

Reducing children's exposure to environmental tobacco smoke: the empirical evidence and directions for future research

Melbourne F Hovell, Joy M Zakarian, Dennis R Wahlgren, Georg E Matt

Abstract

Objective—To summarise the issues and empirical evidence for reduction of children's residential environmental tobacco smoke (ETS) exposure.

Data sources—Literature was obtained by computer search, with emphasis on studies that included quantitative measures of ETS exposure in children's residences and interventions based on social learning theory.

Study selection—Review and empirical articles concerning ETS exposure were included and inferences were drawn based on a synthesis of these studies as contrasted with a quantitative meta-analysis.

Data synthesis—Interventions designed for residential/child ETS exposure control have included policy/legal regulations, minimal clinical services, and counselling services. Divorce court and adoption services have limited custody to protect children from ETS exposure. Controlled trials of clinicians' one time counselling services have shown null results. One controlled trial found that repeated physician ETS counselling increased parent cessation. Three trials found that repeated counselling/shaping procedures reduced quantitative estimates of ETS exposure in asthmatic children.

Conclusions—Insufficient controlled studies of repeated session counselling procedures have been completed to determine efficacy for ETS exposure reduction, but evidence is promising. One time minimal interventions appear ineffective, but large scale studies may be warranted. No studies have been conducted to assess court or adoption agency regulations; no community ordinances for regulating residential ETS exposure have been invoked. Ethical and enforcement issues are discussed.

(Tobacco Control 2000;9(Suppl II):ii40-ii47)

Keywords: environmental tobacco smoke; passive smoking; interventions; counselling

Cigarette smoking is a leading cause of morbidity/mortality.¹ Environmental tobacco smoke (ETS) exposure is associated with lung cancer² and has been classified as a carcinogen.³ ETS exposure is linked to pulmonary and ear disease, and sudden death in

infants.³⁻⁹ ETS is the third leading preventable cause of death.¹⁰

The public health consequences of ETS exposure are enormous. Most smokers are of child rearing age, leading to as many as 50% of children exposed in their homes.⁸⁻¹¹⁻¹⁶ Data from the national health and nutrition examination survey (NHANES) indicated that 43% of US children lived in a home with at least one smoker.¹³ The Centers for Disease Control and Prevention (CDC) reported prevalence of children's ETS exposure in the home ranging from 11.7% to 34.2% by state, based upon numbers of homes with an adult smoker where smoking was reportedly allowed in some or all areas.¹⁷ Huss and associates found that 56% of families with an asthmatic child included a smoker.¹⁸ Prevalence estimates vary, yet suggest extensive residential exposure to children. These rates may be underestimates owing to measurement error,¹⁹ and the true burden of morbidity/mortality attributable to ETS exposure may be greater than they suggest.

The present report summarises issues and empirical evidence for reduction of children's residential ETS exposure. Interventions to reduce ETS exposure are summarised and, based on a synthesis across studies, recommendations for future research are provided.

Data sources and study selection

The literature reviewed was obtained by computer search, from which an illustrative epidemiological background of ETS exposure among children is provided. Studies that emphasised quantitative measures of children's ETS exposure and interventions that followed social learning theory principles were included. The few studies that employed both a quantitative measure of ETS exposure and interventions based on learning theory were contrasted (implicitly) with studies for which less precise measures and less powerful interventions were employed.

Reducing children's ETS exposure

The World Health Organization recommended legislation and education to protect children from ETS exposure.⁸ However, few studies have demonstrated efficacious interventions. Obviously, getting smokers to quit smoking should protect children from ETS exposure.²⁰ However, Wahlgren and colleagues found that 67% of parents were unable to quit or reduce

Center for Behavioral Epidemiology and Community Health, Graduate School of Public Health, San Diego State University, San Diego, California, USA
M F Hovell
J M Zakarian
D R Wahlgren
G E Matt

Correspondence to:
Mel Hovell, PhD, MPH,
C-BEACH, 9245 Sky Park
Court, Suite 230, San Diego,
CA 92123, USA;
behepi@rohan.sdsu.edu

their asthmatic child's ETS exposure after physician advice.²¹ Thus, something more than advice to quit is needed to achieve adequate protection.

THEORY

Borland reviewed theoretical models underpinning health behaviour interventions, including those for reducing ETS exposure.²⁰ He concluded that social learning theory (SLT) provides the best model for understanding ETS exposure practices and for informing means of changing them. This model emphasises reinforcement and modelling, where behaviour is promoted by seeing models and by sustained reinforcement. We have extended this model to a "behavioural ecological model" of behaviour that emphasises cultural contingencies of reinforcement.^{22, 23} First, smoking around children can be broken down into component behaviours that can be targeted for change. This can include smoking outside, smoking only when the child is not present, smoking fewer cigarettes, etc. Second, the model asserts levels of environmental control. At the individual level, biological feedback systems (that is, withdrawal symptoms) prompt smoking and doing so provides relief and pleasure. These reinforcing consequences sustain smoking. However, as family, friends, or others criticise smoking and ETS exposure or encourage alternative behaviour (for example, smoking outdoors), the rate, timing, and context of smoking can change. Social contingencies can compete with biological and industry contingencies.

