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Fruits, Vegetables, and Behavior Change:

A Scientific Overview, 2011

CONTENTS

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Fruits, Vegetables, and Behavior Change: A Scientific Overview, 2011

ABSTRACT

Fruit and vegetable intake in U.S. adults remains well below recommended levels, despite evidence of the health benefits of diets high in fruits and vegetables. Efforts to increase fruit and vegetable intake include behavioral-based interventions. Generally, these interventions have demonstrated small increases in intake during the duration of the study, although the behavioral approaches providing the greatest increase in intake have not been clearly established. A systematic review of MEDLINE PubMed and PsycINFO databases was conducted to identify all reported human intervention trials related to fruit and vegetable intake and behavioral approaches since 1995. Using predetermined limits and selection criteria, 65 manuscripts were identified, providing 57 study samples for inclusion in this systematic review.

The most frequently applied behavioral approach was Stages of Change. Current evidence suggests that statistically significant change in fruit and vegetable intake is achieved with behavior-based interventions, as currently designed and delivered. Behavioral interventions in adult population samples resulted in increased fruit and vegetable intake averaging 1.06 servings/day; in older-adult intervention studies, the same mean change in intake was suggested. Interventions involving minority adults demonstrated a mean increase in daily fruit and vegetable consumption of 0.9 servings. In studies of low-income groups, only 3 of the 5 studies provided daily serving data, and the average increase in fruit and vegetable intake was 0.15 servings/day. Behavioral interventions in children have demonstrated an average increase in intake of 0.65 servings/day. Worksite interventions generally demonstrated less of an increase in mean daily fruit and vegetable intake, with a 0.54 increase in servings/day across 12 studies. There is limited evaluation of or current evidence for sustained change in fruit and vegetable intake with behavioral interventions. No studies have compared two or more specific behavioral theories with regard to differences in change estimates for fruit and vegetable intake.

New and novel approaches are needed to more extensively evaluate behavior-based theories in relation to promoting significant increases in fruit and vegetable consumption in Americans. Efforts to integrate behavior-based strategies with social marketing, social networking, and/or technology-based behavioral control should be more extensively pursued in order to increase fruit/vegetable intake in the population, beyond what is achieved with current, behavioral-based interventions alone. Finally, achieving and sustaining fruit and vegetable intake at currently recommended levels across the population will require stronger interventions, coupled with other approaches including efforts to address taste, convenience, availability and access, competitive foods, and value perceptions.

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INTRODUCTION

For the past several decades public health policy statements have called for an increase in fruit and vegetable consumption among U.S. adults and children (Healthy People 2010, Dietary Guidelines 2010). The rationale for promoting greater fruit and vegetable intake ranges from reduced risk for some cancers (WCRF/AICR, 2007), reduction in blood pressure (Savica, 2010), reduced cardiovascular risk (Chen, 2010), reduced inflammatory symptoms in those diagnosed with rheumatoid disease (Pattison, 2004), and possibly reduction in body weight (Astrup, 2008), or adiposity (LeDoux, 2010).

Numerous programmatic approaches have been evaluated in an effort to identify the most effective strategies for increasing regular fruit and vegetable intake (CDC, 2010). These include, but are not limited to, worksite wellness programs (Soler, 2010), computer-tailored interventions (Neville, 2009), school-based interventions (e.g., 5-a-day Power Play), church-based and other community-based programs (Girl Scouts, YMCA/YWCA, etc.), food policy councils/changed environments and access (CDC, 2010), counseling-based interventions, as well as healthcare interventions targeting primary prevention of disease or interventions among high-risk individuals diagnosed with a specific disease.

Despite scientific support of the potential to improve overall health, including a significant reduction in chronic disease such as cancer, type II diabetes, hypertension, and stroke (Dietary Guidelines, 2005), as well as cardiovascular disease (Dauchet, 2006; Oude Griep, 2010), average daily intake of fruits and vegetables remains well below recommended levels (PBH, 2005; Kimmons, 2009). The 2005 Dietary Guidelines for Americans set recommended fruit and vegetable intake levels of 2 cups fruit and 2.5 cups vegetables per 2000 calories consumed (DG, 2005). Average intake of fruits and vegetables in U.S. adults appears to be relatively stable at approximately 1.13 cups of vegetables and 0.68 cups of fruit daily (PBH, 2005); recent NHANES data suggest that 2.2% of adult males and 3.5% of adult females are meeting current recommendations for daily intake of vegetables and fruits (Kimmons, 2009).

Beyond the population data, a review of the literature regarding the effectiveness of select interventions to enhance fruit and vegetable intake in adults reported average changes in intake ranging from no improvement to a high of 4.9 servings daily in the Lyons Heart Study that employed a Mediterranean diet intervention (Pomerleau, 2005). On average, however, intake changed by less than 1 serving per day, consistent with findings of a 2002 systematic review (Ammerman, 2002). Another review of programs targeting greater fruit and vegetable intake in children reported changes in intake ranging from a 0.3 serving decrease in intake (Gimme 5) over 6 weeks to an increase of 0.99 servings/day (High 5 project) over 4.5 weeks for these classroom-delivered, curriculum-based interventions (Knai, 2006). While these reviews provide some optimism that targeted interventions increase fruit and vegetable intake in the study population for the duration of the intervention, it is not clear that current behavior-based interventions achieve intake at or above recommended intake levels or that improvements in fruit and vegetable intake can be sustained over time. Behavioral interventions need to be optimized and strengthened as well as combined with other approaches in order to establish habitual intakes at levels recommended for health.

To address the gap in fruit and vegetable intake versus recommendations (DG, 2005), the National Fruit and Vegetable Alliance (NFVA), a partnership of public and private organizations led by Produce for Better Health and The Centers for Disease Control and Prevention, developed the 2005

National Action Plan (PBH, 2005). This plan identified over 75 strategies to promote increased fruit and vegetable intake. This effort has likely contributed to the more recent expansion of research focused on community-based interventions to increase fruit and vegetable consumption, as well as interventions grounded in behavioral theory. Further, a 2010 gap analysis provides evidence that the current governmental spending priorities are not consistent with or sufficient to meet current recommendations for increased fruit and vegetable consumption in the U.S. population (PBH, 2010).

A review of the currently available literature suggests that habitual intake of fruit and vegetables in the U.S. population, at an intake level that meets current recommendations, will require significant changes in food choices. Targeting behavior change using recognized behavioral theories or constructs for change is not new. And, while behavior change may be challenging, especially at the population level, it is possible, as has been demonstrated in relation to smoking cessation in the U.S. (NHIS, 1965-2009). In fact, a 2002 review of the evidence supporting the success of behavioral-based interventions demonstrated a median increase in fruit and vegetable intake of 17% when intervention group intake was compared with control (Ammerman, 2002). This suggests that behavior-based interventions, defined as interventions that employ an accepted behavioral theory or construct (Table 1), generally result in a significant increase in fruit and vegetable consumption.

A review of the currently available literature suggests that habitual intake of fruit and vegetables in the U.S. population, at an intake level that meets current recommendations, will require significant changes in food choices.

Several common behavioral theories and approaches have been employed to promote change in health behavior, including greater fruit and vegetable intake (Table 1). Interventions that apply behavior theory are delivered, using a variety of delivery settings (schools, churches, community centers, healthcare organizations, etc.), as well as with a diversity of approaches including face-to-face counseling, telephone-based delivery, printed materials (including tailored and non-tailored documents), and more recently, computer-based, technology-driven strategies for delivery of interventions targeting behavioral change.

The purpose of this systematic review is to provide a description of selected literature reporting the effect of behavior-based interventions on fruit and vegetable consumption, including special subgroups within the population such as children and minorities. Although the initial intent was to identify "best practices" in relation to behavioral approaches/theories applied and reported change in fruit and/or vegetable intake, the lack of consistency and detail in reported study design made this aim unachievable at this time. Finally, the evaluation of reviewed evidence is used to identify gaps in current approaches and to suggest future directions for behavioral-based interventions research.

METHODOLOGY

This systematic review was compliant with current recommendations of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis Approach) in reporting the evidence in a specific topic area (Liberati, 2009; Moher, 2007). Systematic reviews are highly relevant to nutrition science in that they are commonly used to determine efficacy of interventions, identify research needs and priorities, formulate dietary guidelines, establish reference intake amounts, formulate practice guidelines, and evaluate applications for food labeling and/or health claims by the food industry (Lichtenstein, 2008).

This systematic review included the search engines MEDLINE PubMed and PsycINFO and employed the search terms fruit, vegetable, and behavior change, and set limits for the search to include only human, English, clinical trial, randomized controlled trial, and studies with publication dates from 1995 to 2010. An additional 14 studies were identified through select citation references and consultation with experts in the field. To focus the results on studies of greatest relevance with

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regard to the health promotion in the United States, the following study criteria were applied as exclusionary criteria: Non-U.S. studies, studies of subjects with a specific clinical diagnosis (e.g., cancer, hypertension, diabetes, obesity, etc.), and observational association studies. Further, an emphasis was placed on randomized controlled trials given the superior study design and reduced bias of such designs. To promote the inclusion of studies with ample statistical power to test the null hypothesis, studies were only included if they employed a randomized, controlled design and included more than 30 participants or were descriptive pre-post, single-group interventions enrolling more than 80 participants, as these are common sample size cut-offs used to establish effect size in research studies for which statistical effect size is not clearly established. Studies that enrolled individuals with a prior medical diagnosis that could alter motivation for change in fruit and vegetable intake were excluded because reported change in behavior in these samples would potentially reflect a motivation for behavior change (i.e., reduced risk for disease recurrence, co-morbidity, etc.) beyond what was intended in relation to study design. On occasion a second citation for the same study is listed. In these cases the second citation was generally used to further describe the study characteristics or to provide supplemental findings relevant to the fruit and vegetable intake and/or behavioral theory constructs.

Data abstraction for this systematic review was completed in duplicate; 98% of the studies were identified across both data extractions. The review focused on the suitability of the study design and the described study intervention and execution. Importantly, only behavior-based interventions (studies explicitly reporting the behavioral theory or construct used) for which fruit and vegetable intake was a measured outcome were included. Absolute change in total fruit and vegetable intake was considered the optimal measure of outcome. This exposure was estimated using the formula: (Intervention post – Intervention pre) – (Control post – Control Pre). When studies did not include a control/comparison group, the outcome measure of interest was (Intervention post - Intervention pre), and when baseline measures were not clear, the outcome of interest was (Intervention post – Control post). These guidelines are consistent with approaches reported for use in systematic review of literature targeting health outcomes other than total fruit and vegetable intake (Soler, 2010).

Studies not explicitly describing an applied behavioral theory or construct were excluded, as were all studies in which estimates of fruit and vegetable intake were not provided as an outcome. Fruit and vegetable intake was reported as servings/day in all but one study. Fruit and vegetable intake was measured using an array of methods, but most commonly either quick fruit and vegetable screeners or a food frequency questionnaire was administered and intake was quantified in servings/day.

