THEMED REVIEW

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Applying Psychological Theories to Promote Long-Term Maintenance of Health Behaviors

Abstract: *Behavioral health theory provides a framework for researchers to design, implement, and evaluate the effects of health promotion programs. However, limited research has examined theories used in interventions to promote long-term maintenance of health behaviors. The purpose of this review was to evaluate the available literature and identify prominent behavioral health theories used in intervention research to promote maintenance of health behaviors. We reviewed theories used in intervention research assessing long-term maintenance (≥6 months postintervention) of physical activity, weight loss, and smoking cessation. Five prominent behavioral theories were referenced by the 34 studies included in the review: self-determination theory, theory of planned behavior, social cognitive theory, transtheoretical model, and social ecological model. Descriptions and examples of applications of these theories are provided. Implications for future research are discussed.*

Keywords: behavioral theory; public health; health behavior; physical activity; weight loss; smoking cessation

Introduction

Chronic diseases—including heart disease, obesity, cancer, stroke, and diabetes—are the leading cause of death and disability in the United States.[1] National statistics indicate that 7 out of 10 American deaths each year are associated with chronic disease.[1] Furthermore, 50% of all US deaths are attributed to heart disease, cancer, or stroke.[1] The good news associated with these statistics is that most chronic diseases can be prevented and treated through healthy lifestyle behaviors. Thus, adoption and maintenance of certain health-enhancing behaviors can not only prevent the development of these chronic diseases but also reduce the likelihood of premature death.

The Centers for Disease Control and Prevention identifies 4 modifiable risk factors responsible for the majority of illness and death associated with chronic disease: lack of physical activity, poor nutrition, tobacco use, and excessive alcohol consumption.[1] Therefore, if Americans engage in regular physical activity, maintain a healthy weight, and abstain from tobacco and excessive alcohol use, they can greatly reduce the likelihood of developing many chronic diseases. Substantial intervention research has been conducted on the aforementioned modifiable risk factors associated with chronic disease. In fact, recent meta-analyses and systematic reviews on intervention research are available for each of these topics.[2-13] However, few studies have examined or

> . . . research suggests that theoretically based behavioral change interventions are more likely to be successful than atheoretical interventions.

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reviewed the maintenance of these modifiable health behaviors following the conclusion of an intervention period[11,14-16] and even fewer have explored the underlying psychosocial or behavioral health theories used to promote maintenance of these health-enhancing behaviors.[17,18] Theory is essential to intervention development because it provides framework for researchers to design, implement, and evaluate the effects of health promotion programs.[19,20] Moreover, a breadth of research suggests that theoretically based behavioral change interventions are more likely to be successful than atheoretical interventions.[21-27] For example, in a review of Internet-based behavior change interventions, Webb et al[21] concluded that studies reporting extensive use of theory were associated with a greater behavioral outcomes than studies with less extensive or no theory use. Similarly, Noar et al[27] reported comparable findings in a meta-analytic review of tailored print-based health behavior change interventions.

The purpose of the current article was to extend a previous review[28] conducted by our research team, which described psychological theories used in intervention research to initiate or motivate behavior change. The current review focuses exclusively on theories used in interventions evaluating long-term maintenance of health behaviors. We focused solely on maintenance because long-term adoption of health-enhancing behaviors is imperative for reducing chronic disease risk. However, while this is understood, long-term maintenance of health behaviors is challenging for many to achieve. A recent review of randomized controlled trials promoting physical activity in older adults[16] highlights the difficulty associated with behavioral maintenance. In their study, Hobbs et al[16] found that while many physical activity interventions targeting older adults were generally successful in promoting increased physical activity during early intervention phases (ie, less than 12 months), as time progressed (ie, by months 18 and 24) physical activity attenuated and regressed back to baseline levels. Similar results have also been reported by reviews evaluating long-term maintenance of weight loss[29] and smoking cessation.[14] Therefore, by systematically evaluating theories and models used in intervention research to promote long-term maintenance of health-enhancing behaviors, we aim to provide important insight to researchers regarding the utility and application of theory to promote the maintenance of health behaviors likely to lead to reduced chronic disease risk and other important health outcomes.

In the current article, we reviewed theories and models used in intervention research assessing long-term maintenance (≥6 months postintervention) of physical activity, weight loss, smoking cessation, and reduction of excessive alcohol consumption. These behaviors were selected because they are key modifiable risk factors that help reduce the risk of chronic disease and are generally characterized as healthy lifestyle behaviors. In this article, we first provide a brief overview of relevant health behavior change theories and then describe intervention research using these theories. Findings of this review provide important insight on application and utility of psychological and behavioral theories to promote maintenance of healthy lifestyles.

