

## Review

# The behavioral ecology of secondhand smoke exposure: A pathway to complete tobacco control

Melbourne F. Hovell & Suzanne C. Hughes

## Abstract

**Introduction:** This article outlines a theoretical framework for research concerning secondhand smoke exposure (SHSe) prevention as a means to curtail the tobacco industry.

**Methods:** The Behavioral Ecological Model (BEM) assumes interlocking social contingencies of reinforcement (i.e., rewards or punishments) from the highest level of society (e.g., taxing cigarette sales) to physiological reactions to nicotine that influence smoking and SHSe. We review selected research concerning both policy and clinical efforts to restrict smoking and/or SHSe.

**Results:** Research to date has focused on smoking cessation with modest to weak effects. The BEM and empirical evidence suggest that cultural contingencies of reinforcement should be emphasized to protect people from SHSe, especially vulnerable children, pregnant women, the ill, the elderly, and low-income adults who have not “elected” to smoke. Doing so will protect vulnerable populations from industry-produced SHSe and may yield more and longer-lasting cessation.

**Conclusions:** Interventions that reduce SHSe may serve as a Trojan horse to counter the tobacco industry. Future studies should: (a) guide policies to restrict SHSe; (b) develop powerful community and clinical interventions to reduce SHSe; (c) test the degree to which policies and other contexts enhance the effects of clinical interventions (e.g., media programs disclosing the disingenuous marketing by the industry); and (d) investigate the effects of all health care providers’ ability to reduce SHSe and generate an antitobacco culture, by advising all clients to avoid starting to smoke, to protect their children from SHSe, and to quit smoking.

Behavior change is *required* to prevent morbidity. Behavior explains more than 50% of the variance in infectious diseases, degenerative diseases, and injuries (Cuff & Vanselow, 2004; McGinnis & Foege, 1993). An individual’s health is a function

of the behavior of many people on multiple levels, and a broad systems approach to understanding both the individual’s and the population’s behavior is critical to achieving health promotion for all. Investigators cannot ignore the behavior of politicians who enact legislative policies that influence public health research, the behavior of medical care providers and insurers, and the behavior of industries (e.g., pharmaceuticals, tobacco) that may profit from behavior that prevents disease or that harms the public. The confluence of these many agencies defines complex behavioral ecological subcultures that determine health-related behavior and morbidity outcomes. We have used a Behavioral Ecological Model (BEM), where social ecological systems are emphasized and integrated with individual factors (e.g., genetic and personal learning histories) to understand and engineer change in the populations’ behavior (Hovell, Wahlgren, & Adams, 2009; Hovell, Wahlgren, & Gehrman, 2002). In this context, we discuss the role of secondhand smoke exposure (SHSe) in the overarching process of tobacco control.

This article describes the BEM, how it applies to SHSe research, and how elevating SHSe as the key target within the overarching tobacco control science may be a means of preventing tobacco addiction in whole populations.

## Need for a new model

The tobacco industry creates more smokers and disease than clinicians can prevent by clinical services alone. The focus on clinical care is understandable, as it helps seriously damaged members of society, but it only indirectly contributes to prevention. Alternatively, smoke-free policies and increased taxation hold promise for complete tobacco control, where no one uses tobacco products. Such policies are consistent with the BEM and illustrate a more comprehensive prevention model.

Popular theories offer “rational” or cognitive models of decision making that depend on understanding the health

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consequences of lifestyle practices (Bandura, 1989; Prochaska, DiClemente, & Norcross, 1992). However, these models are not complete, and they underemphasize principles of learning and the influence from physical and social environments. Jeffery (2004) and West (2005) have called for a return to principles of learning with emphasis on contingencies of reinforcement to influence lifestyle practices. Simplistically, contingencies of reinforcement reflect a specific behavior followed by a consequence (usually immediately) that influences the likelihood of future instances of the same behavior class. These behavior consequence chains ultimately become linked to antecedent events or contexts that prompt similar behavior. A contingency of reinforcement is the relationship between a behavior (e.g., smoking) and the preceding (e.g., offer of a cigarette) and following environmental events (e.g., relief from nicotine withdrawal symptoms and social approval from another smoker) that influence future instances of similar behavior (Skinner, 1969).

The BEM is based on principles of behavior (Baer & Wolf, 1987; Baer, Wolf, & Risley, 1968). However, the BEM extends these principles to the role of cultural factors in a complex web of influence that integrates concepts from biology, ecology, and Darwinian selection. Figure 1 depicts sources of influence on behavior, from within the body (lower triangle) and from the society (upper triangle). The model presumes that influences from genetics, and biological (e.g., experienced immune system) and behavioral-learning history (e.g., addiction to smoking), interact with influences from the local family, friends, and to societal ecology, all interacting with physical ecology. This perspective *redirects* public health and medical investigators to understand how contingencies define cultures, how cultures interact across levels of society, and how to change system factors to promote protective behavior community wide.

