Published in final edited form as:

Prev Med. 2008 March ; 46(3): 181–188.

Multiple Health Behavior Change Research: An Introduction and Overview

Judith J. Prochaska, PhD, MPH, Bonnie Spring, PhD, and Claudio R. Nigg, PhD

JJ Prochaska, a founding chair of the Society of Behavioral Medicine's (SBM) Special Interest Group on Multiple Health Behavior Change (MHBC), is in the Department of Psychiatry at the University of California, San Francisco. B Spring, a former co-chair of the SBM Special Interest Group on MHBC and current SBM President, is in the Departments of Preventive Medicine, Psychology, and Psychiatry at Northwestern University. CR Nigg is co-chair of the SBM Special Interest Group on MHBC and is in the Department of Public Health Sciences at the University of Hawaii at Manoa

Abstract

In 2002, the Society of Behavioral Medicine's special interest group on Multiple Health Behavior Change was formed. The group focuses on the interrelationships among health behaviors and interventions designed to promote change in more than one health behavior at a time. Growing evidence suggests the potential for multiple-behavior interventions to have a greater impact on public health than single-behavior interventions. However, there exists surprisingly little understanding of some very basic principles concerning multiple health behavior change (MHBC) research. This paper presents the rationale and need for MHBC research and interventions, briefly reviews the research base, and identifies core conceptual and methodological issues unique to this growing area. The prospects of MHBC for the health of individuals and populations are considerable.

Keywords

multiple health behavior change; methodology; interventions; review

Overview

In 2002, the Society of Behavioral Medicine formed a special interest group (SIG) to contribute to the development of a science of multiple health behavior change (MHBC) for health promotion and disease management. This multidisciplinary group of researchers and practitioners focuses on the interrelationships among health behaviors and interventions designed to promote change in more than one health behavior at a time. Recognizing that intervention on multiple behaviors presents a unique set of challenges, the group addresses theoretical, methodologic, intervention, statistical, and funding issues and fosters networking, mentorship, career development, and scientific discussion among its members.

Corresponding Author: Judith J. Prochaska, PhD, MPH, University of California, San Francisco, 401 Parnassus Ave – TRC 0984, San Francisco, CA 94143-0984. Ph: (415) 476-7695. Fax: (415) 476-7719. Email: JProchaska@ucsf.edu.

Précis

This paper presents the rationale and need for multiple health behavior change research, briefly reviews the research base, and identifies core conceptual and methodological issues unique to this growing area.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

In March 2006, the SIG held a pre-conference event entitled *Increasing the Impact of Behavioral Medicine on Physical and Mental Health*. The pre-conference showcased innovative research programs on MHBC interventions and demonstrated how new paradigms of research and practice can complement traditional paradigms to produce greater impacts on physical and mental health. Following the pre-conference, SIG members sought to create a special journal issue dedicated to this growing area of research. The SIG members served as contributors, guest editors, and peer reviewers.

This special issue of *Preventive Medicine* is dedicated to research focused on efforts to study and treat multiple health behaviors. The collection of papers reflects the current state of the science on core topics in multiple health behavior change (MHBC) research. As an introduction to this special issue, we cover the rationale and need for MHBC research, offer key definitions for the field, and provide a broad overview of the research conducted to date. Core conceptual and methodological issues unique to MHBC research also are presented.

Rationale for MHBC Research

The major causes of morbidity and premature mortality in the United States – heart disease, cancer, and stroke – are influenced by multiple health risk behaviors, including smoking, alcohol abuse, physical inactivity, and poor diet. The 52-nation INTERHEART study identified tobacco use, obesity, lipids, and psychosocial factors as accounting for about 90% of the population-attributable risks for myocardial infarction. (Lanas, et al., 2007, Yusuf, et al., 2004). Fruit and vegetable consumption and exercise were identified as protective. Mental illness, as well as stress and distress more broadly, also place a significant burden on health and productivity in the US and globally (USDHHS, 1999).

When the major multiple health protective behaviors are studied, few individuals meet criteria for a healthy lifestyle. In the US, only 3% of adults meet all four health behavior goals of being a nonsmoker, having a healthy weight, being physically active, and eating 5 or more fruits and vegetables a day (Reeves & Rafferty, 2005). Similarly, among German college students, only 2% were physically active, nonsmokers, with adequate consumption of fruits and vegetables, and healthy levels of alcohol consumption (Keller, et al. (2008, this issue)).

In fact, multiple unhealthy behaviors often co-occur. In the US, a majority of adults meet criteria for two or more risk behaviors (Fine, et al., 2004, Pronk, et al., 2004). Tobacco users, in particular, tend to have poor behavioral profiles: about 92% of smokers exhibit at least one additional risk behavior (Fine, et al., 2004, Klesges, et al., 1990, Pronk, et al., 2004). Overweight women also appear to be a particularly high risk group. Sanchez and colleagues (2008, this issue) report that 9 out of 10 overweight women in their sample had at least two eating or activity risk behaviors. De Vries and colleagues (2008, this issue) further demonstrate that the clustering of lifestyle behaviors replicates across different educational levels.

Among youth there is evidence of a clustering of healthy dietary patterns and physical activity (Sallis, et al., 2000). Conversely, tobacco use increases the likelihood of experimentation with illicit drug use (Lai, et al., 2000). Also, tobacco and other substance use are highly predictive of youth engagement in multiple risk behaviors including bicycling without a helmet, violence and weapon carrying, not using a seatbelt, and suicidal ideation (DuRant, et al., 1999). In Driskell and colleagues' (2008, this issue) analysis of behavioral risk clustering among students in grades 4 through 12, the likelihood of having multiple risks increased with age.

