

disease risk. Confounding implies that the confounding factor has an effect on risk that is independent of secondhand smoke exposure. Some factors considered as potential confounders may, however, be in the same causal pathway as a secondhand smoke exposure. Although socioeconomic status (SES) is often cited as a potential confounding factor, it may not have an independent effect but can affect disease risk through its association with secondhand smoke exposure (Figure 1.2). This figure shows general alternative relationships among SES, secondhand smoke exposure, and risk for an adverse effect. SES may have a direct effect, or it may indirectly exert its effect through an association with secondhand smoke exposure, or it may confound the relationship between secondhand smoke exposure and disease risk. To control for SES as a potential confounding factor without considering underlying relationships may lead to incorrect risk estimates. For example, controlling for SES would not be appropriate if it is a determinant of secondhand smoke exposure but has no direct effect.

Nonetheless, because the health effects of involuntary smoking have other causes, the possibility of confounding needs careful exploration when assessing associations of secondhand smoke exposure with adverse health effects. In addition, survey data from

the last several decades show that secondhand smoke exposure is associated with correlates of lifestyle that may influence the risk for some health effects, thus increasing concerns for the possibility of confounding (Kawachi and Colditz 1996). Survey data from the United States (Matanoski et al. 1995) and the United Kingdom (Thornton et al. 1994) show that adults with secondhand smoke exposures generally tend to have less healthful lifestyles. However, the extent to which these patterns of association can be generalized, either to other countries or to the past, is uncertain.

The potential bias from confounding varies with the association of the confounder to secondhand smoke exposures in a particular study and to the strength of the confounder as a risk factor. The importance of confounding to the interpretation of evidence depends further on the magnitude of the effect of secondhand smoke on disease. As the strength of an association lessens, confounding as an alternative explanation for an association becomes an increasing concern. In prior reviews, confounding has been addressed either quantitatively (Hackshaw et al. 1997) or qualitatively (Cal/EPA 1997; Thun et al. 1999). In the chapters in this report that focus on specific diseases, confounding is specifically addressed in the context of potential confounding factors for the particular diseases.

Tobacco Industry Activities

The evidence on secondhand smoke and disease risk, given the public health and public policy implications, has been reviewed extensively in the published peer-reviewed literature and in evaluations by a number of expert panels. In addition, the evidence has been criticized repeatedly by the tobacco industry and its consultants in venues that have included the peer-reviewed literature, public meetings and hearings, and scientific symposia that included symposia sponsored by the industry. Open criticism in the peer-reviewed literature can strengthen the credibility of scientific evidence by challenging researchers to consider the arguments proposed by critics and to rebut them.

Industry documents indicate that the tobacco industry has engaged in widespread activities, however, that have gone beyond the bounds of accepted scientific practice (Glantz 1996; Ong and Glantz 2000, 2001; Rampton and Stauber 2000; Yach and Bialous

2001; Hong and Bero 2002; Diethelm et al. 2004). Through a variety of organized tactics, the industry has attempted to undermine the credibility of the scientific evidence on secondhand smoke. The industry has funded or carried out research that has been judged to be biased, supported scientists to generate letters to editors that criticized research publications, attempted to undermine the findings of key studies, assisted in establishing a scientific society with a journal, and attempted to sustain controversy even as the scientific community reached consensus (Garne et al. 2005). These tactics are not a topic of this report, but to the extent that the scientific literature has been distorted, they are addressed as the evidence is reviewed. This report does not specifically identify tobacco industry sponsorship of publications unless that information is relevant to the interpretation of the findings and conclusions.

