INVITED PAPER

Five roles for using theory and evidence in the design and testing of behavior change interventions

L. Kay Bartholomew, EdD; Patricia Dolan Mullen, PhD

Center for Health Promotion and Prevention Research, The University of Texas Health Science Center at Houston, Houston, TX

Abstract

Objective: The prevailing wisdom in the field of health-related behavior change is that well-designed and effective interventions are guided by theory.

Methods: Using the framework of intervention mapping, we describe and provide examples of how investigators can effectively select and use theory to design, test, and report interventions.

Results: We propose five roles for theory and evidence about theories: a) identification of behavior and determinants of behavior related to a specified health problem (i.e., the logic model of the *problem*); b) explication of a causal model that includes theoretical constructs for producing change in the behavior of interest (i.e., the logic model of *change*); c) selection of intervention methods and delivery of practical applications to achieve changes in health behavior; d) evaluation of the resulting intervention including theoretical mediating variables; and e) reporting of the active ingredients of the intervention together with the evaluation results.

Conclusions: In problem-driven applied behavioral or social science, researchers use one or multiple theories, empiric evidence, and new research, both to assess a problem and to solve or prevent a problem. Furthermore, the theories for description of the problem may differ from the theories for its solution. In an applied approach, the main focus is on solving problems regarding health behavior change and improvement of health outcomes, and the criteria for success are formulated in terms of the problem rather than the theory. Resulting contributions to theory development may be quite useful, but they are peripheral to the problem-solving process.

Introduction

The prevailing wisdom in the field of health-related behavior change is that well-designed and effective interventions are guided by theory and informed by empiric evidence regarding the target behavior. For example, meta-analyses of cancer screening interventions have found that larger effect sizes are achieved when interventions are based on theory (1-3). However, single theories typically predict or explain only a small percentage of the variance in any health behavior (4-6). Investigators need to know not only that the use of theory is a requirement in the field, but also how to effectively select and use multiple theories to design, test, and report interventions.

This paper suggests one framework for guiding the use of theory in intervention research. Rather than suggesting one proper way to use theory, this paper presents the "places" in intervention development and testing that a researcher should be "thinking with theory" and provides some examples of a comprehensive theoretical approach. We propose five roles for theory and evidence about theories: a) identification of behavior and determinants of behavior related to a specified health problem (i.e., the logic model of the *problem*); b) explication of a causal model that includes theoretical constructs for producing change in the behavior of interest (i.e., the logic model of *change*); c) selection of intervention methods and delivery of practical applications to achieve changes in health behavior; d) evaluation of the

resulting intervention including theoretical mediating variables; and e) reporting of the intervention characteristics along with the evaluation results.

In our view, theory is necessary for behavior change research to ensure that researchers identify relevant causal factors of the behavior (referred to by McKinnon and Leuken, this issue, as concept theory), and identify change methods that address the concept theory and maximize intervention effectiveness (referred to by McKinnon and Leuken as action theory). Further, use of theory helps researchers measure and describe the pathways through which change occurs or the points where change breaks down, making the findings, even of failed trials, useful in informing subsequent research. Importantly, the use of theory must go beyond mere lip service and should continue throughout intervention development and testing.

Effective development, testing, and reporting of interventions often requires approaching theory in a way that is fundamentally different from either the generation of theory, testing single theories, or comparing theory effectiveness for explaining or changing behavior (7-9). Researchers seeking a solution to a behavior change problem have a different task than testing theory. In problem-driven applied behavioral or social science, researchers use one or multiple theories, empiric evidence, and new research, both to assess a problem and to solve or prevent a problem. Furthermore, the theories for description of the problem may differ from the theories for its solution. In an applied approach, the main focus is on solving problems regarding health behavior change and improvement of health outcomes, and the criteria for success are formulated in terms of the problem rather than the theory. Resulting contributions to theory development may be quite useful, but they are peripheral to the problem-solving process.

Clarifying terminology: theories, models, and frameworks

We use the term theory to refer to a cohesive explanation for a set of specific causal relations among constructs, and between these constructs and target behaviors. For instance, Social Cognitive Theory (SCT) views behavior as a result of causal, reciprocal interactions among individual cognition, behavior, and the environment (10). This theory has inspired decades of health behavior research, including scores of interventions purporting to target its theoretical constructs.

We use the term model throughout this paper to mean a hypothesized set of general relations between constructs and one or more target behavior(s). The purpose of a model is to identify the full range of constructs that may be relevant to one or more target behavior(s). Constructs described in a model may or may not be derived from

theory, and constructs from multiple theories may be included in the same model. For instance, the Integrated Behavior Model identifies constructs from multiple theories that seem to be similar to one another (11-13), and also seem to have similar relationships to health behavior change (14).

We distinguish a theory from a model by its specificity, cohesiveness, and purpose. A theory is a cohesive explanation describing specific causal relationships between constructs; a model is a heuristic representation of multiple constructs that may be relevant to a target behavior, and the possible relationships between constructs and that behavior. Please note, however, that there is much confusion generated in the literature by the interchangeable use of the words model and theory. For example, later in this paper we refer to the Health Belief *Model* (HBM) which is a *theory,* and some theoreticians argue that the Integrated *Model of Behavior,* which is a synthesis of theoretical constructs is a meta-theory (11-13). Also, we rely heavily on the development of logic models, which are a specific type of explanatory model derived from the evaluation field. Logic models are typically graphic representations of the demonstrated or hypothesized causal relationships between interventions, their mechanisms of change, and their behavioral, environmental, and health outcomes (15-19).