Studies were reviewed for specific data on population sample characteristics, study design (including interventions and behavioral theories and constructs applied), outcome measurement instruments, and time points for measurement; results with regard to fruit and vegetable intake are summarized in table format when available. Results are categorized for the following subsamples: healthy adults, older adults, children, minority and low-income populations, and employees in the workplace.

LITERATURE REVIEW

As shown in Figure 1, 65 citations from 57 studies were considered for inclusion in this systematic review. Clinical disease diagnosis of the sample population was the most common exclusionary criteria applied, followed by non-U.S. study samples. All but one randomized controlled trial met the sample size criteria (n=<30 subjects). The majority of studies were randomized controlled trials; only six studies were non-randomized, single group, prospective measure design (Eun-Jeong, 2009; Shankar, 2007; Klassen, 2008; Blom-Hoffman, 2004; Auld, 1999; Heim, 2009). The majority included a usual care, no contact, or delayed intervention control group, although some provided minimal intervention as control (Alexander, 2010; Walker, 2009; Djuric, 2010; Haire-Joshu, 2008; Foerster, 1998; Thompson, 2009; Haire-Joshu, 2003; Resnicow, 2008; Resnicow, 2009; Wolf, 2009; McCarthy, 2007; Feldman, 2000; Nitzke, 2007; Sorenson, 1998; Kim, 2010; Sorenson, 2005).

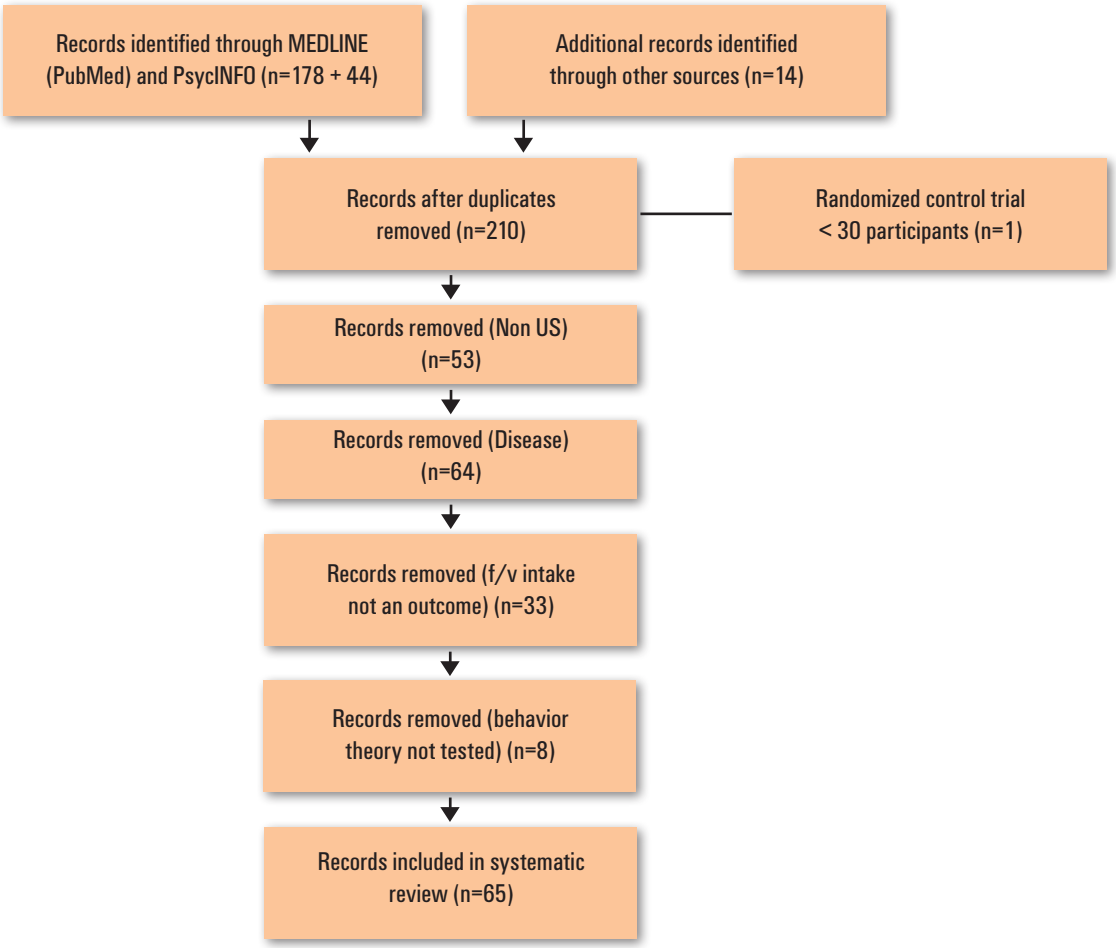

Figure 1. *Systematic review process for behavior-based interventions targeting change in fruit and vegetable (f/v) intake in U.S. sample populations, guided by Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA).*

. . . behavior-based interventions, defined as interventions that employ an accepted behavioral theory or construct (Table 1), generally result in a significant increase in fruit and vegetable consumption.

Behavioral Theories and Constructs

Stages of Change Construct and Social Cognitive Theory

Several behavioral theories and constructs have been applied in intervention trials targeting an increase in fruit and vegetable intake (Table 1). In the studies included in this systematic review, the Transtheoretical Model (TTM) and specifically the Stages of Change construct was the most frequently applied behavioral approach in study design, followed by Social Cognitive Theory (SCT). For several studies Stages of Change was used as a baseline measure from which interventions were tailored for delivery. A few studies evaluated individuals to identify their stage of change (pre-contemplation through action) in relation to overall change in fruit and vegetable intake. Results were inconsistent: some studies showed that the stage an individual reported at study enrollment informed on outcome (Cullen, 1997; Feldman, 2000; Do, 2008) and others showed no association with outcome and/or participation in study activities (Delichatasios, 2001; Resnicow, 2003; Campbell, 2004). Similar inconsistent results were reported in studies testing the association between change in intake and self-efficacy (Carcaise-Edinboro, 2008; Wilson, 2002; Heim, 2009; Fuemmeler, 2006; Sorensen, 2007). At least one study in children suggested that parental change in intake influenced intake in preschool-aged children (Haire-Joshu, 2008). High autonomy was associated with increased intake in one study of African American adults (Resnicow, 2008).

Motivational Interviewing

Motivational interviewing (MI) was another commonly employed construct across the subgroups of study populations examined. When applied, MI seemed to consistently result in an increase in the target behavior (Bowen, 2009; Stevens, 2003; Alexander, 2010; Satia, 2001; Richards, 2006; Emmons, 2005; Greene, 2008; Resnicow, 2001; Elliot, 2007), with the exception being a study of 423 African American adults (Resnicow, 2008). However, in a study by Wilson et al. wherein Social Cognitive Theory (SCT) and SCT plus MI intervention groups were compared, results suggested that the combination of theoretical approaches was not more effective than SCT alone. Both groups demonstrated a significant improvement in intake as compared to the comparison, education-only group (Wilson, 2002).

Fruit and Vegetable Change by Sub-groups of Study

Results of the systematic review are presented in Tables 2 through 7, categorizing findings by age (adults or children), as well as for special populations such as older adults and studies targeting low-income or minority enrollment. Worksite interventions are also presented in a separate table.

Most studies provided demographic data to describe the study population, although not consistently. Relevant to this review, studies varied in regards to providing detailed description of the behavior theories and/or constructs applied. They also varied in terms of the selection of dietary intake instruments used to measure fruit and vegetable intake. Most of the studies did report using the USDA National Database System to quantify intake and applied standardized measures of serving size for estimation.

Healthy Adults

Table 2 summarizes studies of behavioral interventions promoting fruit and vegetable intake to healthy adults. Nine studies were identified for inclusion, with sample sizes of 80 to 2200+. Of the 7 studies reporting outcomes in servings/day, all showed some increase in fruit and vegetable intake above control condition (Bowen, 2009; Stevens, 2002; Alexander, 2010; Woodall, 2007; Kristal, 2000; Ha, 2009; Richards, 2006; Delichatasios, 2001; Carcaise-Edinboro, 2008). In a study by Emmons in 2005 the intervention resulted in a 3% increase in percentage of the population achieving intake levels of 5 servings daily. Across the studies reported here for healthy adults, participation in the interventions was associated with an average increase in intake of 1.06 servings of fruits and vegetables per day. Similar results also were shown in the additional studies that enrolled older adults where average intake increased by 1.06 servings/day (Table 3).

Children

In addition to interventions in adults, numerous studies have also been conducted in children (Table 4). In the studies included in this systematic review, 5 interventions provided null results and the remaining 12 indicated a significant change in fruit and vegetable intake over time, when comparing intervention to control groups. Across all studies, the change in intake ranged from no change to an increase of 2.7 servings daily, with an estimated average increase in intake in the intervention groups of +0.65 servings per day. Of the 15 studies reporting outcomes as servings/day, all but 3 demonstrated some rise in intake with behavioral interventions.

Minority and Low-Income Populations

Studies that sampled minority (Table 5) and low-income populations were also described (Table 6). In these 9 studies the application of behavioral theory tended to be broader and to include such theories as Social Ecological Theory, Self-Determination Theory, and Ethnic Identity Theory as complementary to the more commonly applied theories. Of these 9 studies, one 1 reported null results. The average reported change in fruit and vegetable intake in minority studies was +0.9 servings per day, slightly below estimates of the general adult sample populations. Results of studies in low-income adults, for which 3 of the 5 studies reported fruit and vegetable intake in servings/day, demonstrated an increase for intervention group participants of +0.15 servings per day.

Employees in the Workplace

Employees at worksites are an additional subgroup that is commonly studied in regards to promoting change in fruit and vegetable intake using behavioral strategies. Thirteen different worksite behavior-based interventions are described (Table 7). In these studies the Social Ecological Model, Activation Theory, and Social Contextual Theories are more commonly applied. Seventeen percent of the worksite studies suggested there was a statistically significant increase in fruit and vegetable intake with behavioral-based intervention. The mean increase ranged from 0.0 to 1.52 servings/day.

KEY FINDINGS FROM LITERATURE REVIEW

Behavior-Based Interventions Increase Fruit and Vegetable Intake

The studies reviewed in this systematic review were published between 1995 and 2010 and used behavioral theories and constructs for changing intake of fruits and vegetables. This review included 57 studies that used behavior-based interventions delivered to a variety of study population samples with variable intensity, duration, and outcomes. The results of these studies suggest that behavior-based interventions generally result in a statistically significant increase in fruit and vegetable consumption. However, the absolute change in fruit and vegetable intake compared to baseline intake or control group intake tends to be small, in comparison to the increase required to achieve recommended levels of fruit and vegetable intake, according to national policy statements (DG, 2005). Mean fruit and vegetable total intake in the adult trials evaluated ranged from a low 0.77 servings/day to a high of 5.4 servings/day. Even with a mean average increase of 1.05 servings/day, the overall mean intake would remain well below recommended intake levels (Kimmons, 2009). Additionally, it remains unclear if an increase in intake averaging 1.05 servings per day, even if adopted habitually, would provide significant protective effects in relation to disease risk; empirical evidence suggests that it may (DG, 2005, and 2010).