An increasing number of risk factors multiplies healthcare burden in terms of both medical consequences and costs (Edington, et al., 1997). Effectively treating two behaviors reduces medical costs by about \$2000 per year (Edington, 2001). Consequently, targeting change in

multiple risk behaviors offers the potential of increased health benefits, maximized health promotion, and reduced health care costs.

Success in changing one or more lifestyle behaviors also may increase confidence or self-efficacy to improve risk behaviors that individuals have low motivation to change. As such, health behavior change may serve as a gateway to overall healthful lifestyle change. Unger (1996) observed that adults in the later stages of change for smoking cessation had more healthful levels of alcohol use and exercised more than subjects in the earlier stages of change, suggesting that people changing on their own may have made improvements in several health behaviors concurrently. A recent 7-year prospective observational study with 750 Japanese men found that increased habitual exercise was associated with smoking cessation; conversely, smoking relapse was associated with decreased habitual exercise (Nagaya, et al., 2007). To the extent that the change process for different health behaviors is similar, it might be efficient to intervene on multiple behaviors at the same time. Conversely, Dutton and colleagues (2008, this issue), in their analysis of a physical activity intervention's impact on dietary quality showed no effect on fruits and vegetables or dietary fat intake, suggesting targeting a single behavior for change will not necessarily translate into healthy changes in a second untargeted behavior.

Given limited contact opportunities for health promotion, it would be ideal if interventions could simultaneously improve multiple risk behaviors relevant to an individual's health profile. Inevitably, interventions targeted at single risk behaviors, even if effective, will be limited in their impact (Hayes, et al., 1999). Drawing from successful approaches in industries such as telecommunications and insurance, the concept of "bundling" of services recently has been applied to multiple health behavior change efforts (Ickovics (2008, this issue)). The idea is to package complimentary and reasonably low cost services (e.g., HIV prevention) into organizations with clinical capacity (e.g., prenatal care) to maximize reach and cost-effectiveness. Greater attention to the science of multibehavioral change is needed to capitalize on windows of opportunity to address the health risks of individuals and populations.

MHBC Definitions

MHBC interventions can be defined as efforts to promote two or more health behaviors. By health behaviors, we mean actions in which individuals engage that influence health. The impact can be negative, as with tobacco and other drug use and risky sexual behaviors, or positive, as with physical activity, fruit and vegetable consumption, and the wearing of helmets or seatbelts. Engaging in medical screening, such as mammography, colonoscopy, cholesterol testing, blood pressure screening, HIV tests, and glucose screening also clearly represents a set of positive health behaviors and thus a relevant behavioral target for MHBC interventions.

The field of MHBC research is young and its boundaries are still being defined. Historically, much MHBC research focused on promoting multiple healthful behaviors within populations. Fewer studies have targeted multiple risks within individuals, and the distinction is meaningful (see Table 1). The main difference between MHBC interventions at the population versus the individual level is that the former targets an entire community or population and matches the intervention strategies to the modal needs of the participants within the community (i.e., not all participants in the community receive intervention on all behaviors). The latter usually focuses on a more select high-risk group of individuals or patients and targets multiple behaviors with all participants.

MHBC Intervention Research

Studies of MHBC Interventions in Populations

The idea of intervening on multiple risk behaviors concurrently became a focus of attention in the early 1970s as a means of preventing cardiovascular disease (CVD) (Labarthe, 1998). One early proposal was a factorial design to evaluate the independent and joint contributions of intervention on diet, physical activity, and smoking habits in a single trial named “Jumbo.” The proposal was deemed too costly, however, and the trial was never conducted. Large-scale multifactorial CVD risk factor interventions that were conducted include the Multiple Risk Factor Intervention Trial (Multiple Risk Factor Intervention Trial Research Group, 1990), the North Karelia Project (Puska, et al., 1985), the Stanford Three-City and Five-City Projects (Farquhar, et al., 1990), and the Pawtucket (Elder, et al., 1986) and Minnesota (Luepker, et al., 1994) Heart Health Programs. Youth multifactor interventions also were developed, with a movement toward comprehensive school health programs.

With the exception of the North Karelia Project (Puska et al, 1985), the multibehavioral studies conducted over the past 30 years have had disappointing (largely null) outcomes. The interventions have focused almost entirely on practitioner-based modalities such as health advice and/or counseling from a physician, dietician, or nurse; home visits; and group health education. Community-level promotional materials (e.g., public service announcements; billboards) also have been incorporated. Sometimes significant changes were seen on a few, but not all, targeted behaviors (Emmons, et al., 1994, Sorensen, et al., 1996). A Cochrane review of these large multifactor interventions estimated the net reduction in smoking prevalence at 20% (Ebrahim, et al., 2006). Changes in dietary and physical activity behaviors, unfortunately, were not reported in the review. The pooled effects suggested that the MHBC interventions had no effect on mortality.

Findings from 14 youth obesity prevention studies that intervened upon physical activity and dietary change were summarized in another Cochrane review (Summerbell, et al., 2005). The studies were conducted in schools and communities, with children and adolescents, in the US and Europe, representing a diversity of ethnic groups and socioeconomic levels. Most studies followed a social learning or environmental theoretical framework. Only 1 of the 14 studies achieved significant changes in both dietary and physical activity behaviors, with the finding significant only for girls and not for boys (Gortmaker, et al., 1999). This same study was the only one to report significant reductions in youth body mass index; again, however, the finding was specific to girls. A recent Dutch, school-based, obesity prevention trial used individual and environmental intervention components (Singh, et al., 2007). The intervention yielded significant reductions in waist-to-hip ratio for girls and boys and in the sum of skin fold measurements for girls. Changes in body mass index and fitness, however, were not statistically significant, and changes in physical activity and dietary behaviors were not reported.