We propose developing logic models that integrate constructs from multiple theories and from empirical evidence into a single causal model. This position is somewhat controversial, especially among investigators whose main focus is on theory building and testing, rather than intervention building and testing (20).

Finally, we use the term framework to describe a way of approaching intervention development and testing. We base our description of the five roles of theory on Intervention Mapping, a framework that has been used to develop many health promotion and behavior change programs (7-9,21-24). The purpose of Intervention Mapping is to provide those who develop behavior change programs with guidance for effective decision making at each step of intervention planning, implementation, and evaluation. The six fundamental steps of the Intervention Mapping process are the following:

- Describe the health problem and related behavior.
- Create matrices of change objectives that combine specific behavioral performance with theoretically and empirically derived determinants.
- Select theory-based intervention methods and practical applications for behavior change.
- Organize methods and applications into an intervention program.
- Plan for program implementation with fidelity.
- Generate an evaluation questions, design, and measurement.

Five roles for theory and evidence in intervention development and evaluation

Developing a logic model of the problem behavior and its determinants

The first role for theory in the development of a behavior change intervention is in describing the health problem one wishes to address, including its behavioral and environmental causes and their determinants. Later, we will develop a logic model of change as a basis for intervention, but first, we suggest beginning with a question about the specific health or behavior change issue and its determinants, and then identifying evidence for as many causal relations between constructs and the behavior as are reported in the literature (7-9). This sort of comprehensive literature search will typically produce elements of the logic model that are based on theory and those that are atheoretical. See Figure 1.

To illustrate the roles of theory, we will use the example of oral cancer and the impact of late diagnosis on health out-comes (25-28). In our literature searches, we first sought answers to the question of what causes late diagnosis and drafted a simple logic model of the problems including both theoretical and non-theoretical factors related to late diagnosis of oral cancers and their impact on health outcomes. Figure 1 is based on a review of selected studies of patient and health care provider factors related to delay in diagnosis of oral cancer.

The example we present in Figure 1 illustrates the process of using theory and evidence. We do not mean the example to be a fully researched, definite description of factors related to late stage diagnosis of oral cancer. In this example of a logic model of the problem, theory is used in several ways. First, an ecological approach is adopted that considers both the behavior and motivations of the population at risk and the environmental conditions that may either facilitate or limit the behavior's occurrence. In Figure 1, both the behaviors of the risk group (adults, particularly those with the risk behaviors of tobacco and alcohol use) and the behaviors of their health care providers that have been found to be related to late-stage cancers and diagnostic delay rather than primary prevention
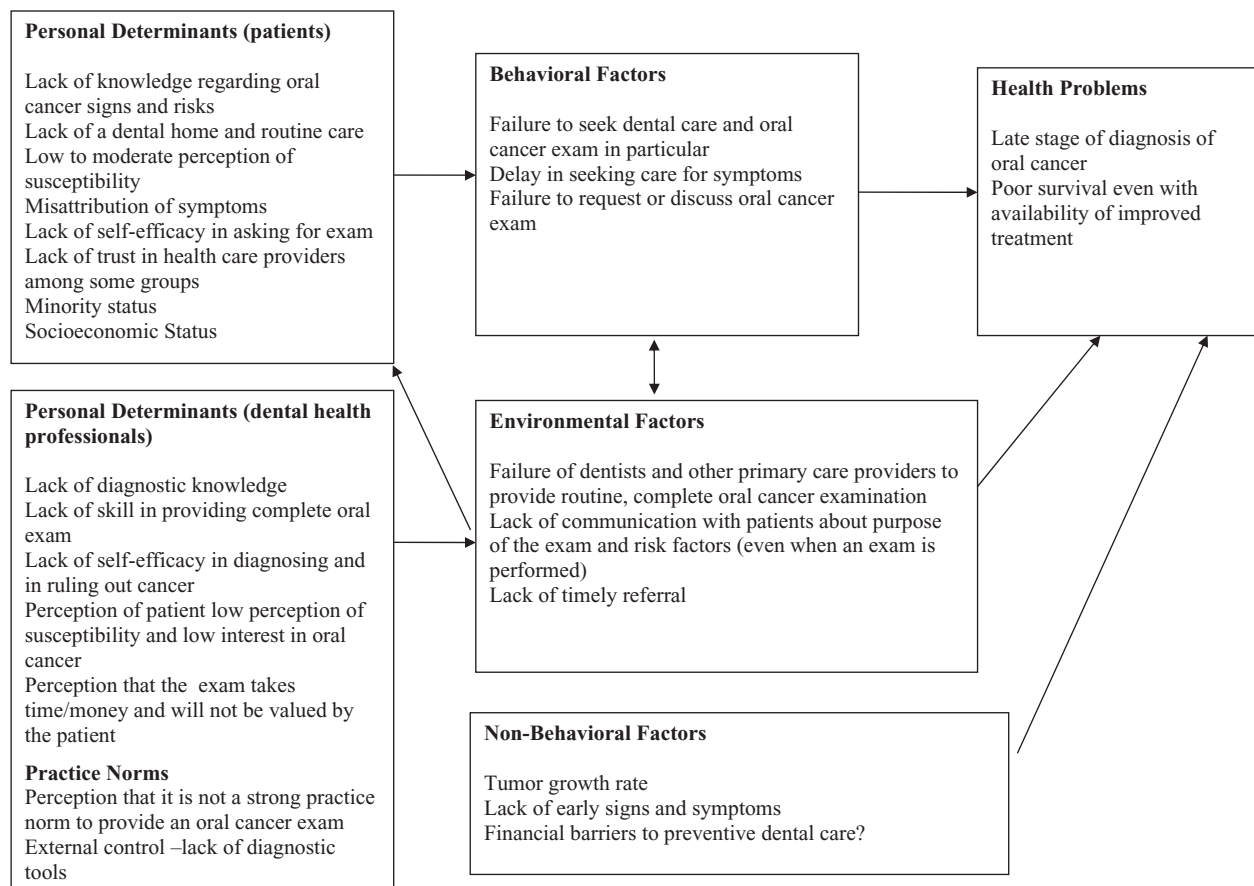

