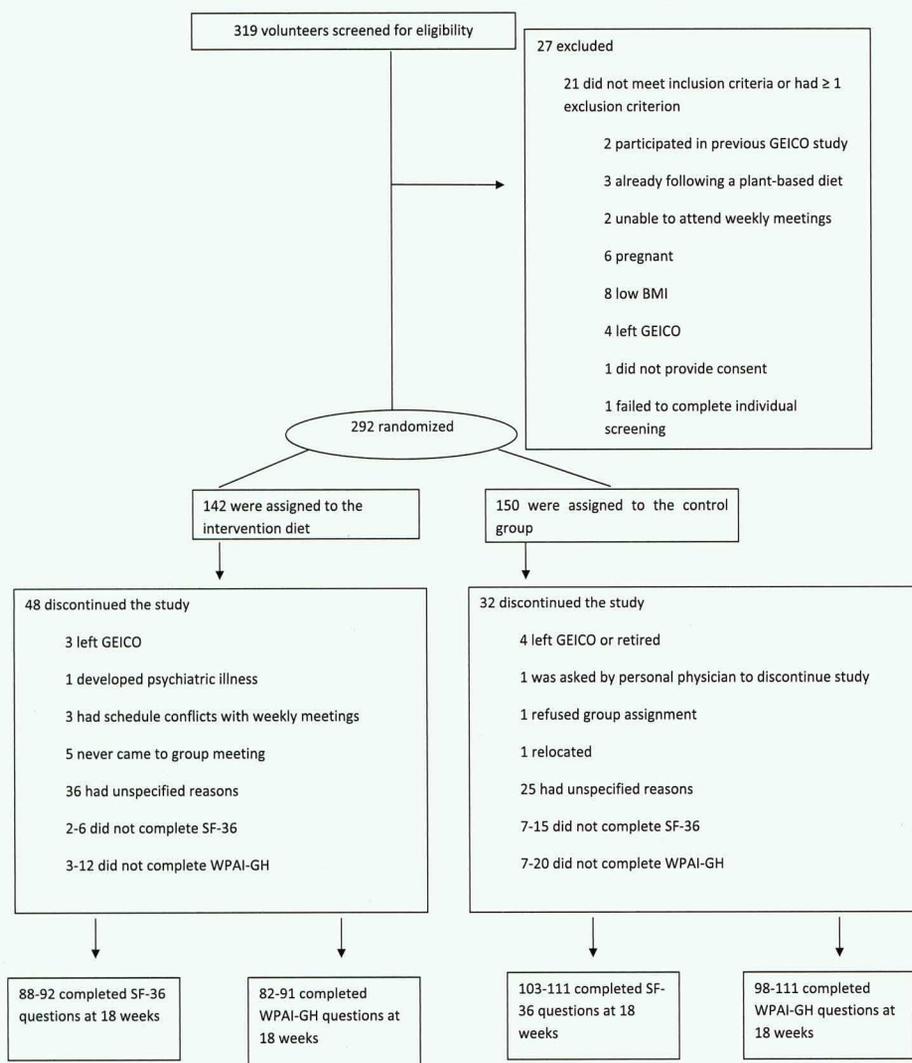
role limitations or daily functioning because of emotional health, and emotional well-being). We added two additional subscales to isolate specific mental health measures (depression, anxiety).[36] Physical role limitations are defined as problems with work or regular daily activities as a result of one's physical health. Emotional role limitations are defined as problems with work or regular daily activities as a result of one's emotional problems. Items on the SF-36 are scored on a scale of 0 to 100, with a higher score indicating better health-related quality of life. The SF-36 has undergone extensive validity and reliability trials,[37] and published reliability statistics have exceeded the minimum standard recommended for measures used in group comparisons.[38]