Recent Successes in Population-based MHBC Interventions

Although many attempts at achieving population-wide change in multiple risk behaviors have met with limited success, recent results have been more positive.

Three parallel, population-based MHBC studies targeting smoking, high fat diet, and high-risk sun exposure were conducted with employees in worksites, parents of high school students, and patients in primary care (J. O. Prochaska, et al., 2004, J. O. Prochaska, et al., 2005, Velicer, et al., 2004). Combined, the studies included nearly 10,000 participants. The interventions used computerized expert system interventions delivering tailored individualized feedback based on participants’ stage of change and responses to measures of self-efficacy, pros and cons, and processes of change. In all three studies, across all three behaviors, treatment effects were

significant at 12 and 24 months follow up, with the exception of smoking in the worksite study, which had a relatively small number of smokers. Importantly, the smoking cessation effects obtained in these MHBC studies were comparable to previously reported intervention effects for the stage-based expert system when focused on smoking alone (J. J. Prochaska, et al., 2006). Further, among smokers in the three trials, treatment of one or two coexisting risk factors (diet and/or sun exposure) did not decrease the effectiveness of smoking cessation treatment, and treatment for the co-existing factors was effective as well. A fourth population-based, stage-based, expert system intervention targeting individuals with high cholesterol reported significant effects on lipid medication adherence, physical activity, and dietary fat reduction (Johnson, et al., 2006). A fifth population-based trial, targeting weight management, smoking, stress, and inactivity demonstrated significant effects at 6-months follow-up for a repeated stage-based expert system intervention or three motivational interviewing counseling sessions relative to a health risk assessment with brief feedback condition (J. O. Prochaska, et al. (2008, this issue)).

Social cognitive theory, which focuses on the interaction of personal factors, behavior, and the environment, also has been applied to multiple risk behaviors with some success. PREVENT, a telephone-delivered intervention plus tailored materials, based on motivation to change and social cognitive theory, targeted six behavioral risks for colon cancer (Emmons, et al., 2005). Participants were 1,247 adults with recent diagnosis of adenomatous colorectal polyps. Intervention participants were more likely to change two or more risk behaviors relative to the standard care condition. For the individual behaviors, intervention effects were significant for improved multivitamin intake and red meat consumption, with less decline in physical activity levels over the course of the study. There were no between-condition differences in smoking, alcohol, or fruit and vegetable consumption.

The Mediterranean Lifestyle Program, based on social learning theory, targeted healthful eating, physical activity, stress management, smoking cessation, and social support with postmenopausal women with type 2 diabetes (Toobert, et al., 2007). At 12- and 24-months, intervention participants demonstrated improvements in all targeted lifestyle behaviors except smoking because there were too few smokers to analyze tobacco use effects. Additionally, significant treatment effects were seen in psychosocial measures of use of supportive resources, problem solving, self-efficacy, and quality of life.

Studies of MHBC Interventions in Individuals

Few studies have directly evaluated the effectiveness of multifactor versus single factor interventions within individuals, and findings have been inconsistent. A recent review of MHBC interventions in primary care identified large gaps in the field's knowledge base (Goldstein, et al., 2004). The review emphasized the successes of interventions targeted on singular risks, such as tobacco, alcohol use, dietary interventions, and to a lesser extent, physical activity, but acknowledged the dearth of studies in primary care aimed to treat multiple risks.

The strongest evidence for MHBC interventions in individuals has aimed at secondary rather than primary prevention, specifically interventions focused on individuals at high-risk for or already diagnosed with CVD (Ketola, et al., 2002) or diabetes (Diabetes Prevention Program Research Group, 2002, Norris, et al., 2001). These interventions have targeted tobacco use, physical activity, and diet as well as more specific disease management care, for example, adherence to lipid lowering drugs and hypertension medications for CVD and blood glucose monitoring and foot exams for diabetes. Even in these studies, while the evidence generally has been strong for short-term effects, sustained effects have been difficult to achieve.

A notable exception is the Lifestyle Heart Trial for patients with moderate to severe CVD. The intensive intervention promotes a 10% fat, whole foods, vegetarian diet; aerobic exercise; stress management; smoking cessation; and group psychosocial support. In a small efficacy trial (N=48), program adherence was reported as excellent and significant intervention effects were seen at 1 and 5 years for reductions in weight and LDL cholesterol, as well as reduction in arterial diameter stenosis and cardiac events (Ornish, et al., 1998).

Johnson and colleagues (2008, this issue) report on the success of an expert system intervention for overweight women that targeted physical activity, healthy eating, and emotional distress. The intervention resulted in significant changes on all targeted behaviors and reduction in weight at 24 months relative to the standard care control group.

Individuals with drug and alcohol problems are another high-risk group of interest for multibehavioral change. In particular, rates of tobacco use are high, and tobacco is a primary cause of death among individuals treated for substance abuse (Hser, et al., 1994, Hurt, et al., 1996). Concerns about potential compromised sobriety, however, have limited access to tobacco cessation treatments in practice. A recent meta-analysis examined smoking cessation interventions delivered to individuals in substance abuse treatment (J. J. Prochaska, et al., 2004). The 12 randomized trials were built on a variety of theoretical frameworks including stage-based or motivational enhancement, cognitive behavioral, relapse prevention, and pharmacological treatments. Smoking cessation effects were significant at post-treatment, but not sustained at long-term follow up. Importantly, exposure to the smoking cessation interventions was associated with a 25% increased likelihood of long-term abstinence from alcohol and illicit drugs. The study concluded that, contrary to previous concerns, smoking cessation interventions delivered during addictions treatment appeared to enhance rather than compromise long-term sobriety.