Figure 1 Hypothetical logic model of the problem of late stage diagnosis of oral cancer.

are described. Therefore, the risk behaviors of tobacco and alcohol use or practices that promote oral human papillomavirus infection are not depicted in this example.

Most of the studies of patient and provider behaviors related to diagnosis of oral cancer identified for this example were not theoretically based. The study reports occasionally mentioned theory and less often described how it was used to guide their research question; for example, Self-regulatory Theory (29), the Co-orientation Model of Communication (30), the HBM (31), and the Theory of Planned Behavior (TPB)(32). Therefore, in our logic model of the problem, some of the factors that are hypothesized to predict late diagnosis are described as theoretical constructs, while others are predictors without theoretical labels. Looking at the middle column of the model, the patient behaviors have been described as a) not pursuing care by a dental or other primary care provider, or not having a dental home (33,34); b) delaying response to oral symptoms (35,36); c) not seeking regular dental care or examination for oral cancer; d) not discussing risk factors for or symptoms or oral cancer with a dental care provider; and e) not recognizing when an exam is performed (30). In this model, theory points to the interaction between at-risk group behavior and environmental influences. Both patients and dentists avoid discussion of cancer or the importance of oral cancer examinations, diminishing the likelihood of their being conducted; further, dentists report that they do not routinely perform exams during patient visits, reducing the chance they will talk with their patients about oral cancer or increase the patients' awareness of the need for vigilance regarding oral cancer signs and symptoms (30). The reciprocal logic model of the problem suggests that provider behavior should include both best practice examination *and* best practice communication with the patient (30).

The left column of Figure 1 comprises factors that may influence the behavior of patients and their health care providers. Theoretical constructs are more apparent in this part of the model than in the description of behaviors above. Influences on patient behaviors include the constructs of perceived susceptibility and seriousness from the Health Belief Model (which is a *theory*) (31), lack of knowledge about symptoms and risks for oral cancer (30,33), misattribution of cancer-related symptoms when they occur, and competing priorities regarding seeking primary dental care (35,36). Other important patient characteristics include minority status, lack of trust in health care providers, and not having a dental home (33,34). Some of these behaviors and their determinants have been described only in particular subgroups and serve to remind us that logic models and resulting interventions should specify the particular priority populations to which they refer. In this example, these are likely to be the groups with a disproportionate burden of late diagnosis of oral cancer.

As mentioned, health care provider behavior also contributes to late diagnosis, so the model includes factors that may lead to the lack of exams and communication by providers. The left column includes providers' lack of knowledge about diagnosis and diagnostic tools (37), poor diagnostic skill, poor provider/patient communication skills, and low self-efficacy regarding ruling out cancer (all constructs from SCT) (30). Self-efficacy is the degree of confidence someone feels regarding the performance of a specific behavior (10,14,38). Choi and colleagues (30) also found that providers underestimated patient concerns about and interest in oral cancer, felt uncomfortable discussing oral cancer, and had concerns about time and finances. Finally, Wade and colleagues (32) used constructs from the TPB (14) in their study, and findings suggest that providers may experience a lack of strong practice norms for providing the exam (subjective norms from the TPB) and diagnostic tools as unavailable (external control from TPB) (32).

This logic model of the problem suggests the importance of moving beyond a narrow focus on awareness and knowledge, to a broader array of constructs and predictors that could inform intervention development. Even though our literature search was topic-specific, pertaining to oral cancer, and not explicitly theory-related, theoretical constructs appeared in the empiric evidence and were used to build the logic model. A way to develop greater theoretical breadth and depth in this initial model of the problem would have been to review the literature regarding prediction of related behaviors – for instance, either cancer screening or preventive dental care – to see if more theoretical constructs might be imported.