The results of these studies suggest that behavior-based interventions generally result in a statistically significant increase in fruit and vegetable consumption. However, the absolute change in fruit and vegetable intake compared to baseline intake or control group intake tends to be small, in comparison to the increase required to achieve recommended levels of fruit and vegetable intake.

Variety in Fruit and Vegetable Intake Increases Consumption

Beyond quantity of intake, variety of fruit and vegetable consumption is another important factor in terms of efforts to increase fruit and vegetable intake to improve health. Further, promoting variety has been a useful strategy in expanding fruit and vegetable intake, especially for children, and recent media campaigns increasingly include variety messaging (e.g. Fruits & Veggies—More Matters®). Variety is seldom evaluated in dietary behavioral-change interventions; in fact only one of the studies specifically evaluated change in intake in relation to the variety of fruits and vegetables consumed over the course of the intervention. In the study by Heim et al. conducted at a YMCA summer camp, a behavioral intervention grounded in Social Cognitive Theory and addressing self-efficacy, role playing, and goal setting, resulted in significant change in variety of fruit and vegetable intake (Heim, 2009). The lack of emphasis on variety as a modifiable outcome for these behavioral studies is of interest, especially given the importance of variety to optimize exposure to healthful nutrients and bioactive compounds found in fruits and vegetables. Of note, some studies did describe pre-established reporting criteria that called for exclusion of high-fat vegetables in the quantification of total fruit and vegetable intake, suggesting nutritional quality was considered but not explicitly evaluated.

Nutritional Quality of Food Intake is Important

One aspect of fruit and vegetable variety relates to the nutritional quality of specific food items. For example, deep-fried potatoes or cauliflower may provide some nutritional density, but do so in the context of an increase in dietary fat intake that may be a less desirable outcome for dietary change. Importantly, only one of the studies included an evaluation of the nutrient quality of the fruits and vegetables consumed. In this study of Boy Scouts, total and low-fat vegetable intake were both outcome measures. Of interest, an increase in overall fruit and vegetable intake, but not low-fat vegetable intake, was demonstrated in response to the intervention (Thompson D, 2009).

Clustering of Healthy Behaviors Promotes Positive Behavior Change

There is evidence that healthy behaviors, including greater fruit and vegetable intake, tend to cluster in and among individuals and groups. In other words individuals who eat more fruits and vegetables also report other healthy lifestyle choices, including the decision not to smoke tobacco, a higher level of daily physical activity, and attention to weight control (De Vries, 2008). Among "Healthy choices" and "Eating well" clusters, programs targeting greater intake are less likely to demonstrate a significant increase in intake, since intake is commonly at or above recommended intake levels at the time of study initiation for those individuals. Methods need to be considered or developed to promote enrollment of individuals described as "Average American" or as being in the "Most challenged" cluster that is comprised of individuals demonstrating the greatest need to increase intake (Reedy, 2005). Many of the studies represented in Reedy's systematic review targeted several behaviors simultaneously. It remains to be determined whether the clustering of healthy behaviors makes sense in terms of the magnitude of change that can be expected, either short- or long-term. In this review no studies included efforts to target an increase in fruit and vegetable intake in combination with improvements in other health behaviors (i.e., diet, physical activity, smoking cessation, etc.). Testing of such multifaceted interventions, as well as assessing change in multiple health behavior outcomes in future behavioral research, could be informative in terms of identifying the optimal study design for short- and long-term health behaviors research.

In a review by Shaikh in 2008, self-efficacy, social support, and knowledge were determined to be the most consistent predictors of change in fruit and vegetable intake.

Study Limitations Cited in Behavior-Based Intervention Research

Several limitations in design are common to behavior-based intervention research and were notable in the studies reviewed. First, every study in this systematic review used a self-report of dietary intake to measure change in fruit and vegetable servings over time or across treatment groups. Social desirability constructs would suggest that self-reported fruit and vegetable intake may be overestimated, particularly in the intervention group over time. Plasma carotenoid concentrations are an accepted biological marker to validate fruit and vegetable intake/exposure; however, correlation with actual intake remains modest (P=0.02-0.7) (Natarajan, 2006). These measures also add to participant burden and study costs. Further, the self-reported instruments varied in terms of total number of items, details regarding frequency of intake, time period for intake estimates, etc. This may be an issue when making comparisons across studies, in that a larger number of fruit and vegetable items generally will result in greater reported intake. The NCI Fruit and Vegetable Screener was the most frequently reported instrument for outcomes measurement related to fruit and vegetable intake, although several studies modified the instrument. Standardization of measurement would help to support a more formal meta-analysis of dietary change response across studies in the future.

Unclear Link Found Between Behavior Theory/Constructs and Efficacy

An additional limitation to this body of evidence is the lack of clear linkage between the behavioral theory and/or constructs used and the intervention administered. While some studies explicitly explained the theoretical underpinnings and constructs applied, as well as the specifics of application in terms of materials development, delivery approaches, rationale, and/or behavioral measurements, in almost half of the studies reported, the behavioral theory was described only briefly. It was also not uncommon for studies to report using a number of behavioral theories and constructs during

the intervention, yet for many it was unclear when and how each construct was applied. Thus the capacity to evaluate the efficacy of one approach over another or to prioritize one versus another was not possible.

A few studies did administer behavioral scales pre- and post-intervention with the purpose of identifying behavioral variables that may act as mediators of change in fruit and vegetable intake. An example is a study of African American church members (Fuemmeler, 2006) in which the administration of several behavioral questionnaires used to assess autonomy, controlled motivation, social support, and self-efficacy allowed the authors to determine what behavioral constructs are most relevant to change in fruit and vegetable intake. In this case, the authors estimated that social support and self-efficacy mediated 20.9% of the change in intake, thus indicating that these constructs are highly relevant when designing interventions to change fruit and vegetable intake in African American church members. Of interest, autonomous motivation was not identified as a significant mediating variable in this study, but it was in a separate study of 423 African American adults (Resnicow K, 2008).

Another intervention study demonstrated that change in fruit and vegetable intake was associated with movement to higher stages of change at 3 months only and that completion of motivational interviewing telephone calls, as well as intrinsic and extrinsic motivation, was associated with increases in fruit and vegetable intake (Satia, 2001). However, the EatSmart study (Delichatasios, 2001) found that stage of change at baseline did not inform on change in fruit and vegetable intake over time nor did it inform on results in a CD-ROM tailored intervention (Campbell, 2004). Behavioral constructs were also not associated with change in fruit and vegetable intake in the TEENS study (Birnbaum AS, 2002). A worksite study in Massachusetts suggested that more supportive social norms and self-efficacy were associated with larger increases in intake of fruits and vegetables, depending on type of worksite (Sorensen, 2007). Unfortunately for the large majority of the research selected for inclusion in this systematic review, behavioral constructs were not specifically evaluated in terms of how their use informed on intervention success.

Best Practices Difficult to Identify

Separate from the intervention trials reviewed for this analysis, behavioral dietary research has also described psychosocial correlates of dietary behavior change, although models of change generally show low predictiveness (Baranowski, 1998), suggesting a complexity and individuality of eating behavior that warrants integrated approaches targeting several theoretical models and behavioral constructs. In a review by Shaikh in 2008, self-efficacy, social support, and knowledge were determined to be the most consistent predictors of change in fruit and vegetable intake. Lower, but plausible predictive values were related to barriers, intentions, attitudes, beliefs, stage of change, and autonomous motivation (Shaikh, 2008).

The lack of consistent results in achieving significant behavior change in relation to fruit and vegetable intake, when similar behavioral theories and/or constructs are applied, is of concern and makes the identification of "best practices" impractical based on the current body of evidence. However, there is a growing body of evidence from which some inferences can be made. For example, the Stages of Change construct appeared to inform on expected change in behavior and/or the need for greater intensity of intervention to achieve the desired change in some studies. In addition, evidence suggests that Motivational Interviewing is an effective behavioral tool to promote an increase in fruit

and vegetable intake overall, although caution should be exercised when applying this approach for minority populations, as the data testing this theory in minority populations are sparse. Additionally, there are select theories and constructs that have been shown to be generally effective for weight control, such as self-monitoring (Burke, 2011), implementation intentions, or goal setting that have not been evaluated in relation to fruit and vegetable intake. Several other promising constructs and theories have yet to be evaluated in relation to fruit and vegetable intake, including constructs like hypocrisy and optimistic bias, as well as select behavioral theories such as Social Modeling Theory and Media Exposure Theory.

ALTERNATE APPROACHES TO BEHAVIORAL-INTERVENTION

The lack of consistent results in achieving significant behavior change in relation to fruit and vegetable intake when similar behavioral theories and/or constructs are applied is of concern and makes the identification of "best practices" impractical, based on the current body of evidence.

Currently less than 25% of the U.S. adult population consumes 5 or more servings of fruits and vegetables daily, and overall intake has changed little over the past decade (Kimmons, 2009; Blanck 2008). The overall effectiveness of behavioral interventions to increase fruit and vegetable intake, as evaluated in this systematic review, indicates that the estimated increase in fruit and vegetable intake using these approaches will be modest given the current evidence. Efforts to identify alternate approaches to be applied at the individual, community, and/or population level are necessary to promote optimal intake.

National Action Plan Strategies

Among the more comprehensive reports addressing the issue of increasing fruit and vegetable intake in the U.S. is the *National Action Plan to Promote Health Through Increased Fruit and Vegetable Consumption, a 2010 Report Card*. This comprehensive report summarizes the current status of fruit and vegetable intake and further describes several approaches to be considered and potentially adopted at the individual, community, and population levels to increase consumption of fruits and vegetables (NFVA, 2010). While some of the proposed changes require governmental funding (i.e., food and nutrition education assistance programs), many suggest that partnerships between and among influential organizations will be imperative to achieve and sustain greater fruit and vegetable intake. Approaches that could be considered include but are not limited to enhanced point-of-purchase efforts to educate and influence purchasing, accessibility to and diversity in sites of purchase, increased palatability, as well as increased convenience (CDC, 2010). Certainly, these approaches would need to be evaluated to determine effectiveness over time.

Health Beliefs Model

Another alternative approach to increasing fruit and vegetable intake was described in a 2007 review suggesting that health communication campaigns have significant potential to improve community health behaviors, including fruit and vegetable consumption (Snyder, 2007). Specifically the review suggested that there is a need to formulate nutrition communication campaigns that tailor messaging at the community level and that messages targeting intrinsic and extrinsic motivation are most likely to impact change in relation to fruit and vegetable consumption. The application of the Health Beliefs Model including risk perception has been an effective approach for select health behaviors such as smoking, but may or may not be effective for increasing intake of fruits and vegetables in the general population, as perceived risk may be much lower. This approach also could work for those with a real or perceived risk of chronic disease (Ammerman, 2002).

