

Chapter 10. Changing behavior using ecological models

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Abstract

Ecological models have their origins in ecological psychology which acknowledges the importance of human-environment interactions in understanding and changing human behavior. Most ecological models incorporate multiple levels of influence including policy, community, organizational, social and individual. Some ecological models have been further developed to inform interventions to change human behavior, however, many lack the specificity of behavioral theories. For this reason they have often been paired with theories such as social cognitive theory, organizational theory, behavioral choice theory, etc. A review of 157 intervention studies targeting nutrition, physical activity, smoking, sexual behavior, alcohol/substance use, disease screening and other behaviors reported that fewer than 10% used ecological models to inform intervention design, and 63% focused on just one or two levels of the ecological model. A meta-analysis of 96 health promotion interventions that used ecological models to target child and adolescent smoking, physical activity and diet found an overall effect size of $g=0.2$, and an effect of $g=0.07$ after approximately 12-months follow-up. However, organizational and policy targets remain understudied, with a further review reporting just 9% of interventions to prevent unhealthy weight amongst children were multi-level. A major challenge with ecological models is their partial use in interventions. It is recommended that behavior change interventions target all levels of ecological models. Future research should focus on how ecological models can help change the behavior of whole communities, how ecological models can be used within a systems framework, and how they can assist with the scaling up of interventions to improve population reach.

Practical Summary

Human behavior is influenced by factors at multiple levels. For example, people's engagement in behaviors that are good or bad for their health can be influenced by their own preferences and beliefs, by whether their friends or family also engage in these behaviors, access or availability in their physical environment, by workplace policies, and by government mandates or laws. There is evidence that ecological approaches are effective at changing behavior, and often they are paired with behavior theories, such as social cognitive theory. However, few programs have focused on influences at the physical environment, organizational and policy levels. Further evidence of the effectiveness of programs that have focused on behavior change at all levels of the ecological model is needed. Future research should focus on how ecological models can be used within a systems framework, and how they can assist with the scaling up of interventions to improve population reach.

Introduction

Behavior change involves targeting or influencing many aspects of people's lives. For example, changing people's voting patterns in a political election will not only involve persuasion through information, but it could be strongly influenced by individual's social and economic circumstances as well as local environments. Similarly, enabling people to eat healthy foods is much more than persuasion and advertising. Pricing, attractiveness, knowledge, availability and accessibility will all play a significant part. Companies pay a great deal of money to have their products placed in highly accessible locations in supermarkets (Thornton et al., 2012). For example, placing confectionary next to the checkout and creating demands from children to purchase such products – so-called 'pester power' – can be very frustrating for parents.

What these examples illustrate is that behavior change is likely to be enhanced through an approach that tackles multiple contexts and levels of influence. Typically, these have been described as 'social ecological models', widely used in behavior change work. Ecology refers to how living organisms relate to each other and the environment around them. As the term 'ecological' incorporates the social environment, the word 'social' is redundant. Consistent with Sallis and Owen (2015), we will use the term 'ecological models'. This chapter will provide a brief outline of ecological models, their purpose and history. We will summarise evidence of the use and effectiveness of ecological models for understanding and changing behavior from early childhood to adulthood. We will also present examples of the use of ecological models in different fields, disciplines and contexts, and identify theories that ecological models have frequently been paired with. The strengths, limitations, and future research needs will be discussed.

Brief overview of ecological models

The origins of contemporary ecological frameworks that are used for behavior change stem from psychological thinking at least as far back as the 1930s. German (Prussian) born psychologist, Kurt Lewin, is usually credited with the development of ‘ecological psychology’ through his field theory approach published four years after his death (Lewin, 1951). His work 15 years prior on ‘typological psychology’ provides the foundation for recognising person-environment interactions as important facets of human behavior (Lewin, 1936). Writing more than 80 years ago, Lewin (1936) referred to his now-famous equation $B = f(PE)$, stating that behavior is a function of the person (P) and environment (E); “the behavior depends on the state of the environment and that of the person: $B = f(PE)$. In this equation P and E are not independent variables.” (p. 166). Lewin considered perceptions of the environment to be more important than direct effects.