The Logic Model of Change: Identifying targets of the intervention

The second use of theory and evidence in intervention development is to describe the hypothesized mechanisms of change (Figure 2). This logic model depicts the causal pathway from the intervention through the determinants, to the expected health promoting patient and provider behaviors, and ultimately to program outcomes of changes in oral cancer diagnosis. The first targets of the intervention are the hypothesized determinants (also referred to as mediators, McKinnon and Lueken, this issue). While interventions are based on causal assumptions, the factors designated as possible determinants of behavior and the focus of the planned intervention are often derived of a mix of research types – cross-sectional and longitudinal surveys and experiments. Intervention developers will not usually have firm empirical support for causal assumptions and must do the best they can to build a case for the validity of their hypotheses regarding the factors that mediate behavior. Some authors refer to this
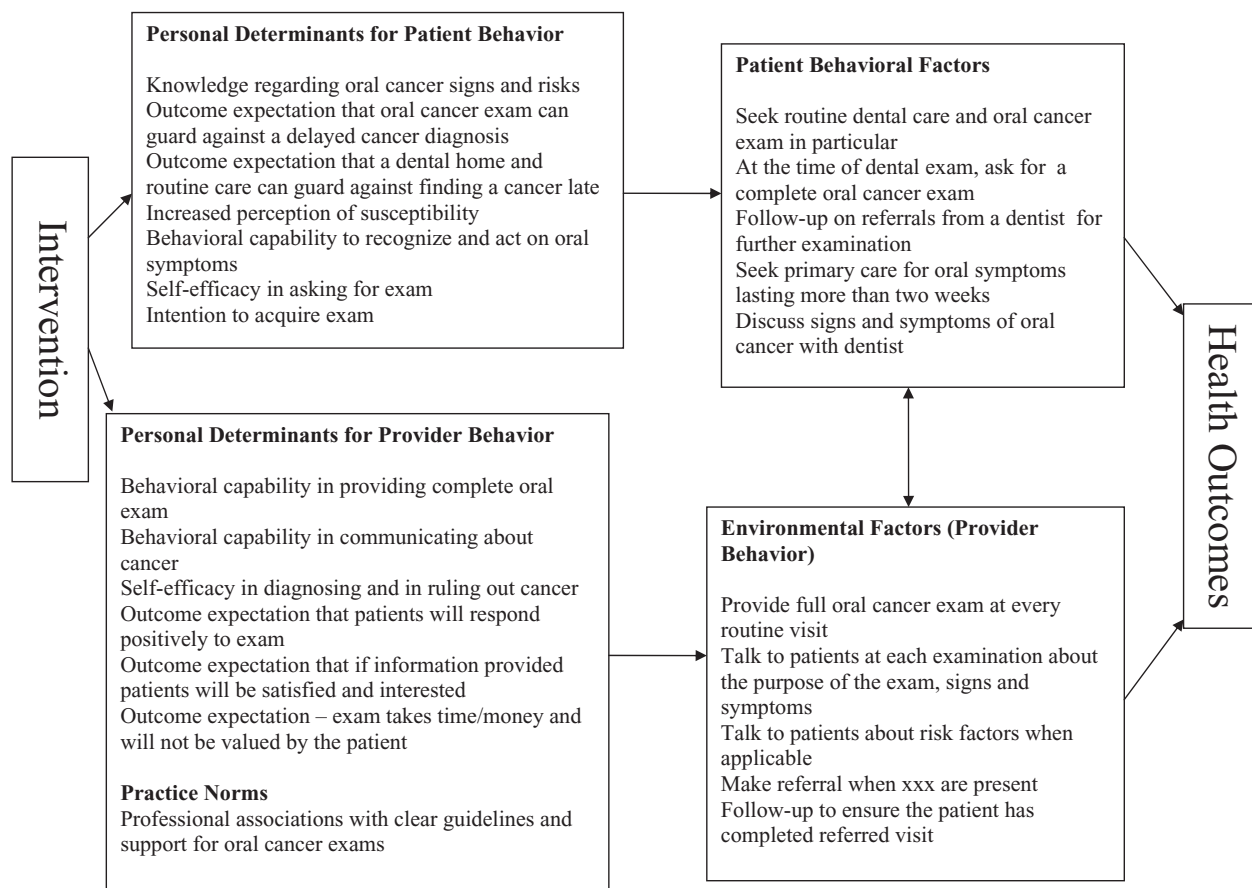
Personal Determinants for Patient Behavior

Knowledge regarding oral cancer signs and risks
Outcome expectation that oral cancer exam can guard against a delayed cancer diagnosis
Outcome expectation that a dental home and routine care can guard against finding a cancer late
Increased perception of susceptibility
Behavioral capability to recognize and act on oral symptoms
Self-efficacy in asking for exam
Intention to acquire exam

Patient Behavioral Factors

Seek routine dental care and oral cancer exam in particular
At the time of dental exam, ask for a complete oral cancer exam
Follow-up on referrals from a dentist for further examination
Seek primary care for oral symptoms lasting more than two weeks
Discuss signs and symptoms of oral cancer with dentist

Intervention

Health Outcomes

Personal Determinants for Provider Behavior

Behavioral capability in providing complete oral exam
Behavioral capability in communicating about cancer
Self-efficacy in diagnosing and in ruling out cancer
Outcome expectation that patients will respond positively to exam
Outcome expectation that if information provided patients will be satisfied and interested
Outcome expectation – exam takes time/money and will not be valued by the patient

Practice Norms
Professional associations with clear guidelines and support for oral cancer exams

Environmental Factors (Provider Behavior)

Provide full oral cancer exam at every routine visit
Talk to patients at each examination about the purpose of the exam, signs and symptoms
Talk to patients about risk factors when applicable
Make referral when xxx are present
Follow-up to ensure the patient has completed referred visit

Figure 2 Hypothetical logic model of change.

as developing a theory of change, theory of the program, or a tacit theory (19,39,40).