References

- Armstrong BK, White E, Saracci R, editors. *Principles of Exposure Measurement in Epidemiology*. Monographs in Epidemiology and Biostatistics. Vol. 21. New York: Oxford University Press, 1992.
- Benowitz NL. Biomarkers of environmental tobacco smoke. *Environmental Health Perspectives* 1999;107(Suppl 2):349–55.
- Bero LA, Glantz SA, Rennie D. Publication bias and public health policy on environmental tobacco smoke. *Journal of the American Medical Association* 1994;272(2):133–6.
- California Environmental Protection Agency. *Health Effects of Exposure to Environmental Tobacco Smoke*. Sacramento (CA): California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Reproductive and Cancer Hazard Assessment Section and Air Toxicology and Epidemiology Section, 1997.
- California Environmental Protection Agency. *Proposed Identification of Environmental Tobacco Smoke as a Toxic Air Contaminant. Part B: Health Effects*. Sacramento (CA): California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, 2005.
- Copas JB, Shi JQ. Reanalysis of epidemiological evidence on lung cancer and passive smoking. *British Medical Journal* 2000;320(7232):417–8.
- Coultas DB, Peake GT, Samet JM. Questionnaire assessment of lifetime and recent exposure to environmental tobacco smoke. *American Journal of Epidemiology* 1989;130(2):338–47.
- Diethelm PA, Rielle JC, McKee M. The whole truth and nothing but the truth? The research that Phillip Morris did not want you to see, November 11, 2004; <<http://image.thelancet.com/extras/03art7306web.pdf>>; accessed: January 6, 2005.
- Emerson JA, Hovell MF, Meltzer SB, Zakarian JM, Hofstetter CR, Wahlgren DR, Leaderer BP, Meltzer EO. The accuracy of environmental tobacco smoke exposure measures among asthmatic children. *Journal of Clinical Epidemiology* 1995;48(10):1251–9.
- Fleiss JL, Gross AJ. Meta-analysis in epidemiology, with special reference to studies of the association between exposure to environmental tobacco smoke and lung cancer: a critique. *Journal of Clinical Epidemiology* 1991;44(2):127–39.
- Flue-Cured Tobacco Cooperative Stabilization Corp. v. United States Environmental Protection Agency* (M.D.N.C. June 22, 1993), cited in 8.2 TPLR 3.97 (1993).
- Flue-Cured Tobacco Cooperative Stabilization Corp. v. The United States Environmental Protection Agency*, No. 98-2407 (4th Cir., December 11, 2002), cited in 17.7 TPLR 2.472 (2003) (Overturning lower court's decision invalidating EPA's findings that secondhand smoke is a "known human carcinogen").
- Fontham ET, Correa P, Reynolds P, Wu-Williams A, Buffler PA, Greenberg RS, Chen VW, Alterman T, Boyd P, Austin DF, Liff J. Environmental tobacco smoke and lung cancer in nonsmoking women: a multicenter study. *Journal of the American Medical Association* 1994;271(22):1752–9.
- Garne D, Watson M, Chapman S, Byrne F. Environmental tobacco smoke research published in the journal *Indoor and Built Environment* and associations with the tobacco industry. *Lancet* 2005;365(9461):804–9.
- Glantz SA. The ledger of tobacco control. *Journal of the American Medical Association* 1996;276(11):871–2.
- Glantz SA. Lung cancer and passive smoking: nothing new was said. *British Medical Journal* 2000;321(7270):1222–3.
- Hackshaw AK, Law MR, Wald NJ. The accumulated evidence on lung cancer and environmental tobacco smoke. *British Medical Journal* 1997;315(7114):980–8.
- Hammond SK, Leaderer BP. A diffusion monitor to measure exposure to passive smoking. *Environmental Science & Technology* 1987;21(5):494–7.
- Hong MK, Bero LA. How the tobacco industry responded to an influential study of the health effects of secondhand smoke. *British Medical Journal* 2002;325(7377):1413–6.
- International Agency for Research on Cancer. *IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans: Tobacco Smoking*. Vol. 38. Lyon (France): International Agency for Research on Cancer, 1986.
- International Agency for Research on Cancer. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Tobacco Smoke and Involuntary Smoking*. Vol. 83. Lyon (France): International Agency for Research on Cancer, 2004.
- Jaakkola MS, Jaakkola JJ. Assessment of exposure to environmental tobacco smoke. *European Respiratory Journal* 1997;10(10):2384–97.