Although weight gain is a common side effect and potential deterrent to quitting smoking, efforts to integrate dietary restraint components within tobacco treatment interventions have raised concerns about potential deleterious effects on quitting smoking (S. M. Hall, et al., 1992). Clinical tobacco treatment guidelines even discourage weight control efforts through dieting so as not to detract from motivations to quit smoking (Fiore & Staff, 2000). As with tobacco cessation among substance users, the concern is with multiple intervention interference – that change in one behavior may negatively impact change in another. When there is concern about multiple intervention interference, a sequential treatment approach may be undertaken. A recent study evaluated a dietary intervention implemented early in the quit attempt versus after cessation relative to a no-diet control group (Spring, et al., 2004). The study reported no difference in smoking cessation rates among the three groups with some advantage in weight gain prevention among participants in the delayed diet group. Similarly, a recent study evaluating immediate versus delayed smoking cessation among veterans in substance abuse treatment reported comparable quit smoking rates with some apparent benefit to sobriety among participants treated for tobacco in the delayed treatment group (Joseph, et al., 2004).

In contrast, the study by Vandelanotte and colleagues (2008, this issue) found no effect of study design when examining a sequential versus concurrent expert system intervention for physical activity and dietary fat intake. Another study, targeting exercise, dietary sodium intake, and tobacco use using a stage-based approach concluded that sequential was not superior to, and may be inferior to, a simultaneous approach (Hyman, et al., 2007). The theoretical model employed and the types of behaviors targeted certainly may influence the efficacy of a simultaneous versus a sequential approach. More research is needed to address this key intervention design issue.

Health behaviors also may be used as a treatment strategy. For example, the effect of exercise for supporting smoking cessation has been tested. A Cochrane review concluded, however, that while exercise promotion did not appear to harm smoking cessation efforts, there was limited evidence that it helped (Ussher, 2005). Only one of the 11 identified trials (Marcus, et al., 1999) found evidence for exercise aiding smoking cessation at long term follow-up. Unfortunately, only two of the studies reported changes in physical activity, limiting our understanding of the feasibility of smokers making changes in their tobacco use and exercise patterns concurrently. Of note, the one study that had significant effects for both quitting smoking and increasing fitness matched exercise and smoking cessation strategies to participants' readiness to quit, rather than prescribing immediate action (Marcus, et al., 1999).

Co-occurring mental illness often is an exclusionary criterion for clinical trials and, as a result, the field knows very little about intervening on multiple risks with these populations. Two recent studies evaluated tobacco treatments among smokers with current mental illness – one focused on clinically depressed smokers (S. M. Hall, et al., 2006) and the other on veterans with post-traumatic stress disorder (McFall, et al., 2006). Both reported significant intervention effects for long-term smoking cessation with no adverse effects on mental health functioning (J. J. Prochaska, et al. (2008, J. J. Prochaska, et al. (in press)). The study with veterans demonstrated the value of integrating tobacco treatment within mental health services rather than referring out to a separate system of care. Studies examining exercise as a treatment for clinical depression have reported significant changes in physical activity with significant reductions in depressive symptoms (Blumenthal, et al., 1999, Dunn, et al., 2005). Exercise's immediate effects in treating depression were comparable to those of antidepressant medication, with a significantly lower likelihood of depression relapse over time (Babyak, et al., 2000). As a self-help strategy, individuals with clinical depression rank exercise among the most commonly tried and effective for managing depression (Parker, et al., 2007).

Methodological Issues

Methodological challenges with multibehavioral interventions include design considerations, participant burden, and lack of agreement on how best to conceptualize and analyze multiple risk behavior change.

Design Issues

When and how to address multiple health behaviors is a key consideration for MHBC research. For example, as mentioned in the review above, are the behaviors targeted concurrently or consecutively? If consecutively, how is the order determined – by the investigator? by the participant? Is selection determined by severity of risk, participants' readiness to change, or some other factor? Does the intervention promote immediate behavior change or match intervention strategies to participants' readiness to change each respective behavior? More research is needed to evaluate optimal design approaches for different risk factor combinations. Allegrante and colleagues (2008, this issue) examined predictors of participant choice in selecting risk behaviors to change. DePue and colleagues (2008, this issue) examined physician and patient predictors of preventive counseling on multiple cancer risk behaviors. They reported low rates of provider assistance and arranging of follow-up for the risk behaviors, though more thorough behavior counseling was associated with greater patient satisfaction with care.

Measuring Changes in Multiple Risk Behaviors

To minimize participant burden, investigators are attempting to simplify assessment tools, while maintaining rigorous psychometrics, and moving towards more technologically

sophisticated, and hopefully more objective, assessment tools that ideally place less burden on participants for data collection. Health risk appraisals are one option for quickly assessing engagement in a wide range of risk behaviors (Smith, et al., 1989). More objective behavioral measures include biologic measures of dietary changes (e.g., plasma carotenoid concentrations), tobacco (e.g., cotinine, anabasine), and metabolites of other drug use; objective measures of physical activity (pedometers, accelerometers) and fitness (VO₂max); and computer devices to assess medication adherence (e.g., MEMScaps). All measures, of course, have their limitations. With biomarkers, a metabolite's half-life may be too short to detect sustained behavioral changes, research costs can be high, and participants may not adhere to assessment protocols.

Rather than measuring changes separately for each targeted behavior, alternative approaches are to conceptualize and assess change on a composite measure of healthy lifestyle behaviors or on health outcomes. Health outcome measurement might include changes in weight, blood pressure, cholesterol, or blood glucose due to changes in diet, exercise, and/or tobacco use. Overarching self-report measures of change may include health-related quality of life (Rasanen, et al., 2006). The Mediterranean Life Program, for example, reported changes in behavioral, psychological, and quality of life measures (Toobert, et al., 2007). Economic measures may include medical, pharmaceutical, and disability costs. If MHBC interventions ultimately aim toward positive health systems change, then economic outcomes, including medical, pharmaceutical, and disability costs are also relevant and should be assessed. Longer follow up periods, however, will likely be necessary to detect changes in those more distal outcomes.