Working from the logic model of the problem, the intervention planner would judge the strength of the evidence for the mechanisms of change. Mechanisms of change are derived from the logic model of the problem, from any research that specifically addresses the health-promoting behaviors in either the at-risk or provider group or the environment, and any theoretical variables that have been shown to be important in changing oral cancer behaviors or similar behaviors. There is no real need to specify a *single* theory in this type of applied work. However, sometimes the nature of the behaviors and their determinants in the logic model of change will suggest a unifying theory. For example, in Figure 2, the behaviors of patients and providers, the interaction of these behaviors, and the determinants suggest the utility of SCT. We did not find all the constructs of SCT in our search regarding oral cancer behavior; however, the theoretical constructs of skills, knowledge of what to do and how to do it, and self-efficacy were found. Also, some patient and provider beliefs can be defined as the SCT construct of

outcome expectations – if I do X, Y will happen. For example, "If I talk to my patients about an oral cancer exam, I will increase their awareness." So, in reality, we are "thinking harder with theory" at this second point for using theory, than we were in the logic model of the problem above, and one might ask "Why go to this trouble to consider additional theoretical constructs at this point"? The reason is that theoretical constructs make the model more robust as we often know more about an idea that has been defined and studied as a theoretical construct than we do about a non-theoretical predictor. For example, many researchers have studied the constructs of self-efficacy and outcome expectations; they are well defined, have been measured in relation to many behaviors, and have related theoretical methods of change (which will be important as we move toward intervention in the next role for theory).

Interpreting some concepts in terms of theory (when justified), even when original studies were not based on theory, can be beneficial because the entire theory provides additional constructs that may be added to the model. After choosing SCT, we added the SCT construct of outcome

expectations. We interpret the findings of provider concerns about discussing cancer, patient flow, and practice finances in relation to services as provider outcome expectations regarding the effects of providing an exam and discussing oral cancer. We also further specified knowledge as behavioral capability when the knowledge was a precursor to skills and behavior. Despite tightening up the model with some focus on SCT, we did not delete from our model theoretical constructs other than SCT constructs or non-theoretical predictors when there was evidence from the literature to support their relation to the behaviors of interest.

We created Figure 2 to provide a hypothetical logic model of change, stemming from the logic model of the problem. We specified the health-promoting behaviors of both the at-risk group and the agents in the environment, and provided detail about the performance that could be expected to lead to earlier diagnosis of oral cancer. This logic model is intended to lay out fully the factors that must change in order for an intervention to be effective.

We suggest working from the logic model of change to create a matrix of the change objectives for a planned intervention. Table 1 presents a sample matrix based on the logic model of change in Figure 2. The matrix includes rows for the at-risk group and for the health care providers. The left column is the behavioral performance expected, and the column heads of the other columns indicate hypothesized determinants of the performance (behavioral capability, skills, self-efficacy, and outcome expectations from SCT; perceived threat from HBM; and subjective norms from TPB) that are posited to result in the targeted behavior change. For example, to develop or read the first row in the matrix under the column headed by self-efficacy, the researcher asks "what does the intervention have to change in order for the patient to seek routine dental care and oral cancer exams?" This type of matrix can provide the foundation for intervention development by specifying who and what will change as a result of the intervention.

Selection of theory-based intervention methods and feasible delivery strategies

The third use of theory and evidence is in the selection of one or more intervention methods and practical intervention delivery strategies to change determinants resulting in target behavior change. The links between methods and the determinants and behavior described in the logic model of change can easily be lost in this crucial step because the theories used to understand or predict a behavior may offer little or no guidance on how to change the determinants related to the behavior. Other theories may be needed for this purpose. For example, the HBM suggests the importance of perceived susceptibility in predicting action, but offers little guidance about how to change this belief.

A theory-based change method [also referred to as technique (41)] is a defined process by which theories postulate – and empiric research provides evidence for – how interventions can influence change in the determinants of behavior of individuals, groups, or social structures. Theory-based methods are chosen to match the combination of behaviors and determinants as depicted in Table 1 (above). It should be obvious at this point that the determinants of behavior almost always include many factors other than knowledge and awareness; therefore, methods must include processes to influence factors other than simple knowledge. Theory-based methods are likely to be the program's *active ingredients,* because they have been matched directly to the change objectives based on evidence or theoretical argument.

Once the theory-based change methods are decided on, practical ways to deliver them need to be specified and both methods and the ways they are to be delivered can be added to the logic model of change to obtain a full view of the logic of the intervention. There should be a clear link from the logic model of change and matrix of determinants and behaviors to theoretical methods, and then to the ways that they are made salient and practically deliverable to the priority population. All too often, intervention developers think about the delivery strategies that might be attractive to an audience without the prior steps of describing the mechanism of change and choosing intervention methods that evidence suggests can be effective.

Table 2 displays some preliminary ideas about theory-based methods of change that could be used in an intervention based on Table 1. For example, for the provider, skills and self-efficacy for performing oral cancer exam, identifying suspicious lesions, and ruling out suspicious lesions might be influenced by guided practice, verbal persuasion, and role modeling from SCT (38). Also, provider goal setting might increase self-efficacy and intention to change practice procedures (42). These methods might be delivered via visits with providers in which these intensive methods could be delivered. Intervention developers would work from these ideas about methods and the delivery of practical applications to develop a coherent program with scope, sequence, and implementation plans.

