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A description of the social–ecological framework used in the trial of activity for adolescent girls (TAAG)

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Abstract

Social–ecological (SE) models are becoming more widely used in health behavior research. Applying SE models to the design of interventions is challenging because models must be tailor-made for each behavior and population, other theories need to be integrated into multilevel frameworks, and empirical research to guide model development is limited. The purpose of the present paper is to describe a SE framework that guided the intervention and measurement plans for a specific study. The trial of activity for adolescent girls (TAAG) is a multi-center study of interventions to reduce the decline of physical activity in adolescent girls. The TAAG framework incorporates operant learning theory, social cognitive theory, organizational change theory and the diffusion of innovation model in a multi-level model. The explicit and practical model developed for TAAG has already benefited the study and may have elements that can generalize to other health promotion studies.

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Introduction

Psychosocial models have been dominant in guiding the design of health behavior change programs, and interventions based on such models have been effective [1]. However, psychosocial models alone cannot inform the development of intervention strategies that target changes beyond the individual level. From the earliest years of the development of the field of health promotion, guiding frameworks have emphasized the need to intervene in domains beyond psychological and social variables, such as supportive environments, policies and a reorientation of health services [2,3]. Ecological (for ease of presentation, at this point on we will shorten 'social–ecological' to 'ecological', which for purposes of this manuscript are interchangeable) and social–ecological (SE) models of health behavior characterized by multiple levels of influence on behavior and an emphasis on environmental and policy influences have become common [4–8]. Multi-level ecological models have been widely accepted in specific areas, such as tobacco control [9,10], as well as in broad areas, such as guiding the public health and science policy agendas of *Healthy People* [11] and the Institute of Medicine [12]. Despite the use of these models to explain health behavior and set broad policy agendas, many health behavior change programs continue to be targeted to the individual level only [13].

The development of ecological models for intervention purposes presents challenges distinct from the use of psychosocial models. First, ecological frameworks typically present domains of variables to be considered and do not give specific guidance on which variables within each domain might be most important for the topic at hand. However, other models and theories need to be integrated into ecological frameworks to provide specificity for selected domains. Second, environmental and policy influences that are hallmarks of ecological models are specific to certain health risks and behaviors. This is in contrast to psychosocial models in which proposed behavioral influences, such as self-efficacy [14], decisional balance and processes of change [15] have more generalized applicability across a broad range of behaviors. Thus, ecological models need to be tailor-made for each behavior or health condition. Models must be tailored to each population because, for example, adolescents will perform different physical activities in different settings using different equipment than older adults; therefore, implementation strategies could differ for each population but components of the model could be used across various populations. Third, psychosocial models are often developed via correlational studies, but there are very few studies of the environmental and policy correlates of most health behaviors [16]. Thus, behavior-specific ecological models must often be based on consensus of practitioners and participants. Despite the difficulties of applying ecological models, substantial progress is being made.

Interest in ecological models is particularly strong in the physical activity field, possibly because physical activity must be done in specific settings, and early studies showed consistent associations with a wide range of environmental variables [17]. Several physical activity-specific multi-level models have been proposed that include variables at the individual, social, environmental and policy levels [4,18,19]. Federal and foundation funding agencies have initiatives to study relationships between environmental factors and physical activity. However, no ecological model has been reported, to our knowledge, that has guided the development of a major multi-level physical activity intervention.

Girls are less active than boys at all ages studied [20], and early adolescence appears to be the age of greatest decline in physical activity [21,22]. These findings inspired the trial of activity for adolescent girls (TAAG). Briefly, TAAG is a multi-center randomized controlled trial investigating the effectiveness of interventions to reduce the decline of physical activity in adolescent girls [23]. Six sites (in Arizona, California, Louisiana, Maryland, Minnesota and

South Carolina) with six schools per site participated, of which three were randomized to receive the TAAG intervention and TAAG measurements while three received the TAAG measurements only. After collecting baseline data, the TAAG interventions took place over two school years [23]. The purpose of the present paper is to describe a SE model that has guided the intervention, formative research and process evaluation components of TAAG, as well as complementary theories that inform it. There are three sections of this paper that describe the SE model used in TAAG: (i) environmental settings for adolescent physical activity, (ii) contributing theories and (iii) implication of the theories for TAAG.