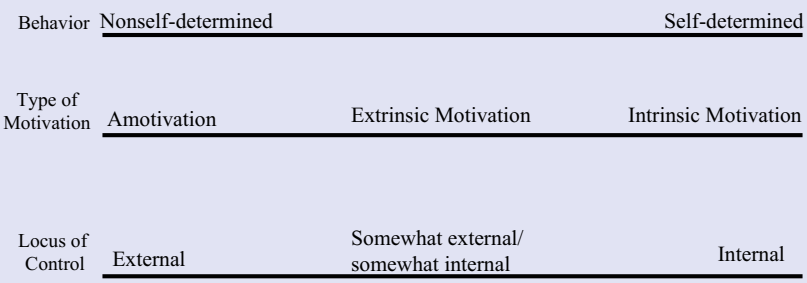
Method of Review

We searched randomized trials of physical activity, weight loss, tobacco cessation, and abstinence from excessive alcohol consumption that reported relevant lifestyle behavior outcomes at ≥6 months postcompletion of the intervention. To be eligible, studies were required to explicitly state a psychological or behavioral health theory as an underpinning of intervention activities, focus on adult populations (individuals ≥18 years old), and report an objective or self-reported outcome of the behavior/risk factor of interest. Only studies published after 1990 were included in the review. Studies targeting multiple behaviors/risk factors were eligible for inclusion; however, we report only results for the risk factors of interest in the current study. Studies were excluded if they included a pharmacological intervention component or if they focused on participants with severe mental disorders (ie, schizophrenia); as inclusion of such studies would confound the influence of behavioral theory. We also excluded studies referencing cognitive behavioral therapy (CBT) as the basis of intervention activities unless the authors specifically stated a psychological or behavioral theory (eg, social cognitive theory, transtheoretical model) underpinning the cognitive behavioral approach (or if it could not be identified through a reference search). While we acknowledge that CBT overlaps and precedes many psychological and health behavior change theories, we chose to focus on a select few health behavior change theories commonly seen in this research literature. Thus, as in our past review, we did not highlight studies using less commonly used approaches (such as CBT).

Articles were searched using the electronic databases of PubMed and PsycINFO. Four structured searches were conducted. The first included the search terms of (physical activity OR exercise), the second included the terms (weight loss OR weight maintenance), the third including (smoking cessation OR tobacco cessation), and the fourth included (binge drinking OR excessive alcohol consumption). All 4 searches also included the following terms: (intervention OR program AND follow-up OR maintenance AND behavior theory). Abstracts of articles retrieved during search procedures were independently reviewed by 3 reviewers. Reference lists of relevant articles were also manually searched in order to identify studies not retrieved during initial search procedures. Because of the heterogeneity of study designs and intervention activities across studies, several instances arose where studies retrieved during search procedures did not clearly fit within the a-priori defined

Figure 1.

Self-determination theory.[31,32]



inclusion/exclusion criteria for the review. In these instances, articles were examined on a case-by-case basis by the authors and a decision on inclusion was reached by consensus among authors. Additionally, only 1 alcohol cessation study[30] met inclusion criteria; therefore, this topic was subsequently excluded from the review because of the limited available research on this topic.

Results

Search procedures identified 34 unique interventions meeting inclusion criteria (n = 14 weight loss, n = 12 physical activity, n = 8 smoking cessation). The total number of participants across the studies was 20,645 (median = 276, range 19-2,827 participants). Most participants were female (63%) and the mean age of participants was 49.9 years (SD = 10.7). Study durations ranged from 6 to 36 months with a median duration of 13.5 months (*M* = 16.4 months, SD = 8.3).

Overview of Behavioral Health Theories Referenced by Studies Included in the Review

Five behavioral health theories were referenced in studies evaluating long-term maintenance of physical activity (PA), weight loss, and smoking cessation. These theories included self-determination theory,[31,32] theory of planned behavior,[33] social cognitive theory,[34] transtheoretical model,[35] and social ecological model,[36] which are briefly described here. For more in-depth descriptions of these theories and models, we refer readers to additional reference texts.[19,31,32,37] We classify these theories into 3 levels of influence: intrapersonal, interpersonal, and ecological.[19] Intrapersonal level theories focus on individual-level factors (ie, knowledge, attitudes, beliefs, and skills) and how these factors influence behavior. Interpersonal level theories assume individuals are part of a larger social environment and focus on how relationships between individuals and their immediate social networks (ie, family, friends) can promote behavior change. Ecological level models include aspects of both intrapersonal and interpersonal theories and extend the focus to areas outside an individual's immediate social group to include larger social systems (ie, communities, organizations, and public policies) and physical environmental characteristics.

Intrapersonal Level

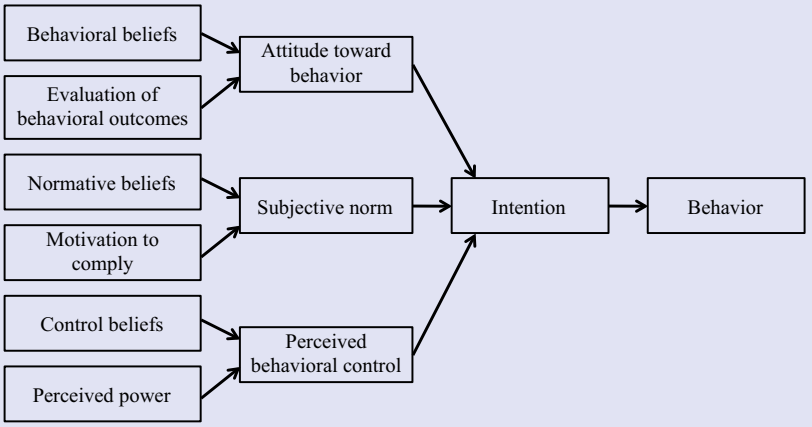
Self-determination theory. Self-determination theory (SDT),[31,32] depicted in Figure 1, is a theory of human motivation and behavior. This theory proposes that the extent to which behaviors are performed is based on the type of motivation one has to engage in a given behavior. In SDT, behavioral motivation is viewed as a continuum, with intrinsic (intrapersonal) motivation on one polar end of the continuum, amotivation (no motivation) on the other end of the continuum, and extrinsic (external) motivation residing between these 2 extremes.[31] According to SDT, people are most likely to engage in a behavior when motivation is intrinsic and least likely to engage in behavior if it is driven solely by extrinsic motivation. The SDT further proposes that most behaviors are comprised of varying degrees of both intrinsic and extrinsic motivation, and that the likelihood of engaging in a behavior is highly dependent on the combination of these 2 motivational factors.[31,32]