Work productivity was assessed using the Work Productivity and Activity Impairment questionnaire, general health version (WPAI-GH).[39] The WPAI-GH consists of six questions that ask participants to rate the extent to which their health problems impaired productivity at work and in daily activities during the preceding 7 days. Participants are asked how many hours they missed from work because of health problems or for other reasons and asked to rate how health problems affected their productivity at work or outside of it. Outcomes are expressed as percentages, with higher values indicating greater impairment and less productivity. Overall work impairment was calculated as (percent work time missed) + [(percent work time attended) × (percent impairment while at work)], as defined by the original instrument. The WPAI is validated[39] and has undergone substantial psychometric testing.[40]

Analysis

Data were checked for extreme values, and the distributions of variables were examined for skewness. Baseline characteristics were examined by t-test for continuous variables and χ^2 test for categorical variables. Analysis of covariance models were adjusted for baseline covariates. The analysis of covariance approach adjusts for baseline differences, is efficient, and maintains proper α level and power, both conditionally and unconditionally.[41]

Figure
Recruitment and Flow of Participants Through Trial*

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┌──────────────────────────────────────────┐
│ 319 volunteers screened for eligibility   │
└──────────────────────────────────────────┘
                    │
                    │          ┌──────────────────────────────────────────┐
                    │─────────▶│ 27 excluded                              │
                    │          │                                          │
                    │          │  21 did not meet inclusion criteria or   │
                    │          │  had ≥ 1 exclusion criterion             │
                    │          │                                          │
                    │          │  2 participated in previous GEICO study  │
                    │          │                                          │
                    │          │  3 already following a plant-based diet  │
                    │          │                                          │
                    │          │  2 unable to attend weekly meetings      │
                    │          │                                          │
                    │          │  6 pregnant                              │
                    │          │                                          │
                    │          │  8 low BMI                               │
                    │          │                                          │
                    │          │  4 left GEICO                            │
                    │          │                                          │
                    │          │  1 did not provide consent               │
                    │          │                                          │
                    │          │  1 failed to complete individual         │
                    │          │  screening                               │
                    │          └──────────────────────────────────────────┘
            ┌───────────────┐
            │ 292 randomized │
            └───────────────┘
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142 were assigned to the intervention diet	150 were assigned to the control group

48 discontinued the study	32 discontinued the study
3 left GEICO	4 left GEICO or retired
1 developed psychiatric illness	1 was asked by personal physician to discontinue study
3 had schedule conflicts with weekly meetings	1 refused group assignment
5 never came to group meeting	1 relocated
36 had unspecified reasons	25 had unspecified reasons
2-6 did not complete SF-36	7-15 did not complete SF-36
3-12 did not complete WPAI-GH	7-20 did not complete WPAI-GH

88-92 completed SF-36 questions at 18 weeks	82-91 completed WPAI-GH questions at 18 weeks	103-111 completed SF-36 questions at 18 weeks	98-111 completed WPAI-GH questions at 18 weeks

*GEICO indicates Government Employees Insurance Company; BMI, body mass index; SF-36, 36-Item Short Form Health Survey; and WPAI-GH, Work Productivity and Activity Impairment questionnaire, general health version.

The assumption of homogeneity of regression slopes for analysis of covariance was tested. General linear model univariate analysis (analysis of covariance) was used to determine between-group differences in changes in health-related quality measures and work productivity from baseline to 18 weeks, where treatment group, gender, cluster, and psychiatric medications were included as fixed factors and baseline variables as covariates. Paired t-tests were used to determine within-group differences.

Analyses were done in two ways. First, an intention-to-treat analysis was performed to assess the effects of assignment to the intervention condition regardless of the degree to which individuals actually participated. In this analysis, baseline data were used in cases of missing information. A separate analysis was performed on those participants who completed week 18 assessments to determine the effect of the intervention among program completers. The number of completers varied slightly from question to ques-

tion on both SF-36 and WPAI-GH assessment scales because omitted questions were not included in the analysis.