Environmental settings for adolescent physical activity

The Centers for Disease Control and Prevention guidelines recommend promotion of the participation of youth in enjoyable physical activity in school, community and home settings [24]. Linking these three systems and providing increased access to and promotion of physical activities that adolescents, particularly girls, can enjoy now and continue throughout their adult lives could provide important short- and long-term health benefits for these adolescents.

Two behavioral settings that are predominant in physical activity among youth are schools and the community.

School setting

Schools are important physical, social and normative environments in which students observe, imitate, learn and practice health behaviors. As such, schools have a great opportunity to positively influence levels of physical activity, but this potential has remained largely untapped [11]. Most secondary schools (88.5–89.1%) allow students to be exempted or excused from physical education (PE) courses [25]. Even though many children actually do have PE within the school day, it may be inadequate to build motor skills and fitness because large amounts of class time are spent being inactive [26,27]. Baseline data from the child and adolescent trial for cardiovascular health (CATCH) study showed that in third-grade PE classes, students were involved in moderate to vigorous physical activity (MVPA) (any activity that involves intensity at least as high as walking) for only ~ 10 min of a 30-min PE class. The greatest improvement in physical activity for CATCH participants was through social structural change, namely improved PE classes [28]. In addition to increasing MVPA during PE class, schools can increase opportunities for students to be active during other times of the school day.

The middle school physical activity and nutrition (MSPAN) study was explicitly based on an ecological model and had the goal of intervening on multiple environments and policies within schools to improve physical activity and nutrition. In addition to improving PE, the intervention was designed to increase the amount of available equipment (physical environment), access to physical activity spaces (policies) and supervision for physical activity (social environment). The intervention was effective in increasing total physical activity at school, with contributions from PE and non-PE settings [29].

Community settings

Although school-based programs are important for youth, broader community-based programs are also needed for several reasons. First, children and adolescents spend considerable time in community settings that are conducive to physical activity. Second, community-based programs have the capacity to involve parents and other adult role models from the community (e.g. relatives, coaches, religious leaders, older students) who can influence the physical activity behavior of children [20]. Third, community activities, in contrast to school programs, often involve children in informal activities that are not affected by the pressure of grades and competition. Fourth, decisions to choose active recreation are affected by community

characteristics, such as the relative availability of and/or access to recreation programs and facilities. Appropriate modifications of these community characteristics should make it easier for young people to implement the knowledge and behavioral skills they learn in school.

Participation in community physical activity programs is also associated with high levels of physical activity in children [30]. However, many community-sponsored physical activity programs for youth are competitive sports. Although these may be more inclusive than school sports teams, they are still competitive activities and thus may comprise barriers to participation, especially for those girls who are not attracted to higher levels of competition. In addition, lack of transportation to community recreation centers may be a barrier, and many facilities are staffed by people who are not inclined to prioritize health or physical activity.

Contributing theories

Theories that helped guide and inform the TAAG SE model are operant conditioning, social cognitive theory (SCT) and organizational change theory, including diffusion of innovations. These theories are incorporated into the TAAG model (see Fig. 1), which serves to put all relevant theories into a unified whole. The model, then, informs the intervention development by providing its theoretical grounding. Brief descriptions of those theories and how they informed the TAAG model follow.

Operant conditioning

Operant conditioning (i.e. behavior modification) presents an important complement to the SE model. Whereas SE models emphasize the behavior of large numbers of individuals in various ‘behavior settings’ (i.e. in certain physical locations and at certain times and days), operant psychology describes the direct mechanism by which individual behaviors may be changed [31]. Specifically, behaviors are strengthened through the process of reinforcement or weakened through punishment or extinction (i.e. the discontinuation of reinforcement). Cues, prompts, modeling and other antecedents to the behavior may also make it more likely to occur, at least initially. Behavior followed by an aversive consequence or impeded by various social or environmental barriers will be less likely to occur again in the future.

The operant basis for behavior change has been demonstrated to be central in the promotion of physical activity. In a meta-analytic review of 127 physical activity intervention studies, Dishman and Buckworth [32] studied the effect sizes produced by behavior modification, cognitive behavior change, health education and PE curriculum interventions. They concluded that behavior modification had on the average an impact more than four times greater than that for PE curricula and nine times that of cognitive behavior change and health education [19].