Analyzing Changes in Multiple Risk Behaviors

Use of overarching, integrative measures also would serve to simplify analysis of outcomes in MHBC interventions. Historically, MHBC interventions have included separate measures for each risk behavior targeted, sometimes incorporating multiple measures for each behavior. The consequence is multiple significance testing with the potential for inflating the type I error rate as well as confusion in describing inconsistent findings across the different outcomes. J. J. Prochaska and colleagues (2008, this issue) present five analytic strategies for reporting changes in multiple risks in MHBC trials with examples using actual study data. Approaches include MHBC behavioral indices, standardized statistical behavior change score indices, and an impact factor expanded to account for targeting of multiple risks. Progress towards a consensus on measurement would greatly benefit the field.

Theory Testing Across Behaviors

Theories of behavior and behavior change have been applied across a wide variety of risk factors, demonstrating that the same skills and strategies can be applied to multiple behaviors. A model of lifestyle behavior change has suggested that with behaviors that co-occur (e.g., alcohol abuse and smoking) change in one may support change in the other (Wankel, et al., Bouchard RJS, & T. Stephens 1994). At this time, however, no theory of behavior change directly addresses the issue of how to intervene on more than one behavior simultaneously. Noar and colleagues (2008, this issue) consider applications of health behavior theory to multiple risk behavior change, and K.L. Hall and colleagues' (2008, this issue) quantitative analysis demonstrates consistency in key decision-making principals to over 100 target behaviors

The National Institutes of Health, the American Heart Association, and the Robert Wood Johnson Foundation jointly funded a Behavior Change Consortium (BCC) focused on multiple risk behavior change. The BCC studies include assessment of the utility of different theoretical

models for changing two or more health risk behaviors (Nigg, et al., 2002). The field looks forward to the findings from these theory-comparison and MHBC research studies.

Conclusions

MHBC research is steadily increasing in sophistication, relevance, and impact. The editorial by J. O. Prochaska (2008, this issue) identifies future research needs and provides a vision of the developing MHBC field research. The prospects for the health of the individuals and populations we serve are considerable.

Acknowledgements

This work was supported by the National Institute on Drug Abuse (#K23 DA018691), the State of California Tobacco-Related Disease Research Program (#13KT-0152), the National Cancer Institute (#R01 CA109941), and the Hawaii Medical Service Association, an Independent Licensee of the Blue Cross and Blue Shield Association. The authors have no financial interests related to the material in the manuscript. We thank Andrea Kozak, PhD, James Prochaska, PhD, Wayne Velicer, PhD, and Ken Wallston, PhD for their comments on earlier drafts of the manuscript.

References

- Allegrente JP, Peterson JC, Boutin-Foster C, Ogedegbe G, Charlson ME. Multiple health-risk behavior in a chronic disease population: What behaviors do people choose to change? *Prev Med* 2008;XX:xxx-xxx.
- Babyak M, Blumenthal JA, Herman S, Khatri P, Doraiswamy M, Moore K, Craighead WE, Baldewicz TT, Krishnan KR. Exercise treatment for major depression: maintenance of therapeutic benefit at 10 months. *Psychosom Med* 2000;62:633-638. [PubMed: 11020092]
- Blumenthal JA, Babyak MA, Moore KA, Craighead WE, Herman S, Khatri P, Waugh R, Napolitano MA, Forman LM, Appelbaum M, Doraiswamy PM, Krishnan KR. Effects of exercise training on older patients with major depression. *Arch Intern Med* 1999;159:2349-2356. [PubMed: 10547175]
- de Vries H, van't Riet J, Spigt M, Metsemakers J, van den Akker M, Vermunt JK, Kremers S. Clusters of lifestyle behaviors: Results from the Dutch SMILE study. *Prev Med* 2008;XX:xxx-xxx.
- DePue JD, Goldstein MG, Redding C, Velicer WF, Sun X, Fava JL, Kazura A, Rakowski W. Cancer prevention in primary care: predictors of patient counseling for four risk behaviors over 24 months. *Prev Med* 2008;XX:xxx-xxx.
- Diabetes Prevention Program Research Group. Reduction in the incidence of type 2 diabetes with lifestyle intervention or Metformin. *N Engl J Med* 2002;346:393-403. [PubMed: 11832527]
- Driskell M-M, Dymont S, Mauriello L, Castle P, Sherman K. Relationships among multiple behaviors for childhood and adolescent obesity prevention. *Prev Med* 2008;XX:xxx-xxx.
- Dunn AL, Trivedi MH, Kampert JB, Clark CG, Chambliss HO. Exercise treatment for depression: efficacy and dose response. *Am J Prev Med* 2005;28:1-8. [PubMed: 15626549]
- DuRant RH, Smith JA, Kreiter SR, Krowchuk DP. The relationship between early age of onset of initial substance use and engaging in multiple health risk behaviors among young adolescents. *Arch Pediatr Adolesc Med* 1999;153:286-291. [PubMed: 10086407]
- Dutton G, Napolitano MA, Whiteley JA, Macus BH. Is physical activity a gateway behavior for diet? Findings from a physical activity trial. *Prev Med* 2008;XX:xxx-xxx.
- Ebrahim S, Beswick A, Burke M, Davey Smith G. Multiple risk factor interventions for primary prevention of coronary heart disease. *Cochrane Database of Systematic Reviews* 2006:CD001561.
- Edington DW, Yen LT, Witting P. The financial impact of changes in personal health practices. *J Occup Environ Med* 1997;39:1037-1046. [PubMed: 9383715]
- Edington DW. Emerging research: a view from one research center. *Am Jour Health Promot* 2001;15:341-349. [PubMed: 11502015]
- Elder JP, McGraw SA, Abrams DB, Ferreira A, Lasater TM, Longpre H, Peterson GS, Schwertfeger R, Carleton RA. Organizational and community approaches to community-wide prevention of heart disease: the first two years of the Pawtucket Heart Health Program. *Prev Med* 1986;15:107-117. [PubMed: 3714665]