To determine within-group changes in dietary variables, paired t-tests were used. Differences between the intervention and control group were determined by t-tests. Between-group differences were calculated as baseline value minus week 18 value. For the SF-36, because a higher score indicates better health-related quality of life, a negative between-group difference indicates an improvement in health-related quality of life measures at week 18. For the WPAI-GH, because a higher score indicates more impairment and less productivity, a positive between-group difference indicates an improvement in work productivity measures at week 18. All analyses were conducted using SPSS version 18.0 (Chicago, Illinois). P values <.05 were considered significant.

RESULTS

Of the 319 participants screened for eligibility, 292 (142 at intervention sites and 150 at control sites) met participation criteria and were enrolled in the study. Twenty-seven participants did not meet the participation criteria and were excluded for reasons of pregnancy, already following a plant-based diet, low BMI, participation in the previous study, departure from employment, inability to attend weekly classes, unwillingness to provide consent, and failure to complete screening (Figure). The intervention sites were in Tucson, Macon, Chevy Chase, Woodbury, and Fredericksburg. The control sites were in San Diego, Lakeland, Buffalo, Dallas, and Virginia Beach. There were no differences in baseline characteristics among volunteers excluded prior to randomization and those who were enrolled (p values ranged from .1 to .8). At baseline, no significant differences were found between the intervention and control groups for any demographic or clinical measures except gender ($p = .02$) (Table 1). There were no intervention-related serious adverse events. The attrition rates (i.e., the percentage of individuals who failed to attend 18-week assessments)

Table 1
Baseline Characteristics by Group Assignment

Characteristics	Intervention		Control		P*	
	SF-36 (n = 137)	WPAI (n = 136)	SF-36 (n = 145)	WPAI (n = 144)	SF-36	WPAI
Age, years (SD)	43.84 (10.61)	43.65 (10.56)	45.38 (11.29)	45.35 (11.32)	0.24	0.20
Gender no. (%)					0.02	0.02
Men	31 (22.63)	31 (22.79)	18 (12.41)	18 (12.50)		
Women	106 (77.37)	105 (77.78)	127 (87.59)	126 (87.50)		
Race no. (%)					0.30	0.30
White	87 (63.50)	85 (62.50)	97 (66.90)	96 (66.67)		
Black	30 (21.90)	31 (22.79)	37 (25.52)	37 (25.69)		
Asian	10 (7.30)	10 (7.35)	5 (3.45)	5 (3.47)		
Other	10 (7.30)	10 (7.35)	6 (4.14)	6 (4.17)		
Occupation no. (%)					0.28	0.30
Sales/service	7 (5.11)	8 (5.88)	10 (6.90)	10 (6.94)		
Supporting staff	33 (24.09)	33 (24.26)	23 (15.86)	23 (15.97)		
Professional	86 (62.77)	84 (61.76)	103 (71.03)	102 (70.83)		
Other	11 (8.03)	11 (8.09)	9 (6.21)	9 (6.25)		

SF-36 indicates Short Form-36; and WPAI, Work Productivity and Activity Impairment questionnaire.

* P refers to χ^2 test for categorical variables and t-test for continuous variable for differences between groups.

for the intervention and control groups were 33.8% vs. 21.3%, respectively.

SF-36. In the intention-to-treat analysis, after adjustment for gender, cluster, and psychiatric medications for analysis of covariance (ANCOVA), improvements in depression ($p = .02$), anxiety ($p = .04$), fatigue ($p < .001$), emotional well-being ($p = .01$), daily functioning because of physical health ($p = .01$), and general health ($p = .02$) in the intervention group were all significantly greater than those in the control group (Table 2).

In the analysis on study completers adjusted for gender, cluster, and psychiatric medications, the between-group differences in improvements in depression ($p < .01$), anxiety ($p = .01$), fatigue ($p < .001$), emotional well-being ($p < .05$), daily functioning because of physical health ($p < .001$) and general health ($p < .01$), daily functioning because of emotional health ($p < .01$), social functioning ($p = .04$), physical functioning ($p = .02$), and pain ($p = .04$) were all significant, favoring the intervention group in each case.