Theory of planned behavior. The theory of planned behavior (TPB),[33] developed by Ajzen and Fishbein, posits that behavioral intention is the most proximate predictor of actual behavior. As illustrated in Figure 2, the TPB views behavioral intention as the product of 3 main constructs: (*a*) attitudes toward the behavior, (*b*) subjective norms, and (*c*) perceived behavioral control. In the TPB, attitude is viewed as one's beliefs about a behavior weighted by the value he or she places on each of those beliefs. Subjective norms refer to perceived social pressure one feels to engage in a behavior, and are viewed as a product of normative beliefs (whether others approve or disapprove of performing the specific behavior) weighted by the one's motivation to comply with these normative beliefs. The third construct of the TPB is perceived behavioral control: one's belief in his or her ability to perform a specific behavior based on facilitators or barriers associated with it. According to the TPB, people will have greater behavioral intention and thus be more likely to perform a behavior if they have favorable attitudes and subjective norms toward the behavior, and have high perceived control over performing the behavior.

Transtheoretical model. The transtheoretical model (TTM) was developed by Prochaska and DiClemente[38] in an attempt to understand and describe the processes by which people naturally change behaviors.[35] The TTM is a synthesis of many psychotherapy and behavior

Figure 2.

Theory of planned behavior.[33]



change theories condensed into a single model. Original research for the development of the TTM was conducted on smoking cessation behaviors, but the theory has since been applied to various other behaviors. It assumes that behavior change is a continual process and happens as people progress through 5 stages (described in Supplemental Table 2; available at http://ajl.sagepub.com/content/by/supplemental-data): precontemplation, contemplation, preparation, action, and maintenance. Movement through the stages of change is often cyclical rather than linear.[35] As opposed to progressing straight through the stages of change, many individuals find themselves taking a few steps forward and then a few steps back when attempting to adopt a new health behavior. Backward movement through the stages of change is often called relapse,[35,38,39] and even individuals who have successfully modified and/or adopted a new behavior for long periods of time (ie, the maintenance stage of change) may still relapse and regress to earlier stages of change.

The second construct in the TTM is the processes of change. These processes describe *how* behavior change occurs and help facilitate transition between the stages of change. The processes of change (presented in Supplemental Table 3; available at http://ajl.sagepub.com/content/by/supplemental-data) are classified as either cognitive or behavioral. Cognitive processes of change are more frequently used during the earlier stages of adopting a new behavior to help facilitate movement into the later stages of change. In the latter stages of change, behavioral processes are predominantly used to facilitate behavior change.

The remaining 2 constructs in the TTM are self-efficacy (described below in the social cognitive theory description) and decisional balance. Decisional balance refers to the internal process in which an individual analyzes the pros and cons of engaging in a specific behavior. As Prochaska and DiClemente suggest, examination of the costs and benefits of a new behavior usually occurs in the beginning stages of behavior change, and as progression through the stages occur, the benefits of engaging in the new behavior are perceived to progressively outweigh the cons of the behavior.[35]

Interpersonal Level

Social cognitive theory. Social cognitive theory (SCT), developed by Bandura, explains behavior in a triadic and reciprocal model in which behavior, personal factors, and environmental factors interact.[19,40,41] The SCT is composed of many constructs, all of which influence one or more factors in reciprocal determinism (Figure 3). A primary construct of the SCT is self-efficacy, which refers to one's conviction in his or her ability to successfully execute a behavior in order to achieve a desired outcome despite obstacles or barriers.[40] According to Bandura, self-efficacy is the product of 4 sources of information (defined in Supplemental Table 1; available at http://ajl.sagepub.com/content/by/supplemental-data): performance accomplishments or mastery experience, vicarious experience, verbal persuasion, and emotional arousal. Other constructs of the SCT vary according to reference text; however, commonly identified SCT constructs include: behavioral capability, outcome expectations, observational learning or modeling, self-regulation, and reinforcements (described in more detail in Supplemental Table 4; available at http://ajl.sagepub.com/content/by/supplemental-data).

Ecological Level

Social ecological model. Social ecological models (SEMs) have become increasing prevalent in health promotion literature and are suggested health behavior change frameworks by both the US Department of Health and Human Services[42] and the Institute of Medicine.[43] The SEM commonly used in health behavior research was developed by McLeroy et al,[36] and is an expansion of Broffenbrenner's ecological model.[36] SEMs view individuals as part of a larger social system that includes many interrelated dynamic components that affect one another. In these systems, behavior is affected by, and exerts effects on, the social environment.[36,42] SEMs recognize that many public health challenges are too complex to be adequately understood and addressed from a single level of analysis, and suggest a more comprehensive approach that integrates multiple levels of influence

Figure 3.

