



Theory-Based Interventions for Long-Term Adherence to Improvements in Diet Quality: An In-depth Review

Abstract: *Many interventions aim to improve dietary patterns but not all are able to maintain these changes long term. Interventions informed by theory may facilitate dietary behavior changes and maintenance of these changes for longer periods of time. PubMed and PsychInfo were searched for theory-based interventions with long-term assessments of fruit and vegetable (FV) and fat intake. We identified 335 unique titles; 20 were included for review. Most interventions (65%) were based on social cognitive theory. Assessments of FV and fat ranged from 12 to 72 months postrandomization, and 15 studies reported significant intervention effects. Only 6 studies directly tested theory in relation to diet and of those, significant findings indicated self-efficacy, motivation for dietary change, perceived competence to eat more FV and less fat, and multiple processes of change were associated with long-term maintenance of healthy eating. Overall, this review*

indicates that theory-informed interventions are generally successful for long-term improvements in diet quality, although such improvements are often modest. Most studies did not directly measure theoretical constructs in relation to diet outcomes, thus limiting our ability to describe how

Keywords: diet quality; behavioral theory; maintenance; fruit and vegetable intake; dietary fat

Long-term maintenance of positive changes in nutrition habits remains elusive for many people. Although

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theory-based interventions specifically promote long-term diet change. Recommendations for future research and practical recommendations for long-term maintenance of diet change are discussed.

numerous research trials have focused on dietary modification, relatively few have incorporated long-term follow-up and reported successful outcomes with regard to maintenance of behaviors. To support persistent behavior change, the

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use of theory-based approaches is recommended,¹ yet little is known about how theory may directly contribute to the long-term effectiveness of diet interventions.

Interventions that purposefully incorporate theory-based strategies have been recommended for improving dietary behaviors both initially and in the long term.^{2,3} However, the literature remains equivocal in this area, with some suggesting that commonly used theories, including social cognitive theory (SCT) and the transtheoretical model (TTM), are unlikely to enhance intervention effectiveness for diet change.⁴ In contrast, a recent systematic review found interventions informed by theory were more successful in improving diet compared with those not utilizing theory²; however, the authors did not specifically examine the long-term impact of such interventions. Several theoretical elements, including self-monitoring, self-efficacy, and goal setting, have been identified as integral features shared by many diverse theories and have been linked to successful diet outcomes.^{5,6} An examination of theory-based interventions targeting long-term improvements in diet quality, including key components for achieving target outcomes, may provide insight into successful strategies for maintaining behavior change.

The purpose of this review was to identify and describe the components of theory-based interventions capable of generating long-term improvements in diet quality. We focused on studies that sought to improve markers of fruit and vegetable (FV) and fat intake, as these changes are recommended by nearly every major health organization and are primary components of most chronic disease prevention programs. Moreover, a recent analysis of diet quality of US adults from 1999-2012 noted improvements in several dietary components (whole grains, fish, sugar sweetened beverages), but no observed change in total FV or saturated fat intake over the same period of time.⁷ This null finding for FV and fat highlights the need to identify and analyze interventions

capable of achieving sustained improvements in these diet patterns.

Method of Review

We searched the online databases PubMed and PsychInfo for theory-based behavioral lifestyle interventions with a focus on long-term change in dietary patterns as a component of the intervention. The search was conducted on June 9, 2016. For the purpose of this review, long-term was defined as follow-up point(s) ≥ 12 months postrandomization, irrespective of intervention length. Articles were searched using the following terms: intervention OR program; long-term OR maintenance; diet quality OR diet pattern OR behavior; and theory. After removal of 29 duplicates, a total of 335 unique articles were identified. We further limited articles to those that explicitly stated a behavioral theory as a basis of the intervention and reported change in a dietary outcome among adults with no history of eating disorders. Titles and abstracts were independently reviewed by the four authors, leading to the subsequent exclusion of 305 articles due to lack of compliance with the specified criteria or because they were a review, editorial, or methods paper, or cross-sectional/qualitative in nature. In addition to the 30 remaining articles, 7 articles identified outside of the search were admitted after searching references from relevant papers, particularly a review by Chapman.⁸ Finally, articles that did not report changes in both FV and fat (total and/or saturated fat) intake and those published prior to 2000 were excluded, thus yielding 20 articles for review. All eligible studies were in the form of randomized controlled trials (RCTs) or cohort randomized trials. Studies with interventions targeting multiple lifestyle behavioral outcomes (physical activity, smoking cessation, etc), as well as those with multiple dietary outcomes in addition to FV and fat intake (fiber, sodium, etc), were admitted for review. However, this review only reports on the outcomes of interest.