From an operant perspective, physical activity may fail to occur because of a ‘skill deficit’ or a ‘performance deficit’. Skill deficits refer specifically to a child not having the current capability for her or him to be physically active with a specific behavior. Performance deficits refer more specifically to the nature of the behavior–environment relationship and assume that the adolescent has sufficient skills to perform the behavior but is not doing so because of the specific environment. The performance deficit side of the equation is complicated when the child receives a substantial positive reinforcement for sedentary behavior. ‘Competing behaviors’ such as these often make behavior change goals difficult to achieve.

Functional reinforcers for physical activity may vary substantially between individuals and in different subgroups. For example, boys may cite competition and girls may cite weight management as reasons for engaging in physical activity (PA) [33].

In summary, an operant framework indicates that performance of MVPA may result from either performance or skill deficits. Behavior modification strategies offer a highly promising approach to changing adolescent physical activity. The three key elements used in TAAG are as follows: increased positive reinforcement for activity, reduced barriers and aversive consequences that impede activity and reduced positive reinforcement for sedentary behaviors. Reinforcement and other consequences (the concluding process presented in Fig. 1) may be applied not only at the individual level but also to entire organizations as well, by providing feedback and verbal or written reinforcement to gatekeepers, school staff and agencies that have improved their organizational environments to optimize physical activity.

The SCT

Social cognitive (learning) theory describes relationships among self-regulatory behavior and supportive functions of social environments for adopting and maintaining health-promoting behaviors [14]. Several cognitive variables are identified as important mediators of behavior change. Regardless of physical skill level, high levels of self-efficacy may lead to a greater likelihood of engaging in specific physical activity behaviors. Positive outcome expectations comprise both the expectation of positive reinforcement consequent to behavior, and that 'punishment' is unlikely.

SCT posits that behavior can be affected by vicarious learning and vicarious reinforcement, via observing behavioral models. For adolescents making decisions about how to use their free time, peers and family serve as important role models. TAAG is attempting to create a social environment in schools, community agencies and families, where adolescent girls have positive role models in their peers and families and where they can both directly and vicariously experience positive reinforcement for being active.

SCT has played a key role in the development of nutritional health promotion [34,35], tobacco use prevention [10] and heart health [36,37]. In addition, SCT is also closely related to health communication models (e.g. McGuire's [38] communication/persuasion model), tailoring [39] and social marketing [40]. Correlational studies support the relevance of SCT-derived variables for explaining youth physical activity [41]. SCT has generated a wide variety of strategies and approaches for increasing modeling, teaching individual behavior change skills and enhancing inter-personal mediators (see Fig. 1).

Organizational change and diffusion of innovation

Organizational change applied to health promotion—The TAAG SE model envisions girls' behaviors in the broader context of their social and physical environments, which are in turn, influenced by not only schools and community organizations but also the linkage between the two. Goodman *et al.* [42] provide an overview of inter-organizational relations as informed by organizational change theories. Potential benefits of organizational collaboration include access to resources and the ability to make better use of existing resources; however, the promotion of physical activity and PE is seen by few as a primary mission of public schools. Therefore, potential costs of collaboration for physical activity promotion include diversion of the organization's resources, dilution of the organization's primary mission or purpose and incompatibility of positions among differing organizations.

Although effective process is needed to initiate partnerships for physical activity promotion or other efforts, structural changes may be required to sustain them. Development of an effective organizational structure for the collaborative group enables the group to carry out essential functions including making decisions, allocating resources, sharing information, documenting activities and assessing the success or failure of its activities [43].

An innovative intervention goal of TAAG is to create sustainable school-community collaborations (one of the initial processes presented in Fig. 1) to provide physical activity programs and events. The diversity of activity-providing organizations that can be involved requires flexibility in the structures and processes that can be applied to the collaborations.

Diffusion of innovation in school settings—The diffusion of innovations model [44, 45] has been applied to organizational adoption of programs in school settings such as PE or after school physical activity. Diffusion within organizations is complex and requires consideration of multiple factors, such as the organization's goals, authority structure and decision-making mechanisms. In schools, diffusion may depend upon involving multiple groups such as administrators, teachers, parents and students [46].