## The BEM: Extension to the cultural level

Tobacco control requires more than altering nicotine addiction. Social processes can enhance the addicting properties of nicotine or compete with nicotine to prevent or treat addiction. This means that engineering social/cultural systems offers both prevention and treatment for tobacco addiction. Research on SHSe may inform such engineering.

### Cultural practices and interlocking contingencies

Culture begins with interlocking behavior across individuals, within and across generations (Glenn, 1988, 2004; Malagodi & Jackson, 1989). "Interlocking behavior" occurs when a person's behavior, or its consequences, serves as prompt and reciprocal reinforcement for another's behavior (Houmanfar & Rodrigues, 2006). For example, accepting an offer to light a cigarette and later offering to return the favor promotes and reinforces smoking. These behaviors are embedded in a complex social context of attracting a sex partner and other possible reinforcers. These social reinforcers are achieved in a probabilistic (i.e., intermittent) but contingent manner, thereby sustaining smoking practices.

Nicotine addiction is one example of a biological contingency for smoking. The most proximal consequence for smokers is relief

from nicotine withdrawal symptoms that build when they go without nicotine. These consequences interact or add to social consequences taking place proximal to smoking. These interactions represent interlocking physical contingencies (relief from nicotine withdrawal symptoms), social contingencies, and more delayed financial or sexual contingencies reflected by paying for one another's drinks or by establishing sexual relationships. These examples reflect a cluster of interacting contingencies that support smoking and recruitment of new smokers. These proximal contingencies are independent of health effects of smoking or SHSe. To emphasize health consequences in order to motivate smoking avoidance or cessation is to ignore inadvertently a myriad of more powerful and immediate contingencies.

### Social contingencies

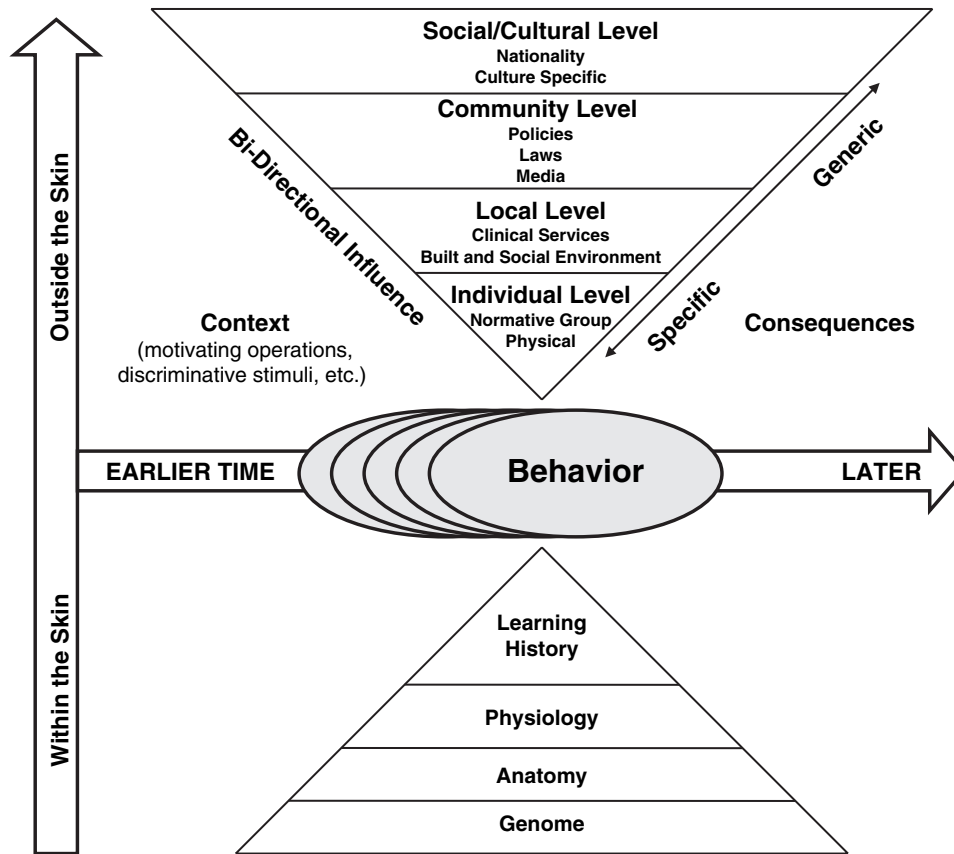
Social contexts are markers for unique contingencies of reinforcement. As an individual moves from one social context to another, his/her behavior changes to match the contingencies in the new context. For example, moving from one nation to another involves acculturation, where the contingencies from the new culture compete with those of the old (Kottak, 2006). Acculturation implies social contingencies and adoption of new social practices by the immigrant. However, the BEM guides the identification of explicit social contingencies operating that result in new normative behavior. Entering a bar where smoking is allowed increases the likelihood of reinforcement for smoking and for "tolerating" SHSe consistent with the "bar culture."