WPAI-GH. In the intention-to-treat analysis, when changes in each subscale were compared between the two groups, after adjusting for gender and cluster in the ANCOVA, improvements in impairment while working because of health ($p < .01$), overall work impairment because of health ($p = .02$), and non-work-related activity impairment because of health ($p < .001$) in the intervention group were all significantly greater than those in the control group (Table 3).

When an analysis was performed for study completers, results remained the same as the intention-to-treat analysis for within-group, between-group, and ANCOVA analyses.

Adherence to the Intervention. Significant changes in diet indicators of fat, cholesterol, fiber, and phytonutrients were seen in the intervention group.[42] Because dietary cholesterol is only present in animal products, dietary cholesterol intake was used as a measure of adherence to the vegan diet. Among study completers, cholesterol intake at 18 weeks was ≤75 mg/day for 85% (66/78) of intervention group participants and 21% (22/105) of control group participants ($P < .001$).

Cholesterol intake was ≤50 mg/day for 74% (58/78) of intervention group participants but only 13% (14/105) of control group participants ($P < .001$). Total and saturated fat intakes were used as a measure of adherence to a low-fat diet. Total fat intake was ≤35% of the total calorie intake for 86% (67/78) of intervention group participants compared with 40% (42/105) of the control group participants ($P < .001$). Fat intake was ≤25% for 49% (38/78) of intervention group participants and for 8% (8/105) of control group participants ($P < .001$). Saturated fat (SFA) intake was ≤10% of total calorie intake for 88% (69/78) of intervention group participants and 38% (40/105) of control group participants ($P < .001$). SFA intake was ≤5% of total calorie intake for 51% (40/78) of intervention group participants but only for 5% (5/105) of control group participants ($P < .001$). During the 18-week intervention, both groups reduced the reported energy intake, but the between-group difference was not significant. Comparing nutrient intake changes over time between the two groups in the intention-to-treat analysis, adjusting for baseline values, and accounting for within-site correlations in outcome, the intervention group significantly reduced the mean reported intake of fat, particularly of SFA but also of monounsaturated fat. The intervention group also increased carbohydrate and fiber intake and reduced protein and cholesterol intake. The intervention group also significantly increased the reported intake of b-carotene, vitamin C, magnesium, and potassium, both within group and compared with the control group, indicating a significantly increased intake of fruits and vegetables.

DISCUSSION

The current findings demonstrate that an intervention using dietary instruction with a low-fat vegan diet improves indicators of depression, anxiety, and work productivity in a large, multicenter, corporate setting. Specifically, participants in the intervention group reported significant improvements in depression, anxiety, fatigue, emotional well-being, daily