Barker’s (1968) ‘real world’ studies in ecological psychology at the Midwest Field Station concluded that it is not possible to predict human behavior without knowing the environmental setting or situation that the person is in. This is consistent with Gibsonian ecological psychology (Gibson, 1979), or ecological dynamics (Davids et al., 2016). Gibson introduced the notion of ‘affordances’ which refer to the functional and relational properties of an environment. These could be positive or negative, depending on the people and context. For example, upward moving escalators in a train station offer some people the chance to rest but others the opportunity to get some exercise through walking, or even choosing the adjacent stairs.

Table 1 provides examples of ecological models that have been developed in behavior change research since Lewin’s seminal work. While there is no ‘single’ or definitive ecological model, some models have been used more than others. For example, Bronfenbrenner’s ‘bio-ecological’ model of micro-, meso-, exo-, and macro-system influences proposes that behavior can be influenced at multiple levels (1977). A good

example for behavior change is that of reduction of smoking rates in high-income countries. Most levels of the model will have been targeted and affected, leading to significant shifts in social and cultural norms (macro-system). McLeroy's social ecological model (1988) has been frequently used in health promotion. There are two main concepts with this model; that there are multiple levels of influence on behavior, and reciprocal causation. McLeroy identified five levels of influence (Table 1); however, factors such as culture, social class, and economics are not accounted for.

Table 1. Examples of ecological models that have been developed and used in predicting and changing behavior

Ecological model	Components
Lewin (1936) <i>Field Theory</i>	<ul style="list-style-type: none"> • Life space • Environment • Person • Behavior
Barker (1968) <i>Environmental/ecological psychology</i>	<ul style="list-style-type: none"> • Behavior settings –physical & social situations
Bronfenbrenner (1977) <i>Ecological Systems Theory</i>	<ul style="list-style-type: none"> • Microsystems • Mesosystems • Exosystems • Macrosystems
Bandura (1977; 1986) <i>Social Learning Theory</i> <i>Social Cognitive Theory</i>	<ul style="list-style-type: none"> • Behavior • Person • Environment (mainly social) • Reciprocal determinism
McLeroy et al. (1988) <i>Social Ecological Model</i>	<ul style="list-style-type: none"> • Intrapersonal • Interpersonal • Organizational

	<ul style="list-style-type: none"> • Community • Public policy
Stokols (1992) <i>Social ecology model for health promotion</i>	<ul style="list-style-type: none"> • Personal attributes • Physical environments • Social environments • Environments are multi-dimensional (i.e., varying levels of complexity and scale) • Human-environment interactions occur at multiple levels and are reciprocal

Albert Bandura (1977; 1986) also believed in the concept of ‘reciprocal determinism’ where all three variables – behavior, person, environment – interact with each other in reciprocal ways. He criticised Lewin’s approach as being too simplistic; “personal and environmental factors do not function as independent determinants, rather they determine each other” (1977; p. 9). He argued that the relative influence of each factor will vary across settings and for different behaviors. Unlike Bandura’s Social Cognitive Theory, a challenge for many ecological models is they are very high level general frameworks that do not explicitly explain or guide changes in human behavior. They have been defined as a “metaconcept” which should guide research and practice, rather than generating specific hypotheses to be tested (Richard et al 2011).