Third, influence can come from social agencies more distant than family and friends. This includes clinicians, the broader society, and media. These sources of influence range from minimal to intensive in nature. Physician advice might be considered minimal and ongoing counselling might be considered more intensive interventions. Borland²⁰ has noted that clinical interventions are unlikely to be cost effective for tobacco control. However, this judgment may be premature and may miss the larger principle. Tobacco control requires all available interventions simultaneously in order to reduce both smoking and ETS exposure to near zero levels, especially in light of the ongoing tobacco industry's effort to promote smoking. Cost effectiveness concerns should be postponed until efficacious interventions, including multi-level community wide interventions, have successfully offset the effects of the tobacco industry.

Interventions employed for ETS exposure control have been policy based restrictions in public buildings, legal sanctions for residential exposure to children, media/educational influences, and clinical services. Almost all of these interventions have evolved based on anecdotal evidence and limited use of learning theories. None has yet been perfected or applied in an extensive manner throughout a community. Studies of these interventions have been few and usually limited to surveys. Future intervention development and research should be based on learning theory, including integra-

tion of cultural contingencies and combined interventions.

POLICY AND REGULATIONS OF ETS IN PUBLIC BUILDINGS

Ordinances that ban smoking in public buildings are effective in controlled environments, may influence ETS exposure in residences, and may serve as models for residential policies. Thompson and colleagues surveyed over 20 000 adults and found that ETS exposure was related to degree of regulation at work.²⁴ Moskowitz and colleagues found that more restrictive community ordinances were associated with less ETS exposure.²⁵ Eisner and colleagues studied bartenders before and after smoking prohibition and found ETS exposure was reduced from 28 to 2 hours per week.²⁶ Respiratory symptoms decreased and pulmonary function increased after the policy was in effect, suggesting improved health. Based on particle size and density, Repace has computed estimates of ETS exposure under varying degrees of ventilation and room size. He concluded that the most reliable means of reducing ETS exposure is to ban smoking indoors.²⁷ Abernathy and associates used air dosimeters in public places for one week before and following a ban on smoking.²⁸ A 67% decrease in nicotine levels was observed. They suggested that bans for public buildings might decrease ETS exposure in homes.

This possibility is supported by data showing that bans in public settings are associated with fewer adults remaining smokers and lower levels of smoking.²⁹ This should reduce ETS exposure in residences. A recent survey of over 48 000 adults suggested that smokers who lived or worked in a home or worksite with a ban on smoking were more likely to quit and were more likely to be light smokers, respectively.³⁰ Odds ratios for quitting were larger for those living with a ban on smoking compared to odds ratios for those who worked with a workplace ban. This was significant for families with only one smoker. Winkelstein and colleagues found that children's urine cotinine was negatively associated only with smoking outside.³¹ This suggests that a ban on all in-residence smoking may be required to decrease children's ETS exposure. However, banning home exposure is not the same as banning smoking in public buildings. Punishment is not as easily constructed for violators in homes as it is in public buildings. Home "policies" may be limited to signs and instructions prohibiting smoking in the home. These are likely to work only if the policy "setter" is able to apply some type of reinforcement for not smoking indoors and/or punishment for violations. Research is needed to determine the social factors that cause a parent to set anti-smoking policies and that determine his/her enforcement procedures and their effectiveness.

RESIDENTIAL POLICIES FOR ETS EXPOSURE CONTROL.

Community ordinances banning smoking in homes are summarised by Ezra.³² He points out that competition exists between individuals' rights to privacy and the community's obligation to protect children's health. Though no laws have been enacted to restrict children's ETS exposure in homes, legal sanctions have been employed in special cases. Ezra³² and Ashley and Ferrance³³ point out that ETS exposure has limited child custody/visitation privileges in divorce cases and disqualified adoption applicants. These cases set precedence and may be forerunners of community ordinances to protect children in homes.

Policies restricting visitation rights only if the parent does not expose his/her child to ETS have face validity. *However, no research has verified that restrictions actually result in lower ETS exposure.* Parents restricted from smoking around their children as a condition of custody might do so in private. Enforcing court orders is difficult and exposure will depend on degree of enforcement. Effective enforcement may require development of real time objective measures as well as ethical considerations about penalties.

Sanctions to control ETS exposure in residential settings imply punishment for violators. This could have unintended consequences, including counter aggression from smokers. Ezra cites a case in which a smoker was asked to not smoke in a restaurant and returned and killed the non-smoker with a shotgun.³² Future research should target positive means of reducing exposure, especially since smokers themselves are victims of the tobacco industry. Sweda suggests that policy restrictions in residences will be necessary.³⁴ If so, research is needed to define efficacious and acceptable policies that do not infringe on traditional constitutional rights.