Table 2
Responses to SF-36 Questionnaire at Baseline and Week 18

Clinical Measure	Intervention			P*
	Baseline Mean	18-wk Mean	Within-Group Difference	
Physical functioning				
Intention to treat (intervention = 133) (control = 137)	79.06 (20.57)	83.46 (22.53)	−4.40**** (17.33)	0.004
Completers (intervention = 88) (control = 103)	80.91 (19.78)	87.56 (21.89)	−6.65**** (20.99)	0.004
Physical role limitation				
Intention to treat (intervention = 137) (control = 140)	71.35 (38.05)	81.02 (34.24)	−9.67**** (32.55)	0.001
Completers (intervention = 92) (control = 107)	73.64 (36.6)	88.04 (28.34)	−14.40**** (38.91)	0.001
Emotional role limitation				
Intention to treat (intervention = 135) (control = 143)	76.05 (35.89)	90.86 (67.83)	−14.82***** (66.13)	0.01
Completers (intervention = 92) (control = 109)	76.95 (36.28)	84.25 (31.46)	−7.30**** (37.74)	0.01
Fatigue				
Intention to treat (intervention = 129) (control = 144)	45.81 (21.14)	57.05 (22.10)	−11.24*** (17.41)	<0.001
Completers (intervention = 85) (control = 111)	45.88 (21.80)	62.94 (20.88)	−17.06*** (19.01)	<0.001
Emotional well-being				
Intention to treat (intervention = 135) (control = 144)	69.69 (17.77)	74.76 (17.99)	−5.07*** (13.65)	<0.001
Completers (intervention = 91) (control = 109)	70.77 (17.06)	78.29 (16.35)	−7.52*** (16.09)	<0.001
Social functioning				
Intention to treat (intervention = 129) (control = 138)	73.55 (25.18)	80.33 (25.71)	−6.78**** (24.41)	0.002
Completers (intervention = 87) (control = 104)	76.58 (24.77)	86.64 (23.64)	−10.06**** (29.21)	0.002
Pain				
Intention to treat (intervention = 137) (control = 144)	71.79 (23.79)	75.46 (26.34)	−3.67 (22.58)	0.06
Completers (intervention = 92) (control = 110)	75.19 (22.52)	80.65 (25.51)	−5.46 (27.42)	0.06
General health				
Intention to treat (intervention = 137) (control = 139)	59.56 (21.09)	68.25 (32.48)	−8.69*** (27.12)	<0.001
Completers (intervention = 92) (control = 107)	62.39 (20.08)	75.33 (34.43)	−12.94*** (32.30)	<0.001
Depression				
Intention to treat (intervention = 136) (control = 144)	73.33 (19.13)	78.14 (19.64)	−4.80*** (15.04)	<0.001
Completers (intervention = 91) (control = 110)	74.65 (18.09)	81.83 (17.90)	−7.18*** (17.95)	<0.001
Anxiety				
Intention to treat (intervention = 136) (control = 145)	64.04 (19.75)	69.26 (18.60)	−5.22*** (15.87)	<0.001
Completers (intervention = 92) (control = 110)	64.89 (19.53)	72.61 (16.83)	−7.72*** (18.82)	<0.001

SF-36 indicates Short Form-36; and CI, confidence interval.
† Unadjusted from t-test.
‡ Adjusted for gender, cluster, medications, and baseline values in univariate analysis.
* P refers to χ^2 tests for categorical variables and t-tests for continuous variables for differences within groups.
** P refers to χ^2 tests for categorical variables and t-tests for continuous variables for differences between groups.
*** $p < 0.001$.
**** $p < 0.01$.
***** $p < 0.05$.

functioning because of emotional health, impairment while working because of health, overall work impairment because of health, and non-work-related activity impairment because of health, compared with the control group at 18 weeks.

Improvements in depression and anxiety are consistent with previous findings that, while limited, suggest that vegetarian and vegan diets may improve mood.[25–28,43] A number of studies have shown that consumption of plant-based foods is associated with a lower risk of depression. Intake of fruits and vegetables have been found to be significantly lower in older Mexicans with depressive symptoms.[44] A lower intake of vegetables was linked to higher depressive symptoms in Finnish men and women 25 to 64 years old[45] and in a sample of adults 18 years and older derived from the 2002–2003 cross-sectional Decennial Health Survey.[46] Woo et al.[47] observed an inverse association of fiber and vegetable intakes with depression in an elderly Chinese population. Dietary patterns that favor plant-based foods have been found to improve depression. A Japanese dietary pattern of high intakes of fruits, vegetables, mushrooms, and soy products was associated with less depression in Japanese municipal employees aged 21 to 67.[48] A Mediterranean dietary pattern with intake of fruits, nuts, vegetables, cereals, legumes, and fish, has been linked to a lower risk of depression[49] and has been linked to prevention of depression in college graduates.[50] Tsai et al.[51] found vegetables to be associated with