Reciprocal determinism according to the social cognitive theory.[40]

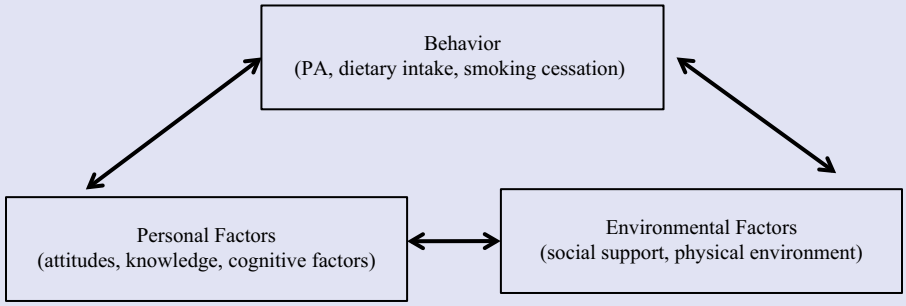
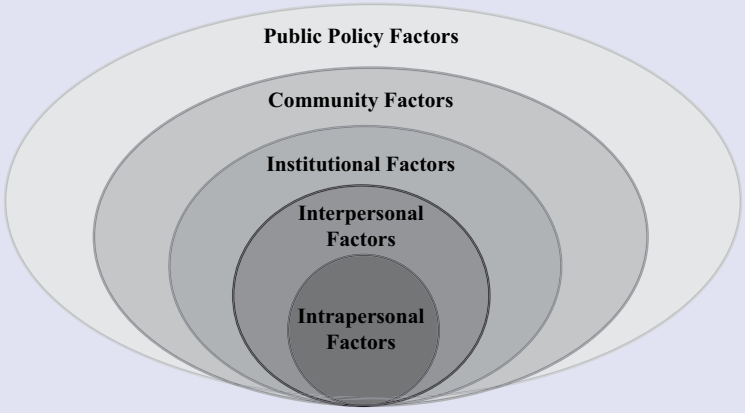


Figure 4.

McLeroy's social ecological model.[36]



to affect health behavior and ultimately health outcomes.

Social ecological models are unique in that they do not have constructs. Instead, they are comprised of levels of influence that impact behavior. As depicted in Figure 4, the 5 levels of influence according to the SEM framework of McLeroy et al[36] are intrapersonal, interpersonal, organizational (or institutional), community, and public policy. According to this model, there is a dynamic interplay among various levels of influence and, therefore, a change in one level of influence will elicit a change in another level. SEMs illustrate that, in order to change behavior, it is necessary to address factors at varying levels of influence.

Review of Intervention Research

We identified 34 theoretically based interventions evaluating long-term maintenance of PA, weight loss, and smoking cessation behaviors. This section of the article reviews these studies and highlights key applications of SDT, TPB, TTM, SCT, and the SEM to promote long-term maintenance of health behaviors.

Self-Determination Theory. Four studies referenced SDT as the theoretical background underpinning intervention activities (Supplemental Table 5; available at http://ajl.sagepub.com/content/by/supplemental-data). Two of these studies focused on smoking cessation,[45,47] 1 focused on PA,[44] and 1 focused on weight loss.[46] All 4 studies reported positive behavioral outcomes at the most distal follow-up periods for participants randomized to the SDT-based intervention groups, providing favorable evidence for this theory in promoting long-term maintenance of health behaviors. However, we note that the PA study conducted by Buman and colleagues[44] also identified the SCT as theoretical background, limiting inferences about the effectiveness of SDT when used independently.

In a noteworthy study, Silva et al[46] used SDT as the theoretical framework for a 1-year weight loss intervention that included a 2-year no-contact follow-up

assessment period. Participants were randomized into either an SDT-based weight loss group or a generic health group (control group). Both groups received intervention materials through in-person, biweekly group meetings and were attention-matched. Researchers identified 6 primary SDT-based intervention strategies used to promote autonomy among participants assigned to the SDT-based weight loss group[48,49]: (*a*) providing clear rationale to adopt healthy behaviors and increasing knowledge that facilitated informed choices, (*b*) acknowledging internal conflict and encouraging choice and self-initiation, (*c*) providing participants with a variety of options and choices for behavior change, (*d*) promoting confidence in decision making by practicing decision making tasks, (*e*) avoiding the use of external incentives throughout intervention activities, and (*f*) providing positive feedback to promote behavior change. Results indicated that participants in the SDT weight loss group lost significantly more weight (as determined by percentage of initial body weight) than the control group immediately following the 1-year intervention period (−7.3% vs −1.7%, $P < .001$) and at both the 1-year (−5.5% vs −2.2% $P = .004$) and the 2-year postintervention follow-ups (−3.7% vs 1.9%, $P = .040$).

In another study, Williams et al[47] evaluated the effectiveness of a SDT-based smoking cessation intervention. Participants in this 2-group randomized controlled trial received either a standard self-help smoking cessation booklet or the booklet plus 4 in-person smoking cessation counseling sessions based on SDT. The in-person SDT sessions focused on encouraging participants to make the autonomous decision whether or not to quit smoking. Key strategies used in these sessions included (*a*) having participants meet with a counselor to discuss their attitudes about smoking and how their personal experiences and environments hindered and/or facilitated smoking cessation, (*b*) providing participants with information on the health benefits associated with smoking cessation, and (*c*) having participants work with their counselors to develop individualized smoking cessation plans. Results showed that participants who received the SDT-based counseling in addition to the self-help booklet were more likely to demonstrate a 7-day smoking cessation prevalence at the 6-month follow-up in comparison to participants who received the self-help book alone (odds ratio = 3.11, confidence interval = 1.67-5.79; $P = .001$).