Although diffusion can occur naturally through informal channels, it is useful to develop structures to facilitate the diffusion process. One approach is to develop a 'linkage system' to develop a close partnership between the 'resource system' (the group promoting the innovation) and the 'user system' (potential users of the innovation) [47]. Another strategy is using a program champion, a representative of potential users of the innovation, to facilitate adoption of the physical activity program or other innovation. This person can serve as a link between the group promoting change and the potential adopters [46]. Being very familiar with the target population, the program champion will be better suited than outsider to determine how best to motivate behavior change. TAAG employed these two strategies to facilitate the diffusion of the intervention.

One goal of implementation is to insure that the innovation is adopted as intended (fidelity) and with all components intact (completeness). However, diffusion theory posits that some mutual adaptation, also known as reinvention, may be needed for successful implementation as well as sustaining the innovation. From an intervention perspective, it may be best to anticipate the process and facilitate it in a manner that promotes program effectiveness. Consistent with TAAG's application of ecologic, operant and social cognitive models to achieve physical activity change in girls, strategies to facilitate program implementation should focus on developing skills, self-efficacy and reinforcement of program adopters [46]. Through such a process, these adopters will develop a sense of empowerment that will hopefully sustain their efforts over the longer term.

The final stage can be conceptualized more broadly as sustainability to include the concepts of institutionalization, maintenance, routinizing and capacity building. In some settings, the goal may be for the innovation to be adopted as routine practice in the organization (e.g. institutionalization), but can take diverse forms including transferring the whole program, program parts or program outcomes to community ownership [46].

Implications for TAAG

In summary, the TAAG intervention, requiring school-community collaboration, was an innovation for the participating school and community partners. The source of the change was most closely described as adaptation, in that the innovation is developed externally (by TAAG researchers) and implemented with modification in the school and community agency settings. The type of change TAAG entailed may vary depending on the specific organization. If promotion of physical activity was considered an existing goal of the organization, TAAG may have been seen as a new approach to achieving that goal (technical change). However, if promoting physical activity was a new goal for the organization, TAAG would have involved changes in both the goal and the method of achieving the goal (transformation).

Suggested strategies by diffusion of innovations included the use of a linkage system and a program champion. Developing a linkage system (e.g. TAAG team) will provide a mechanism for TAAG, school and community agency personnel to communicate; to provide input and to develop local ownership. Program champions also facilitated adoption, implementation and coordination of TAAG. In an effort to increase the chances of TAAG institutionalization in schools and communities (the final step in the diffusion process), program champions were proactively identified and trained by TAAG intervention staff during the active intervention phase. While research support was still active, program champions developed action plans for how TAAG would continue in future years.

Development and implementation of the TAAG intervention

Planning for the TAAG intervention began by using a program planning process [48] that helped the research team work through the stages of preparing for program development, determining the most potent program components and feasible channels, creating intervention objectives and thinking through implementation and maintenance issues. The TAAG SE model was developed where relevant theories of behavior change and the predictive factors related to the behavior in question were organized to clearly describe the causal pathway leading to the desired behavioral outcome, either through direct behavior change interventions or through broader environmental changes or more focused intra-personal factors. Table I provides examples of applications of the SE framework to specific intervention activities.

As Fig. 1 shows, the TAAG intervention activities operated at multiple levels to target policy and organizational change in schools and community agencies, and to provide cues, messages and reinforcers to school staff, families and students to positively influence levels of MVPA for adolescent girls. Policy and organizational changes were targeted through PE classes, other physical activity opportunities (e.g. at lunch), after-school activities in the community and after-school activities in the school. Cues, messages and reinforcers were targeted through social marketing efforts and through changing health education curricula to facilitate and reinforce actual physical activity.

The policy and organizational intervention components and cues, messages and reinforcers were conceptualized to work together on multiple levels to create environments with more opportunities for physical activity and provide girls with skills and encouragement to use those opportunities. The overall purpose was to create environments at school and in the community that facilitate physical activity, enhance social support in those environments and provide the girls with the motivation and skills to seek out activity in all settings. The ‘physical environment’ included facilities, programs and equipment in school and community settings, and reinforcers that facilitated increased levels of MVPA. The ‘social environment’ included social support, encouragement and both direct and vicarious reinforcement by school staff, community agency personnel and peers. ‘Policies’ were created to stimulate changes in the physical environment and support all program components. Intervention components also engaged adolescent girls directly though educational, motivational and reinforcing messages.