Control				Between-Group Difference in Change Score, Mean, Unadjusted† (95% CI)	Between-Group Difference in Change Score, Mean, Adjusted‡ (95% CI)	
Baseline Mean	18-wk Mean	Within-Group Difference	P*			P**
75.07 (25.13)	77.55 (23.03)	−2.48 (16.96)	0.09	−1.92 (−6.03 to 2.19)	2.86 (−1.01 to 6.73)	0.15
74.71 (24.60)	78.01 (21.70)	−3.30 (19.51)	0.09	−3.35 (−9.17 to 2.48)	6.38 (1.14 to 11.62)	0.02
72.14 (36.37)	71.61 (39.35)	0.536 (33.46)	0.85	−10.21***** (−18.04 to −2.40)	9.07 (2.00 to 16.14)	0.01
69.86 (37.26)	69.16 (41.00)	0.701 (38.31)	0.85	−15.10**** (−25.94 to −4.27)	17.36 (8.08 to 26.63)	<0.001
76.69 (37.12)	77.86 (36.887)	−1.17 (34.58)	0.69	−13.65***** (−26.238 to −1.061)	11.01 (−1.02 to 23.04)	0.07
75.54 (37.58)	77.06 (37.322)	−1.53 (39.65)	0.69	−20.21***** (−37.26 to −3.16)	13.20 (5.05 to 21.34)	0.002
45.90 (19.97)	48.61 (21.79)	−2.71***** (14.45)	0.03	−8.53*** (−12.31 to −4.73)	7.67 (4.04 to 11.29)	<0.001
44.28 (19.35)	47.79 (21.96)	−3.51***** (16.39)	0.03	−13.55*** (−18.65 to −8.45)	13.50 (8.80 to 18.19)	<0.001
72.44 (16.93)	72.47 (17.80)	−0.028 (12.33)	0.98	−5.039**** (−8.10 to −1.98)	3.82 (0.89 to 6.75)	0.01
72.04 (17.23)	72.07 (18.35)	−0.037 (14.19)	0.98	−7.480**** (−11.75 to −3.21)	6.26 (2.29 to 10.24)	0.002
78.89 (22.85)	81.34 (22.21)	−2.45 (18.61)	0.12	−4.33 (−9.54 to 0.88)	1.55 (−3.20 to 6.30)	0.52
76.32 (22.50)	79.57 (21.97)	−3.25 (21.40)	0.13	−6.81 (−14.05 to 0.43)	6.41 (0.26 to 12.56)	0.04
69.67 (24.39)	72.01 (23.14)	−2.34 (15.14)	0.07	−1.32 (−5.82 to 3.17)	2.05 (−2.22 to 6.31)	0.35
68.93 (23.49)	72.00 (21.82)	−3.07 (17.27)	0.07	−2.40 (−8.65 to 3.87)	5.96 (0.21 to 11.72)	0.04
57.37 (20.06)	60.32 (20.57)	−2.95**** (11.88)	0.004	−5.74***** (−10.69 to −0.79)	5.97 (0.96 to 10.98)	0.02
56.50 (20.21)	60.33 (20.95)	−3.83**** (13.43)	0.004	−9.10**** (−15.85 to −2.36)	11.40 (4.52 to 18.28)	0.001
76.25 (18.59)	75.88 (18.10)	0.37 (14.32)	0.76	−5.17**** (−8.63 to −1.72)	3.72 (0.49 to 6.94)	0.02
76.06 (19.08)	75.58 (18.45)	0.49 (16.40)	0.76	−7.66**** (−12.49 to −2.84)	6.38 (2.06 to 10.70)	0.004
66.69 (18.71)	67.24 (20.19)	−0.552 (14.42)	0.65	−4.67***** (−8.24 to −1.10)	3.59 (0.25 to 6.92)	0.04
66.09 (19.07)	66.82 (20.98)	−0.73 (16.57)	0.65	−6.99**** (−11.96 to −2.02)	5.82 (1.31 to 10.32)	0.01

reduced risk of depression 4 years later in older Taiwanese adults.