In communities that prohibit smoking in pubs, such microenvironments no longer represent cultures defined by smoking, SHSe, and supportive contingencies. This change can have far-reaching effects (Pierce & León, 2008). It disrupts the interlocked behaviors of drinking, smoking, and SHSe; it disassociates social/sexual and other powerful reinforcers for smoking and tolerating SHSe. Theoretically, disruption of these interlocking contingencies may generalize to other microenvironments, to weaken the tobacco industry's influence on smokers more broadly.

Government policies also influence local social contingencies. Such is the case with bars that have restricted smoking. Most of these changes have been predicated on new national or local government policies that restrict SHSe in public buildings. Thus, policies can jump-start the prohibition of smoking (to prevent nonsmokers' SHSe) and by doing so speed the new culture that disassociates smoking, SHSe, and drinking and their past common contingent reinforcers. The combination defines multiple levels of "contingencies" where policies alter bar owners' practices that alter smoking, and that alters SHSe, and so forth. Changes in community norms in turn can produce feedback to influence new government policies. While more research is necessary to test these hierarchical relationships, there is already a growing body of research that has shown an association between implementation of smoke-free public policies and more favorable attitudes toward secondhand smoke (SHS) regulations (e.g., Fong et al., 2006; Hyland et al., 2009) and adoption of household smoking bans (e.g., Borland et al., 2006; Fong et al.; Norman et al., 2000).

### Culture at the center of control of tobacco

Korean businessmen serve as a model subculture with respect to tobacco use and interlocking contingencies. Traditional



**Figure 1.** Behavioral ecological model. *Note.* From “Adolescent Health: Understanding and Preventing Risk Behaviors,” by R. J. DiClemente, J. S. Santelli, and R. A. Crosby. Copyright 2009 by the John Wiley & Sons., San Francisco, CA. Reproduced with permission.

Korean men smoke as part of a social contingency system that includes providing cigarettes and tobacco paraphernalia as gifts. Business success depends on smoking, drinking, and partying with supervisors and coworkers after work. However, when these men emigrate to California, their smoking prevalence drops from about 60% to about 30% (Song et al., 2004). We believe that this is due to the antitobacco culture in California countering the effects of former Korean cultural contingencies. Korean males emigrating from Korea to California might compromise their business standing if they continue to smoke. When Korean women move to California, their smoking prevalence goes from 7% in Korea to 17% in California as they approximate full acculturation (Song et al., 2004). This probably represents the effect of acculturation in California, with substantially more gender equity, interacting with the previous Korean contingencies that suppressed female smoking (Hofstetter et al., 2004). These results show that “gender” acts as a marker for unique social contingencies for males and females. This interaction demonstrates the power of subculture contingencies and the importance of engineering gender-specific contingencies to protect women or other “high risk” immigrants from the tobacco industry. One such example is a media program modeled after the “truth” campaign (Farrelly et al., 2002), to counter the industry’s luring women to smoke with promises of equality and freedom.

## The BEM and the tobacco industry

### The tobacco industry knows how to change behavior

The tobacco industry has been changing cultures. Brandt (2007) summarized how the industry has employed concepts from the BEM (e.g., promoting tobacco use among women as a demonstration of gender equality) and made tobacco a central feature of Western culture, if not worldwide cultures. The industry lobbies for laws that protect it. The industry illustrates how to engineer social contingencies that define our tobacco culture.

### Litigation is working but not without compromise

Even as the industry has come under attack through civil litigation, it has turned failures into protectionist policies. However, as recent large-scale litigation has produced “losses” for the industry, there is an impression that the larger culture can exact counter-control (Gostin, 2007). However, negotiated settlements have included clever stipulations. For example, awards to the Flight Attendant Medical Research Institute (FAMRI) were provided to conduct research to prevent or control diseases

linked to SHSe. This spans basic, clinical, and epidemiological science, including large centers of excellence. The FAMRI will yield discoveries that contribute to disease prevention; some studies will improve clinical treatment of tobacco-related diseases, and some will inform effective smoking cessation treatments or prevention of SHSe. However, the settlement precluded research funding for new tobacco policies, including those that might inform means of population-wide protection from SHSe. Nevertheless, the FAMRI remains a model settlement, in contrast to the track record for the Master Settlement Agreement (MSA) between the tobacco industry and attorneys general of 46 states. The MSA is the largest dollar “award” from the industry (Wilson, 1999) but provides almost no support of tobacco control interventions such as media campaigns or tobacco prevention research. So when the industry “loses” a civil suit or fails to block new tobacco taxes, the industry promotes contingencies that deflect attention from tobacco control. As antismoking advocate Godshall (1999) has asserted, “[W]ith unprecedented future legal protection granted by the state [attorneys general] in exchange for money, it appears that the tobacco industry has emerged from the state lawsuits even more powerful.”