Intervention activities were implemented to increase opportunities for physical activity in the physical environment. These included increasing the number of available, accessible and appealing structured and unstructured physical activity programs and opportunities in schools and communities during and after school. In addition, the implementation of the intervention included decreasing barriers to participation (e.g. lack of girl-preferred activity offerings).

Intervention activities were implemented to increase opportunities in the social environment including encouragement, modeling and social support to facilitate adolescent girls’ participation in physical activity. Increased social facilitation was targeted for school staff, community agencies, families and students, stimulating and helping to sustain organizational

change, as well as individual change. The intervention staff worked to reduce social barriers such as gender discrimination, gender stereotyping and misperceptions of safety or appropriate behavior. Changes in the social environment could be accomplished through training PE teachers and community activity leaders, assisting schools and community agencies to adopt policies to provide more resources, and assisting schools in adopting policies that support all components of the TAAG social marketing and health education interventions.

Mediators of the intervention's effects

Physical and social environment changes were expected to change behavior by two pathways. We hypothesized that the implementation of activities to influence the physical and social environments will have 'direct effects' on increased MVPA. In addition to the direct effects, some of the behavior change was expected to be 'mediated' by intra-personal factors such as (i) change in self-efficacy resulting from having an enjoyable experience in PE class, (ii) change in perception of the physical environment or (iii) change in perception of the social environment. Individual-level mediators affecting individual pre-disposing factors and perceptions of opportunities and barriers pertained to both the girls themselves and other individuals in the girls' social environments.

The reinforcement component

Both the organizational and individual components of the intervention framework were designed to provide reinforcement for change. Reinforcers acted at two points in the conceptual model: (i) reinforcing policy and organizational change to promote and maintain intervention activities and (ii) reinforcing adolescent girls to promote and maintain their participation in intervention activities. The 'reinforcers at the organizational and policy level' included tangible reinforcers (e.g. money), as well as intangible reinforcers (praise and publicity) that were offered to schools and communities to encourage their participation in TAAG activities and to encourage maintenance and expansion of activities over time.

'Reinforcers at the individual level' include tangible reinforcers (e.g. prizes) as well as intangible reinforcers (praise), which were offered to girls to encourage their participation in TAAG activities and to encourage maintenance and expansion of activities over time.

Utility of the TAAG model

SE frameworks or models are essential in programs or studies that employ multi-level interventions and measurement strategies. The SE model provides a conceptual framework that allows for selecting and integrating multiple theoretical approaches and strategies as appropriate for the scope of work to be undertaken. In addition, formative and process evaluation designs can use the same theory-driven constructs for any study or program.

The TAAG model was used to ensure that the organizational and individual components of the intervention complement each other. The model explicitly focuses on the design of the intervention framework, the implementation of intervention activities and the integration of reinforcement into most intervention components.

The TAAG model integrates intervention and measurement activities of the study. The emphasis placed on adequate implementation of the intervention at the environmental, behavioral and intra-personal levels (see Table I), which necessitates rigorous evaluation of process variables at each level. Individual-level mediators of environmental and individual intervention strategies were targeted. Although reinforcement is conceptualized as having direct effects on behavior, delivery of reinforcers can be viewed as a process variable and perception of reinforcers can be viewed as a mediator.

In addition to guiding intervention design and measurement procedures, the TAAG model also aided in the interpretation of results. Analyses of process and mediator variables can help determine the contributors to intervention failure or success. We believe the application of an explicit SE model, integrated with other models and theories is relatively unique in health promotion. The novelty of creating and applying a multi-level model presented a challenge to the TAAG investigators. Nevertheless, although the outcome evaluation of the TAAG program is >1 year in the future, extensive planning produced an explicit and practical model that benefits the TAAG study in several ways and may have elements that can generalize to other health promotion studies.