Social Ecological and Social Contextual Theories

Fruit and vegetable intake was associated with the use/employment of interventions based on Social Ecological and/or Social Contextual Theory in several of the randomized, controlled studies examined, including the Rural Physicians Cancer Prevention Project (Carcaise-Edinboro, 2008), the Health Centers Study (Emmons, 2005), the Health Works study (Campbell, 2002), the WellWorks Study (Sorenson, 1998), the Small Business study (Sorenson, 2005), Tools for Health Study (Sorenson, 2007), and the High 5, low-fat intervention in African American parents and preschoolers in

Missouri (Haire-Joshu, 2003). Several of these studies targeted worksites and employees within a select job classification. In these studies the social behavioral theories used may have demonstrated different results than what would be expected from studies enrolling participants beyond a select worksite, although no comparative studies were found to evaluate for these potential differences.

Social Marketing Applications

The results of this review did not identify studies that relied on social marketing as an outreach application of Socioecologic and Social Contextual Theories to increase fruit and vegetable intake. Yet, a 2006 report suggested there is "strong evidence" for the effectiveness of social marketing to change diet behaviors (McDermott, 2006). Further, limited studies using social marketing have demonstrated an effect, whether or not the messaging is framed in a positive light (van Assema, 2001). Mass media communications to promote fruit and vegetable intake are limited and generally lack specific behavioral theoretical underpinnings. Social marketing may provide a complementary approach to promote greater fruit and vegetable intake. Such combinational approaches will need to be strategically evaluated (Abbatangelo-Gray, 2007).

Technology

Several studies are currently underway to assess the role of technology (i.e., internet applications, web-based behavior tracking sites, cellular phone messaging of health communications, etc.) in evoking dietary change, including increased intake of fruits and vegetables. These approaches should not only consider process and outcome evaluation, but should also integrate behavior theory and constructs to enhance uptake and/or adherence to these new technology-driven approaches. Important questions such as age-appropriateness, demographic influences, social influences, and dose will need to be addressed before optimal prescriptions for these interventions can be developed.

Early Childhood and Development of Healthy Habits

Establishing behaviors early in life has been shown to sustain behaviors into adulthood. The national Parents As Teachers (PAT) Program employed a parent role-modeling approach, and outcomes from the program are beginning to demonstrate success for short- and longer-term change in eating behaviors when healthy eating habits are introduced and modeled early in life (Wagner, 1999). While children are a focus of much of the research examined, even greater efforts to formulate healthy habits such as regular, varied intake of fruits and vegetables in early life are needed. Additional research and resources should be directed toward early life exposures, including increasing intake in pregnant and lactating women and young mothers, as well as introducing infants and toddlers to fruits and vegetables of a wider variety and on a more frequent basis.

CONCLUSION

This systematic review suggests that statistically significant increases in fruit and vegetable intake are demonstrated when behavior-based interventions are employed. However, these increases in fruit and vegetable intake are small compared to that necessary to achieve recommended intake levels (DG 2005). Among the most supported are interventions applying Motivational Interviewing or Stages of Change at the individual level and Social Ecological or Social Contextual Theories at the group (e.g., worksite, church) level. Only with a multifaceted approach that integrates individual, group, governmental, industry, and social involvement and includes all ages, including early life exposure, is it expected that substantial and clinically relevant improvements in fruit and vegetable intake will be achieved. Achieving and sustaining fruit and vegetable intake at currently recommended levels across the population also will require stronger interventions that are strategically combined with other approaches, including efforts to address taste, convenience, availability and access, and competitive foods, as well as enhance the perceived value of habitually adopting this behavior.

Table 1. *Common Behavioral Theories and Constructs used to Effect Change in Fruit and Vegetable Intake*

Behavioral Theory/Constructs	Brief Description
THEORY	
Diffusion of Innovations Theory	Spread of new ideas. Behavior change requires clear application of constructs including knowledge (exposure), persuasion (attitude), decision (commitment), implementation (use), and confirmation (reinforcement).
Goal Attainment and Self-regulation Theory	Suggests that behavior change is the result of setting specific goals and monitoring progress toward goals.
Health Belief Model/Health Promotion Model	The balance of perceived barriers and perceived benefits or risk-benefit predicts behavior change.
PRECEDE-PROCEED	Precede is diagnostic planning: predisposing, reinforcing, and enabling constructs in educational diagnosis and evaluation. Proceed is the subsequent implementation and evaluation including policy, regulatory, and organizational constructs in educational and environmental development.
Social Cognitive Theory (SCT)	Interaction among behavior, environment, and personal factors predicts behavior change (includes techniques such as modeling, skill training, self-monitoring, and contracting).
Social Influence Theory Social Communication Theory Media Exposure Theory	Social context influences behavior change. Communication between parent-child. Cues in mass media affect attitudes and behavior change.
Social Ecological Model	Theory related to the relationships between individuals, social groups, and the environment or community.
Social Learning Theory	Behavior is established in observing and imitating those with direct influence, reinforcement, and punishment.
Theory of Reasoned Action/Theory of Planned Behavior	Process preceding behavior based on expectancy and intentions. Decision to behave in a certain way is the result of the likelihood of specific outcomes.
The Trans-theoretical Model (TTM)/Stages of Change	Leading stage model in health behavior research; individuals reside at a given stage in relation to specific behavior change: pre-contemplation, contemplation, preparation, action, maintenance, and termination. Stage influences likelihood of behavior change.
CONSTRUCTS	
Barriers	Perceived estimate of obstacles to behavior change including social, personal, and economic challenges.
Motivation	Behavior change is grounded in intrinsic and/or extrinsic motivation to make change; commonly uses Motivational Interview (MI) techniques.
Normative beliefs	Extent to which others of influence are in agreement.
Problem-solving	A non-routine activity aimed to change an undesirable activity or undesirable state of affairs; based in decision-making and awareness of problems.
Reciprocal determination	Behavior can be changed or conditioned through operant conditioning of personal factors, reward, and punishment.
Self-efficacy	A person's confidence in coping with barriers in order to change behavior; sense of control facilitates change.
Self-management	Engagement in self-monitoring of behavior influences behavior change.

Adapted from: National Cancer Institute Behavioral Research Program at: http://cancercontrol.cancer.gov/brp/constructs/index.html. Accessed January 2, 2011.

Table 2. *Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake in Healthy Adults*

Study/Citation	Population Sample (demographics/inclusion)	Study Design/Intervention	Behavioral Theory/Constructs	Dietary Measures and Time Points	Results
Eating for Healthy Life (Bowen DJ, 2009)	2175 members of religious organization attending church regularly; Mean age: 54.0 (SD-15.9) years; 85% female; 89% NHW	Randomized controlled trial; randomized by religious organization (church) Low-intensity dietary intervention Control: no intervention	Social Learning Theory, MI, Stages of Change	Fat and Fiber Eating Behaviors Questionnaire and single 24- hour recall in 30% subsample Measured at baseline and 12 months	Intervention: Servings per day of fruits and vegetables increased from 3.76 to 4.05 Control: Servings per day of fruits and vegetables increased from 3.66 to 3.82 P-value for difference=0.03
MENU program study (Alexander GL, 2010)	2540 participants; Mean age: 46.3 (SD-10.8) years; 69% female; 24% African American; 8% Hispanic	Randomized controlled 3-arm trial with stratification for health plan, gender, and baseline stage of change. Intervention focus on diet: Group 1: untailored control Web, Group 2: tailored Web, Group 3: tailored Web plus MI session via email. Four Web sessions each delivered over 15 weeks. Control: breast self-exam, counseling and telephone call (non-diet)	SCT, MI, and TTM Stages of Change	16-item NCI Fruit and Vegetable Screener and 2-item screener Measured at baseline and 12 months	Results reported in servings per day of fruits and vegetables for the 16-item instrument: Group 1: 4.57 at baseline and 6.83 at 12 months Group 2: 4.23 at baseline and 6.98 at 12 months Group 3: 4.46 at baseline and 7.18 at 12 months P=0.17 for control versus tailored Web and 0.05 for control versus tailored Web plus MI emails.
5-a-day Rio Grande Way (Woodall WG, 2007)	755 adults from six rural communities in Colorado and New Mexico; 66.5% over age 50 years; 88% female; 133 NHW and 246 Hispanic	Randomized controlled trial Intervention: Immediate access to website-based information and email delivery Control: delayed-access	Website applied SCT and Diffusion of Innovations Model	FFQ Measured at baseline and 4 months	Results presented for intervention arm only. 23.5% responded to at least one email to visit website; visit to website within 5 days of email receipt were associated with larger increase in fruit and vegetable intake (r=0.14, P=0.049).
Puget Sound Eating Patterns Study (Kristal AR, 2000; Satia JA, 2001)	1459 adults in Washington state; Mean age: 44.9 years; 50.9% male; 85.9% NHW	Randomized controlled, two-group trial Intervention: Tailored, self-help messaging Control: Usual care (no intervention)	SCT, TTM, Stages of Change, MI	FFQ Measured at baseline, 3 and 12 months	Results in servings per day for fruits and vegetables: Intervention: 3.62 at baseline, 4.03 at 3 months, 4.09 at 12 months Control: 3.47 at baseline, 3.55 at 3 months, 3.61 at 12 months or +0.46 servings/day for intervention at 12 months P-value of intervention effect <0.0001 at both time points Intervention associated with movement to higher Stages of Change at 3 months only Greater increases with MI call; intrinsic and extrinsic motivation associated with change in diet
Kent State College Student Study (Ha, 2009)	80 college students at single university; Mean age: 20.2 years (range: 18 to 24 years); 88% female	Single-group intervention 3 classes/week for 15 weeks	Class content integrated SCT including behavioral capability, expectations, self-control, environment, reinforcements, and reciprocal determination	3-day diet records Measured at baseline and 16 weeks	Vegetable intake in servings/day: pre 0.77 (0.62), post 1.52 (1.03) Fruit intake in servings/day: pre 0.94 (0.92), post 1.33 (0.99) P-value for change <0.001

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Table 2, Continued. *Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake in Healthy Adults*