Theory of Planned Behavior. The theory of planned behavior (TPB)[33] was referenced as the theoretical basis for 2 studies (Supplemental Table 6; available at http://ajl.sagepub.com/content/by/supplemental-data) retrieved during search procedures,[50,51] both focusing on PA promotion. In the first study, McEachan et al[50] evaluated the efficacy of a 3-month TPB-based worksite PA program among 44 UK worksites. In this randomized controlled trial, worksites were assigned to either receive the TPB-based PA promotion intervention delivered by trained volunteer employees and TPB-based print materials, or to a control group that received a brief atheoretical pamphlet describing ways of improving health through diet and PA. The TPB-based PA promotion program was developed through formative research and focused the TPB constructs of affective and instrumental attitude, injunctive and descriptive norms, self-efficacy and perceived behavioral control, and behavioral intention.[50] Results of the study suggest that the TPB program was not advantageous in promoting PA with null PA findings at all 3 postintervention follow-up assessments (immediately following the intervention, 3-month postintervention, 9-month postintervention).

The second study, conducted by Vallance et al,[51] evaluated 6-month postintervention outcomes of a 3-month TPB-based PA program among breast cancer survivors. All study participants received standard public health recommendation to perform 30 minutes of moderate-to-vigorous PA 5 days a week and were randomized into 1 of 4 study groups: (*a*) standard public health recommendation only (control group), (*b*) breast cancer–specific PA print materials based on the TPB, (*c*) pedometer only, or (*d*) breast cancer–specific physical activity print materials based on TPB plus a pedometer. The TPB breast cancer PA print material consisted of a guidebook that addressed salient exercise beliefs among breast cancer survivors.[52] Development of the guidebook was informed by previous research with breast cancer survivors and was designed to enhance PA-associated TPB constructs of attitudes, subjective norms, and perceived behavioral control. The 3 intervention groups self-reported 40- to 60-minute increases in their PA compared to a 9-minute increase in the control group immediately postintervention; however, these PA increases were not statistically significant. Results at the 6-month postintervention follow-up were similar, with none of the intervention groups demonstrating statistically superior PA levels (all *P*s >.05) in comparison the control group, indicating that the TPB-based PA guidebook did not provide any additional long-term encouragement for PA behavior among breast cancer survivors.

Transtheoretical Model. The transtheoretical model (TTM)[35] was referenced as a theoretical framework in 10 studies included in the review. Supplemental Table 7 (available at http://ajl.sagepub.com/content/by/supplemental-data) illustrates studies referencing the TTM or associated constructs as the sole theoretical basis for intervention activities (n = 5) and Supplemental Table 8 (available at http://ajl.sagepub.com/content/by/supplemental-data) illustrates studies based on both the TTM and the SCT (n = 5). Of these 10 studies,[53-58,60,61,63,64] 8 (80%) reported favorable outcomes of the risk factors of interests (all 5 weight loss studies,[55-57,61,63] two[58,64] of the 3 PA studies, and one[54] of the 2 smoking cessation studies), providing considerable support for the use of the

TTM in the promotion of long-term behavior and lifestyle change.

In a smoking cessation study conducted by Cabezas et al,[54] participants were randomized to receive either a 6-month TTM-based smoking cessation program or to a usual care group that received brief smoking cessation advice. Individuals' level of readiness to change was assessed by questionnaire and participants subsequently received intervention elements tailored to their determined stages of readiness. For example, participants classified as being in precontemplation or contemplation stages of change received brief motivational interviewing and a motivational leaflet. Participants categorized as being in preparation or action could choose between receiving 9 scheduled follow-up visits over 6 months or a leaflet containing practical information and one follow-up visit/phone call. Results at an 18-month postintervention follow-up showed an 8.1% continuous smoking abstinence rate among participants randomized to the TTM group compared with 5.6% of usual care participants (odds ratio = 1.5, confidence interval = 1.05-2.14, $P = .014$).

In another TTM-based study, Riebe et al[56] evaluated a 6-month weight loss intervention that included an 18-month postintervention weight loss maintenance period. All participants received individualized stage-matched feedback according to their weight loss progress during the initial 6-month weight loss intervention and were then randomly assigned to 1 of 2 weight loss maintenance groups: (*a*) received 2 additionally tailored TTM-based feedback reports encouraging weight loss at months 9 and 12 or (*b*) received generic information about diet and exercise at months 9 and 12. Results showed significant weight loss among participants immediately following the intervention phase (mean loss of 5.6 kg, $P < .05$). At the 12- and 24-month postintervention follow-up periods, participants in both groups regained weight at similar rates (difference in weight between groups, $P > .05$); however, weights for both remained significantly lower ($P < .05$) at month 24 than at baseline (TTM group weight loss = 2.8 kg, comparison group weight loss = 3.0 kg). Therefore, findings of this study provided positive support for the initial TTM-based weight loss intervention despite limited evidence of the long-term efficacy of the intervention.

Social Cognitive Theory. Social cognitive theory (SCT)[34] was the most frequently referenced theory among all the studies included in the review. The SCT or specific constructs within the SCT were referenced by 20 studies (see Supplemental Tables 7 and 9; available at http://ajl.sagepub.com/content/by/supplemental-data): 7 weight loss,[61,63,65,66,69,70,83] 10 PA,[44,58,60,62,78,80,84] and 3 smoking cessation.[76,77,82] Moreover, 2 additional weight loss studies identified Bandura's social learning theory[72,79] (a precursor for the SCT) as the theoretical framework underpinning intervention activities. Among the 22 studies that referenced the SCT or social learning theory as the theoretical basis for intervention activities, 15 (68%) reported positive findings for the behaviors of interests (8 of the 9 weight loss/weight loss maintenance studies,[61,63,65,66,69,70,72,79] 6 of the 10 PA studies,[44,58,62,71,80,84], and 1 of the 3 smoking cessation studies[82]). These favorable findings suggest that SCT is an advantageous framework to promote maintenance of multiple health behaviors.