MEDIA AND POLICY INTERVENTIONS

Borland and colleagues assessed the effects of ordinances and educational/media campaigns on smoking practices of six different samples of 2500 adults from 1989 through 1997.³⁵ Results showed an increase in the proportion (14% to 33%) of respondents who did not smoke near children and an increase in the proportion (20% to 28%) who smoked outdoors. Adults who lived with non-smokers, with children in the house, and who whose worksite banned cigarette smoking were most likely to restrict indoor smoking. This study implies that public building ordinances and media may influence residential smoking practices. However, these results also suggest that the majority of smokers did not reduce children's ETS exposure as a result of these interventions. Since the media emphasised health effects of ETS exposure, and since the majority of families did not change, more than information about health effects is needed to reduce ETS exposure for most families.

CLINICAL SERVICES FOR ETS EXPOSURE REDUCTION

A number of studies have tested clinical/educational interventions for ETS exposure reduction among children. These have included brief interventions to repeated counselling over weeks. Woodward and associates found no effects when they provided women with a pamphlet that instructed them to protect their infants from smoke exposure.³⁶ Chilmonezyk and colleagues assigned mother/child to groups at random.³⁷ Physicians phoned mothers to report their baby's cotinine concentration and advised them to avoid exposing their baby to tobacco smoke. No significant differences were obtained in cotinine measures at post-test. It is likely that their use of cotinine "feedback" served as a weak prompt for action. Use of feedback may be more powerful as a consequence for actions already taken.

Vineis and colleagues studied patients receiving vaccinations by nurses who counselled for 15 minutes concerning ETS exposure and accident prevention.³⁸ No short term outcomes were reported and two year follow up assessments showed no differences in exposure. Brief interventions rarely have effects that last as long as two years.

Murray and Morrison³⁹ conducted surveys of two cohorts of parents and found a lower rate of smoking in the room with an asthmatic child and fewer symptoms in a second, compared to an earlier cohort. They suggested this effect might be owed to physician advice, but numerous confounding variables also could explain the observed association. McIntosh and associates provided a more extensive but minimal intervention for families with an asthmatic child.⁴⁰ Patients were assigned at random to conditions. Controls were provided with physician advice and a booklet about ETS exposure. The treatment group obtained the same plus cotinine feedback and a letter from the physician. Significant group differences were found for "trying" to smoke outside, but differences for actually smoking outside did not reach significance. In light of the relatively small differences between control and treatment procedures, these results are encouraging. Irvine and associates conducted a similar study of asthmatic children.⁴¹ Patients were assigned at random to control and experimental conditions. Parents were provided with education/counselling regarding ETS exposure and health effects, exposure reduction, and smoking cessation. Brochures were mailed with a letter at four and eight months. At one year, no significant differences were found for child cotinine or parent smoking. Previously, Eriksen and Bruusgaard conducted a controlled trial of ETS exposure reduction for healthy children.⁴² During well-child clinical visits, parents were counselled and given brochures explaining ETS effects, how to protect children from ETS exposure, and smoking cessation. No significant differences were found.

Wall and colleagues⁴³ conducted a controlled trial of newborns. Offices were assigned at

random and analyses adjusted for cluster effects as well as other covariates. Over 2000 patients completed the study. Control patients were provided with an ETS information packet and a letter from their physician advising tobacco control. The "extended" intervention group received the same packet along with two minutes of physician counselling and additional written materials at two, four and six month visits. Physician training and quality assurance procedures were employed to maximise physician counselling. Although ETS exposure was not measured, results showed significantly higher rates of smoking cessation (2.7% *v* 5.9%) and sustained non-smoking status (45% *v* 55%) at six months in the extended treatment group. This study shows that under precise supervision minimal ETS interventions carried out *over repeated contacts* can reduce smoking rates and by implication ETS exposure for newborns. The authors also noted that the presence of another smoker in the home (often a husband) was associated with failure to quit among smokers or with relapse among quitters.

These studies suggest that brief, usually one time, counselling sessions are not sufficient to reduce ETS exposure in asthmatic or healthy children. It is not surprising to find that a powerful addiction such as smoking is difficult or impossible to change by brief counselling. The reinforcing contingencies that maintain smoking and exposure practices must be changed or new contingencies added to counter them. One time interventions are unlikely to change contingencies. However, some parents may be undergoing changes in social contingencies—friends and family, media, and worksite influences—to stop smoking or avoid exposing others. The addition of physician advice may yield the cumulative level of combined interventions to evoke reductions in ETS exposure practices. To detect the few individuals for whom the confluence of events might lead to ETS exposure changes requires very large samples and very accurate measures. Since these interventions are relatively inexpensive, future studies should be conducted with sufficient sample size and accurate measures to test minimal interventions more thoroughly.^{44 45}

The study by Wall and colleagues⁴³ suggests that minimal interventions that are delivered over time in response (implicitly) to changing patterns of smoking or ETS exposure may be efficacious for tobacco control, including ETS exposure reduction. This study focused on newborn infants and capitalised on motivation of mothers to protect their newborn children. Butz and associates surveyed parents of children with respiratory disease (for example, cystic fibrosis) and found that 80% had decreased smoking or smoked outside after diagnosis.⁴⁶ Only 40% of parents with healthy children reported similar changes. These findings suggest that newborn status and respiratory disease may enhance parents' motivation to alter tobacco use to protect their children. Theoretically, in the study by Wall and colleagues,⁴³ the combination of ongoing physician support and motivation to protect

a new child was sufficient to evoke an important but small proportion to quit or stay quit after delivery. Additional studies need to determine if these effects are replicable and whether they are durable beyond six months. These studies also collectively show that even when minimal interventions "work", they do so only for a small proportion of the population. This means additional interventions will be needed for the majority of children who live with a smoker.