Measurement and evaluation

When intervention developers have been careful to specify the logic model of change, the intervention they have built should guide evaluation questions and measurement. Beginning with the logic model of the problem, the researcher begins to decide what outcome variables to measure. Moving to the logic model of change, the researcher asks evaluation questions about intervention effects on behavior, and on the determinants or mediators of the behavior. It is extremely important that the researcher measures not only primary

Table 1 Matrices for At-Risk Group and Health Care Provider Mechanisms of Change to Promote Early Diagnosis of Oral Cancer

Behavior	Behavioral capability (knowledge of what to do and how to do it)	Perceived susceptibility and seriousness (threat)	Skills	Self-efficacy	Outcome expectations	Subjective norms
At-risk group (patients)						
Seek routine dental care and oral cancer exam in particular (including asking for an oral cancer exam).	Explain that an oral cancer exam is a simple brief inspection of the mouth for signs of oral cancer.	Judge oral cancer as a serious condition that must be discovered early to be effectively treated. Explain that oral cancer is more common in people with risk factors of alcohol use, tobacco use and HPV but that it can occur in anyone.	Demonstrate planning routine preventive care.	Express confidence in planning routine, preventive care.	Explain that when an oral cancer exam is performed routinely, cancer can be discovered early when treatment can be successful.	Characterize friends and family as thinking that preventive care is important. Characterize friends and family as being assertive about getting an oral cancer exam. Describe opinion of friends and family about dental health as important.
Follow-up on referrals from a dentist for further examination.	Describe that delaying in the diagnosis of oral cancer can allow the cancer to grow and become more difficult to treat.	Explain that cancer that is discovered in a late stage can be difficult to treat and can cause severe disability.	Demonstrate providing information to get an expedited appointment.	Express confidence in scheduling an expedited appointment.	Expect that following up on a referral for oral symptoms will result in better health outcomes.	Predict that friends and family would follow up on a referral for oral symptoms as rapidly as possible.
Seek primary care for oral symptoms lasting more than three weeks.	Describe that sores in the mouth heal in about two weeks. Distinguish a sore that lasts more than two weeks as a condition that needs to be seen by a primary care provider such as a dentist.	Describe oral cancer as a very serious condition that needs to be caught early to be treated. Explain that oral cancer as a condition that can cause severe disability if not caught early.	Demonstrate skills in self-monitoring a condition that does not go away. Demonstrate skills in seeking health care for a condition that does not go away.	Express confidence in deciding to visit a health care provider for a condition that may be minor, but that does not go away or respond to treatment.	Expect that health outcomes will be better if unresolved oral problems are examined by a health care provider.	Predict that friends and family would visit a health care provider for symptoms that do not go away.
Health care providers (dentists)						

Dentists and other Primary care providers Provide full oral cancer exam at every routine visit.	Describe the steps of a complete oral cancer exam. Describe the characteristics of lesions that require biopsy. Describe diagnostic aids for oral cancer and how to use them.	Demonstrate performing a complete exam.	Express confidence in providing a complete exam. Express confidence in identifying suspicious lesions. Express confidence in recognizing when no suspicious lesions are present.	Expect that patients are interested in protecting themselves from cancer and will appreciate the exam. Expect that the exam will not disrupt patient flow. Expect that routine provision of oral cancer exams by dentists can decrease late stage diagnosis and improve patient outcomes.	Recognize that professional guidelines include full oral cancer exam at patient visits. Explain that exams are important even for patients without obvious risk factors. Describe colleagues as providing complete exams routinely.
Explain the exam to patients.	Describe the importance of routine exams so that cancer can be found early and treatment can be effective.	Demonstrate explaining the exam.	Express confidence in talking to patients about oral cancer and the exam.	Expect that providing and explaining the exam will increase patient satisfaction. Expect that explaining the exam to patients will improve public awareness.	Characterize peers as explaining the exam to patients.
Make and follow-up on referral when suspicious lesions are present.	Describe options for patients to receive examination and biopsy of suspicious lesions. Describe common reasons for patient delay in scheduling visits for confirming or ruling out cancer. Propose ways that dentists and other primary care providers can encourage follow-through with visit.	Keep referral network and procedures current.	Express confidence in guiding patients with suspicious lesions to the next step in the cancer diagnostic process.	Expect that effort put into closing the referral loop will result in better patient outcomes.	Characterize peers as closing the referral loop.

HPV, human papillomavirus.