### The Food and Drug Administration

With regulation of the industry (the Family Smoking Prevention and Tobacco Control Act), a new experiment in tobacco control may begin (Kennedy, Cornyn, Waxman, & Davis, 2007). Theoretically, such regulation would eliminate nicotine and toxic agents from cigarettes. However, it is unlikely that the Food and Drug Administration (FDA) will be allowed to eliminate the industry. Thus, the outcome of regulation, based on the BEM, will involve new contingencies that may limit the industry’s life or prolong it.

### Complex contingencies produce dependence

Since the World Health Organization tobacco treaty (Framework Convention Alliance, 2008), the processes now unfolding are a function of changes in the antitobacco subculture in the United States, western Europe, and other nations. This suggests future curtailments as nations develop antitobacco cultures, but the timing and degree remain uncertain. One reason for this is that the industry actively pursues systems that guarantee long-term existence. Its ability to lobby legislators is partially based on incredible wealth acquired by selling an addictive product. The industry has also systematically supported all levels of society, from funding local fire departments to funding science in our most prestigious universities (Chapman & Shatenstein, 2001). Its business success attracts investors, including pension funds. Thus, efforts to curtail the industry may hurt the retirement and health services of thousands of workers in the United States alone. Theoretically, such contingencies cause legislators to pause in their efforts to curtail a deadly industry. Research to confirm this is warranted.

The tobacco industry funds academic research in the context of academic freedom norms, offering the public possible “cures” for cancer, heart disease, and so forth. By targeting treatment first and smoking cessation second, the industry ensures minimal effect on its business. These industry contingencies support research and clinical care by the very professionals who should be leading efforts against a harmful

industry. Potentially biased behavior of academics is supported by cultural contingencies of academic freedom. Recognizing these interacting contingencies is a step toward altering them. More research should focus on the direct and indirect effects of industry support for civil governments as well as academic investigators.

### The right to smoke guarantees new addicts

Concepts of self-control and personal decision making prevail in most cultures. These are not consistent with systems theory or the BEM with regard to empirically defined bases for behavior, but such cultures define social contingencies that promote risk practices and suppress the communities’ effort to curtail them. Smokers assert that they have a “right” to smoke (Cardador, Hazan, & Glantz, 1995; Smith & Malone, 2007) and can decide whether to smoke or quit. Such cultural norms of self-control are contradicted by biological and behavioral sciences and retard tobacco control. Exaggerated concepts of self-determination are symbiotic with industry contingencies and are promoted by the industry (Cardador et al., 1995; Smith & Malone), producing a pathological social system. Thus, tobacco control might require reeducation of the public on the complex social systems that determine “personal decisions.”

### Implications and a macro view

The picture we have provided is incomplete but sufficient to show that the United States and other cultures support the industry. This context is so pervasive and continuing to be built by the industry that it is critical to take a macro view of these systems and to launch a tobacco control research policy that includes study of policies that transition the industry to a health neutral or health promoting business. We suggest that one pathway toward this end might emphasize SHSe control.

## Emphasis on SHSe

### SHSe consequences

It is established that SHSe can harm nonsmokers. The adverse health effects include respiratory infections, otitis media, sudden infant death syndrome (SIDS), heart disease, and lung cancer (U.S. Department of Health and Human Services [USDHHS], 2006). Secondhand smoke exposure also increases the risk of a person’s becoming an addicted smoker as a young adult (Becklake, Ghezzo, & Ernst, 2005). This SHSe may occur through prenatal or postnatal exposure to nicotine that could establish early sensitivity to nicotine and predispose the child to addiction. These theoretically plausible effects warrant confirmation by empirical studies. Exposure to secondhand smoke also might cause children to imitate smoking as a function of modeling and socially reinforcing contingencies for smoking, starting with parents, family members, close friends, and ultimately adolescent peers who smoke. For susceptible youth, symptoms of dependence appear within 2 days of first inhaling (Difranza et al., 2007). The industry exploits these modeling processes by advertisements that promote smoking by women and preteens and this perpetuates smoking into the next generation.



The damage done by SHSe is huge. From coronary heart disease alone, up to 75,000 deaths are attributable to SHSe (Lightwood, Coxson, Bibbins-Domingo, Williams, & Goldman, 2009). Secondhand smoke exposure costs billions of dollars in excess medical care for U.S. children and billions more in annual loss of life (Adams & Young, 1999; Aligne & Stoddard, 1997).

### Population standards for SHSe

In 2000, 25% of U.S. children were exposed to SHS (Soliman, Pollack, & Warner, 2004). Healthy People 2010 objectives are to reduce child SHSe prevalence below 10% (USDHHS, 2000). However, the U.S. Surgeon General has declared that there is no safe level of SHSe (USDHHS, 2006). Ultimately, no one should be exposed.