The mechanism by which plant-based diets may reduce the risk of depression is not yet known, but it has been suggested that B vitamins (such as B_6 and folate) and antioxidants may play a role. Consumption and plasma levels of B_6 and folate have been found to be inversely associated with depressive symptoms,[52,53] and supplementation with these vitamins has been shown to be effective in reducing the risk of depressive symptoms. Vegetarian diets are typically rich in antioxidants, which may play a role in reducing depressive symptoms via reduction of oxidative stress.[54] Plant-based diets have also been reported to reduce blood viscosity, which reduces blood pressure and improves blood flow.[55] Whether improved blood flow has positive effects on brain function is not clear.

Dietary carbohydrates may also play a role in depressive symptoms.[56] Because dietary carbohydrates and proteins affect plasma concentrations of tryptophan and the other proteins,[57,58] they also affect brain tryptophan concentrations and the synthesis and release of serotonin.[59,60] Dietary carbohydrates raise the plasma tryptophan ratio and facilitate tryptophan's entry into the brain, whereas proteins lower the plasma tryptophan ratio.[57,58] Changes in brain serotonin have been thought to cause the cravings for carbohydrates seen in mood disorders such as seasonal depression.[61]

To the extent that diet changes lead to better physical health, individuals may be more physically and socially active, leading to better emotional adjustment. A 2013 study found that individuals with type 2 diabetes consuming a vegetarian diet felt less constrained than did those consuming a conventional diet, disinhibition decreased, feelings of hunger decreased, and they were less likely to overeat as a response to stress, improving their overall quality of life and mood.[62] However, we note that our study was not designed to isolate the effects of the dietary change from those of the overall intervention, which involved weekly group meetings, and may have had an effect on mood and adjustment.

Our findings that a dietary intervention at the workplace increased work productivity are consistent with

Table 3
Responses to WPAI-GH Questionnaire at Baseline and Week 18

Clinical Measure	Intervention				Control		
	Baseline Mean	18-wk Mean	Within-Group Difference	P^*	Baseline Mean	18-wk Mean	Within-Group Difference
Work time missed due to health (%)							
Intention to treat (intervention = 131) (control = 137)	0.05 (0.14)	0.06 (0.18)	−0.01 (0.17)	0.41	0.03 (0.11)	0.05 (0.14)	−0.02 (0.16)
Completers (intervention = 85) (control = 100)	0.04 (0.10)	0.05 (0.18)	−0.01 (0.21)	0.41	0.04 (0.13)	0.07 (0.16)	−0.03 (0.19)
Impairment while working due to health (%)							
Intention to treat (intervention = 131) (control = 140)	0.17 (0.23)	0.12 (0.20)	0.04***** (0.20)	0.01	0.16 (0.21)	0.19 (0.27)	−0.03 (0.20)
Completers (intervention = 83) (control = 101)	0.15 (0.23)	0.08 (0.18)	0.69***** (0.25)	0.01	0.17 (0.21)	0.21 (0.29)	−0.04 (0.24)
Overall work impairment due to health (%)							
Intention to treat (intervention =1 29) (control = 136)	0.19 (0.25)	0.15 (0.23)	0.04***** (0.23)	0.04	0.17 (0.23)	0.20 (0.29)	−0.03 (0.23)
Completers (intervention = 82) (control = 98)	0.18 (0.25)	0.11 (0.21)	0.65***** (0.28)	0.04	0.18 (0.23)	0.22 (0.30)	−0.04 (0.27)
Activity impairment due to health (%)							
Intention to treat (intervention = 134) (control = 141)	0.23 (0.25)	0.08 (0.20)	0.15*** (0.30)	<0.001	0.25 (0.27)	0.20 (0.27)	0.05***** (0.28)
Completers (intervention = 91) (control = 111)	0.19 (0.24)	0.12 (0.23)	0.07***** (0.27)	0.01	0.25 (0.25)	0.25 (0.28)	0.00 (0.26)