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References

1. Glanz, K.; Rimer, BK.; Lewis, FM. Health Behavior and Health Education: Theory, Research, and Practice. Vol. 3. San Francisco, CA: Jossey-Bass; 2002.
2. Green, LW.; Kreuter, MW. Health Promotion Planning: An Educational and Ecological Approach. Vol. 3. Mountain View: Mayfield; 1999.
3. World Health Organization. Ottawa Charter for Health Promotion. Geneva, Switzerland: WHO; 1986.
4. Booth SL, Sallis JF, Ritenbaugh C, et al. Environmental and societal factors affect food choice and physical activity: rationale, influences, and leverage points. Nutr Rev 2001;59:S21–39. [PubMed: 11330630]Discussion: S57–65
5. Cohen DA, Scribner RA, Farley TA. A structural model of health behavior: a pragmatic approach to explain and influence health behaviors at the population level. Prev Med 2000;30:146–54. [PubMed: 10656842]
6. McLeroy KR, Bibeau D, Steckler A, et al. An ecological perspective on health promotion programs. Health Educ Q 1988;15:351–77. [PubMed: 3068205]
7. Stokols D. Establishing and maintaining healthy environments. Toward a social ecology of health promotion. Am Psychol 1992;47:6–22. [PubMed: 1539925]
8. Green LW, Richard L, Potvin L. Ecological foundations of health promotion. Am J Health Promot 1996;10:270–81. [PubMed: 10159708]
9. Centers for Disease Control and Prevention (CDC). Best Practices for Comprehensive Tobacco Control. Atlanta: Centers for Disease Control and Prevention; 1999. Office on Smoking and Health.
10. Elder JP, Stern RA. The ABCs of adolescent smoking prevention: an environment and skills model. Health Educ Q 1986;13:181–91. [PubMed: 3721881]
11. US Department of Health and Human Services (USDHHS) . Healthy People 2010. (Conference edition in two volumes). 2000.
12. Institute of Medicine. Promoting Health: Intervention Strategies from Social and Behavioral Sciences. Washington, DC: National Academy Press; 2001. Committee on Capitalizing on Social Science and Behavioral Science Research to Improve the Public's Health.
13. Richard L, Potvin L, Kishchuk N, et al. Assessment of the integration of the ecological approach in health promotion programs. Am J Health Promot 1996;10:318–28. [PubMed: 10159711]
14. Biddle SJH, Whitehead SH, O'Donovan TM, et al. Correlates of participation in physical activity for adolescent girls: a systematic review of recent literature. J Phys Act Health 2005;2:423–34.
15. Prochaska JO, Velicer WF, Rossi JS, et al. Stages of change and decisional balance for 12 problem behaviors. Health Psychol 1994;13:39–46. [PubMed: 8168470]
16. Sallis, JF.; Owen, N. Ecological models of health behavior. In: Glanz, K.; Rimer, BK.; Lewis, FM., editors. Health Behavior and Health Education: Theory, Research, and Practice. Vol. 3. San Francisco, CA: Jossey-Bass; 2002. p. 462-84.