Study/Citation	Population Sample (demographics/inclusion)	Study Design/Intervention	Behavioral Theory/Constructs	Dietary Measures and Time Points	Results
South Dakota State University Study (Richards A, 2006)	437 college students at South Dakota State University; age 18 to 24 years; non-dietetics majors; 78% male; 96.8% NHW	Randomized controlled trial Intervention: Stages of Change letter, 4 stage-based fruit and vegetable informational newsletters, one MI session and 2 email contacts Control: no contact	TTM, MI	26-item FFQ Measured at baseline and 4 months	Results in servings per day of fruits and vegetables: Intervention: 5.4 at baseline, 6.3 at 4 months Control: 5.2 at baseline, 5.2 at 4 months P=0.04 for difference in change across groups
EatSmart (Delichatasios HK, 2001)	6 group practices within HMO; 504 enrolled adults; Intervention: Mean age: 49.9, control 56.8 yrs. of age Intervention 83.3% NHW, control 97% NHW	Randomized controlled trial; Center was the randomization unit Intervention: mailed diet information, PCP endorsement of materials and behavior change, and MI Control: no intervention	Stages of Change assessed pre-post	PrimeScreen brief diet screening tool Measured at baseline and 3 months	Results in servings/day of fruits and vegetables: Intervention: 2.9 at baseline; 4.0 at 3 months Control: 3.3 at baseline; 3.7 at 3 months Difference suggested intervention resulted in 40% difference in change in fruit and vegetable intake across groups. Stages of Change was not associated with change in fruit and vegetable intake
Rural Physicians Cancer Prevention Project (Carcaise-Edinboro, 2008)	754 patients at three rural health clinics in Virginia; age 48.5 (13.2) years; 65.3% female; 60.5% NHW (Completers)	Randomized controlled trial Intervention: personalized diet feedback, nutrition information as 4 self-help booklets mailed weekly Control: no intervention	Social Contextual Theory	5-item fruit and vegetable subscale of FFQ Measured at baseline, 1, 6, and 12 months	No fruit/vegetable change data provided for overall sample subgroups: Results in servings/day of fruits and vegetables: <43 years: 2.47 at baseline, 3.16 at 1 month (P=0.003), 3.43 at 6 months (P=0.023), 3.14 at 12 months >56 years: 2.77 at baseline, 3.78 at 1 month (P=<0.001), 3.72 at 6 months (P=0.001), 3.33 at 12 months (ns) No significant change for 43- to 55-year-olds No change in self-efficacy shown
Health Centers Study (Emmons KM, 2005)	2219 patients from 10 Community Health Centers in predominantly working-class neighborhoods; Intervention: 61.5% female control: 70.9% female Intervention: 72.9% NHW, control: 50.6% NHW	Randomized controlled trial Intervention included tailored behavior prescription by PCP, in-person counseling, 4 follow-up telephone counseling sessions, 6 sets of tailored materials	Social Contextual Theory, MI	NCI Fruit and Vegetable Screener Measured at baseline and 8 months	% of sample consuming > 5 servings fruit and vegetable daily: Intervention: 13.9% at baseline, 17.2% at 8 months Control: 14.8% at baseline, 11.0% at 8 months Change + 3.3% intervention, -3.8% control (P=0.005)

Abbreviations Used: NHW–non-Hispanic white; %–percentage; FFQ–Food Frequency Questionnaire; NCI–National Cancer Institute; TTM–Transtheoretical Model; SCT–Social Cognitive Theory; MI–Motivational Interviewing; OR–Odds Ratio

Table 3. *Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake in Older Adults*

Study/Source	Population Sample (demographics/inclusion)	Study Design / Intervention	Behavioral Theory/Constructs	Measures and Time Points	Results
The Rhode Island SENIOR project (Greene GW, 2008)	834 adults age 60 and over, Mean age: 74.7 (6.4) years; 72.9% female; 79.5% NHW	2 X 2 experimental design Intervention groups: Exercise only, diet with focus on fruit/vegetable intake, exercise plus diet and control fall prevention Included tailored (Stages of Change) educational training manuals, newsletters, expert reports, coaching calls (3 over 12 months)	TTM, Stages of Change, MI	NCI portion size screener, NCI frequency of intake screener, 5-A-day screener, and single-item screener (How many servings of fruits and vegetables do you usually eat each day?) Measured at baseline, 12, and 24 months	NCI Fruit/vegetable screener; results in servings of fruits and vegetables per day: Intervention: 5.49 at baseline, 6.46 at 12 months, 6.49 at 24 months Control: 5.28 at baseline, 5.78 at 12 months, 5.99 at 24 months Fdifference = 0.018
The Wellness for Women project (Walker SN, 2009; Walker SN ,2010)	225 women aged 50 to 69 Mean age: 57.8 (5.4) years; Females only; Tailored intervention: 99.1% NHW, Comparison: 89.1% NHW	Randomized, two-group intervention study Participants were randomized to receive either tailored newsletters plus plans of action or generic newsletters plus general physical activity videos; Feedback on diet assessment for both groups at 12-month intervention	Health Promotion Model with tailored messages	Web-based Block Health Habits and History Questionnaire (1998) Measured at baseline, 12, 18, and 24 months	Results in servings of fruits and vegetables per day: Tailored: 5.67 at baseline, 6.59 at 12 months, 6.31 at 18 months, 6.28 at 24 months Comparison: 5.44 at baseline, 5.34 at 12 months, 5.21 at 18 months, 5.03 at 24 months Tailored messaging associated with significant change as compared to comparison control group
Telephone counseling to increase f/v intake (Djuric Z, 2010)	96 adults aged 40 and older, Mean age: Group 1: 54.0 yrs Group 2: 53.5 yrs Group 3: 52.9 yrs 19.6 to 24.8% female across groups; 14.2 to 19.6% NHW across groups;	Randomized, 3-group design Group 1: written materials, Group 2: written materials with a one-page form with daily plans for healthy substitutions, and Group 3: as above and behavior-based telephone counseling from a dietitian	No theory identified—self-efficacy, barriers	19-item NCI Fruit and Vegetable Screener and single 24-hour recall Measured at baseline and 12 weeks	Groups 1, 2, and 3 changed mean intakes of fruits and vegetables by +0.4, -0.7 and +1.4 (P=0.04) servings per day, respectively Group 3 reported > fruit/vegetable intake/1000kcal than Group 2 (P=0.025)
Kaiser Dietary Health Behaviors study (Stevens VJ, 2003)	616 Members of Kaiser Northwest HMO; Mean age: 54.4 (intervention), 53.1 (control); All female; >90% NHW	Randomized controlled trials; randomized by individual Intervention: One-to-one counseling (90 minutes total) plus telephone contact Control: video and counseling on breast exam	MI, SCT, problem-solving, Self-Efficacy, Stages of Change	Block FFQ Measured at baseline and 12 months	Results in fruit and vegetable servings per day: Intervention: 3.09 at baseline, 4.33 at 12 months Control: 3.21 at baseline, 3.40 at 12 months Group difference +0.93 (P=<0.001)

Abbreviations Used: NHW–non-Hispanic white; %–percentage; FFQ–Food Frequency Questionnaire; NCI–National Cancer Institute; TTM–Transtheoretical Model; SCT–Social Cognitive Theory; MI–Motivational Interviewing; OR–Odds Ratio

Table 4. *Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake in Children*

Study/Source	Population Sample (demographics/inclusion)	Study Design/ Intervention	Behavioral Theory/Constructs	Measures and Time Points	Results
Every Day, Lots of Ways (Blom-Hoffman, 2004)	91 African- American kindergarten and 1st grade students in 6 schools 55% Female	Pre- and post-program evaluation 10 lessons in the classroom over 5 weeks, family newsletters, lunchtime monitoring, identity of fruits/vegetables, and sticker distribution	Social Learning Theory	Plate waste at school lunch observation Completed during 3 pre- and 3 post-intervention meals	No significant change in vegetable intake pre-post or between groups at the post-intervention time point
Computer Mediated Intervention (Di Noia J, 2008)	507 African-American adolescents aged 11-14 from 27 Youth Services organizations in Northeastern states Mean age: 12.44 years; 61% Female; 85% NHW	Randomized controlled study, site as unit for randomization Intervention: Computer intervention of four 30-minute CD-ROM lessons tailored for individual stage of change Control: no intervention	TTM, Stages of Change, Self-Efficacy, risk-benefit	Single item "about how many servings of fruits and vegetables do you usually eat each day?" Measured at baseline and 2 weeks (post intervention)	Fruit and vegetable servings per day at 2 weeks: Intervention: 3.25 Control: 2.46 Post intervention showed a +0.9 servings/day in intervention with no change in the control group. Significant difference
Team-Up (Wilson DK, 2002)	53 African-American adolescents from inner-city Richmond, Virginia Age 11-15 years; 41% Female	3-arm randomized controlled trial; randomized by school Intervention group 1: Social cognitive interventions plus motivational interviewing Intervention group 2: Social cognitive interventions only. Both groups received education regarding increasing fruit and vegetable intake and physical activity. Tailored one-hour sessions delivered weekly for 12 weeks. Control: Education alone	SCT and MI, self-concept, self-efficacy, motivation	Three-day food record Measured at baseline and 12 weeks	Results in fruit and vegetable per day: Intervention group 1: 2.6 (1.4) at baseline, 5.7 (2.2) at 12 weeks (P=0.05) Intervention group 2: 2.5 (1.2) at baseline, 4.8 (2.4) at 12 weeks (P=0.05) Control: 2.3 (1.0) at baseline, 3.3 (2.1) at 12 weeks(ns) SCT alone and with MI equally effective
Girl Scouts (Cullen KW, JBM, 1998; Cullen KW, JNE,1997)	259 9-12-year-old Girl Scouts All female 75% NHW	Randomized controlled trial, stratified by grade level Intervention: 8 activities over the course of 4 troop meetings and earned an 'Eat-5' badge Control: no intervention	TTM, Stages of Change, self-efficacy, barriers, subjective norms	One-day food recognition form modified from FFQ with 12 fruit and 13 vegetable line items Measured at baseline, 4 weeks, and 3 month follow-up	Results in servings of fruits and vegetables per day: Intervention: 3.02 (2.21) at baseline, 3.39 (1.93) at 4 weeks (P=<0.01), 2.89 (1.60) at 3 months Control: 2.20 (1.96) at baseline, 2.06 (1.71) at 4 weeks, 2.32 (1.81) at 3 months Higher stages associated with > increase in intake
Integrated Nutrition Project (Auld GW, 1999; Auld GW, 1998)	502 second-to-fourth grade elementary school students Plate waste result group Intervention: 52% female, Control: 58% female; Intervention: 88% Hispanic Control: 94% Hispanic	Quasi-experimental pre-post test design Intervention: 1 hour weekly lessons were taught on alternating weeks by the classroom teacher and a special resource teacher plus 6 mini-lessons at lunchtime taught by parents	SCT and Cognitive Development Theory	Plate waste estimated from school lunch Baseline and 16 weeks	Intervention versus control change in fruit and vegetable intake: Intervention +0.36 servings/lunch meal above control (0.35 attributed to decreased intake in control)

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Table 4, Continued. *Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake in Children*