- Emmons KM, Marcus BH, Linnan L, Rossi JS, Abrams DB. Mechanisms in multiple risk factor interventions: smoking, physical activity, and dietary fat intake among manufacturing workers. Working Well Research Group. *Prev Med* 1994;23:481–489. [PubMed: 7971876]
- Emmons KM, McBride CM, Puleo E, Pollak KI, Clipp E, Kuntz K, Marcus BH, Napolitano M, Onken J, Farraye F, Fletcher R. Project PREVENT: a randomized trial to reduce multiple behavioral risk factors for colon cancer. *Cancer Epidemiol Biomarkers Prev* 2005;14:1453–1459. [PubMed: 15941955]
- Farquhar JW, Fortmann SP, Flora JA, Taylor CB, Haskell WL, Williams PT, Maccoby N, Wood PD. Effects of communitywide education on cardiovascular disease risk factors. The Stanford Five-City Project. *JAMA* 1990;264:359–365. [PubMed: 2362332]
- Fine LJ, Philogene GS, Gramling R, Coups EJ, Sinha S. Prevalence of multiple chronic disease risk factors. 2001 National Health Interview Survey. *Am J Prev Med* 2004;27:18–24. [PubMed: 15275670]
- Fiore MC. Staff TUaDCPGUPa. A clinical practice guideline for treating tobacco use and dependence: A US public health service report. *JAMA* 2000;283
- Goldstein MG, Whitlock EP, DePue J. Multiple behavioral risk factor interventions in primary care. Summary of research evidence. *Am J Prev Med* 2004;27:61–79. [PubMed: 15275675]
- Gortmaker SL, Peterson K, Wiecha J, Sobol AM, Dixit S, Fox MK, Laird N. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. *Arch Pediatr Adolesc Med* 1999;153:409–418. [PubMed: 10201726]
- Hall KL, Rossi JS. Meta-analytic examination of the strong and weak principles across 48 health behaviors. *Prev Med* 2008;XX:xxx–xxx.
- Hall SM, Tunstall CD, Vila KL, Duffy J. Weight gain prevention and smoking cessation: cautionary findings. *Am J Public Health* 1992;82:799–803. [PubMed: 1585959]
- Hall SM, Tsoh JY, Prochaska JJ, Eisendrath S, Rossi JS, Redding CA, Rosen AB, Meisner M, Humfleet GL, Gorecki JA. Treatment for cigarette smoking among depressed mental health outpatients: a randomized clinical trial. *Am J Public Health* 2006;96:1808–1814. [PubMed: 17008577]
- Hayes, SC.; Barlow, DH.; Nelson-Gray, RO. The scientist practitioner: research and accountability in the age of managed care. 2. Boston: Allyn & Bacon; 1999. Pages
- Hser YI, McCarthy WJ, Anglin MD. Tobacco use as a distal predictor of mortality among long-term narcotics addicts. *Prev Med* 1994;23:61–69. [PubMed: 8016035]
- Hurt RD, Offord KP, Croghan IT, Gomez-Dahl L, Kottke TE, Morse RM, Melton LJ 3rd. Mortality following inpatient addictions treatment. Role of tobacco use in a community-based cohort. *JAMA* 1996;275:1097–1103. [PubMed: 8601929]
- Hyman DJ, Pavlik VN, Taylor WC, Goodrick GK, Moye L. Simultaneous vs sequential counseling for multiple behavior change. *Archives of Internal Medicine* 2007;167:1152–1158. [PubMed: 17563023]
- Ilckovics JR. “Bundling” HIV prevention: integrating services to promote synergistic gain. *Prev Med* 2008;XX:xxx–xxx.
- Johnson SS, Driskell MM, Johnson JL, Dymant SJ, Prochaska JO, Prochaska JM, Bourne L. Transtheoretical model intervention for adherence to lipid-lowering drugs. *Dis Manag* 2006;9:102–114. [PubMed: 16620196]
- Johnson SS, Paiva AL, Cummins CO, Johnson JL, Dymant SJ, Wright JA, Prochaska JO, Prochaska JM, Sherman K. Transtheoretical Model-based multiple behavior intervention for weight management: Effectiveness on a population basis. *Prev Med* 2008;XX:xxx–xxx.
- Joseph AM, Willenbring ML, Nugent SM, Nelson DB. A randomized trial of concurrent versus delayed smoking intervention for patients in alcohol dependence treatment. *J Stud Alcohol* 2004;65:681–691. [PubMed: 15700504]
- Keller S, Maddock JE, Hannover W, Thyrian JR, Basler H-D. Multiple health risk behaviors in German first-year university students. *Prev Med* 2008;XX:xxx–xxx.
- Ketola E, Sipila R, Makela M. Effectiveness of individual lifestyle interventions in reducing cardiovascular disease and risk factors. *Ann Med* 2002;32:239–251. [PubMed: 10852140]
- Klesges RC, Eck LH, Isbell TR, Fulliton W, Hanson CL. Smoking status: effects on the dietary intake, physical activity, and body fat of adult men. *Am J Clin Nutr* 1990;51:784–789. [PubMed: 2333836]