Results

The search process identified 20 unique studies with theory-based interventions and assessments of FV and fat intake at periods ≥ 12 months after randomization. Across all studies, the total number of participants was 28 743 (range 77 to 5407 participants), and intervention lengths ranged from 2 weeks to 48 months. Nearly all studies assessed diet outcomes immediately postintervention. Six studies conducted follow-up assessments at more than 1 long-term time point, with the longest follow-up at 72 months postrandomization. Table 1 provides an overview of the characteristics of included studies.

Overall, 15 studies demonstrated a significant intervention effect (between-group differences) for either FV and/or fat at 1 or more long-term follow-up. Three studies did not report a significant intervention effect for either FV or fat but rather reported a significant change from baseline, indicating a within-group difference at a long-term follow-up.⁹⁻¹¹ Two studies^{12,13} did not report significant findings for FV or fat outcomes at any long-term follow-up (Table 2).

Long-Term Changes in Fruit, Vegetable, and Fat Intake

Fifteen studies reported significant between-group differences for increased FV intake at 1 or more long-term follow-up, indicating a successful intervention effect¹⁴⁻²⁷ (Table 2). Of the 5 studies that did not achieve long-term intervention effects for FV increases: Kattelman et al¹² reported significant between-group differences at a 3-month assessment, although those findings had attenuated by the long-term follow-up; Griffin et al¹³ had a usual care control group that may have obscured significant findings; Riebe et al⁹ reported unexpected findings with a significant decrease in FV intake at 24 months; and both Peters et al¹¹ and Racette et al¹⁰ had significant increases in FV from baseline but not compared with a control group. About half of the studies in this review (8 studies) reported intervention effects for FV intake that

Table 1.
Characteristics of Studies Included in the Review.

Theory	No. of Articles (%)	Study	Intervention Length (Months)	Follow-up (Months Postrandomization)	Diet Assessment Method	Setting	Participants	Intervention
Combination	6 (30)							
SCT, TTM, SS, SEM		Campbell et al ¹⁵	18	18	FFQ	United States; rural worksite	859 female adults; ≥18 years	IL; computer modules + peer support
SCT, TTM		Kristal et al ¹⁸	12	12	FFQ; 24-hour recall	United States; HMO participants	1459 adults; 18-69 years	IL; self-help program via print materials; diet
SCT, SEM		Lin et al ¹⁹	18	18	24-hour recall	United States; multisite; research centers	810 adults with hypertension; ≥25 years; BMI 18.5-45 kg/m ²	IL + GL; in-person meetings
SCT, TTM		McCarthy et al ²⁰	2	12	FFQ	United States; community	366 African American female adults	GL; in-person meetings with supervised exercise
SCT, TTM		Steptoe et al ²⁴	0.5	12	FFQ	England; primary care center; urban, low-income community	271 adults; 18-70 years	IL; 2 brief in-person counseling sessions + printed materials
SCT, HBM, TTM		Toft et al ²⁶	6	12, 36, 60	FFQ	Denmark; urban community	9415 adults	IL + GL; in-person meetings
SCT Only	7 (35)	Hageman et al ¹⁶	12	12, 18	FFQ	United States; rural community	289 female adults; prehypertension; 40-69 years	IL; in-person + phone OR newsletters
		Mosher et al ²¹	10	12	FFQ	United States and Canada; home-delivered	519 adults; breast and prostate cancer history	IL; workbook + tailored newsletters
		Pakiz et al ²²	12	12	24-hour recall	United States; university research center	77 adults; 18-80 years; high risk for recurrence of colorectal adenomas	IL; telephone counseling
		Peters et al ¹¹	12	12	24-hour recall	United States; university research center	86 postmenopausal female adults; 50-72 years; BMI ≥18 and <30 kg/m ²	GL; weekly sessions tapering to monthly sessions + newsletters
		Pierce et al ²³	48	48, 72	24-hour recall	United States; multisite; research centers	3008 female adults; history of breast cancer; 18-70 years	Telephone sessions + cooking classes + newsletters

(continued)

Table 1. (continued)