Study/Source	Population Sample (demographics/inclusion)	Study Design/ Intervention	Behavioral Theory/Constructs	Measures and Time Points	Results
TEENS (Birnbaum AS, 2002)	3503 seventh graders in the Minneapolis area; 49.3% female; 68.6% NHW, 2.6% Hispanic	4-arm randomized controlled trial, randomized by school Intervention group 1: School environment only Intervention group 2: classroom and school environment Intervention group 3: classroom and school environment plus peer leaders Delivered in 7th and 8th grade years Control: no intervention	SCT, Theory of Planned Behavior, Outcomes Expectations, social norm, barriers, intentions scale, attitudes	Modified Behavioral Risk Factor Surveillance System Measure (6-items of frequency of fruit and vegetable intake) Measured at baseline and 9 months	Results in servings of fruits and vegetables per day: Group 1: 4.76(0.03) at baseline, 4.44 (0.04) at 9 months Group 2: 4.51 (0.04) at baseline, 4.95 (0.04) at 9 months (P=0.10) Group 3: 4.88 (0.06) at baseline, 5.80 (0.05) at 9 months (P=<0.05) Control: 4.76(0.04) at baseline, 4.80 (0.03) at 9 months Psychosocial constructs did not predict change
Switch What You Do, View, and Chew (Gentile DA, 2009)	1323 third-through-fifth grade students and their parents from 10 elementary schools in Midwestern states Mean age: 9.6 (0.9) years, 53% female	Randomized controlled trial where school is the unit of randomization; Family as the target with school reinforcement Intervention: behavioral and environmental strategies Control: no intervention	Social Ecological Framework, goal-setting	Modified Behavioral Risk Factor Surveillance System measure (items of frequency of fruit and vegetable intake)—parent report for previous week, child, previous 24 hours Measured at baseline, 9 months, and 6 months post-intervention	Child report (servings per day): Intervention: 4.9 (3.2) at baseline, 4.4 (0.2) at 9 months Control: 4.1 (2.9) at baseline, 4.2 (0.1) at 9 months Parent report (servings/week): Intervention baseline 25.4 (14.1), 9 month 24.9 (0.7); Control: 23.0 (12.8), 9 month 22.6 (0.4) By parent report post-intake lower in control versus intervention (P=0.05), significance of change not reported
Squire's Quest (Baranowski T, 2003; Cullen KW, 2004)	1578 fourth-grade students from 26 schools in Houston 55.3% 9-year-olds (range 8-12 years); 50.1% female; 43.7% Euro-American	Randomized controlled two-group study, school is unit of randomization Intervention: Psycho-educational multimedia games with two 25-minute sessions per week for 10 sessions Control: no intervention	SCT, problem-solving, goal setting	Food Intake Recording Software System (FIRSST) computer-based recall system for children Measured at baseline and 10 weeks	Results in servings of fruit and vegetable per day: Intervention: 3.5 (3.1) at baseline Control: 3.8 (3.8) at baseline Difference in mean intake at post-assessment +1.0 servings/day for intervention group Goal-setting had modest effective on change in intake
PACE+ for Adolescents (Patrick K, 2001)	117 children ages 11 to 18 years of age from four Pediatric Medicine clinics in San Diego and Pittsburgh Mean age: 14.1 (2.0) years; 37% female; 57% NHW	Randomized controlled, four-group study targeting changes in multiple behaviors Intervention group 1: Frequent mail only Intervention group 2: telephone and infrequent mail Intervention group 3: Frequent telephone and frequent mail; tailored plans for behavior change Control: no contact	TTM, SCT, Theory of Planned Action goal setting, social support, problem-solving, plus Relapse Prevention Model	2 items summed, one number of servings of fruit consumed on a typical day, one number of servings of vegetables consumed on a typical day Measured using computer at baseline, measured by telephone interview at 4 months	Report for teens targeting change in fruit and vegetable versus not targeting Results in servings of fruits and vegetables per day: Targeting: 3.21 (1.88) at baseline, 4.47 (1.78) at 4 months Not targeting: 4.91 (2.37) at baseline, 5.36 (2.20) at 4 months No significant difference for targeting versus not; no significant difference across treatment arms

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Table 4, Continued. *Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake in Children*

Study/Source	Population Sample (demographics/inclusion)	Study Design/ Intervention	Behavioral Theory/Constructs	Measures and Time Points	Results
High 5 for Kids (Haire-Joshu D, 2008)	1658 parents and their preschool-aged children in southeast Missouri Age Intervention 67.3% ages 1-3 years, Control: 60.5% ages 1-3 years; Intervention 47.4% female, Control: 39.5% female; Parental Race-Intervention 86.3% NHW, Control: 79.7% NHW	Group randomized controlled nested cohort design Intervention: Parent educators, home visits (5 or more), + on-site group activities and tailored, mailed newsletters Control: standard program with parent-child materials including storybook/audio cassette lessons = tips to improve feeding environment	SCT and ecological framework, Reciprocal Determinism	St. Louis for Kids FFQ, intake of 27 fruits/vegetables over past 7 days Measured at baseline and post-intervention	Results in servings per day of fruits and vegetables: Intervention: 4.91 at baseline, 4.92 post-intervention Control: 4.79 at baseline, 4.74 post-intervention Not significant except for subgroup analysis wherein normal weight children showed a significant increase with intervention (P=0.02) Change in intake in child correlated with parental change in intake (P=0.001)
Eat Well and Keep Moving (Gortmaker SL, 1999)	479 fourth-grade students from six public elementary schools in Baltimore Mean age: 9.2 years; Intervention: 56% female, Control: 61% female; Intervention: 92% African American: Control: 90% African American	Randomized, matched control study with school as unit of randomization Intervention: Teachers delivered the Eat Well and Keep Moving lessons in class. Thirteen classroom-delivered, integrated curriculum, Eat Well cards to integrate with food service, built links with family activities Control: no intervention	Classroom materials were developed based on SCT and Behavioral Choice Theory Constructs include self-efficacy and social support	Food and Activity Survey, two in-person 24-hour recalls (Follow-up only) and Youth FFQ Measured at baseline and 2- year follow-up	Repeat 24-hour recall for post-intervention fruit and vegetable intake in servings/day/1000 kcal: Intervention: 1.78 Control: 1.41 Difference 0.36 (0.10-0.62), P=0.01
Healthy Youth Places (Dzewaltowski DA, 2009)	1582 7th and 8th grade students at 16 middle schools 54% Female; Intervention: 81.07% NHW, Control: 87.35% NHW	Randomized controlled, Nested cohort design, school as unit of randomization, stratified by school size and ethnicity Intervention schools: Environmental change in school lunch and after-school programming, group goal setting, internet support, Control schools: no intervention	Environmental Model, Self-efficacy	Youth/Adolescent FFQ (YAQ) Measured at baseline, year 1, and year 2	No significant change or difference in change between study groups over time
Gimme 5 (Baranowski T, 2000)	4th and 5th graders at 16 elementary schools	Randomized controlled intervention trial, schools as unit of randomization Intervention: 12 classroom sessions, two 45-min sessions/week, curriculum, newsletters, videotapes, and education on point-of-purchase Control: no intervention	SCT, goal setting, problem-solving	7- day food record by students Measured annually	Results in servings of fruits and vegetables per day: Intervention: 2.32 at baseline, 2.36 at year 1, 2.31 at year 2 Control: 2.43 at baseline, 2.2 at year 1, 2.06 at year 2 Group by Time effects (P=0.03)

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Table 4, Continued. *Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake in Children*

Study/Source	Population Sample (demographics/inclusion)	Study Design/ Intervention	Behavioral Theory/Constructs	Measures and Time Points	Results
California Children's 5 a Day-Power Play! (Foerster SB, 1998)	3966 4th and 5th grade students from 49 schools, randomized by community 48-53% female across group assignments; 30-90% Hispanics	Intervention group 1: 14 activities from 5 a day Power Play Intervention group 2: activities from group 1 as well as community activities. (Farmers' markets, media, supermarket, point-of-sale ads, and public service announcements) Control: No intervention	SCT, Resiliency Theory, Social Learning Theory, Reciprocal Determinism	California Children's Food Survey 2 repeat measures Measured at baseline and 8 weeks	Results in servings of fruits and vegetables per day: Group 1: 2.7 at baseline, 2.9 at 8 weeks (P=0.05) Group 2: 2.9 at baseline, 3.3 at 8 weeks(P=0.05) Control: 2.6 at baseline, 2.3 at 8 weeks
YMCA Garden Pilot Project (Heim S, 2009)	93 4th-6th grade students	Non-randomized convenience sample, delicious and nutritious garden component of summer camp program Variety of activities twice/ week for 20-30 minutes each for 12 weeks	SCT, self-efficacy, goal setting, and role playing	Yes or no response to 11 vegetable and 5 fruit items Measured at baseline and 12 weeks	Percentage 'ever eaten' vegetable increased from mean (SD) 7.80 (2.24) to 9.17 (2.09) P<0.001. Percentage 'ever eaten' fruit increased from mean (SD) 4.72 (0.61) to 4.86 (0.41) P<0.02 Self-efficacy was not associated with intake
Boy Scout 5 a Day Badge (Thompson D, 2009)	473 10-14-year-old Boy Scouts from 42 different troops in Houston area Mean age: 13 years; All male; >68% NHW	Randomized controlled trial Intervention: 5-A-Day badge achievement with 9 activities, including group and internet components Control: Active-attention	SCT, Self-efficacy, social desirability, goal-setting, problem-solving	Modified FFQ with 21 fruit and 17 vegetable line items Measured at baseline, 9 weeks, and 6 months	Group by Time interaction for fruit and juice intake P=0.03 Mean increase of 0.94 (0.0) servings/day in intervention, 0.56 (0.0) servings/day decrease in control Low-fat vegetable intake did not show change or differ by group
High 5 Project (Reynolds KD, 2000)	1698 families of 4th-grade students from 28 elementary schools in Alabama Mean age: 8.7 years 50% female; 83% Euro-American	Randomized controlled study, school as unit of randomization, matched for ethnicity and free-meal programs Intervention: 14-session curriculum taught by curriculum coordinators, 3 per week plus parent kick-off night, Freggie Book activity book with 7 weekly family lessons Control: usual care	SCT, Modeling, self-monitoring, problem-solving, reinforcement	24-hour recalls for 7-day period (5 in school, 2 days by telephone) Measured at baseline (end of 3rd grade) and follow-up at end of 4th and end of 5th grade	Results in servings per day of fruits and vegetables: Intervention: 2.61 at baseline, 3.96 after year 1 Control: 2.51 at baseline, 2.28 after year 1 P=<0.0001 for follow-up difference between groups

Abbreviations Used: NHW–non-Hispanic white; %–percentage; FFQ–Food Frequency Questionnaire; TTM–Transtheoretical Model; SCT–Social Cognitive Theory; MI–Motivational Interviewing

Table 5. *Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake in Minority Populations*