Ecological models have been further developed to guide behavioral interventions. For example, Stokols’ ‘Social Ecology Model for Health Promotion’ applies to the promotion of health behaviors (1992), and recognises that there are reciprocal relationships between individual behavior and the social and physical environments at multiple levels of influence (e.g., child, school, family, culture, whole populations). An example of a discipline-specific application of an ecological model is seen in the Youth Physical Activity Promotion Model (Y-PAP) (Welk et al., 1999). The Y-PAP proposes ‘enabling’ factors such as an adolescent’s

fitness, skills, access and environment; ‘predisposing’ factors, which include self-efficacy, perceived competence, enjoyment, beliefs and attitudes; and ‘reinforcing’ factors including family, peer and coach influences. Moderating characteristics such as personal demographics and socioeconomic position are also considered in this model. Ecological models have also been used to guide implementation research. For example, May et al. (2016) argue that a ‘benefit’ of the lack of specificity of ecological models is their increased ‘elasticity’, which is important for adapting to different contexts. Context is a critical ingredient of successful translation and implementation of health promotion programs (Koorts et al., 2018). In spite of these adaptations, many ecological models fail to identify specific variables and how the broader levels of influence interact across levels to change behavior. To overcome these shortcomings, general ecological models have often been used in conjunction with behavior change theories.

How have ecological models been used to change behavior?

Ecological models have primarily been used to identify multiple levels of influence by exploring (usually theory-guided) correlates or determinants of behaviors. The importance of correlates research for informing the development of interventions is highlighted by the behavioral epidemiology framework (Figure 1). This framework proposes a systematic sequence of five phases of studies on health-related behaviors with the aim of leading to evidence-based interventions (Sallis et al. 2000). Phase 3 of this framework, identifying influences on the behavior, suggests that demographic correlates (i.e., individual level factors such as sex, age, ethnic group, socioeconomic position) can be useful for identifying those most in need of intervention. Additionally, this phase suggests that modifiable psychological, social, and environmental factors that may influence behavior should be identified.

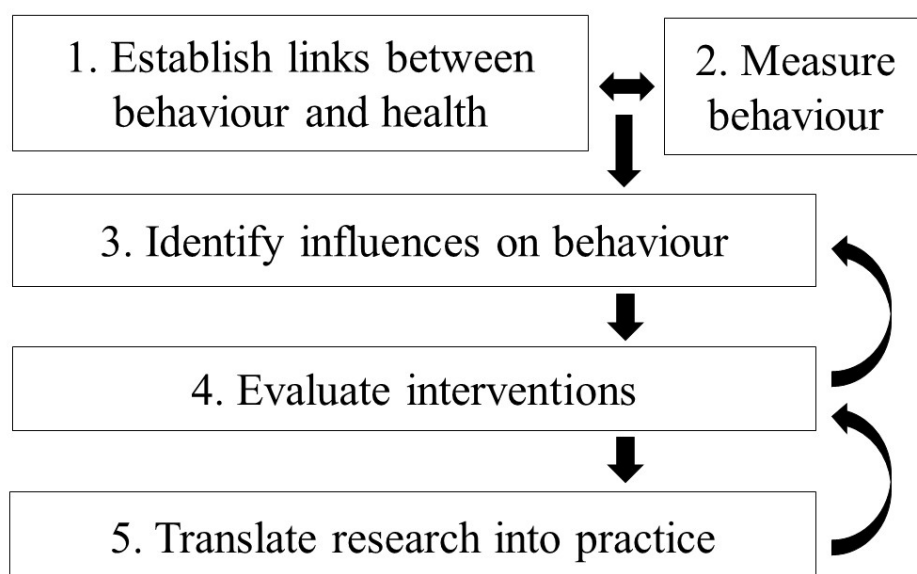


Figure 1. Behavioral epidemiology framework

Within behavior change research, ecological models have commonly been used in the earlier phases of the behavioral epidemiology framework, particularly phase 3, to help frame understanding of behaviors and targets for intervention. Interventions (phase 4 of the framework) typically utilise evidence derived from ecological models about how behavior is developed and influenced to identify targets and settings for behavior change strategies. Subsequently, interventions that target multiple levels of influence (i.e. multilevel interventions or programs) are developed; however, they are often paired with a behavior change theory to guide the development of the interventions (see Chapters 16 and 28).