- Labarthe, DR. Epidemiology and Prevention of Cardiovascular Disease: A Global Challenge. Gaithersburg, MD: Aspen Publishers, Inc., Pages; 1998.
- Lai S, Lai H, Page JB, McCoy CB. The association between cigarette smoking and drug abuse in the United States. *J Addict Dis* 2000;19:11–24. [PubMed: 11110061]
- Lanas F, Avezum A, Bautista LE, Diaz R, Luna M, Islam S, Yusuf S. Risk factors for acute myocardial infarction in Latin America: the INTERHEART Latin American study. *Circulation* 2007;115:1067–1074. [PubMed: 17339564]
- Luepker RV, Murray DM, Jacobs DR Jr, Mittelman MB, Bracht N, Carlaw R, Crow R, Elmer P, Finnegan J, Folsom AR, et al. Community education for cardiovascular disease prevention: risk factor changes in the Minnesota Heart Health Program. *Am J Public Health* 1994;84:1383–1393. [PubMed: 8092360]
- Marcus BH, Albrecht AE, King TK, Parisi AF, Pinto BM, Roberts M, Niaura RS, Abrams DB. The efficacy of exercise as an aid for smoking cessation in women: a randomized controlled trial. *Arch Intern Med* 1999;159:1229–1234. [PubMed: 10371231]
- McFall M, Atkins DC, Yoshimoto D, Thompson CE, Kanter E, Malte CA, Saxon AJ. Integrating tobacco cessation treatment into mental health care for patients with posttraumatic stress disorder. *Am J Addict* 2006;15:336–344. [PubMed: 16966189]
- Multiple Risk Factor Intervention Trial Research Group. Mortality rates after 10.5 years for participants in the multiple risk factor intervention trial. Findings related to a priori hypotheses of the trial. *Journal of the American Medical Association* 1990;263:1795–1801. [PubMed: 2179590]
- Nagaya T, Yoshida H, Takahashi H, Kawai M. Cigarette smoking weakens exercise habits in healthy men. *Nicotine Tob Res* 2007;9:1027–1032. [PubMed: 17943618]
- Nigg CR, Allegrante JP, Ory M. Theory-comparison and multiple-behavior research: common themes advancing health behavior research. *Health Educ Res* 2002;17:670–679. [PubMed: 12408211]
- Noar SM, Chabot M, Zimmerman RS. Applying health behavior theory to multiple behavior change: Considerations and approaches. *Prev Med* 2008;XX:xxx–xxx.
- Norris SL, Engelgau MM, Narayan KM. Effectiveness of self-management training in type 2 diabetes: a systematic review of randomized controlled trials. *Diabetes Care* 2001;24:561–587. [PubMed: 11289485]
- Ornish D, Scherwitz LW, Billings JH, Brown SE, Gould KL, Merritt TA, Sparler S, Armstrong WT, Ports TA, Kirkeeide RL, Hogeboom C, Brand RJ. Intensive lifestyle changes for reversal of coronary heart disease. *JAMA* 1998;280:2001–2007. [PubMed: 9863851]
- Parker G, Crawford J. Judged effectiveness of differing antidepressant strategies by those with clinical depression. *Australian & New Zealand Journal of Psychiatry* 2007;41:32–37. [PubMed: 17464679]
- Prochaska JJ, Delucchi K, Hall SM. A meta-analysis of smoking cessation interventions with individuals in substance abuse treatment or recovery. *J Consult Clin Psychol* 2004;72:1144–1156. [PubMed: 15612860]
- Prochaska JJ, Velicer WF, Prochaska JO, Delucchi K, Hall SM. Comparing intervention outcomes in smokers treated for single versus multiple behavioral risks. *Health Psychol* 2006;25:380–388. [PubMed: 16719610]
- Prochaska JJ, Hall SM, Tsoh JY, Eisendrath S, Rossi JS, Redding CA, Rosen AB, Meisner M, Humfleet GL, Gorecki JA. Treating tobacco dependence in clinically depressed smokers: effect of smoking cessation on mental health functioning. *Am J Public Health*. 2008;100:2105/AJPH.2006.101147
- Prochaska JJ, Velicer WF, Nigg CR, Prochaska JO. Methods of quantifying change in multiple risk factor interventions. *Prev Med* 2008;XX:xxx–xxx.
- Prochaska JO, Velicer WF, Rossi JS, Redding CA, Greene GW, Rossi SR, Sun X, Fava JL, Laforge R, Plummer BA. Multiple risk expert systems interventions: impact of simultaneous stage-matched expert system interventions for smoking, high-fat diet, and sun exposure in a population of parents. *Health Psychol* 2004;23:503–516. [PubMed: 15367070]
- Prochaska JO, Velicer WF, Redding C, Rossi JS, Goldstein M, DePue J, Greene GW, Rossi SR, Sun X, Fava JL, Laforge R, Rakowski W, Plummer BA. Stage-based expert systems to guide a population of primary care patients to quit smoking, eat healthier, prevent skin cancer, and receive regular mammograms. *Prev Med* 2005;41:406–416. [PubMed: 15896835]