### Changing priorities to SHSe control

A recent study estimated that California's antismoking program saved the state \$86 billion in health expenditures between 1989 and 2004 (Lightwood, Dinno, & Glantz, 2008). These estimates exclude the treatment costs for other diseases or indirect costs. This study also showed that declining SHSe rates can prevent disease, related deaths, and related costs. The results suggest that culture change can produce huge health effects and cost savings. Realizing billions of dollars in health benefits and financial savings warrants far more attention to SHSe prevention research and related policies to effect culture-wide change. Smokers are products of the industry and our cultures. Based on the BEM, antitobacco efforts should capitalize on existing societal contingencies to protect vulnerable members and members who have not "elected" to smoke but are exposed to SHS. One such norm is the protection of vulnerable members of society, such as infants, young children, the poor, and the ill. Another norm is that nonsmokers should not suffer the consequences of smokers. Imitating the techniques employed by the industry to address SHSe including half of the world's children (World Health Organization, 1999) would likely be powerful "medicine" against tobacco. However, these should be restricted to legal and ethical interventions. Consider SIDS: Some cases of SIDS probably reflect medically compromised infants who happen to obtain sufficient exposure to maternal smoking during pregnancy and to postnatal SHS (Brownson, Eriksen, Davis, & Warner, 1997; USDHHS, 2006). It seems critical to protect all infants from SHSe to avoid these unnecessary deaths. For others, lifelong exposure to low doses of SHS remains a public health problem of importance due to the increased risk of morbidity and premature mortality.

A greater investment in prohibiting SHSe is theoretically likely to curtail the industry. The United States and other nations should emphasize the elimination of SHSe in all microenvironments such as work settings, private homes, and outdoor settings where nonsmokers could be exposed, such as parks (Giles-Corti et al., 2001; Henriques, Newton, & Marshak, 2003). The new agenda represents a shift to prevention. To be comprehensive, modeling of smoking and SHSe should be avoided, including in artistic and recreational media (e.g., TV, movies, the Internet).

Public health harm-reduction proponents argue correctly that smokeless tobacco products are less harmful than smoke (and may eliminate SHSe). If emphasis on SHSe were to eliminate cigarette smoking and SHSe (possibly in favor of smokeless products), it would reduce the disease burden. However, the

contribution from smokeless products and SHSe reduction requires empirical confirmation. We suggest that public health policies and tobacco control research that emphasizes SHSe prevention will move the industry to alter its products, possibly starting with smokeless tobacco. The harm reduction proponents would see such change as a major public health success. We agree. However, advertising and modeling smokeless products will communicate more use of smokeless products, leading to disease, even if in a smaller subgroup than is true of cigarettes. Thus, smokeless tobacco products are not free of harm. Should such a shift take place, we would argue that since there is no benefit derived by the tobacco user or the public from tobacco products, any harm justifies precluding the production and sale of even smokeless tobacco products.

The BEM provides concepts of additive and synergistic effects of community level contingencies. This includes the role of clinicians in treating existing tobacco-related diseases, promoting tobacco cessation, and even promoting SHSe prevention in private homes and cars for their patients. Increased services focused on tobacco control in general and SHSe reduction in particular will sensitize patients and whole families, possibly supporting larger scale community-wide interventions aimed at prevention of SHSe, tobacco initiation, and consequential addiction and disease. The combination will yield an antitobacco culture that might eliminate or change the industry. Such culture change might be sufficient to preclude tolerance of smokeless tobacco products. Research is needed to identify specific policies and social contingencies that greatly reduce smoking and SHSe.

### Directions for clinical intervention to reduce SHSe

Secondhand smoke exposure is caused by smoking. In addition to smoking cessation interventions, we need programs that focus on SHSe to protect children and others, since most smokers do not quit and most who do quit return to smoking within 1 year (Fiore, Bailey, & Cohen, 2000; Fiore, Smith, Jorenby, & Baker, 1994; Ranney, Melvin, Lux, McClain, & Lohr, 2006; Rigotti, Munafo, & Stead, 2007).

Following the BEM, a community-wide systems approach should be constructed to protect all nonsmokers from SHSe. This will require designing interlocking contingencies that promote a culture that does not tolerate smoking in the presence of nonsmokers. Theoretically, such a system would involve community-wide "interventions," including policies, media campaigns, educational services, and clinical services, to name a few.

The clinical service industries offer a potential means of moving the culture forward without having to build major new policies. All clinical services, not limited to smoking cessation, can include requests to stop smoking, referral to clinical cessation services, and advice to protect children and other nonsmokers by never smoking at home, in the car, or other settings. If such advice were routinely delivered, most of the population would obtain advice and recommendations to stop smoking and to protect all others from SHSe. Theoretically, the degree to which such advice becomes universal begins to define an antitobacco culture.

## Smoking cessation services

Five minutes of brief smoking cessation advice by physicians could increase quit rates from about 5% at baseline to about 15% at follow-up (Folsom & Grimm, 1987; Janz et al., 1987; Russell, Wilson, Taylor, & Baker, 1979). The current U.S. policies promote the “five A’s” (ask, advise, assess, assist, and arrange) and encouraging physicians to ask and advise their patients not to smoke. While more physicians are delivering brief advice, more research is needed to learn how to promote such advice from all health care providers. If all providers employed brief advice, the cumulative effects might be significant.