CLINICIAN COMPLIANCE

Even if these interventions are efficacious for a small proportion of patients, getting clinicians to provide these services is not automatic. Hymowitz surveyed paediatricians and found that fewer than 50% distributed smoking control and ETS materials, and fewer than 12% provided follow-up sessions.⁴⁷ Narce-Valente and Kligman provided physicians with training to conduct screening and counselling for passive smoking.⁴⁸ Fewer than 50% attended the training and chart reviews showed no more than 6% provided screening or counselling. These studies suggest that more will be needed to get clinicians to perform even minimal interventions for tobacco control. Our investigations suggest that social learning variables, including reimbursement, apply to clinician prevention services as they do to patients' practices.⁴⁹⁻⁵¹

SHAPING CHANGE IN ETS EXPOSURE PRACTICES

Similar to and predating the study by Wall and colleagues,⁴³ two investigative teams have conducted experimental studies using quantitative measures of ETS exposure and repeated counselling interventions based on social learning theory. Meltzer and colleagues conducted a quasi-experimental study where counselling was provided over four weeks.⁵² Counselling included information about asthma, ETS exposure effects, and means of reducing exposure without having to quit smoking. Counsellors used problem solving and shaping to guide parents to smoke outdoors or away from children. Counselling was associated with 40–80% reductions in reported ETS exposure. Additional reductions were obtained at a one month follow up.

Greenberg and co-investigators conducted a controlled trial of newborns using multivariate analyses of trends in ETS exposure.⁵³ A nurse provided four 45 minute in-home counselling sessions using procedures similar to those of Meltzer and colleagues.⁵² Mothers identified means of reducing ETS exposure and/or requested assistance for quitting. Refinements were negotiated at follow up visits. Measures were obtained at baseline, seven months, and 12 months. For mothers who were smokers, those in the experimental group decreased exposure significantly more than did controls. Among non-smokers, overall level of ETS exposure was lower than for smokers and trends showed increases in both experimental and control groups. However, the increase was smaller for the experimental group and this difference reached significance. Most of the reported intervention effect was attributable to change in a smoking mother. Patterns of

reported ETS exposure reduction among smoking mothers showed six month maintenance from end of counselling to 12 months. Cotinine results showed increases over time in both the control and experimental groups and differences did not reach significance.

Hovell and colleagues⁵⁴ replicated the Meltzer⁵² intervention with asthmatic children about the same time that Greenberg and colleagues⁵³ conducted their trial. Families of asthmatic children (n = 91) were assigned at random to a control, monitoring or counselling condition. Counselling sessions in the clinic or home were provided over six months. Results for reported ETS exposure showed decreases in all groups with monitoring alone. Exposure in the control group decreased the least followed by the monitoring and then the experimental group. Group by time interactions showed that the counselling group obtained greater decreases in ETS exposure than either the control or monitoring condition. Lowered ETS exposure was sustained for six months. Correlations with passive nicotine dosimeter and symptoms validated reported ETS exposure.⁵⁵⁻⁵⁷ Wahlgren and colleagues showed that decreases in ETS exposure were sustained for up to two years. In both the original and follow up analyses, significant decreases in symptom reports were obtained for the counselling group.⁵⁸

These trials suggested that counselling may be efficacious and the two controlled trials provided evidence of valid reported measures. However, Greenberg and colleagues⁵³ were not able to confirm effects using cotinine as an outcome measure. The degree to which cotinine measures are appropriate remains controversial, but confirmation of counselling effects remains to be verified by changes in biological markers or health outcomes. These three trials concerned only children with respiratory disease and thus raise questions about the degree to which similar counselling procedures might work with families who have healthy children. Hovell and associates recently completed a similar study of healthy children exposed to ETS in their home and results suggest similar success from counselling, including therapeutic differences in urine cotinine.⁵⁹ Even with one study showing promising outcomes for healthy children, additional studies are needed to verify the degree to which such interventions are efficacious. Future studies should be conducted with samples representing varying populations and should include greater use of environmental and biological measures from which changes can be confirmed. If results are replicated, research should begin determining the components needed to make these procedures most efficient and to explore health benefits.

Conclusions and recommendations

EFFICACY OF MINIMAL AND COUNSELLING INTERVENTIONS

Though only a few controlled trials have been completed that show reduction in ETS exposure for children, a few generalisations seem warranted. First, one time clinical

interventions appear marginally or not efficacious. Second, although most repeated *minimal* interventions did not reliably change ETS exposure, one provided near significant and one statistically powerful and precisely conducted study showed significant outcomes. These suggest that repeated but minimal interventions may be efficacious, but additional large sample controlled trials are needed to verify these observations. Even if minimal interventions are found efficacious, they will only reduce ETS exposure for a small proportion of a population. The majority "non-responders" may be appropriate candidates for repeated counselling services designed to shape ETS exposure reduction practices. This seems especially important for children with asthma or other respiratory diseases.