(SIDE BAR) Examples of correlates research using an ecological framework

Systematic review to identify factors related to nicotine replacement therapy for adolescent smoking cessation (*King et al., 2018*)

Population: children aged <18years

Behavior: smoking cessation

Overview of findings: 51 articles identified factors from studies at each level of the social-ecological model: Intrapersonal (n=20); Interpersonal (n=2); Organizational (n=7); Community (n=11); Public policy (n=14).

Systematic review of factors influencing ethical issues in nursing practice to inform the development of a framework to discuss, debate and create interventions to address ethical issues (*Davidson et al., 2018*).

Population: Nurses

Behavior: Ethical considerations in nursing practice

Overview of findings: Eight dimensions that influence ethical practice are identified as individual factors (patients and families); individual factors (nurses); relationships between healthcare professionals; relationships between patients and nurses; organizational healthcare context; professional and education regulation and standards; community; and social, political and economic.

Although ecological models are typically paired with behavioral theories, the conceptual frameworks and theories underlying research and how these have been paired tend not to be explicitly described. Table 2 provides a summary of common pairings that have been reported or implied in published research, with some example references.

Table 2. Pairings of ecological models and theories

Theory paired with	Target behavior (examples)
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Organizational theory	School-based mental health services amongst children in poverty (Cappella et al., 2008)
Social cognitive theory	Obesity prevention trial in pre-school children (Fitzgibbon et al., 2011)
	Physical activity promotion in African-American pre-schoolers (Annesi et al., 2013)
	Obesity prevention and school readiness trial (Winter and Sass, 2011)
Behavioral choice theory	Transform-Us! Physical activity and sedentary behavior RCT (Salmon et al., 2011)
Self-determination theory	Obesity prevention trial in pre-school children (Fitzgibbon et al., 2011)
Empowerment theory	Bullying and cyberbullying prevention program (Ortega-Baron et al., 2019)

(SIDE BAR) Example of how the ecological model is paired with the social cognitive theory

Wang et al. (2016) described the development of the H₂GO! study, a community-based intervention to reduce sugar-sweetened beverage consumption among youth, guided by the ecological model and the social cognitive theory. As briefly described in Table 1, social cognitive theory (see Chapter X) proposes that behavioral, cognitive/personal, and environmental factors interact with each other reciprocally to influence behavior (Bandura 1986). The H₂GO! study targeted theoretical constructs from social cognitive theory including knowledge, attitudes (outcome expectations, self-efficacy), behavioral capabilities

and skills (self-monitoring, problem-solving, self-regulation skills), and behaviors. The strategies targeting these constructs, in the individual, social, and physical environment levels of the ecological model, are shown in Table 3.

Table 3. Strategies and constructs targeted by the H2GO! intervention (adapted from Wang et al. (2016))

Intervention strategies and activities	Theoretical constructs targeted			
	Knowledge	Attitudes	Behavioral Capabilities and Skills	Behaviors
Individual level				
<i>Enactive mastery experiences</i>	✓	✓	✓	✓
<i>Modeling, self-monitoring</i>		✓	✓	✓
<i>Persuasive communication</i>	✓	✓		✓
<i>Active learning</i>	✓	✓	✓	✓
<i>Reinforcement</i>		✓		
<i>Didactic instruction</i>	✓			✓
Social level				
<i>Family support</i>	✓	✓	✓	✓
<i>Peer modeling</i>		✓	✓	✓
<i>Group-based guided practice</i>	✓	✓	✓	✓
Physical environmental level				
<i>Environmental restructuring</i>		✓		✓

Evidence base for use of the ecological model in changing behavior

In acknowledging the varying and inter-related levels of influence on behavior, a 2001 report from the Division of Health Promotion and Disease Prevention within the Institute of Medicine at the US National Academy of Sciences recommended an ecological approach for

behavior change interventions and for the development of recommendations (Committee on Capitalizing on Social Science and Behavioral Research to Improve the Public's Health, 2001). An ecological approach that considers the individual and their environment is also supported by the World Health Organization (WHO) through their global recommendations for physical activity and health and their guide for population-based approaches to increase physical activity (World Health Organization, 2004). The WHO's report summarizing the interventions that are most effective at improving physical activity and diet also indicates that multi-component interventions that consider the local context and environment are most successful (World Health Organization, 2009).