- Prochaska JO. Multiple health behavior research represents the future of preventive medicine. *Prev Med* 2008;XX:xxx-xxx.
- Prochaska JO, Butterworth S, Redding C, Burden V, Perrin N, Leo M, Flaherty-Robb M, Prochaska JM. Initial efficacy of MI, TTM tailoring and HRI's with multiple behaviors for employee health promotion. *Prev Med* 2008;XX:xxx-xxx.
- Pronk NP, Anderson LH, Crain AL, Martinson BC, O'Connor PJ, Sherwood NE, Whitebird RR. Meeting recommendations for multiple healthy lifestyle factors. Prevalence, clustering, and predictors among adolescent, adult, and senior health plan members. *Am J Prev Med* 2004;27:25-33. [PubMed: 15275671]
- Puska P, Nissinen A, Tuomilehto J, Salonen JT, Koskela K, McAlister A, Kottke TE, Maccoby N, Farquhar JW. The community-based strategy to prevent coronary heart disease: conclusions from the ten years of the North Karelia project. *Annu Rev Public Health* 1985;6:147-193. [PubMed: 3873246]
- Rasanen P, Roine E, Sintonen H, Semberg-Konttinen V, Ryyanen OP, Roine R. Use of quality-adjusted life years for the estimation of effectiveness of health care: A systematic literature review. *Int J Technol Assess Health Care* 2006;22:235-241. [PubMed: 16571199]
- Reeves MJ, Rafferty AP. Healthy lifestyle characteristics among adults in the United States, 2000. *Arch Intern Med* 2005;165:854-857. [PubMed: 15851634]
- Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Medicine & Science in Sports & Exercise* 2000;32:963-975. [PubMed: 10795788]
- Sanchez A, Norman GJ, Sallis JF, Calfas KJ, Rock C, Patrick K. Patterns and correlates of multiple risk behaviors in overweight women. *Prev Med* 2008;XX:xxx-xxx.
- Singh AS, Paw MJ, Brug J, van Mechelen W. Short-term effects of school-based weight gain prevention among adolescents. *Arch Pediatr Adolesc Med* 2007;161:565-571. [PubMed: 17548761]
- Smith KW, McKinlay SM, McKinlay JB. The reliability of health risk appraisals: a field trial of four instruments. *Am Jour Public Health* 1989;79:1603-1607. [PubMed: 2817186]
- Sorensen G, Thompson B, Glanz K, Feng Z, Kinne S, DiClemente C, Emmons K, Heimendinger J, Probart C, Lichtenstein E. Work site-based cancer prevention: primary results from the Working Well Trial. *Am Jour Public Health* 1996;86:939-947. [PubMed: 8669517]
- Spring B, Pagoto S, Pingitore R, Doran N, Schneider K, Hedeker D. Randomized controlled trial for behavioral smoking and weight control treatment: effect of concurrent versus sequential intervention. *J Consult Clin Psychol* 2004;72:785-796. [PubMed: 15482037]
- Summerbell CD, Waters E, Edmunds LD, Kelly S, Brown T, Campbell KJ. Interventions for preventing obesity in children. *Cochrane Database of Systematic Reviews* 2005;CD001871.
- Toobert DJ, Glasgow RE, Strycker LA, Barrera M Jr, Ritzwoller DP, Weidner G. Long-term effects of the Mediterranean lifestyle program: a randomized clinical trial for postmenopausal women with type 2 diabetes. *Int J Behav Nutr Phys Activ* 2007;4:1.
- USDHHS. Mental Health: A Report of the Surgeon General. Washington D. C.: Department of Health and Human Services; 1999.
- Ussher M. Exercise interventions for smoking cessation. *Cochrane Database of Systematic Reviews* 2005;CD002295.
- Vandelanotte C, Reeves MM, Brug J, De Bourdeaudhuij I. A randomized trial of sequential and simultaneous multiple behavior change interventions for physical activity and fat intake. *Prev Med* 2008;XX:xxx-xxx.
- Velicer WF, Prochaska JO, Redding CA, Rossi JS, Sun X, Greene GW. Efficacy of expert system interventions for employees to decrease smoking, dietary fat, and sun exposure (Abstract). *Int J Behav Med* 2004;11:277.
- Wankel, LM.; Sefton, JM. Physical activity, fitness, and health: international proceedings and consensus statement. In: Bouchard, RJS.; Stephens, T., editors. *Physical activity and other lifestyle behaviors*. Champaign, IL: Human Kinetics Publishers; 1994. p. 530-550.
- Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, McQueen M, Budaj A, Pais P, Varigos J, Lisheng L. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *Lancet* 2004;364:937-952. [PubMed: 15364185]

Table 1
Defining MHBC Interventions within Populations and Individuals

MHBC interventions in populations	<p>A program of interventions is offered to a community and individuals receive intervention only for the behaviors for which they are at risk.</p> <p>Example: In an MHBC population-based intervention, only smokers in a community would receive the quit smoking program, while individuals with high fat diets would receive the nutrition intervention, and individuals at risk for both smoking and high fat diet would receive both intervention components.</p> <p>Analyses: Changes are reported at the population level as a change in means (e.g., servings of fruits and vegetables) or the prevalence (e.g., smoking rates) of the behavior in the population.</p> <p>Considerations:</p> <ul style="list-style-type: none"> Increases the relevance of the intervention to the community and systems being served as all members are likely to be at risk for at least one of the targeted behaviors. Can be costly and time intensive and intervention effects may be diluted. If individuals in the population have multiple health behaviors targeted for change, the same challenges listed below regarding increased behavior change demands and program complexity are likely faced.
MHBC interventions in individuals	<p>All individuals receive intervention on multiple health behaviors.</p> <p>Example: A weight management program that gets all participants to increase their physical activity and make changes to their diet.</p> <p>Analyses: Changes are reported at the individual level as a change in means (e.g., body mass) or prevalence of the behavior among individuals in the sample</p> <p>Considerations:</p> <ul style="list-style-type: none"> Increases the potential overall impact on an individual's health but also likely increases the behavior change demands and program complexity If the intervention promotes concurrent action in multiple behaviors, may be overwhelming and result in poor adherence. Sequencing change goals or matching intervention strategies to individuals' readiness to change may facilitate greater adherence and overall change. If individuals are recruited to be at risk for all targeted behaviors, the intervention is likely to be relevant to a minority of individuals, unless the behaviors co-occur at really high rates (e.g., poor diet and inactivity).