17. Humpel N, Owen N, Leslie E. Environmental factors associated with adults' participation in physical activity. Am J Prev Med 2002;22:188–99. [PubMed: 11897464]
18. Saelens BE, Sallis JF, Frank LD. Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. Ann Behav Med 2003;25:80–91. [PubMed: 12704009]
19. Sallis, JF.; Owen, N. Physical Activity and Behavioral Medicine. Thousand Oaks, CA: Sage; 1999.
20. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. Med Sci Sports Exerc 2000;32:963–75. [PubMed: 10795788]
21. Sallis JF. Age-related decline in physical activity: a synthesis of human and animal studies. Med Sci Sports Exerc 2000;32:1598–600. [PubMed: 10994911]
22. Stone EJ, McKenzie TL, Welk GJ, et al. Effects of physical activity interventions in youth: review and synthesis. Am J Prev Med 1998;15:298–315. [PubMed: 9838974]
23. Stevens J, Murray DM, Catellier DJ, et al. Design of the trial of activity in adolescent girls (TAAG). Contemp Clin Trials 2005;26:223–33. [PubMed: 15837442]
24. Centers for Disease Control and Prevention (CDC). Guidelines for school and community programs to promote lifelong physical activity among young people. MMWR Morb Mortal Wkly Rep 1997;46:1–36. [PubMed: 9011775]
25. Burgeson CR, Wechsler H, Brener ND, et al. Physical education and activity: results from the school health policies and programs study 2000. J Sch Health 2001;71:279–93. [PubMed: 11586871]
26. Simons-Morton BG, Taylor WC, Snider SA, et al. The physical activity of fifth-grade students during physical education classes. Am J Public Health 1993;83:262–4. [PubMed: 8427337]
27. McKenzie TL, Feldman H, Woods SE, et al. Children's activity levels and lesson context during third-grade physical education. Res Q Exerc Sport 1995;66:184–93. [PubMed: 7481079]
28. McKenzie TL, Stone EJ, Feldman HA, et al. Effects of the CATCH physical education intervention: teacher type and lesson location. Am J Prev Med 2001;21:101–9. [PubMed: 11457629]
29. Sallis JF, McKenzie TL, Conway TL, et al. Environmental interventions for eating and physical activity: a randomized controlled trial in middle schools. Am J Prev Med 2003;24:209–17. [PubMed: 12657338]
30. Trost SG, Pate RR, Saunders R, et al. A prospective study of the determinants of physical activity in rural fifth-grade children. Prev Med 1997;26:257–63. [PubMed: 9085396]
31. Skinner, BF. Science and Human Behavior. New York: Macmillan; 1953.
32. Dishman RK, Buckworth J. Increasing physical activity: a quantitative synthesis. Med Sci Sports Exerc 1996;28:706–19. [PubMed: 8784759]
33. Tappe MK, Duda JL, Ehnrwald PM. Perceived barriers to exercise among adolescents. J Sch Health 1989;59:153–5. [PubMed: 2716290]
34. Lytle LA, Kelder SH, Perry CL, et al. Covariance of adolescent health behaviors: the class of 1989 study. Health Educ Res 1995;10:133–46.
35. Contento I, Balch GI. The effectiveness of nutrition education and implications for nutrition education policy, programs, and research: a review of research. J Nutr Educ 1995;27:279–318.
36. Perry CL, Sellers DE, Johnson C, et al. The child and adolescent trial for cardiovascular health (CATCH): intervention, implementation, and feasibility for elementary schools in the United States. Health Educ Behav 1997;24:716–35. [PubMed: 9408786]
37. Edmundson E, Parcel GS, Feldman HA, et al. The effects of the child and adolescent trial for cardiovascular health upon psychosocial determinants of diet and physical activity behavior. Prev Med 1996;25:442–54. [PubMed: 8812822]
38. McGuire, WJ. Theoretical foundations of campaigns. In: Rice, RE.; Atkin, CK., editors. Public Communication Campaigns. Newbury Park, CA: Sage; 1989. p. 43-66.
39. Kreuter MW, Strecher VJ, Glassman B. One size does not fit all: the case for tailoring print materials. Ann Behav Med 1999;21:276–83. [PubMed: 10721433]
40. Kotler, P.; Roberto, N.; Lee, N. Social Marketing: Improving the Quality of Life. Thousand Oaks, CA: Sage; 2002.
41. Sallis JF, Conway TL, Prochaska JJ, et al. School environments are associated with youth physical activity. Am J Public Health 2001;91:618–20. [PubMed: 11291375]

42. Goodman, RM.; Steckler, A.; Kegler, MC. Mobilizing organizations for health enhancement: theories of organizational change. In: Glanz, K.; Rimer, BK.; Lewis, FM., editors. Health Behavior and Health Education: Theory, Research, and Practice. Vol. 2. San Francisco, CA: Jossey-Bass; 1997.

43. Sirotnik, KA.; Goodlad, JI. School-University Partnerships in Action: Concepts, Cases and Concerns. New York: Teachers College Press; 1988.

44. Rogers, EM.; Shoemaker, F. Communication of Innovations: A Cross-Cultural Approach. Vol. 2. New York: Free Press; 1971.

45. Rogers, EM. Diffusion of Innovations. Vol. 5. New York: The Free Press; 2003.

46. Bartholomew, LK.; Parcel, GS.; Kok, G. Changing behavior and environment: how to plan theory- and evidence-based disease management programs. In: Patterson, R., editor. Changing Patient Behavior: Improving Outcome in Health and Disease Management. Chicago: American Hospital Association Press/Jossey Bass; 2001.