PRACTICAL LIMITATIONS AND MAINTENANCE.

The trials that showed significant decreases in ETS exposure provided only limited treatment over one to six months. Most families remained well above zero level exposure at the end of counselling. This suggests that the length of intervention to bring most children to near zero exposure has not yet been determined. It is possible that extending the length of counselling could yield both more substantive decreases in ETS exposure and more parents attempting to quit. Clinical treatment programs should adopt these procedures following traditional service guidelines, and continue services as long as they seem to be working for a given family and until the exposure level is essentially zero.

Future studies also should consider combining ETS exposure counselling with formal cessation counselling in sequence. This might reach otherwise unreachable smokers for cessation purposes. This would make it possible to determine if ETS reduction counselling benefits children whose parents would not be likely to quit smoking in an intervention directed only at cessation. These extended counselling recommendations are likely to be criticised as expensive. However, in relation to lung surgery or chemotherapy for lung cancer or in relation to exacerbation of asthma and repeated visits to the emergency department, even life long counselling may be relatively cost efficient, if it works. Formal cost, cost/benefit and cost/utility analyses should be planned to determine the resources needed to deliver counselling interventions and to determine the relative benefits per dollar required and the relative benefits compared to other possible interventions. However, cost analyses test the efficiency of counselling interventions and thus might be most appropriate only after refined interventions have been developed and shown to be efficacious.

Often, the only source of social reinforcement that might sustain changes in patient behaviour is delivered by clinicians; it is therefore not surprising that patient behaviour often returns to pretreatment levels after discontinuing tested programs. This is often seen in cardiac and other rehabilitation services and is

described as patient non-adherence. All three of the trials showing that repeated counselling can reduce ETS exposure also demonstrated remarkable degrees of maintenance of effects. Meltzer and colleagues⁵² found maintenance at one month, Greenberg and colleagues⁵³ reported six months maintenance, and Wahlgren and colleagues⁵⁸ demonstrated maintenance of the Hovell and colleagues⁵⁴ sample for as long as two years. Maintenance for up to two years is a remarkable finding, perhaps the only illustration of sustained change in the behavioural literature. These findings suggest that ongoing sources of reinforcement are sustaining ETS reduction practices, once established by counselling. This observation deserves additional study to confirm the relationship uniquely with ETS exposure practices. It can be speculated that such maintenance of change may be related to the overall cultural support for protecting children and for tobacco control.

PRACTICAL, THEORETICAL, AND ETHICAL ISSUES. Shaping adults' smoking practices in order to decrease ETS exposure seems simple. This may be true for families in which the mother is the recipient of counselling and the only smoker in the home. However, when the mother is not the only smoker or when the mother is not a smoker at all, the objectives of counselling and the tasks requested of the mother become much more difficult. In these instances, the mother must influence her husband or others in the family to alter their smoking practices. Depending on the nature of relationships and "leadership" in the home, this can be difficult to impossible. A number of studies (from policy to clinical interventions) found less favourable effects of interventions when there were additional smokers in the family. The degree to which counselling mothers to change the smoking practices of other residents can decrease ETS exposure remains to be determined. Hovell and colleagues are testing similar procedures with an exclusively Latino sample.⁶⁰ For the majority of families, mothers are recipients of counselling and fathers are the source of ETS exposure. This study will provide information about the degree to which indirect counselling can be efficacious. Additional studies should test recruitment and counselling procedures tailored to smoking fathers.

A recent study has shown that early traumatic experiences increase the likelihood of becoming a smoker.⁶¹ The specifics of this study are far less important than the implied cause of smoking. People become smokers for a host of reasons, some because of trauma as a child, some because of social pressures from friends, and all because of the ongoing and extensive promotional practices of the tobacco industry. They did not "elect" to become smokers; they were caused to become smokers. This is important in the overall effort to use policies to control smoking and ETS exposure in the home. The policies in place restricting smoking in public buildings may penalise smokers and, in a limited sense, this penalises

victims. However, they probably encourage less smoking and more quitting; in spite of penalising the victim, they may be therapeutic. When such policies are considered for residential settings, the implicit reliance on aversive consequences, possibly as great as removing children from families, may be too great a penalty for "victims" to suffer—a moral compromise too great to implement. This could lead to counter aggression and the criminalisation of smoking around children. This seems untenable in the context of a legal industry responsible for establishing smokers.

If policy contingencies are to be extended to ETS exposure in homes, it is critical that the consequences be predominantly positive for avoiding exposure to children, instead of punitive for exposure. Such contingencies will require ingenuity to brainstorm.

It is likely that real-time measures of ETS exposure will be required to make residential reinforcement contingencies possible and enforceable. Particle monitors can be placed in homes and portable versions can be worn.⁶² This technology might be refined and miniaturised to provide real-time and ongoing information about ETS and exposure to children. Once real-time measures are available, it will be possible to provide reinforcement for smoking outside and not exposing children.