The most affordable interventions are likely to be brief advice, but they tend to be the least powerful. A subset of clinicians—for example, preventive medicine specialists—might offer more intensive interventions. This might include medications such as nicotine replacement therapy and Zyban for assisting with cessation. Some services are a good fit for this type of care. Families returning regularly for well-baby visits might be provided intensive clinical services by the pediatrician or assistants using tailored counseling, feedback, and incentives. Interventions could also provide financial and social contingencies to motivate cessation. Financial contingencies include vouchers—for example, \$50/month to pregnant women for quitting smoking (Donatelle, Prows, Champeau, & Hudson, 2000), or \$100 to employees for completing a smoking cessation program (Volpp et al., 2009). Social contingencies include social support provided by a non-smoker who has a close relationship with the smoker (Donatelle et al.). More research is needed in these promising areas.

## “Minimal interventions” for SHSe

Minimal interventions for SHSe have not yet been tested. In a randomized trial with more than 2,000 families, Wall, Severson, Andrews, Lichtenstein, and Zoref (1995) provided minimal counseling and video materials for maternal smokers and explained that quitting would protect their child from SHSe and its health consequences. Parents were shown a video at the first well-baby visit and were provided written materials and brief advice from the pediatrician at well-baby visits at 2 weeks and 2, 4, and 6 months. This resulted in 7-day abstinence of 2.7% in control families and 5.9% in experimental families at 6 months. However, the study focused on smoking cessation outcomes. No SHSe measures were obtained to determine whether changes in SHSe were obtained in homes, or whether parents smoked outside. Had this study included measures of SHSe, it might have demonstrated a direct effect on SHSe.

Future studies should determine the likely effect of brief and low-intensity interventions for SHSe that could be distributed across many clinical services. Such studies should involve direct instruction on how to establish home bans and how to keep children from contact with smokers outside the home. Following our work with tobacco prevention among preteens, we assume relatively small effects from such minimal interventions (Matt et al., 2008b; Wahlgren, Hovell, Meltzer, Hofstetter, & Zakarian, 1997). If so, these studies require large sample sizes. However, minimal interventions may be sufficient to promote change in an important but small percentage of the patient population. If so, population-wide effects could have profound clinical benefits.

## Clinical interventions addressing SHSe

Clinical interventions for SHSe have emphasized counseling parents to smoke away from their children. Motivational inter-

viewing techniques and similar counseling procedures provide a combination of health education about SHSe and its health consequences and practical means of avoiding smoking around children; and counselors who prompt and provide social reinforcement for parents’ report of change in exposure practices. The number of sessions have varied across studies from as few as 3 to as many as 14 over weeks. A limited number of sessions (e.g., <4) provides education and promotes verbal contracts to avoid smoking when the child is present (e.g., in the same room). Longer and more frequent sessions approximate shaping procedures by gradually encouraging the parent to reduce the child’s exposure.

Several counseling trials have reported significant SHSe reductions, including studies of asthmatic children, Latinos, and low-income mothers (Emmons et al., 2001; Greenberg et al., 1994; Hovell et al., 1994, 2000, 2002; Wahlgren, Hovell, Slymen, Conway, Hofstetter, & Jones, 1997). Thus, individualized parent counseling may reduce children’s SHSe for low-income and racially diverse families. Frequent contacts for home-based interventions appear most effective (Gehrman & Hovell, 2003). However, because most studies have been limited to parents avoiding smoking in the same room with a child, the parent may have met that standard, but SHSe reduction may have been insufficient to detect by air dosimeters or cotinine markers. Nicotine and cotinine markers may better reflect the degree to which all sources of exposure have been eliminated. No study has tried to eliminate all sources of exposure. Almost all studies have been efficacy trials; none has demonstrated effectiveness (Zakarian et al., 2004). Thus, advancing the clinical science requires testing more aggressive efficacy and effectiveness trials that target complete protection from SHSe.

## Motivation versus guidance

In some of our studies, most of the reduction in SHSe followed after 3–5 sessions. This suggests that early responders make relatively easy changes that reduce their child’s exposure. Such changes do not require parenting skills or much compromise in normal smoking patterns. To achieve more will require more powerful interventions not yet tested in counseling. For instance, a home “ban” on smoking might require teaching mothers skills to deal with husbands, grandparents, and other smokers who are not normally restricted from smoking. Future research should focus on the social skills needed to enforce complete tobacco bans in private homes and/or other means of protecting nonsmokers who establish home bans from smokers who disagree (Escoffery, Kegler, & Butler, 2009; Winickoff et al., 2009).