Table 2 Example of Retaining Theoretical Perspective in Proposing Intervention Methods and Practical Applications

Change objectives grouped by theoretical determinants	Theoretical methods (Intervention *Active Ingredients*)	Ideas for practical applications and delivery to the priority populations
At-risk group- (patient-) directed intervention component		
Behavioral capability/awareness (about oral cancer, exams, symptoms, seeking care)	Images [Theories of Information Processing (58)], Discussion, Elaboration [Theories of Information Processing, Elaboration Likelihood Model (59)].	Mass media campaign with information of the importance of early detection, signs, symptoms and seeking care; one-on-one discussion with health care provider (HCP) about the role of the oral exam in early detection and cure.
Seriousness/susceptibility (regarding oral cancer, delay)	Personalized Risk [Precaution-Adoption Process Model (60)] Scenario Based Risk [Precaution-Adoption Process Model (61)], Fear Arousal [Protection Motivation Theory (62), must be used with efficacy enhancing methods]; Consciousness Raising [Trans-Theoretical Model (63)].	Mass media campaign with messages to stimulate personalized risk; One-on-one discussion with HCP about seriousness and need for diagnosis at an early disease stage.
Skills and self-efficacy (symptom monitoring, asking for an exam, obtaining follow-up care)	Verbal Persuasion, Role Modeling [Social Cognitive Theory (38)].	Mass media campaign with role model of early stage detection.
Outcome expectations (finding cancer early)	Persuasion [Communication/Persuasion Matrix (64,65)]; Elaboration [Elaboration Likelihood Model (59)].	Mass media campaign messages focusing on importance of taking action.
Social norms (seeking preventive care)	Role Modeling [Social Cognitive Theory (38)].	
Dentist/other primary care provider-directed intervention component		
Behavioral capability/awareness (oral cancer diagnosis, diagnostic tools)	Images [Theories of Information Processing (58)], Discussion, Elaboration [Theories of Information Processing, Elaboration Likelihood Model (59)], Active Learning [Social Cognitive Theory (10)].	Professional association communication such as newsletter; Academic detailing.
Skills and self-efficacy (performing oral cancer exam, identifying suspicious lesions, ruling out suspicious lesions)	Guided Practice, Verbal Persuasion, Role Modeling [Social Cognitive Theory (38)], Goal Setting [Goal Setting Theory (42)].	Academic detailing (visits with HCPs).
Outcome expectation (patient interest and concerns, patient outcomes)	Belief Selection [Theory of Planned Behavior/Theory of Reasoned Action (66); Extended Parallel Process Model (67)], Persuasion [Communication/Persuasion Matrix (64,65)]; Elaboration [Elaboration Likelihood Model (59)].	Academic detailing; Professional association communication such as letter or newsletter.
Social norms (oral cancer exams, communication)	Role Modeling [Social Cognitive Theory (38)] Information about Others' Approval [Theory of Planned Behavior/Theory of Reasoned Action (68)].	Professional association communication such as letter or newsletter.

intervention outcomes such as behavior or health status, but also the mediating variables that are hypothesized in the logic model of change to influence the behaviors. Investigators should also consider measurement of other factors in the logic model of the problem that may moderate effects such as patient or provider demographics. Understanding what factors mediated or moderated intervention effects is important for understanding how the intervention was effective or determining why it might not have worked. Failing to follow through on the measurement of the theoretical constructs that have been proposed to this point will leave the researcher with a much less interpretable evaluation.

It is preferable in terms of effort and psychometric soundness to choose measures that are already developed and validated to measure theoretical constructs (43). However, in intervention research, it is very important that the exact constructs targeted in the intervention are measured. Table 1 (above) provides an example of a blueprint for specifying the characteristics of the variables to be measured. Each column under the heading of a determinant contains concepts that merge behavior with influences on the behavior that the researcher has designated as important to change; these concepts are also important to measure. In our example, measuring the health care provider's self-efficacy (from SCT) would involve measuring confidence in performing oral cancer examinations, recognizing suspicious lesions, referring appropriately, and communicating about oral cancer.

Intervention description and evidence synthesis

The final use of theory is for the accurate and complete description of interventions – especially their active ingredients. As Borelli (this issue) suggests, knowing what represents the active ingredients in an intervention is crucial for measuring and maintaining fidelity of the methods during implementation. Over time, suggestions for what constitutes sufficient reporting of behavioral and social interventions have become increasingly comprehensive, from the starting point of describing the dose to recommending the inclusion of numerous additional components. These contributions have included publication of a new extension of CONSORT–CONSORT for Non-Pharmaceutical Interventions (http://www.consort-statement.org/index.aspx?o=1068), and commentary from members of the Cochrane Health Promotion and Public Health Field on the complexity of describing context and interventions (44,45).

Abraham and colleagues have urged journal editors to require description of behavioral change interventions that provide enough detail to enable replication (46,47). The WIDER recommendations suggest that readers and reviewers have access to the intervention developers' theoretical considerations and intentions regarding change processes. These characteristics are in addition to details about the intervention that include its recipients, deliverers, setting, mode of delivery, intervention intensity, and fidelity to implementation protocol. When full manuals of operation for interventions have been developed, as they often are for clinical psychology and alcohol and drug treatment interventions (48), they should also be widely available for review (49).

Although new reporting guidance may encourage publication of some of the information necessary for replication of interventions, more work is necessary to fully grapple with the problem of capturing the active ingredients in behavioral and social interventions. When the authors of reports of intervention trials communicate essential aspects of what they have tested more clearly, reviewers can group interventions more appropriately, committees can make more specific recommendations for practice, and practitioners can more readily assess fit of evidence-based interventions more appropriately related to mechanisms of change, and practitioners can adopt interventions that are appropriate for their needs. Researchers and especially those concerned with evidence summary, must be able to discern the aspects of an intervention that have influenced behavior change (41,46). These active ingredients are the parts of the intervention that are responsible for intervention effectiveness in evaluation trials, and the ones that can reasonably be assumed to be necessary components of a disseminated program. The central component of these active ingredients may be the theoretical change methods in the intervention.