The use of existing biomarkers, such as cotinine, could approximate this type of monitoring if routinely part of all medical examinations.^{63 64} Tracking cotinine concentrations, as blood measures are tracked in medical examinations, would prompt physicians to counsel parents and could be used to provide feedback that might reinforce sustained low level exposure. Future studies should be directed to measurement development as components of possible interventions.

The efforts to date to reduce ETS exposure have been aimed at parents of exposed children. This is required for infants. However, for older children, it may be possible to direct education and counselling procedures to the child in order to teach the child to avoid ETS exposure. School based education or paediatric based counselling services might enable children to avoid ETS exposure even if the smoking parent is not willing to participate. This direction of development should be researched with sensitivity to sustaining positive relations among family members.

Finally, many populations plagued by smoking and ETS exposure are low income, minority, and socially disenfranchised. These are likely to be the populations most often targeted and most often responsive to the tobacco industry's efforts to recruit new smokers. This raises the possibility that financial or race/ethnicity based social prejudices and related cultural complications may define susceptibility to smoking and to ETS exposure among children. If so, attention to these disparities in the overall social structure of the community may be prerequisite to complete control of tobacco and ETS exposure of children in homes.

These few recommendations for future research cover many of the components of the behavioural ecological model. However, it is difficult to see how the whole model can be formally tested experimentally for control of ETS exposure or tobacco use in general. This would require testing the simultaneous use of many interventions, such as media programs, community policies banning tobacco use and ETS exposure, clinical programs such as counselling procedures, and legislative action that delimits (if not stops) the legal production and distribution of tobacco. Reports that suggest the efficacy of the media and large scale educational and applied research programs in California⁶⁵ provide evidence that the combination of community wide interventions may be efficacious. However, the full range of community, clinical, and residential interventions that may be possible and may be required to achieve substantial reductions in ETS exposure have yet to be implemented, let alone evaluated.

Preparation of this report was supported by intramural support from the Center for Behavioral Epidemiology and Community Health, GSPH, SDSU and from grants #NIH, NHLBI HL52835 and PHS MCH R40MC00093 awarded to Dr Hovell.