We have seen families in which the parent has skills to require a smoking ban but the child remains exposed. This is a problem of motivation and may not respond to counseling. In these cases, counseling should be bolstered by more powerful “incentives” or formal contingencies of reinforcement, such as payments for change in smoking behavior (Donatelle et al., 2000; Petry, Alessi, Marx, Austin, & Tardif, 2005).

## Future clinical services for SHSe reduction

We have not yet identified the combination of procedures that reliably produces marked reductions in SHSe (Priest et al., 2008). One direction is to test combinations of existing clinical

procedures. This might involve counseling, financial, and social contingencies for change. Evidence to date suggests that counseling can reduce exposure, but not always and not completely. To test more intensive interventions, clinical services should be more sophisticated by use of shaping and contingency contracting procedures and by immediate and ongoing feedback; cotinine assays should be available to providers; and both financial and social contingencies should be engineered as part of the intervention. With additional tests of intensive interventions for SHSe reduction and with new trials devoted to minimal interventions, it may be possible to identify both relatively intensive treatments for highly addicted smokers and minimal interventions that may be sufficient for most families to protect children from SHSe. Collectively, combined procedures, minimal interventions, and intensive interventions could yield interventions theoretically more powerful than any tested yet and might contribute to an antitobacco culture.

### Improving community-wide interventions and changing cultures

#### Clinical services to influence culture

Clinical services are part of the process of influencing communities to change risk practices. Varying degrees of educational, clinical, and motivational interventions could be institutionalized in all types of services. This includes all medical specialties, incidentally providing brief advice not to start smoking, not to smoke around anyone else and never in one's home or car, and to quit, if a smoker. If this advice were provided for all non-emergent patient visits, it would reach a huge proportion of the population. Most parents and their children would obtain advice multiple times per year. Ignoring the potential direct effects, the cumulative effects of such advice might change community-wide norms from tobacco acceptance to intolerance of SHSe. Since this logic is dependent on both theory and limited empirical evidence that brief advice can change a small but important proportion of the population's behavior dramatically (e.g., quit rates when advised by physicians) and might result in more subtle changes in larger groups, wholesale adoption of brief advice may be premature. However, it could be implemented and tested in selected communities following quasi- and natural experimental models. Women, Infants, and Children programs might add tobacco control services as families return for nutritional services for one or more children over years. Extension to services outside the health care system (such as advice from one's barber or hairdresser) across social classes of the population could produce significant results. There is precedence for such research (Linnan, Emmons, & Abrams, 2002; Solomon et al., 2004) suggesting a prevention role for businesses in the community.

#### Engineering social contingencies

We have shown that measuring tobacco use and SHSe can be "reactive" and can decrease the "control group's" smoking level and its children's SHSe (Hovell et al., 1994; Wahlgren, Hovell, Meltzer, et al., 1997). Parents are sensitive when studies use cotinine biomarkers, nicotine wipes, air dosimeters, and vacuuming of dust samples from homes and cars (Matt et al., 2004, 2008a).

Such reactivity complicates randomized trials and raises questions about use of minimal measurement to reduce reactivity. Most measures are not provided frequently or immediately following behavior change; this may reduce their reactive influence. Measurement itself might be designed as inexpensive interventions with relatively powerful effects. Principles of learning suggest that immediate and frequent feedback could be more influential. If clinicians provide parents with feedback at the office about their child's cotinine, it might prompt greater changes at home; if the child's cotinine decreased at subsequent visits, feedback and praise from the provider might reinforce decrease in SHSe to the child. If feedback were provided in the home immediately as the exposure occurs, it might prompt and reinforce changes in exposure even without the clinician's involvement. However, if the clinician also received home exposure readings via telemetry, he/she could provide additional prompts for change and/or offer social reinforcement for successfully keeping one's home smoke free for extended periods. The *biomarker* technology is available for clinic-based feedback but not immediate feedback. The technology for *environmental* markers to deliver immediate SHSe feedback to family members is available now but requires system development and effectiveness testing. Studies of feedback systems are exciting directions for SHSe research.

#### Addressing "thirdhand" exposure

Homes and cars become contaminated by cigarette smoke. Such contamination can be a source of thirdhand exposure when the child comes in contact with contaminated surfaces or breathes the air when such contamination "off-gasses" (Matt et al., 2004, 2008a). Children are more likely to engage in floor contact and hand-to-mouth behavior (e.g., putting contaminated objects in their mouths), and, compared with adults, their higher rate of respiration may result in greater inhalation of off-gassing from cigarette smoke contaminants. Thus, allowing children into homes contaminated by cigarettes, even if no one smokes when the child is present, may result in thirdhand exposure. Since most counseling studies have relied on cotinine as the "objective" outcome measure, and cotinine may be sensitive to contamination sources of exposure that were not the targets of change, this may contribute to failure to reduce cotinine or to find group-by-time interactions. Future trials should use environmental markers to verify parent reports for proximal effects of counseling, such as reduced air contamination. Eventually, counseling should promote complete bans of smoking in the home, car, and all microenvironments that children frequent. This will require more intensive counseling procedures than have been tested to date. Future research should also determine levels of SHSe attributable to contaminated homes and cars versus visible smoke and the time it takes to off-gas completely. Depending on the results, this information can be leveraged for stronger tobacco control policies against smoking in microenvironments that include children, such as banning smoking in housing where children live or might live in the near future (Winickoff et al., 2009).