Theory	No. of Articles (%)	Study	Intervention Length (Months)	Follow-up (Months Postrandomization)	Diet Assessment Method	Setting	Participants	Intervention
		Stevens et al ²⁵	2.5	12	FFQ	United States; HMO primary care offices	616 female adults; 40-70 years	IL; computer modules and telephone
		Winnett et al ²⁷	3	16	FFQ	United States; multisite church-based centers	1071 adults; BMI > 25 kg/m ²	IL; internet-based program with church environmental supports
TTM	5 (25)	Johnson et al ¹⁷	9	12, 24	Stages of Change	United States; home-delivered; Stages of Change	1277 adults; BMI 25-39.9 kg/m ²	IL; assessments with feedback and TTM stage and tools
		Kattelmann et al ¹²	2.5	15	FFQ	United States; 13 college campuses	1639 college students; 18-24 years	IL; internet and email
		Prochaska et al ³²	12	12,24	Diet Behavior Questionnaire	United States; home-delivered; primary care offices	5407 adults	IL; 3 computer reports with TTM stage and tools
		Racette et al ¹⁰	12	12	NIH FVS and KFFBQ	United States; worksite	151 adults	IL + GL; assessments with feedback + group meetings
		Riebe et al ⁹	6	24	24-hour recall	United States; university research center	144 adults; ≥18 years; BMI 27-40 kg/m ²	GL; in-person meetings with supervised exercise
SDT	1 (5)	Brown et al ¹⁴	12	12,18	FFQ	US; SHARE study; recruited in Catholic churches	801 adults; ≥18 years; Hispanic/Latino or non-Hispanic white	IL; partner enrollment; combination of self-help; in-person workshop; 5 phone calls; newsletters
TPB	1 (5)	Griffin et al ¹³	12	12	Plasma vitamin C + FFQ	England; ADDITION-Plus study; recruited from primary care	478 adults; 40-69 years; new type 2 diabetes	IL; 7 in-person meetings + 4 phone calls

Abbreviations: BMI, body mass index; FFQ, Food Frequency Questionnaire; GL, group level; HBM, health belief model; HMO, health maintenance organization; IL, individual level; KFFBQ, Kristal Fat and Fiber Behavior Questionnaire; NIH FVS, National Institutes of Health Fruit and Vegetable Screener; SCT, social cognitive theory; SDT, self-determination theory; SEM, social ecological model; SS, social support; TPB, theory of planned behavior; TTM, transtheoretical model.

Table 2. Significant Improvements in Fruit and Vegetable or Fat Intake at Long-Term Follow-up Time Points by Theory.

	12 Months	16 Months	18 Months	24 Months	36 Months	48 Months	60 Months	72 Months
<i>Fruit and vegetable</i>								
Theory								
Combination (SCT + other)	Step toe, ^{a,b} Kristal, ^{a,b} Toft, ^{a,c} McCarthy ^d	Winnett ^a	Campbell, ^a Lin ^{a,b}	Haegman ^a	Toft ^a		Toft ^{a,c}	
SCT	Mosher, ^a Peters, ^b Pakiz, ^a Pierce, ^a Stevens ^{a,b}			Haegman ^a		Pierce ^a		Pierce ^a
SDT	Brown ^a							
TTM	Proschaska, ^{a,b} Racette, ^b Johnson ^a			Proschaska, ^{a,b} Johnson ^a				
<i>Fat</i>								
Theory								
Combination (SCT + other)	Step toe, ^b Kristal, ^{a,b} Toft, ^b McCarthy ^b		Lin ^b		Toft ^b		Toft ^{a,b}	
SCT	Mosher, ^a Peters, ^b Pakiz, ^a Pierce, ^a Stevens ^{a,b}			Haegman ^a		Pierce ^a		Pierce ^a
SDT	Brown ^a							
TTM	Riebe, ^b Proschaska, ^{a,b} Racette, ^b Johnson ^a			Riebe, ^b Proschaska, ^{a,b} Johnson ^a				

Abbreviations: SCT, social cognitive theory; SDT, self-determination theory; TTM, transtheoretical model.

^aDifference between intervention and control group at time point (between-group difference).

^bdifference from baseline at timepoint (within-group difference).

^cVegetable only.

extended beyond 12 months. Two studies measured and were successful at maintaining an increase in FV intake at 36 months or more^{23,26}; however, while Toft et al²⁶ reported a significant intervention effect for FV at 36 months, the differences only remained for vegetables at the 60-month follow-up. Of the 4 studies with multiple follow-up time points, only Pierce et al²³ reported regression toward baseline intake values. However, this study utilized the longest follow-up period of all studies and achieved recommended levels of intake for FV at all long-term time points.