Study/Source	Population Sample (demographics/inclusion)	Study Design/ Intervention	Behavioral Theory/Constructs	Measures and Time Points	Results
Parents as Teachers High 5, Low Fat Program (Haire-Joshu D, 2003)	738 high-need African-American parents of children ages 2 to 5 years; school districts in St. Louis, Missouri Mean age: 29 years; 98% Female	Randomized, nested cohort trial, matched on ethnicity and economic factors Intervention: home visits, parent-child newsletters, and group meetings in addition to the *Parents as Teachers* program Control: *Parents as Teachers* program alone	SCT, Social Ecological Theory Role modeling	Telephone-administered Block FFQ enhanced for African American food preferences Measured at baseline and 2 years	Results in servings per day of fruits and vegetables: Intervention: 4.65 (0.14) at baseline 4.65 and 4.84 (0.14) at 2 years Control: 4.86 (0.17) at baseline 4.86 (0.17) and 4.52 (0.15) at 2 years difference post-intervention 0.03
Tailoring fruit and vegetable intervention on novel motivational constructs (Resnicow K, 2008)	423 adult African Americans enrolled in healthcare systems in Detroit and Atlanta Mean age: 48.2 years; 71.6% female	Randomized, two-group design Intervention: SCT plus MI and Social Determination Theory Control: SCT All received 3 monthly multipage newsletters by mail	SCT, MI, and Self Determination Theory Autonomous versus controlled behavior change	Long- and short-form FFQ Measured at baseline and 3 months	Results in servings per day of fruits and vegetables; based on composite of 2 instruments: Intervention: 3.8 (1.8) at baseline, 4.5 (2.2) at 3 months (P<0.01) Control: 3.7 (1.7) at baseline, 4.3 (2.0) at 3 months (P<0.01) High reported autonomy associated with greater increase in intake compared to control
Tailoring fruit and vegetable intervention on ethnic identity (Resnicow K, 2009)	468 African American adults in Detroit and Atlanta Mean age: 48.7 years; 72.9% female	Randomized, two-group trial Intervention: newsletters tailored by ethnic identity Control: generic 'afrocentric' newsletters	SCT and Ethnic Identity	Long- and short-form FFQ Measured at baseline and 3 months	Results in servings per day of fruits and vegetables; based on composite of 2 instruments: Intervention: 3.5 (1.8) at baseline, 4.6 (2.0) at 3 months Control: 3.8 (2.0) at baseline, 4.6 (2.1) at 3 months Pre-post change P=<0.01 Ethnic identity predicted greater increase in intake (P=<0.05)
Black Churches United for Better Health (Campbell MK, 1999)	2519 African American adults from 50 churches in 10 counties Intervention: 53.2 % >52 yrs of age, Control: 58.9% >52 yrs of age; 72.8% female	Randomized controlled trial with churches as the unit of randomization Intervention: tailored bulletins, printed materials, gardening, educational sessions, recipe tasting, serving fruits and vegetables at church functions, health advisors, pastor support, community coalitions, grocer vendor involvement, and church initiated activities. Control: delayed intervention	TTM, SCT PRECEDE-PROCEED Model, Stages of Change	NCI 7-item Fruit-Vegetable Screener Measured at baseline and 20 months with a follow-up at 2 years	Results in servings per day of fruits and vegetables: Intervention: 3.84 (0.10) at baseline, 4.45 (0.08) at 20 months Control: 3.65 (0.10) at baseline, 3.60 (0.08) at 20 months P difference at 20 mo=.00001

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Table 5, Continued. *Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake in Minority Populations*

Study/Source	Population Sample (demographics/inclusion)	Study Design/ Intervention	Behavioral Theory/Constructs	Measures and Time Points	Results
Eat for Life (Resnicow K, 2001; Resnicow K, 2003)	14 African American churches Mean age: 43.9 years; 73.3% female	Randomized controlled 3-group study Intervention group 1: Self-help (cookbook, video, print materials, cue materials, and quarterly newsletter) with one phone call, Intervention group 2: Self-help with one phone call and 3 counseling calls based on MI at 3, 6, and 10 months Control: No intervention	MI, TTM, Stages of Change	7-item FFQ, 2-item measure of usual intake of fruits and vegetables daily, 36-item FFQ modified from Health Habits and Health History Questionnaire Measured at baseline and 1 year	Results in servings per day of fruits and vegetables; based on mean intake of 3 instruments: Intervention group 1: 3.78 at baseline, 5.17 at 1 year Intervention group 2: 3.97 at baseline, 4.38 at 1 year Control: 3.64 at baseline, 3.91 at 1 year P difference for 1 year measure=<0.01 Follow-up showed stage did not predict difference
Body and Soul (Fuemmeler BF, 2006)	14 African American churches, study population comes from previous studies Eat For Life and Black Churches United Mean age: 49.7 (12.8) years; 73.4% female	Clustered, randomized effectiveness trial, churches served as the unit of randomization; convenience sampling Intervention: church-wide activities, policy changes, self-help materials, peer counseling with MI Control: delayed intervention	MI, Self-efficacy, social support, autonomous motivation	2-item and 19-item FFQs Measured at baseline and 6 months	Results in servings per day of fruits and vegetables; based on 19-item FFQ: Intervention: 5.51 (4.89) at baseline, 6.83 (5.16) at 6 months Control: 4.82 (4.48) at baseline, 5.36 (4.46) at 6 months Social support and self-efficacy were significant mediating effects
Tailored telephone education in urban immigrant black men (Wolf RL, 2009)	490 African American males in New York City Intervention 47.1% >55 years, Control: 51.5%>55 years	Randomized trial Intervention: fruit and vegetable education, brochures by mail, and two tailored phone calls Control: prostate education, brochures by mail, and two tailored phone calls	Health Beliefs Model, TTM, Stages of Change	Three-item FFQ Measured at baseline and 8 months	Results in servings per day of fruits and vegetables: Intervention: 3.2 (2.5) at baseline, 4.6 (3.8) at 8 months Control: 3.1 (1.9) at baseline, 3.4 (2.2) at 8 months Change +1.2; P difference=<0.001
Nutrition Education in Public Housing (Shankar S, 2007)	212 African American women, public housing residency Ages 20-50 years	Single group, pre-post design Intervention: Six 90-minute classes twice weekly for 3 weeks, booster at 9 weeks	Social-Ecological Theory, Self-Efficacy	Computer-assisted, interviewer-collected 24 -hour recall Measured at baseline and 4 months	No significant change in fruit and vegetable intake
Fighting Cancer with Fitness (McCarthy WJ, 2007)	366 African American women; Mean age: intervention 44.56 years, Control: 46.52 years	Randomized controlled trial with intervention and control on-site on alternate days Intervention: weekly 2-hour fitness plans and nutrition education sessions for 8 weeks Control: weekly 2-hour general health sessions for 8 weeks	Social Learning Theory	24-hour recalls Measured at baseline and 12 months	Results in servings per week of fruits and vegetables: Intervention: 30.01 at baseline, 39.46 at 12 months Control: 29.54 at baseline, 31.01 at 12 months

Abbreviations Used: %–percentage; FFQ–Food Frequency Questionnaire; NCI–National Cancer Institute; TTM–Transtheoretical Model; SCT–Social Cognitive Theory; MI–Motivational Interviewing

Table 6. *Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake in Low-Income Populations*

Study/Source	Population Sample (demographics/inclusion)	Study Design/Intervention	Behavioral Theory/Constructs	Measures and Time Points	Results
Low-Income AA Study (Klassen AC, 2008)	156 low-income African American women 52% age 20-39 years, 48% age 40-50 years	Pre and post study, no randomization 20-week nutrition education delivered as six 90-minute lessons in local kitchen centers	Empowerment Model, Self-Efficacy and family-related, problem-solving	24-hour recalls Measured at baseline and 4 months; stratified by BMI	Results in servings per day of fruits and vegetables: In women with BMI <30: 3.7 (0.3) at baseline, 3.8 (0.4) at 4 months In women with BMI ≥30: 2.8 (0.4) at baseline, 3.2 (0.5) at 4 months Post-class fruits and vegetables intake was not different from baseline for either group
Maryland WIC (Feldman RHL, 2000)	3122 women in the WIC supplemental feeding program in Maryland; Mean: 27.2 years of age; 56% African American	Randomized controlled study, site is unit of randomization Intervention (8 sites): Nutrition education sessions, print materials, direct mail; Control (8 sites): usual 10-min nutrition education session at clinic	TTM, perceived barriers, goal setting, Stages of Change; Self-Efficacy, attitudes, social support	7-item FFQ Measured at baseline and 6 months	Intervention: 47.7% action/maintenance at baseline, 62.4% at 6 months Control: 52.9% in action/maintenance at baseline, 55.3% at 6 months At earlier stages the intervention group reported greater positive movement than control (P<0.001)
Maryland WIC (Havas, 2003)	2066 women enrolled in Women, Infant, Children Supplemental feeding program in Maryland; 41.8% intervention and 44.4% control between 18-24 years of age; all female; 43.1% intervention and 40.4% controls NHW	Randomized two group study; two intervention sites, 1 control site with crossover of site Intervention: 5-minute video plus print materials, feedback on diet intake, kick-off fair, four 45-min workshops, newsletters, mail packets, personalized invites, incentives, telephone contacts Control: no intervention	TTM, Stages of Change, Self-Efficacy, Social support	90-item, study population adapted FFQ Measured at baseline and 8 months	Results in servings per day of fruits and vegetables: Intervention: 3.5 (0.07) at baseline, 3.6 (0.08) at 8 months Control: 3.5 (0.08) at baseline, 3.3 (0.08) at 8 months Differences by group P=0.0003 and remained significant at 12 months (subsample)
CD-ROM Tailored intervention (Campbell MK, 2004)	307 participants at two WIC clinics in North Carolina; Mean age: 27 years; 96% female; 50% African American	Randomized controlled two-group study Intervention: Video soap opera, infomercials, tailored diet and psychosocial feedback, print materials Control: no intervention	SCT and TTM including Self-Efficacy and tailored feedback constructs	26-item FFQ based on Block Fruit and Vegetable Screener Measured at baseline and 2 months	Results in servings per day of fruits and vegetables: Intervention: 3.5 (2.3) at baseline, 3.6(2.2) at 2 months Control: 3.1 (2.3) at baseline, 3.2 (2.4) at 2 months No significant differences pre-post intervention or by treatment group Participation in the intervention was not associated with change in 'stage of change'
Young Adult Study (Nitzke, 2007; Do M, 2008)	2024 young adults from 10 states; 1255 completers; ages 18-24 years; Intervention 28.9% female, control 33.5% female; 70.6% NHW, 9.0% Hispanic	Randomized two-arm treatment study Intervention: series of mailed materials plus two telephone calls Control: one mailer	TTM, Stages of Change	NCI Fruit and Vegetable Screener Measured at baseline, 4 months, and 12 months	Results in servings per day of fruits and vegetables: (Baseline intake not reported) Intervention: 4.31 at 12 months Control: 3.92 at 12 months (P difference = <0.01) Intervention had greater variety of fruit and vegetable intake than control; 21.0 versus 20.3 (P=<0.01) 11% more intervention adults progressed in stage of change for fruit consumption, 15% more progressed for vegetable consumption