#### Smoking policies, taxation, and media

Public smoking bans and workplace smoking bans may alter the social network in the community, making tobacco and SHSe culturally unacceptable. Policies that restrict smoking in public buildings have reduced SHSe, have been associated with lower

rates of smoking, and have not caused a loss of business revenue (Brownson et al., 1997; USDHHS, 2006). Taxing tobacco sales has also suppressed tobacco purchases and contributed to lower level smoking if not cessation (Levy, Chaloupka, & Gitchell, 2004; USDHHS, 2006). Media campaigns offer face valid means of educating the public but may have limited influence for those already addicted. However, if media conveyed an antitobacco culture or a tough love approach, where nonsmokers were encouraged not to tolerate smokers while they are smoking, it might reduce smoking and SHSe rates (Bala, Strzeszynski, & Cahill, 2008; Evans et al., 2006; USDHHS, 2006). Media also can promote consumer activism by encouraging the public not to patronize businesses that directly or indirectly support tobacco. This could include boycotting movies that show smoking. Policies are difficult to pass through legislative systems and media advertising is expensive, with most “programs” designed to entertain and/or promote commercial products. Thus, it will require considerable empirical support and culture change to motivate legislators to aggressively establish policies that counter the industry and protect the public from SHSe. It will also require legislative policies to promote media programs to the same end. This will take time, and cumulative research concerning SHSe prevention may contribute to such media and policies.

## Litigation and regulations

SHSe policy development is advancing for high-density housing and families undergoing divorce. Some communities are using regulations of the Environmental Protection Agency for protection from SHSe in apartments and condominiums (Bandura, 1989; Helburn, 2007; Hong, Barnes, & Glantz, 2007; Prochaska et al., 1992; U.S. Environmental Protection Agency, 2005). These usually involve formal restriction policies and even threats of fines or eviction if others are exposed to smoke. Divorce proceedings also have considered the child’s SHSe in custody rulings (Rosenblatt, 2005). Again, these custody decisions threaten parents with aversive consequences, such as loss of custody. These policies are evolving in the absence of adequate consideration of policies that might promote positive means of restricting SHSe to children and nonsmoking adults. Addicted parents, even if divorcing, are a product of an industry and culture that promotes such addiction. They should not be treated as perpetrators of crime (Hovell & Daniel, 2005). Parents may require tobacco cessation services and intensive social skills training to establish and enforce complete home bans for tobacco use. They might warrant court contingencies for long-term monitoring of their home to ensure that it remains smoke free. This domain warrants more research that emphasizes “natural experiments” and experimental analyses.

## Conclusions

Our research and review suggest that emphasis on treatment of disease or smoking cessation services cannot offset the industry’s ability to produce new addicts. Similarly, smokeless tobacco products will likely promote new addicts via modeling and social contingencies. Thus, even if they reduce harm relative to smoke-producing cigarettes, they too may yield more harm than benefit. We believe that interventions can reduce SHSe, lower smoking initiation, and increase long-term cessation rates. Moreover, as more and more people get accustomed to a smoke-free environment, this strengthens an antitobacco culture.

Based on the BEM, we expect that emphasis on SHSe elimination in all micro- and macroenvironments, in both outdoor and indoor areas, if achieved, will eliminate places where smokers can smoke without criticism. As criticism increases, it may generalize to other sanctions. For example, used cars sell for about 9% less if contaminated by an owner who smoked compared with an uncontaminated car owned by a nonsmoker (Matt et al., 2008b). This suggests that the culture is shifting in subtle ways that generate financial costs for contaminating microenvironments. While the evidence is not yet available, we suspect similar and greater costs for contaminated private homes, apartment owners, and hotels. This is implicitly supported by the trend in hotels restricting all smoking in all rooms (Stoller, 2009; USDHHS, 2006). As smoking areas lessen, we expect smoking initiation to decrease and quitting to increase. Decreases in the prevalence of smokers will further decrease social acceptance of tobacco and make smoking less convenient. This might move many to question investments in the industry or acceptance of its support. With financial pressure, industry stockholders might be motivated to work with governments to transform their business from sale of an addictive product to sale of health-enhancing products.

These types of changes are predicated on cumulative and synergistic changes in contingencies within and across national cultures. It is guided by the BEM. To the extent that this model is valid, it serves as a basis for national and international research to inform the World Health Organization and national government agencies to design policies that could curtail SHSe and promote a change in the industry. One example is the first international health treaty—the Framework Convention for Tobacco Control—which has been signed by most member nations (Framework Convention Alliance, 2008).

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## Declaration of Interests

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