To examine how ecological models have been applied to physical activity determinants and intervention research over 30-years, Richard and colleagues (Richard et al., 2011) conducted an analysis of papers published in eight health promotion, health education and physical activity/exercise/sport journals during three two-year periods (1988-1990, 1998-2000, 2007-2009). They concluded that over time ecological models are being integrated into such research more frequently, more levels of influence were being examined concurrently, and the level of influence being targeted was increasing to where organizational and political targets were often included (Richard et al., 2011).

In a review of 157 intervention papers published over two decades targeting nutrition, physical activity, smoking, sexual behavior, alcohol/substance use, disease screening and other behaviors, Golden and Earp (2012) found that these interventions typically focused on factors at the individual and interpersonal level, with few focusing on institutional, community or policy factors. Fewer than 10% of studies used ecological models to inform their intervention design, and only 63% of articles focused on just one or two levels of the ecological model. Nutrition interventions were significantly more likely to focus on three or more levels than studies that focused on other health behaviors; and studies that focused on

the school setting were also more likely to include multiple levels compared to studies that targeted behavior change in, for example, health care settings, community or family settings. The fidelity and success of the interventions was not reported in this review.

Unlike the previous review, Cushing and colleagues conducted a systematic review of health promotion interventions that used ecological models targeting child and adolescent smoking, physical activity and diet, and also performed a meta-analysis to determine the short and longer-term impact of these studies on these health behaviors (2014). There were 96 independent samples included in the review, which found an overall effect of $g=0.2$, and although small, this effect was also seen at approximately 12 months follow-up ($g=0.07$). There were strongest effects among dietary interventions that targeted schools and communities ($g=0.71$), and among physical activity interventions that targeted individuals and families ($g=0.44$). There were not enough smoking interventions to allow comparisons of ecological model components.

Ecological models have been used to identify the characteristics of interventions targeting individual behaviors (e.g. tobacco control (Richard et al., 2002), breast and cervical cancer screening (Holden et al., 1998) and unhealthy weight gain (Kellou et al. (2014))), from which domains of the ecological model they belong, and where multiple domains are targeted. For example, Kellou et al. (2014) reviewed the factors within interventions promoting physical activity to prevent unhealthy weight amongst children (6-12 years) using an ecological model. Amongst the 54 studies from the past five years, 43% of interventions targeted individual and/or interpersonal determinants of physical activity only, 48% targeted three or four domains including at least one environmental determinant (at the institutional level), and 9% were multi-level interventions within the community. This review concluded that intervention programs which target factors at multiple levels of the ecological framework have the most potential for preventing obesity (Kellou et al., 2014).

(SIDE BAR) Examples of interventions that have used an ecological framework

Transform-Us! (Salmon et al., 2011; Yildirim et al., 2014; Carson et al., 2013)

Population: children aged ~9-11y

Behavior: physical activity, sedentary behavior via a 30month school and home-based intervention

Setting: schools and home

Theory: social cognitive theory, behavioral choice theory and ecological systems theory

Overview of intervention at each level

Individual: children's self-efficacy, enjoyment, behavioral self-management and monitoring and behavior expectations and expectancies were targeted through classroom teacher delivered key learning class lessons, standing class lessons, short active breaks, and active homework tasks

Social: Modelling of physical activity and reductions in sedentary behavior by teachers, parents and siblings were encouraged through teacher professional development sessions and parental newsletters. Parental enforcement of screen time rules were also promoted via newsletters.

Environmental: The school environment was targeted via provisions of asphalt line markings, additional sporting and active play equipment and increases in opportunities for physical activity. Strategies targeting the home environment included increasing the availability of physical activity equipment and reducing opportunities for sedentary behaviors and access to screens (e.g. TV, computer, electronic games)

Outcomes: Reductions in children's sedentary time and improvements in their physical activity at 18-months and 30-months. Improvements to children's BMI, blood pressure and some biomarkers were also evident at 18-months.