In the Obesity Reduction Black Intervention Trial,[70,85] participants were randomized to receive either a 6-month SCT-based weight loss intervention followed by a 12-month maintenance intervention or to a control group that received newsletters covering general health topics. The SCT-based weight loss intervention focused on the SCT constructs of observational learning (ie, modeling) and self-efficacy. Observational learning was achieved by participants observing interventionists as well as other participants engage in various weight loss behaviors.[85] Similarly, self-efficacy was enhanced by participants rehearsing stimulus control, problem solving, and other weight loss strategies during intervention sessions.[85] Results showed that at the end of the 6-month intervention, those who received the SCT-based weight loss program lost a total of 3.4 kg while the control group gained 0.22 kg ($P < .001$ for the difference in weight changes between groups). Findings at the 12-month postintervention follow-up were similar with participants in the intervention group demonstrating statistically significant weight loss in comparison with the control group (loss of 2.26 kg for intervention group vs a gain of 0.51 kg for control participants, $P = .003$).

In another study, Buman et al[44] evaluated a 16-week SCT- and SDT-based PA intervention for older adults (individuals aged 50 years and older) that included an 18-month postintervention follow-up assessment. Participants in the intervention group received support to learn self-management skills for PA initiation and maintenance. This was accomplished through self-efficacy, encouragement and regular feedback, goal setting, problem-solving exercises, mental imagery, and building a PA social support system. Results showed that participants randomized to a peer-led SCT- and SDT-based PA intervention reported significantly greater PA levels ($P = .04$) at 18-month postintervention ($M = 145.73$ min/wk of PA) follow-up when compared with participants who received a standard, atheoretical community-based PA intervention ($M = 58.32$ min/wk of PA).

Several studies also referenced single constructs of the SCT as the theoretical basis for intervention activities. For example, 2 weight loss studies[66,81] referenced the construct of self-regulation as the sole theoretical basis for intervention activities. In a 3-arm randomized controlled trial, Wing et al[81] evaluated the efficacy of face-to-face versus Internet delivery of a self-regulation-based weight loss maintenance program. Participants in both intervention groups were instructed to weigh themselves using a scale

provided by researchers and submit their weight weekly through either an automated telephone system (face-to-face group) or a Web-based forum (Internet group). After each weight submission, participants received automated feedback based on their weight maintenance progress (ie, positive feedback if their weight regain was less than 1.3 kg from baseline, problem-solving feedback for regaining between 1.4 and 2.2 kg, or active weight loss feedback to initiate weight loss if they regained 2.3 kg or greater of their baseline weight). Results showed that participants in the face-to-face group had significantly less weight regain at a 24-month follow-up when compared with the Internet or control groups. However, further analysis showed that adherence to the Internet-delivered intervention was significantly less than the face-to-face group; suggesting that the difference in weight regain between the face-to-face and Internet groups may have been because of intervention fidelity or mode of delivery rather than the intervention's theoretical background. Likewise, Burke et al[66] conducted a similar study that evaluated the mode of delivery (personal digital assistant vs paper diary) of a self-regulation-based weight loss program. Results of this study were comparable to Wing et al[81] where adherence to the self-regulatory program was the best predictor of weight loss, rather than the delivery mode.

Three studies (all focusing on PA)[71,73,74] referenced the SCT construct of self-efficacy[40,86] as the sole theoretical background for intervention activities. Among these studies, only 1 reported significant postintervention increases in PA at long-term follow-up assessment. This study, conducted by Izawa et al,[71] evaluated a self-efficacy-based approach for PA among cardiac rehabilitation patients. After completing the acute phase of a cardiac rehabilitation program, patients were randomized to either a self-efficacy-based self-monitoring cardiac rehabilitation group or a usual care control group (cardiac rehabilitation only). Both groups attended a 5-month cardiac rehabilitation program that included supervised exercise training. In addition to the supervised cardiac rehabilitation, patients in the self-efficacy group were instructed to self-record their physical activity (using pedometers), body weight, blood pressure, and heart rate. To increase self-efficacy for exercise, cardiac rehabilitation staff reviewed self-monitoring logs with patients and provided encouragement, feedback on their progress, and discussed the benefits of PA and adoption of healthy behaviors with participants. Participants in the self-efficacy group were also asked to continue self-monitoring after completing the intervention. Results indicated that participants randomized to the self-efficacy-based cardiac rehabilitation group reported significantly greater steps per day at 6-month post–cardiac rehabilitation than the usual care cardiac rehabilitation group (10 459 steps per day vs 6923 steps per day, $P < .001$).