47. Oldenburg, BF.; Hardcastle, D.; Kok, G. Diffusion of health education and health promotion innovations. In: Glanz, K.; Lewis, BF.; Rimer, B., editors. Health Behavior and Health Education: Theory, Research and Practice. Vol. 2. San Francisco, CA: Jossey-Bass; 1997. p. 270-86.

48. Perry, CL. Creating Health Behavior Change: How to Develop Community-wide Programs for Youth. Thousand Oaks, CA: Sage Publications; 1999.

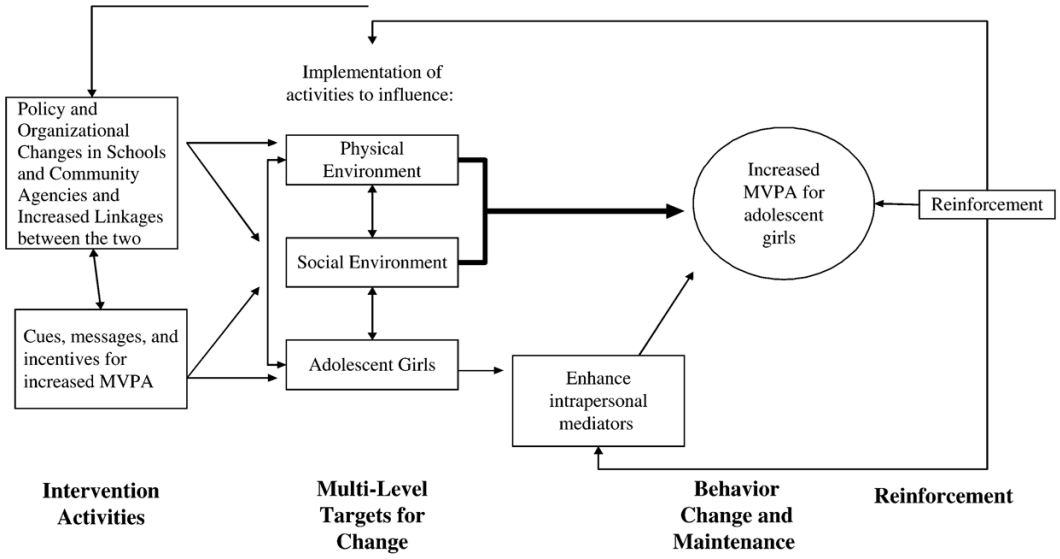

Fig. 1.
TAAG SE model.

Table I

Sample intervention strategies based on TAAG SE framework

Intervention objectives designed to modify …		Strategies designed to achieve objective
… The environment		
Increase the number of accessible PA programs for girls offered in the schools and the communities		Work with school and community partners to create new program opportunities for girls; focus on non-competitive programs since many competitive sports programs were already available
Increase the availability of equipment that will facilitate increased activity levels		Conduct an inventory of available PE equipment and provide additional equipment as needed to reduce the ratio of equipment/student in PE class
Increase affordable, convenient and safe transportation to PA settings		Work with school and community partners to increase availability of after-school transportation via late buses from schools or from school to community venues
Increase girls' and families' awareness of opportunities to be active in the school and community	**1**	Create promotional print material for youth and family regarding upcoming PA programs
	2	Create displays for schools and for use at school conferences to increase student and family awareness of programming opportunities
… Behaviors		
Develop behavioral skills related to choosing to be active, monitoring activity, setting goals to be active, problem-solving barriers and self-reinforcing activity	**1**	Include class activities to enhance behavioral skills to be active, e.g. communication skills and problem solving
	2	Implement a 'pedometer challenge' walking contest emphasizing a pedometer-based monitoring activity and setting goals to be more active
… Intra-personal factors		
Increase girls' confidence in their ability to engage in regular physical activity	**1**	Train PE teachers to provide choices for levels of skills and expertise so that students can gradually increase their levels of self-efficacy
	2	Provide non-competitive after-school PA opportunities for girls such as a walking club, beginning level dance or a fitness sampler
	3	Include lessons in which students identify real and perceived barriers to being physically active and brainstorm ways to decrease
	4	In print materials, depict students of various body types enjoying being physically active