Regarding dietary fat, 10 studies had significant intervention effects for reducing intake of total fat or saturated fat as a result of a theory-based intervention (Table 2). The distribution of significant long-term findings for reductions in dietary fat was similar to those of FV findings. However, changes in fat were less likely to be reported as intervention effects (between-group differences) and more commonly were reported as differences from baseline to follow-up.

Theoretical Aspects of Long-Term Diet Change

A majority of interventions (65%) in this review utilized SCT,²⁸ either alone (7 studies) or in combination with at least 1 other theory (6 studies). The TTM²⁹ was the next most prevalent theory (5 studies), while self-determination theory (SDT)³⁰ and the theory of planned behavior (TPB)³¹ were the basis of 1 study each (Table 1). In this issue, a brief description of these theories is provided by Joseph et al.³ Of the 18 studies with significant changes at any long-term follow-up, 10 explicitly linked theory or a theoretical construct to outcome success in their results or in the discussion of the results* and 6 directly tested theoretical constructs in relation to diet outcomes.^{9,14,17,18,21,32}

Social Cognitive Theory-Based Interventions

SCT was the theory most frequently cited out of all interventions that

achieved significant long-term intervention effects for FV or fat (12 of 15 studies). SCT-based interventions primarily focused on components such as goal-setting, self-efficacy, addressing barriers, knowledge of risks and benefits, and motivation. Among all studies utilizing SCT, only that of Mosher et al²¹ explicitly tested any theoretical construct and found that changes in self-efficacy were associated with improved diet. Only 3 out of 7 studies using a theory other than SCT^{14,17,32} reported significant between-group differences at a long-term follow-up.

Transtheoretical Model-Based Interventions

Four TTM-based interventions reporting significant intervention effects^{9,17,18,32} explicitly stated that theory played a role in the intervention's success and also directly measured a component of the theory. Johnson et al's¹⁷ individually tailored, stage-based intervention was successful for moving intervention participants (in preaction stage at baseline) to action or maintenance for consuming recommended amounts of FV and fat. Prochaska et al³² had similar findings with a multi-behavior, stage-based intervention, showing treatment effects for moving participants to action or maintenance for reducing fat and increasing FV consumption. Kristal et al¹⁸ delivered an intervention based on TTM and SCT and measured participants' movement through stages of dietary change for fat and FV. In contrast to Johnson et al¹⁷ and Prochaska et al³² who used behavioral criterion when measuring stage (eg, readiness to consume less than 30% energy from fat or five servings of FV per day), Kristal et al¹⁸ measured stage of change as a "measure of cognitive and behavioral engagement in the diet change process" with self-reported ratings of "very low, low, in the middle, high or very high" consumption of fat or fruits and vegetables and found significant intervention effects for FV and fat but only for those already in action or maintenance, and not preaction stages. Riebe et al⁹ measured decisional balance,

processes of change, and self-efficacy in relation to dietary outcomes and found a significant reduction from baseline to follow-up for saturated fat intake but, similar to Kristal et al,¹⁸ found that changes were larger for those already in action stages. Additionally, Riebe et al⁹ found a significant increase in FV intake from 5.4 servings per day at baseline to 5.7 servings per day at 6-month follow-up. However, at 12 and 24 months, FV intake significantly decreased below baseline levels to 4.9 and 4.4 servings per day, respectively.

Theory of Planned Behavior or Self-Determination Theory-Based Interventions

Only 1 study in this review utilized TPB, and the authors did not report any long-term change in FV or fat.¹³ The 1 study that based its intervention on SDT reported an intervention effect for both fat and FV and also directly tested constructs in relation to the theory. Specifically, changes in lack of motivation for dietary change and perceived competence to eat more FV were significant among the treatment group. In this study, there was an intervention effect for both FV and fat; however, authors described that it is more likely that the intervention prevented a decline in the treatment group rather than encouraged an increase.