Abbreviations Used: NHW–non-Hispanic white; %–percentage; FFQ–Food Frequency Questionnaire; NCI–National Cancer Institute; TTM–Transtheoretical Model; SCT–Social Cognitive Theory; BMI–Body Mass Index

Table 7. *Worksite-based Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake*

Study/Source	Population Sample (demographics/inclusion)	Study Design/ Intervention	Behavioral Theory/Constructs	Measures and Time Points	Results
Treatwell 5-a-Day (Sorensen G, 1998; Hunt MK, 2000)	22 Community Health Centers in Massachusetts; sites had 27 to 640 adult employees 83% <50 years; 83.8% female; 52.1% NHW	Randomized controlled three group study Intervention group 1: worksite only Intervention group 2: worksite plus family Control: minimal intervention	Social Ecological Model and Principles of Community Organization	7-item NCI Fruit and Vegetable Screener Measured at baseline and 20 months	Co-worker support associated with greater readiness; Worksite only was associated with 7% (0.2 servings/day) increase in fruit and vegetable intake, Worksite plus family showed a 19% increase (0.5 servings/day)
NuPA (Kim Y, 2010)	2470 adults from companies and community organizations Mean age: Group 1: 43.6 (10.1) Group 2: 43.5 (10.3); 80% female; 74% NHW	Randomized controlled trial Intervention group 1: Self help Intervention group 2: Self help plus counseling	Self Determination, SCT, and TTM	Single item: "on a typical day how servings of fruits and vegetables do you consume each day?" Measured at baseline and 6 months	Results in servings per day of fruits and vegetables: Group 1: increased by 1.0 Group 2: increased by 1.3
Health Works for Women (Campbell MK, 2002)	538 female employees of 9 small- to mid-size, blue-color (textile or light manufacturing) workplaces in North Carolina Intervention: 55% age 18-39 years, Control: 50% age 18-39 years; Intervention: 50% African American, Control: 69% African American	Randomized controlled 2 group trial (4 worksites in intervention and 5 in delayed intervention) Intervention: Individual, computer-based, tailored women's magazines and community resource information, and natural helpers for diffusing information in the workplace Control: Delayed intervention without natural helpers	Ecological framework, SCT, Stages of Change, TTM and social support	28-item food frequency checklist (10 fruit and vegetable items) Measured at baseline, 6 months, and 18 months	Results in servings per day of fruits and vegetables: Intervention: increased an average of 0.4 at 6 months and 0.7 at 18 months (P=.01 Control: no significant change in fruit and vegetable intake
Working Well Trial (Sorensen G, 1996; Glanz K, 1998)	111 worksites employing over 13,710 workers in 16 states Mean age: 43.4 years; 71.7% Male; 92.1% NHW	Randomized controlled trial, worksite specific randomization using matched-pairs Intervention: interactive activities, posters, self assessments, self help, contests, direct education and food policy change Control: no intervention	Individual, Organizational, and Community Activation	88-item FFQ Measured at baseline and 2 years	Results in servings per day of fruits and vegetables: Baseline mean intake: 2.6 Intervention: increased by 0.19 Control: increased by 0.02
Seattle 5-a-day (Beresford SAA, 2001)	1,700 employees at 28 worksites with cafeterias in Seattle 86.6% intervention between ages of 25 and 54 years, 87.2% of control between ages of 25 and 54 years; 58% female; 86.4% NHW	Randomized controlled trial, worksite is unit of randomization Intervention (14 sites): work environment and individual behavior change, menu messages and variable channels (poster, paycheck inserts, table tents, newsletter, tip sheets, message cards, and self-help manual Control (14 sites): no intervention	TTM, Stages of Change, environmental change, skill building	FFQ and 3 repeat 24-hour recalls Measured at baseline and 2 years	Results in servings per day of fruits and vegetables based on FFQ data: Intervention: 3.68 at baseline, 4.18 at 2 years Control: 3.63 at baseline, 3.84 at 2 years Intervention effect: 0.30 servings/day (P=0.06)

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Table 7, Continued. *Worksite-based Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake*

Study/Source	Population Sample (demographics/inclusion)	Study Design/ Intervention	Behavioral Theory/Constructs	Measures and Time Points	Results
Next Step Trial (Tilley BC, 1999)	Active and retired autoworkers; 28 worksites; 5042 baseline; >1700 employees completed; Intervention: Mean age: 55 years Control: Mean age: 58 years; 97.5% male; 96% NHW	Randomized controlled trial with worksite as unit of randomization Intervention (15 sites): Five worksite-based nutrition classes, mailed self-help materials and personalized diet feedback Control (13 sites): no intervention	TTM, Stages of Change	NCI FFQ Measured at baseline, year 1, and year 2	Results in servings per day of fruits and vegetables: Intervention: 3.35 (0.05) at baseline, 3.56 (0.04) at year 1, 3.62 (0.04) at year 2 Control: 3.38 (0.06) at baseline, 3.35 (0.05) at year 1, 3.52 (0.05) at year 2 (P=0.001) and 0.10 at year 2 (P=0.08)
The WellWorks Study (Sorensen G, 1998)	5914 workers at 24 worksites in Massachusetts; inclusion: 250 to 2500 workers; turnover <20%, English-speaking; industrial, chemical, textile, dyeing and newspaper companies; 76% male; age and race/ethnicity not reported	Randomized worksite intervention trial; 12 matched pairs of worker-manager participation in program planning and worksite environmental changes; health education	Social Ecological Model, levels of influence	88-item FFQ random subsample of employees Measured at baseline and year 2	Results in servings per day of fruits and vegetables: Intervention: 2.34 at baseline, 2.56 at year 2 Control: 2.31 at baseline, 2.40 at year 2 % change in multivariate model: 4% for control and 9% for intervention
Tools for Health (Sorensen, 2007)	Union members of construction jobs N=82 Mean age: 40 years 94% Intervention and 95% Control male; 70% intervention and 63% controls NHW	Randomized controlled trial, worksite as unit of randomization Intervention: one-on-one counseling, MI; tailored messaging; telephone and mailed information Control: delayed minimal intervention	Social Contextual Theory	NCI Fruit and Vegetable Screener Measured at baseline and 6 months	Results in servings per day of fruits and vegetables: Intervention: 5.39 (3.5) at baseline, 6.91 (4.8) at 6 months Control: 5.19 (3.7) at baseline, 5.1 (4.0) at 6 months P difference X time X group (P=<0.0001)
ALIVE study (Sternfeld B, 2009)	788 administrative Kaiser Northern California Healthcare Organization office workers Mean age: 42.7 (8.2) years for fruit-vegetable intervention path, 43.5 (11.0) for control; 36.8% NHW in fruit-vegetable path, 43.1% controls	Randomized controlled trial; 55% control/45% intervention; 16.2% self-selected to fruit and vegetable path Intervention: 16-week program delivered by email, tailored messaging, 4 to 6 small-step goals, and progress-tracking Control: No intervention	Stage of Change, Self-Efficacy, tailored messaging, goal-setting	Study-specific Block-modified FFQ Measured at baseline and 16 weeks	Intervention group demonstrated a +0.31 (0.13) increase in cups of fruits and vegetables consumed daily versus control
Route H Study (French SA, 2010)	120 garage employees at worksites in Minneapolis area; Mean age: 47 years; 79% male; 63% NHW	Randomized controlled trial, randomized by site Intervention: Healthy items in vending machines, group behavioral programs, intake challenges, health expo, on-site farmers' market, and peer-mentoring Control: no intervention	Self-selected participation in behavioral programs (theory not explicitly described)	FFQ and a single 24-hour recall of sub-sample (n=40) Measured at baseline and 18 months	Results in servings per day of fruits and vegetables based on FFQ data: Intervention: 2.2 at baseline, 2.2 at 16 weeks Control: 2.0 at baseline, 1.9 at 16 weeks Intervention effect: 0.25 (P=0.05)

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Table 7, Continued. *Worksite-based Studies Applying Interventions Based in Behavioral Theory to Promote Change in Fruit and Vegetable Intake*

Study/Source	Population Sample (demographics/inclusion)	Study Design/ Intervention	Behavioral Theory/Constructs	Measures and Time Points	Results
PHLAME: Firefighter Study (Elliot DL, 2007)	Professional firefighters in Portland, Oregon area; 696 employees; Age 41 (9) years; 97% male; 91% NHW	Randomized controlled trial, site as unit of randomization, matched on age and station activity Intervention group 1: team-centered, peer-led prescribed curriculum with 11 onsite 45-minute workbook-based lessons Intervention group 2: individual on-site counseling, MI, and goal-setting based on baseline diet Control: no intervention	SCT, MI	NCI Fruit and Vegetable Screener (116 items) Measured at baseline and one year	Results in servings per day of fruits and vegetables: Intervention group 1: 5.8 (0.2) at baseline, 7.4 (0.3) at 1 year (P=<0.01 Intervention group 2: 5.5 (0.3) at baseline, 6.2 (0.3) at 1 year (P=0.05) Control: 5.7 (0.3) at baseline, 1 5.8 (0.3) at 1 year (not significant)
Healthy Directions-Health Centers Study (Sorensen G, 2007)	2219 patients from 10 Health Centers in the Boston area with 1954 completers; 34% male; 59% NHW; Mean age: 50.2	Randomized controlled study Intervention: tailored instructions in the form of a 'prescription' from a clinician, counseling with a health advisor, follow-up phone counseling sessions, tailored written materials targeting social contextual factors, and connections to local activities Control: no intervention	Social Contextual Theory, tailored messaging	NCI 7-item Fruit and Vegetable Screener Measured at baseline and 18 months	More supportive social norms and self-efficacy were associated with greater increases in intake of fruits and vegetables
Healthy Directions-Small Business Study (Sorensen G, 2005)	26 worksites in Boston-area industrial businesses; 32 to 137 employees per site for a total of 974 employees completing both baseline and follow-up data; 67% male; 68% NHW; Mean age: 44	Randomized controlled trial, worksite as unit of randomization; sites pair-matched on union status Intervention (13 sites): group demonstrations, table-top displays, health fairs, self-assessments, educational materials, group activities, environmental and organizational such as healthy menu items Control (13 sites): minimal intervention	Principles of employee participation, social contextual framework	NCI Fruit and Vegetable Screener Measured at baseline and 18 months	Percentage meeting 5-A-Day: Intervention: 15.4% at baseline, 20.8% at 18 months Control: 11.9% at baseline, 13.7% at 18 months P difference % change = 0.41

Abbreviations Used: NHW–non-Hispanic white; %–percentage; FFQ–Food Frequency Questionnaire; NCI–National Cancer Institute; TTM–Transtheoretical Model; SCT–Social Cognitive Theory; MI–Motivational Interviewing

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