- 1 US Department of Health and Human Services. *Reducing the health consequences of smoking: 25 years of progress. A report of the Surgeon General, 1989*. Rockville, Maryland: Public Health Service, Centers for Disease Control, Office on Smoking and Health, 1989 (DHHS Publication No (CDC)89-8411.)
- 2 US Department of Health and Human Services. *The health consequences of involuntary smoking. A report of the Surgeon General, 1986*. Rockville, Maryland: Public Health Service, Centers for Disease Control, 1986. (DHHS Publication No (CDC) 87-8398.)
- 3 US Environmental Protection Agency. *Respiratory health effects of passive smoking: lung cancer and other disorders*. Smoking and Tobacco Control Monograph No 4. Bethesda, Maryland: US Department of Health and Human Services, Public Health Service, National Institutes of Health, 1993. (NIH Publication No 93-3605.)
- 4 California Environmental Protection Agency. *Health effects of exposure to environmental tobacco smoke*. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment; September 1997.
- 5 Australian National Health and Medical Research Council. *The health effects of passive smoking* (ISBN 0-642-27270-0). Australian Government Publishing Service; 1997.
- 6 Scientific Committee on Tobacco and Health. Report of the Scientific Committee on Tobacco and Health. 1998. Available online at <http://www.official-documents.co.uk/document/doh/tobacco/contents.htm>.
- 7 Cook DG, Strachan DP. Summary of effects of parental smoking on the respiratory health of children and implications for research. *Thorax* 1999;54:357-66.
- 8 World Health Organization. *International consultation on environmental tobacco smoke and child health: consultation report*. World Health Organization, 1999. Available online at: <http://www.who.int/toh/TFI/consult.htm>.
- 9 Wahlgren DR, Hovell MF, Meltzer EO, et al. Involuntary smoking and asthma. *Curr Opin Pulm Med* In press.
- 10 Glantz SA, Parmley WW. Passive smoking and heart disease: epidemiology, physiology, and biochemistry. *Circulation* 1991;83:1-12.
- 11 US Department of Health and Human Services. *Preventing tobacco use among young people. A report of the Surgeon General, 1994*. Atlanta, Georgia: Public Health Service, Centers for Disease Control and Prevention, Office on Smoking and Health, 1994. (US Government Printing Office Publication No S/N 017-001-00491-0.)
- 12 Pierce JP, Gilpin E. How long will today's new adolescent smoker be addicted to cigarettes? *Am J Pub Health* 1996;86:253-6.
- 13 Pirkle JL, Flegal KM, Bernert JT, Brody DJ, Etzel RA, Maurer KR. Exposure of the US population to environmental tobacco smoke: the third national health and nutrition examination survey, 1988 to 1991. *JAMA* 1996; 275:1233-40.
- 14 Gergen PJ, Fowler JA, Maurer KR, Davis WW, Overpeck MD. The burden of environmental tobacco smoke exposure on the respiratory health of children 2 months through 5 years of age in the United States: third national health and nutrition examination survey, 1988 to 1994. *Pediatrics* 1998;101:E8.
- 15 Collaborative Group SIDRIA (Italian Studies on Respiratory Disorders in Childhood and the Environment). Parental smoking, asthma and wheezing in children and adolescents. Results of SIDRIA. *Epidemiol Prev* 1998; 22:146-54.
- 16 Lister SM, Jorm LR. Parental smoking and respiratory illnesses in Australian children aged 0-4 years: ABS 1989-90 national health survey results. *Austr NZ J Public Health* 1998;22:781-6.
- 17 Centers for Disease Control. State-specific prevalence of cigarette smoking among adults, and children's and adolescents' exposure to environmental tobacco smoke—United States, 1996. *MMWR Morbid Mortal Wkly Rep* 1997;44:1038-43.
- 18 Huss K, Rand CS, Butz AM, et al. Home environmental risk factors in urban minority asthmatic children. *Ann Allergy* 1994;72:173-7.
- 19 Jaakkola MS, Jaakkola JJK. Assessment of exposure to environmental tobacco smoke. *Eur Respir J* 1997;10:2384-97.
- 20 Borland R. Background paper: *Theories of behavior change in relation to environmental tobacco control to protect children*. International Consultation on Environmental Tobacco Smoke and Child Health. World Health Organization, 1999. Available online at: <http://www.who.int/toh/TFI/consult.htm>.
- 21 Wahlgren DR, Meltzer SB, Zakarian JM, et al. Predictors of physician counseling to reduce tobacco smoke exposure in children with asthma. *Ann Behav Med* 1993;15(S1 suppl):36.
- 22 Hovell M, Hillman E, Blumberg E, et al. A behavioral-ecological model of adolescent sexual development: a template for AIDS prevention. *Journal of Sex Research* 1994;31:267-89.
- 23 Wahlgren DR, Hovell MF, Slymen DJ, Conway TL, Hofstetter CR, Jones JA. Predictors of tobacco use initiation in adolescents: A two-year prospective study and theoretical discussion. *Tobacco Control* 1997;6:95-103.
- 24 Thompson B, Emmons K, Abrams D, Ockene JK, Feng Z. ETS exposure in the workplace. Perceptions and reactions by employees in 114 work sites. Working Well Research Group [published erratum appears in *J Occup Environ Med* 1995;37:1363]. *J Occup Environ Med* 1995;37:1086-92.
- 25 Moskowitz J, Lin Z, Hudes E. The impact of California's smoking ordinances on worksite smoking policy and exposure to environmental tobacco smoke. *Am J Health Prom* 1999;13:278-81.
- 26 Eisner M, Smith A, Blanc P. Bartenders' respiratory health after establishment of smoke-free bars and taverns. *JAMA* 1998;280:1909-14.
- 27 Repace J. Risk management of passive smoking at work and at home. *St Louis University Public Law Review* 1994; 13:763-85.
- 28 Abernathy T, Grady B, Dukeshire S. Changes in ETS following anti-smoking legislation. *Can J Public Health* 1998;89:33-4.
- 29 Farrelly M, Evans W, Sfekas A. The impact of workplace smoking bans: results from a national survey. *Tobacco Control* 1999;8:272-7.
- 30 Farkas A, Gilpin E, Distefan J, Pierce JP. The effects of household and workplace smoking restrictions on quitting behaviours. *Tobacco Control* 1999;8:261-5.
- 31 Winkelstein M, Tarzian A, Wood R. Parental smoking behavior and passive smoke exposure in children with asthma. *Ann Allergy Asthma Immunol* 1997;78:419-23.
- 32 Ezra D. Sticks and stones can break my bones, but tobacco smoke can kill me: can we protect children from parents that smoke? *St Louis University Public Law Review* 1994;13:547-90.
- 33 Ashley M, Ferrence R. Reducing children's exposure to environmental tobacco smoke in homes: issues and strategies. *Tobacco Control* 1998;7:61-5.
- 34 Sweda E. Protecting children from exposure to environmental tobacco smoke. *Tobacco Control* 1998;7:1-2.
- 35 Borland R, Mullins R, Trotter L, White V. Trends in environmental tobacco smoke restrictions in the home in Victoria, Australia. *Tobacco Control* 1999;8:266-71.
- 36 Woodward A, Owen N, Grgrunovich N, Griffith F, Linke H. Trial of an intervention to reduce passive smoking in infancy. *Pediatr Pulmonol* 1987;3:173-8.
- 37 Chiltonczyk B, Palomaki G, Knight G, Williams J, Haddow JE. An unsuccessful cotinine-assisted intervention strategy to reduce environmental tobacco smoke exposure during infancy. *Am J Dis Child* 1992;146:357-60.
- 38 Vineis P, Ronco G, Ciccone G, et al. Prevention of exposure of young children to parental tobacco smoke: effectiveness of an educational program. *Tumor* 1993;79:183-6.
- 39 Murray A, Morrison B. The decrease in severity of asthma in children of parents who smoke since the parents have been exposing them to less cigarette smoke. *J Allergy Clin Immunol* 1993;91:102-10.
- 40 McIntosh N, Clark N, Howatt W. Reducing tobacco smoke in the environment of the child with asthma: A cotinine-assisted minimal-contact intervention. *J Asthma* 1994; 31:453-62.
- 41 Irvine L, Crombie JK, Clark RA, et al. Advising parents of asthmatic children on passive smoking: randomised controlled trial. *BMJ* 1999;318:1456-9.
- 42 Eriksen K, Bruusgaard D. Effects of information on smoking behaviour in families with school children. *Acta Paediatr* 1996;85:209-12.
- 43 Wall MA, Severson HH, Andrews JA, Lichtenstein E, Zoref L. Pediatric office-based smoking intervention: Impact on maternal smoking and relapse. *Pediatrics* 1995;96:622-8.