WPAI indicates Work Productivity and Activity Impairment questionnaire; and CI, confidence interval.
† Unadjusted from t-test.
‡ Adjusted for gender, cluster, medications, and baseline values in univariate analysis.
* P refers to χ^2 tests for categorical variables and t-tests for continuous variables for differences within groups.
** P refers to χ^2 tests for categorical variables and t-tests for continuous variables for differences between groups.
*** $p < 0.001$.
**** $p < 0.01$.
***** $p < 0.05$.

those from other workplace studies.[25,32] A prior study of a dietary intervention involving two GEICO corporate sites demonstrated that a low-fat plant-based diet with weekly nutrition education was highly acceptable outside of a clinical trial setting in a corporate environment typical of major businesses. Participants in the intervention diet group reported increased satisfaction with their diet and improvements in physical functioning, mental health, vitality, and work productivity compared with control group participants.[29] A 2012 meta-analysis[63] found that large companies that offer wellness programs see substantial positive returns, even within the first few years. Medical costs fall about $3.27 for every dollar spent on worksite wellness programs, and absentee day costs fall by about $2.73 for every dollar spent.

Strengths of this study include a geographically diverse population, sufficient statistical power to show significant changes, and a study design that can be easily implemented in other corporate locations.

This study has several limitations. Males were underrepresented for reasons that are not clear. The volunteers were self-selected and may have been more motivated than other employees, although this was true for both the intervention and control group. This was a quasi-randomized study in that sites were randomized, but individual participants were not. Although there appeared to be reasonable balance among those variables that were reported, this cannot ensure balance on other unreported or unmeasured variables. The control group did not receive any intervention because the study aimed to measure the effects, not only of a low-fat plant-based diet, but also of a nutrition program in the workplace. Thus, the mere presence of an intervention could account for the observed effects.

In summary, this study demonstrates that a dietary intervention using a low-fat vegan diet in the workplace improves indicators for depression, anxiety, and work productivity in a large, multicenter, corporate setting. Further studies of means of introducing such interventions in the workplace more broadly would be helpful.

SO WHAT? Implications for Health Promotion Practitioners and Researchers

What is already known on this topic?

Individuals participating in worksite wellness programs have many health benefits. Individuals following plant-based diets tend to have a lower risk of obesity, type 2 diabetes, heart disease, hypertension, and certain forms of cancer, and they may have better mood and less anxiety, compared with individuals following other dietary patterns.

What does this article add?

Individuals participating in a nutrition program at 10 large corporate sites at diverse locations in the United States experienced improvements in impairment while working because of health ($p < .001$), overall work impairment because of health ($p = .02$), non-work-related activity impairment because of health ($p < .001$), depression ($p = .02$), anxiety ($p = .04$), fatigue ($p < .001$), emotional well-being ($p = .01$), daily functioning because of physical health ($p = .01$), and general health ($p = .02$) compared with individuals with no intervention at 18 weeks.

What are the implications for health promotion practice or research?

Nutrition-related interventions can be implemented in other corporate locations, with benefits for employee quality of life.

Table 3, Extended

P*	Between-Group Difference in Change Score, Mean, Unadjusted† (95% CI)	Between-Group Difference in Change Score, Mean, Adjusted‡ (95% CI)	P**
0.03	0.01 (−0.03 to 0.05)	0.00 (−0.04 to 0.04)	0.94
0.13	0.01 (−0.05 to 0.07)	−0.01 (−0.06 to 0.04)	0.66
0.26	0.07**** (0.02 to 0.12)	−0.07 (−0.11 to −0.02)	0.004
0.11	0.11**** (0.04 to 0.18)	−0.11 (−0.18 to −0.05)	0.001
0.23	0.07***** (0.01 to 0.12)	−0.06 (−0.11 to −0.01)	0.02
0.19	0.10***** (0.02 to 0.18)	−0.11 (−0.18 to −0.03)	0.005
0.01	0.10**** (0.03 to 0.16)	−0.11 (−0.16 to −0.06)	<0.001
0.85	0.07 (−0.00 to 0.14)	−0.10 (−0.17 to −0.03)	0.003

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