Discussion

The current article provides an in-depth review of recent theory-based interventions that facilitated maintenance of long-term changes in FV and/or fat consumption. Of the 20 articles in this review, 18 reported significant findings for either FV and/or fat at 1 or more long-term assessments; however, only 15 described intervention effects signaling that the theory-based intervention played a role in promoting dietary changes. Only half of the studies referenced theory in the discussion of their findings or described findings in relation to the theory used, and even fewer studies^{9,14,17,18,21,32} (6 studies) explicitly

*References 9, 11, 14, 15, 17-19, 21, 26, 32.

measured a theoretical construct and analyzed it in relation to a dietary outcome measure. Additionally, even when theory was explicitly measured, the theory as a whole was not evaluated (ie, only selected constructs of the theory directly tested).

With regard to theory, SCT, either alone or in combination with other theoretical models, was by far the most prominent theoretical basis for interventions. Despite the prevalence of SCT-based interventions in this review, only 1 study directly measured any construct related to the theory. Mosher et al²¹ based the FRESH START intervention on SCT, which has a number of core constructs including self-efficacy, self-regulation, outcome expectations, and observational learning among others.³³ Even though it was the authors' stated purpose to focus specifically on self-efficacy due to it being one of the primary constructs in SCT and due to the lack of other research formally evaluating self-efficacy as a mediator of the effects on diet, self-efficacy alone does not comprise the theory. Therefore, identifying relationships between individual constructs and diet outcomes may be useful for making recommendations regarding the construct measured, but interpretations regarding the use of the whole theory should be based on more inclusive evaluations. This limits our ability to draw conclusions about the specific impact of theory on long-term diet changes.

Studies utilizing TTM were the most consistent regarding overall testing of theory in relation to diet change. Out of 4 TTM-only studies with significant long-term diet outcomes, 3 studies explicitly measured stage of change.^{9,17,32} The fourth study created an intervention that addressed multiple stages of TTM, but it neither individually tailored the intervention nor measured stages of participants.¹⁰ Another study¹⁸ utilized a combination of TTM and SCT for their intervention and measured movement through TTM stages but no SCT constructs. Common components of TTM-based interventions cited in this review included goal setting, stimulus

control, relapse prevention, stage-tailored communications, and enhancing motivation. Only Riebe et al⁹ measured multiple constructs of TTM in addition to stage of change for dietary behavior and reported significant relationships between 4 distinct constructs and the ability to maintain dietary fat at less than 25% total intake at 2 years. However, this study did not report a significant intervention effect for either fat or FV and actually found lower intake of FV at long-term follow-up.

Several limitations of this review are noted. Although most studies reported significant long-term diet change, very few reported participants achieving and maintaining recommended intakes. Current dietary guidelines recommend limiting saturated fat to less than 10% of total energy intake per day.³⁴ Many of the studies in this review reported a reduction in total dietary fat as an outcome variable. Only 2 studies^{14,16} specifically noted a significant reduction in saturated fat, and only 1 study¹⁶ discussed findings in relation to meeting the current recommended intake of less than 10% of total energy from saturated fat. Based on supplemental data, Brown et al¹⁴ likely achieved recommended intakes of saturated fat, although findings were not explicitly stated as such. A similar limitation exists with reports of FV intake. Studies reporting a significant intervention effect for FV intake typically saw only modest increases, and only 1 study reported FV intake meeting the recommended levels of 3 servings of vegetables and 2 servings of fruit per day.³⁴ Another limitation is found in the diversity of measurement procedures used for assessing diet outcomes, making it difficult in some cases to ascertain if recommended levels were achieved. Many studies had multiple follow-up time points and, in most cases, reported detailed descriptions of within-group and between-group differences at each time point. However, in some cases when treatment effects (based on intervention) were reported, we were unable to assess if there were also significant within-group differences.

Practical Recommendations

This review elucidated constructs that have been related to long-term maintenance and therefore might be successful if used by practitioners or those attempting to counsel on maintenance of dietary improvements. The specific theoretical components of interventions directly measured and explicitly linked to maintenance of diet change (increase in FV or decrease in fat) included self-efficacy or self-efficacy-related constructs such as motivation and competence.^{9,14,21} Thus, integrating behavior change techniques that address self-efficacy may be useful when the goal is to maintain long-term changes in FV and/or fat. Additionally, many of the theory-based interventions reviewed utilized tailored feedback, including individualized reports of dietary intake and messages relevant to the population of interest, with most TTM interventions including messages tailored to the stage of change. More detailed evaluations of theory's role in long-term adherence to dietary improvements is needed, specifically direct measures of theory in relation to long-term maintenance of diet quality. **AJLM**

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