The other 2 self-efficacy-based PA studies evaluated Web-based approaches to increase PA through chronic disease self-management programs in middle-aged to older adults.[73,74] These studies were conducted by the same research team and had similar protocols. Participants in these studies were randomized to either a 6-week intervention that consisted of accessing an interactive study Web site composed of educational materials and group discussion forums (self-efficacy-based group) or to a usual care/control group. Interventions in both studies consisted of Web-based modules designed to promote self-efficacy. Modules were moderated by trained facilitators and were composed of Web-based instructions that included individualized exercise programs, a Web-based bulletin board discussion group, and a book containing all content of the program. New content on chronic disease management was posted to the Web site weekly for 6 weeks. To promote self-efficacy for physical activity, the facilitators provided action planning, feedback, and problem-solving advice, as well as encouragement to participants. Participants in the control group received their usual chronic disease care. At the end of the intervention phase, participants had no further contact with study staff until the 1-year postbaseline follow-up assessment. Both studies showed null PA outcomes at the 1-year follow-up. However, because of the similarities of these studies and their focus on disease management rather than solely increasing PA, the lack of positive PA outcomes of these may be attributed to a variety of other factors (ie, study populations, intervention delivery mode, fidelity of intervention activities to self-efficacy constructs) rather than a deficiency in the theory itself.

Social Ecological Model. One study identified an SEM as the theoretical background for intervention activities (Supplemental Table 10; available at http://ajl.sagepub.com/content/by/supplemental-data). In this randomized 2-group smoking cessation trial,[87] participants were placed into either a comparison group where they received generic, print-based smoking cessation material or an intervention group where they received SEM-based print materials and telephone counseling to stop smoking. SEM-based intervention addressed the interaction between cognitive, interpersonal, and environmental elements using a graduated reduction approach allowing participants to set individualized goals. Results of this study showed that both study arms had similar outcomes with no difference between groups ($P > .05$) for cigarette reduction or quit rates at the 12-month follow-up assessment. However, we note that the majority of intervention components in this study focused on the intrapersonal and interpersonal levels of influence (rather than community or public policy factors), which may have limited the application of the SEM to study activities and potentially influenced the null study outcomes.

Discussion

The current article provides an overview of psychological theories that

have been applied to interventions promoting initiation and maintenance of healthy behaviors. We focused this review on intervention research promoting PA, weight loss, and smoking cessation, as these are key modifiable risk factors that contribute to the development of many chronic diseases. Findings provide researchers with insight on theoretical backgrounds to consider when developing interventions to promote long-term maintenance of PA, weight loss, and smoking cessation behaviors.

Search procedures identified 3 individual level theories (SDT, TPB, and TTM) referenced across 16 studies. The SDT was referenced by 4 studies (1 focused on PA and weight loss, 1 focused on PA only, 2 focused on smoking cessation) and all reported positive outcomes of the targeted risk factor at the most distal follow-up assessment. Similarly, 10 studies referenced the TTM (5 weight loss maintenance, 3 PA, 2 smoking cessation), with the majority (80%) reporting positive outcomes for the risk factor of interest at the most distal assessment period. The favorable outcomes of studies identifying SDT and TTM provide promising support for the use of these individual level theories to promote initiation and long-term maintenance of various health behaviors, including PA, weight loss, and smoking cessation.

The TPB was referenced by 2 studies included in the review[50,51] and neither reported significantly different PA levels between the TPB-based intervention groups and comparison groups at long-term follow-up assessments. The results of these 2 studies in conjunction with the limited number of studies referencing the TPB, may suggest that this theory is not well suited as a framework to promote long-term maintenance of select health behaviors (ie, PA, weight loss, smoking cessation) associated with chronic disease prevention. However, an alternative explanation for the limited number of studies referencing the TPB may be because of a selection bias as we only included randomized trials in our review and did not include studies that focused on populations younger than 18 years. For example, the theory of reasoned action, the theoretical precursor for the TPB,[88] is frequently used in studies targeting child or adolescent populations because of their lack of perceived control over their health behaviors (this is particularly the case among studies targeting tobacco or excessive alcohol use prevention and/or cessation since adolescence is the age period when initiation of these behaviors is likely to begin[89,90]).[37] Therefore, not including younger age groups in the review likely limited the number of available studies using the TRA and TPB. The limited use of these theories in studies evaluating long-term maintenance of PA, weight loss, and smoking cessation behaviors indicates the need future research to further explore the use of these theories in adult populations.

At the interpersonal theory level, Bandura's SCT was referenced by 22 studies, making this theory the most frequently identified of all behavioral theories in the review (referenced by 65% of studies: 9 weight loss/ maintenance, 10 PA, 3 smoking cessation). Moreover, 68% of SCT-based interventions reported favorable outcomes for the targeted behavior at the most distal follow-up assessment. The high number of studies referencing the SCT in combination with the positive findings of these studies suggests that SCT is a promising theoretical framework for initiation and long-term maintenance of multiple behaviors associated with prevention and treatment of chronic disease.

Only 1 study included in the review, a smoking cessation study,[87] identified a social ecological approach as the theoretical background for intervention activities, limiting our ability to draw conclusions regarding the usefulness of this theory in promoting maintenance of health behaviors. The paucity of studies referencing an ecological framework was somewhat surprising given the increased focus on using ecological approaches to promote behavior change in recent years. Perhaps, the cost and difficulty associated with designing, implementing, and evaluating SEM-based behavioral change interventions are contributing factors to this outcome. For example, the outer levels of influence of SEMs (ie, community, public policy) often require community/political buy-in for the intervention as well as modifications and changes to environmental structures, which can be expensive and time consuming. Furthermore, given the limited monetary resources of many researchers and the pressure from grant-funding agencies for quick outcomes from funding efforts, it is not always possible for researchers to mobilize all the resources needed to implement SEM-based behavioral change interventions. Despite only identifying 1 SEM-based study meeting inclusion criteria for our review, we are aware of at least one other study currently underway using this framework to promote PA in retirement communities.[91] As more long-term studies are implemented and results of studies currently underway are published, we believe that SEMs will emerge as promising frameworks to promote maintenance of health behaviors because of their attention to the intrapersonal, interpersonal, and community/public policy determinants of health.