- 44 Slymen D, Hovell M. Cluster versus individual randomization in adolescent tobacco and alcohol studies: illustrations for design decisions. *Int J Epidemiol* 1997;26:765-71.
- 45 Hovell MF, Elder J, Blanchard J, et al. Behavior analysis and public health perspectives: Combining paradigms to effect prevention. *Ed Treat Childr* 1986;9:287-306.
- 46 Butz A, Rosenstein B. Passive smoking among children with chronic respiratory disease. *J Asthma* 1992;29:265-72.
- 47 Hymowitz N. A survey of pediatric office-based interventions on smoking. *New Jersey Med* 1995;92:657-60.
- 48 Narce-Valente S, Kligman E. Increasing physician screening and counseling for passive smoking. *J Fam Pract* 1992;34:722-8.
- 49 Russos S, Keating K, Hovell MF, et al. Counseling youth for tobacco use prevention: determinants of clinician compliance. *Prev Med* 1999;29:13-21.
- 50 Hovell M, Kaplan R, Hovell F. Analysis of preventive medical services in the US. In: Lamal PA, ed. *Behavior analysis of societies and cultural practices*. Washington DC: Hemisphere Publishing, 1991.
- 51 Hovell MF, Wahlgren D, Russos S. Preventive medicine and cultural contingencies: a natural experiment. In: Lamal PA, ed. *Cultural contingencies: behavior analytic perspectives on cultural practices*. Westport, Connecticut: Praeger Publishers, 1997.
- 52 Meltzer SB, Hovell MF, Meltzer EO, Atkins CJ, de Peyster A. Reduction of secondary smoke exposure in asthmatic children: parent counseling. *J Asthma* 1993;30:391-400.
- 53 Greenberg RA, Strehler VJ, Bauman KE, et al. Evaluation of a home-based intervention program to reduce infant passive smoking and lower respiratory illness. *J Behav Med* 1994;17:273-90.
- 54 Hovell MF, Meltzer SB, Zakarian JM, et al. Reduction of environmental tobacco smoke exposure among asthmatic children: a controlled trial [published erratum appears in *Chest* 1995;107:480]. *Chest* 1994;106:440-6.
- 55 Emerson JA, Hovell MF, Meltzer SB, et al. The accuracy of environmental tobacco smoke exposure measures among asthmatic children. *J Clin Epidemiol* 1995;48:1251-9.
- 56 Matt GE, Wahlgren DR, Hovell MF, et al. Measuring ETS exposure in infants and young children through urine cotinine and memory-based parental reports: empirical findings and discussion. *Tobacco Control* 1999;8:282-9.
- 57 Matt GE, Hovell MF, Zakarian JM, Bernert JT, Pirkle JL, Hammond SK. Measuring second-hand smoke exposure in babies: the reliability and validity of mother-reports in a sample of low-income families. *Health Psychol* In press.
- 58 Wahlgren DR, Hovell MF, Meltzer SB, Hofstetter CR, Zakarian JM. Reduction of environmental tobacco smoke exposure in asthmatic children: a two-year follow-up. *Chest* 1997;111:81-8.
- 59 Hovell MF, Zakarian JM, Hofstetter CR, Matt GE. Reduction of ETS exposure among WIC babies. Presented at the Sixth Annual Meeting of the Society for Research on Nicotine and Tobacco, Arlington, VA, February 2000. Proceedings abstract PO4-41.
- 60 Hovell MF. Ninos Sanos: reducing ETS exposure in Latino asthmatics. NIH, NHLBI, #HL52835, 6/96-5/00.
- 61 Anda RF, Croft JB, Felitti VJ, et al. Adverse childhood experiences and smoking during adolescence and adulthood. *JAMA* 1999;282:1652-8.
- 62 Brauer M, Hirtle RD, Hall AC, Yip TR. Monitoring personal fine particle exposure with a particle counter. *J Expo Anal Environ Epidemiol* 1999;9:228-36.
- 63 Bahceciler NN, Barlan IB, Nuhuglu Y, Basaran MM. Parental smoking behavior and the urinary cotinine levels of asthmatic children. *J Asthma* 1999;36:171-5.
- 64 Bernert JT, Turner WE, Pirkle JL, et al. Development and validation of sensitive method for determination of serum cotinine in smokers and nonsmokers by liquid chromatography/atmospheric pressure ionization tandem mass spectrometry. *Clin Chem* 1997;43:2281-91.
- 65 Pierce JP, Gilpin EA, Emery SL, et al. *Tobacco control in California: who's winning the war? An evaluation of the tobacco control program, 1989-1996*. La Jolla, California: University of California, San Diego; 1998.