However, as we have pointed out in the sections above, determining which elements might be essential to a program really begins earlier with the questions: what is the behavioral focus of the intervention? Are the correct behaviors of the at-risk group and environmental agents being addressed for change? Also, is the intervention focused toward the determinants of the behaviors that are the most strongly supported by theory and evidence? As noted above, any one or all of these questions can be addressed with theoretical constructs. We suggest that researchers include a full description of the ways in which they have used theory in intervention development and testing; Michie and Prestwich (20) have described a schema for this use. In order to begin to build a true science of health behavior, we suggest that researchers describe the following aspects of each intervention: a) the hypothesized determinants of the target health behavior; b) the hypothesized link between the theory-based change methods and the determinants of the target behavior; c) the practical strategies for delivering the intervention methods; d) the doses of the respective change methods that were delivered and received by participants; and e) the content of the intervention, including topics covered.

Discussion

Problems with our current attempts to integrate theory and evidence into health behavior change interventions have been pointed out by Brug, Oenema, and Ferreira (22). These researchers argue that intervention researchers may be too willing to apply a single theory, to use theories that are not well grounded in empiric research, and to use theories that are too focused on individual motivation without consideration of either social or physical environmental facilitators of or barriers to the behavior of interest. Even when researchers start with an appropriate theoretical approach and a relevant evidence base, the focus is often lost in translation to practical applications that can be delivered to the population for which they are intended.

The emphasis of funders on a theoretical framework in grant proposals is important, but may have contributed to the practice of *citing* but not really *using* theoretical constructs to guide the development of the intervention (i.e., to define the exact behaviors comprising the behavior change of interest, identify or hypothesize their determinants, and choose the theory-based methods that have demonstrable effectiveness in changing the determinants) once funds are allocated. Researchers may choose a theory to support a proposal based on its use in previous studies without much sense of what the theory will mean to the resulting intervention.

Furthermore, the focus on evidence summary and development of an evidence-base for interventions, although generally a methodological leap forward, is fraught with its own

difficulties. Changes in standards for literature reviews have reduced bias and improved reliability, and review-driven reporting guidelines for intervention trials have improved the transparency of study methods (50,51). And although these developments have eased some of the challenges of ambiguous and missing reporting, at the same time, they have highlighted the importance of appropriately describing theory-based interventions (46,47,52). Whether or not theory was used adequately in the processes of intervention development and testing, many reports of behavior change trials contain incomplete descriptions of theory-based interventions and some do little more than mention a theory or model (20). Such descriptions tend to focus on more superficial aspects of the intervention, e.g., the delivery strategy, leaving readers with little to go on when making decisions about adoption or categorizing the intervention when summing up the intervention literature. When authors do try to explain their use of theory, they may conflate the theoretical methods used in an intervention, with the focus on determinants of behavior, and with the type of delivery mechanism or communication channel used (20,46,47,52-55). Work to develop and test theory-driven interventions should always include appropriate reporting of the use of theory, the mechanism of change, the intervention characteristics, and the measurement of fidelity to the design of the program and the implementation protocol.

Conclusion

Theory is widely recommended as a *sine quo non* of intervention development for health behavior change, and logic models are *de rigueur* in many governmental and non-profit agencies (18,56). Many researchers, however, have not begun the intervention development process by assessing determinants of the problem and developing a logic model of the problem, or even by developing a clear logic model of change. Furthermore, even when logic models of the problem and of change are well-articulated, many interventions do not include components that follow from these. Rather, intervention developers may have jumped to choosing communication strategies in terms of their reach and appeal to the intended audience alone rather than asking what methods might succeed in changing determinants and what parameters they should seek to meet when using those methods. For example, research suggests that role models are often effective in demonstrating behavior change and improving self-efficacy. However, to do so, they must be credible to the viewer, garners attention, demonstrates the behavior with a coping rather than mastery orientation, and be reinforced for the behavior (10). However, interventions often fail to use evidence-based methods, such as role models, and even when models are included they may fail to

meet even the most basic requirements for effective use (57).

Dental health researchers who understand the five roles for theory that we have described in this paper, and who recognize that several theories and theoretical constructs may need to be drawn on to fill different roles, stand to reap several benefits: Their understanding of the health and behavior problem they are trying to change should deepen. Importantly, their change model should be better informed and clearer. Their selection of change methods should be more successful. Their evaluations should capture the hypothesized causal chains more fully. Finally, their findings, positive or negative, should make a more complete contribution to the stock of knowledge about how to bringing about better oral health.

Strengths and limitations

This paper presents a limited introduction to how to use theory in intervention development, testing, and reporting. It may serve as a guide for what needs to be done, but researchers who are not experts in behavioral science will inevitably need more resources. Furthermore, this paper is a practical description and does not directly address how to test the relative effectiveness of various theories or constructs (14). Nevertheless, the paper does suggest ways in which tight use of theory can move the science of behavior change by adding information about what constructs mediate intervention effects, and by removing from the literature misleading reports of theory-based methods in interventions. Helping researchers make sure that the theoretical constructs they reference are actually used all the way through the intervention development and description process will improve evidence summaries and thereby advance the field's understanding of which behavior change interventions are effective.

Conflict of interest

LKB received an honorarium or consulting fee from NDCFI. PDM declares no conflict of interest.

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