Transform-Us! is now being up-scaled into a state-wide program available to all primary (elementary) schools in Victoria, Australia.

Stand Up Victoria (Healy et al., 2016)

Population: Adults aged 18-65y

Behavior: Sitting

Setting: Workplaces

Theory: social cognitive theory

Overview of intervention at each level

Individual: Participants' knowledge, attitudes and motivation were targeted using staff information sessions, written materials, individual coaching, support phone calls, and self-monitoring tools.

Social (organizational-level): Workplaces received management consultation, team champion training, staff information sessions, and management emails to staff to promote changes in the organization culture and policy.

Environmental: Participants were provided with sit-to-stand workstations to encourage reduced sitting.

Outcomes: Significant reductions in work-place sitting time, prolonged sitting time (≥ 30 minutes) and sitting time during the entire day (work time, non-work time and non-work days) at intervention conclusion (3 months) and sustained after 12 months.

Summary of the overall evidence

Ecological models are often used to identify the correlates of behaviors (e.g., King et al., 2018) and can be used to inform and provide a structure for intervention strategies and targets. Evidence suggests that targeting all domains within ecological models holds the

greatest potential for behavior change (e.g., Kellou et al., 2014; World Health Organization, 2009). Challenges using the ecological model for behavior change include (Richard & Gauvin, 2018):

- Changing the physical environment and policy environment can be difficult and time consuming (hence the large focus to date on the intrapersonal level)
- Multilevel interventions are time and resource intensive to develop and deliver
- Evaluating interventions targeting multiple levels of the ecological model can be challenging due to the complex inter-related nature of the levels

Recommendations on how ecological models should be used to change behavior

A key challenge remains the partial use of ecological models in interventions. Hawe cites research arguing that ““partial paradigm acquisition” was taking place in prevention science, such as the use of ecological theory in name more than in substance” (2015, p. 309).

Behavior change interventions need to target all levels of ecological models. It is also acknowledged that ecological models lack specific components to guide intervention development (Bartholomew et al., 1998). It is recommended that future interventions clearly identify any behavioral theories used in conjunction with ecological models when developing interventions (intervention mapping) (Bartholomew et al., 1998).

Future research

While the focus of this current book is on how to change human behavior, a greater challenge is to consider how ecological models can help change the behavior of whole communities so as to have maximum impact. Albert Bandura (2001) called this ‘collective agency’ where knowledge, self-efficacy, intentions, and skills interact as ‘group-level property’, and are not simply a sum of the individuals within it. However, interventions targeting collective agency

where individuals within communities have been engaged in social coordination and interdependent efforts are rare and further research is required. Hawe (2016) argues that public health interventions targeting whole-of-community health behaviors (e.g., the Stanford Heart Disease Prevention Project) erroneously applied individual behavior change theories to a community. Therefore, to change the behavior of individuals and of communities, ecological models need to operate within complex systems.

It is important that the application of ecological models is undertaken in recognition of the “delicacy of ecological systems” (Wold & Mittelmark, 2018; p.25). Without such consideration, there is the possibility that a behavior change program could have unintended consequences on a different part of the system. For example, Johnson (2008) argues that an ecological systems approach is needed within complex systems, such as schools. To better understand children’s educational outcomes, she suggests that future research is needed to inform educational policy by “...clarifying the multiple layers within the complex educational system using an ecological systems approach and drawing upon the concepts of complexity” (p.1).

Methodological research is also required that enables assessment of the development of community capacity, and the development of collaborative relationships between program deliverers and the community (Richard, 2011). Further research is needed to better understand the use of ecological models in ‘real world’ contexts and implementation processes (May et al., 2016). Finally, for population reach and maximising public health impact, it is important that we better understand how ecological models can assist with scaling up interventions, and help with understanding of context and the many layers of influence on successful outcomes.

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