In reference to behavioral theories used to promote specific behaviors, the SCT and TTM were the most commonly reported theories referenced by PA and weight loss studies, aligning with other reviews on these topics.[17,24,92] Among smoking cessation studies, a variety of theoretical backgrounds were referenced: 2 studies referenced SCT, 2 referenced the TTM, 2 referenced SDT, and 1 referenced the SEM. We were surprised to identify only 2 smoking cessation studies referencing the TTM, as this model was originally developed to describe the process in which smoking cessation occurred naturally.[35] A potential explanation for this outcome could be because of study selection bias (similar to the small number of studies referencing the TPB in our review), as we excluded studies using pharmacological strategies in their

intervention efforts. Given the rich history of the TTM in promoting smoking cessation, future researchers should further explore the long-term influence of the TTM to promote maintenances of smoking cessation behaviors.

Behavioral theory provides a framework for researchers to design and evaluate health promotion programs. However, some researchers have questioned the need for theoretical backgrounds in intervention research. A recent meta-analysis conducted by Prestwich et al[93] found that nontheoretical behavioral interventions are equally as effective as theoretically based behavioral interventions. Notably though, the authors of this review reported that only 20% of the 107 theoretically based interventions reviewed reported explicit links between theoretical constructs and intervention activities; which raises the question as to whether the results of this meta-analysis were confounded by the fidelity in which intervention activities adhered to and penetrated the theoretical constructs they were designed to target. Moreover, the results of the review by Prestwich et al[93] differ from several other reviews on the topic. Glanz and Bishop[26] reviewed 11 systemic reviews examining theory use in health behavior intervention research and found that 7 of the 11 reviews concluded that interventions based on a behavioral theory (or explicitly described theoretical constructs underpinning intervention activities) were more effective than atheoretical interventions. Given these data, along with the findings of other researchers,[22,26,27,94] it is our belief that rigorously designed, theoretically grounded interventions have the potential to be more successful in the promotion and maintenance of healthy behaviors and lifestyles.

The current review is unique in the fact that we focused solely on theoretically based interventions evaluating maintenance of health behaviors following an intervention period. To our knowledge, this is the first review of its kind that provides key insight on the application of behavioral theory to promote behavioral maintenance of 3 modifiable key risk factors associated with reduction of chronic disease: PA, weight loss, and smoking cessation. We focused exclusively on maintenance for several reasons. First, several recent high-quality reviews have examined the application of behavioral theories to promote initiation of health behaviors.[26,28] Consequently, another review on application of behavioral theory to promote initiation of health behaviors would not necessarily add to the current body of literature. Second, while we acknowledge initiation of health behaviors is an imperative precursor to behavioral maintenance, maintenance is the key to long-term health outcomes and chronic disease prevention.

Several limitations of this review must be noted. Only randomized trials with non-pharmacological interventions approaches were included in the review. Therefore, studies using single group designs and studies evaluating pharmacological strategies in conjunction with behavioral theory to promote weight loss/maintenance and smoking cessation were excluded. We also excluded studies identifying cognitive behavioral therapy as the basis for intervention activities unless authors specifically identified a behavioral health theory that underpinned the cognitive behavioral approach (or it could be identified by through a reference search). The search process was also challenging because of the heterogeneity across studies and the quality of study descriptions provided by the authors. Therefore, in many instances, the determination of whether the articles met our a priori inclusion/exclusion criteria was difficult. Additionally, we did not review the quality or fidelity in which studies applied the behavioral theories to their behavior change intervention activities. This task is beyond the scope of this review and, as others have noted,[93] is difficult to accurately assess because of the variance among study descriptions in the literature. A final limitation of the current review relates to a potential publication bias in the literature. There has been a historic trend in the scientific community favoring the publication of studies with significant or positive outcomes.[95,96] Therefore, it is likely that some studies were not included in this review because of the unwillingness of scientists and/or journal editors to publish studies with null or unfavorable outcomes. The presence of this bias likely positively skewed the findings of the review because of an overrepresentation of studies with positive or significant outcomes.

Summary

The current article provides an overview of behavioral theories used in intervention research to promote long-term maintenance of PA, weight loss, and smoking cessation. Findings provide favorable support for the SCT and the TTM to promote maintenance of PA, weight loss, and smoking cessation behaviors. Likewise, results of studies referencing SDT were also promising; however, fewer studies (n = 4) referenced this theory as the theoretical basis for intervention activities. The sparse number of studies referencing the TPB and SEMs limits our ability to draw conclusions as to the usefulness of these theories to promote long-term maintenance of health behaviors. More research is needed to further explore how these 2 theories can be incorporated into interventions evaluating long-term effects of behavior change.

Acknowledgments

Research assistance for data analysis and manuscript development was supported by training funds from the National Institutes of Health/National Institute on Nursing Research (NIH/NINR), award T32 1T32NR012718-01–Transdisciplinary Training in Health Disparities Science (C. Keller, Principal Investigator), the National Cancer Institute/National Institutes of Health (NCI/NIH), award R25 CA047888–Cancer Prevention and Control Training Program (K. Meneses, Principal Investigator), and the National Cancer Institute/National Institutes of Health (NCI/NIH), award 5 R25 CA057711–Harvard Cancer Prevention Fellowship Program (G. Sorensen, Principal Investigator). AJLM

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