

Injury death excesses in smokers: a 1990–95 United States national cohort study

B N Leistikow, D C Martin, S J Samuels

Abstract

Objectives—Assess injury death relative risks (RR), dose-response, and attributable fractions for current cigarette smokers (smokers) in a recent representative sample of the United States population without and with adjustment for (a) demographic and (b) additional behavioral risk factors.

Setting—United States.

Methods—National Health Interview Survey (NHIS) adult (ages 18+ years) interviewees from 1990 or 1991 were followed through 1995. Referents had never smoked a total of 100 cigarettes. Relative risks were estimated with Stata software's Cox proportional hazard regressions, using NHIS final weights and primary sampling units. The resulting RR and published data were used to estimate population smoking attributable fractions of injury deaths in the United States.

Results—The crude, age-race-gender adjusted, and fully (demographic plus educational attainment, marital status, alcohol use level, and seat belt use) adjusted RRs for injury death in smokers were 1.86 (95% confidence interval (CI) 1.30 to 2.66), 1.60 (CI 1.12 to 2.29), and 1.42 (CI 0.99 to 2.05) respectively. Those RRs correspond to United States injury death smoking attributable fractions of 18%, 13%, and 9%, respectively. Those smoker/injury death RRs each showed a significant dose response relationship ($p < 0.030$). Smokers' unadjusted unintentional injury, motor vehicle crash, and suicide RRs were 1.87 (CI 1.22 to 2.86), 2.14 (CI 1.12 to 4.11), and 2.17 (CI 1.02 to 4.62), respectively.

Conclusions—Smokers in the United States have significant dose-response excesses of injury death, independent of age, race, gender, alcohol use, seat belt use, education, and marital status. This supports earlier studies suggesting that smoking may be a leading contributor to injuries and injury may be a leading burden from smoking, both nationally and globally.

(*Injury Prevention* 2000;6:277–280)

Keywords: smoking; mortality; cohort

Together, injuries and tobacco illnesses account for about 30% of deaths in the United States and nearly a fifth (in 1990) to a third (in the year 2020) of the estimated global burden

of disease.¹ Measures to reduce injuries and smoking are needed.

Understanding the full contributions of smoking to injuries may supply additional means of reducing injury, and additional reasons for reducing smoking. Smoking causes risk factors for injury including fires, depressed reflexes, incoordination, impaired fitness, and, possibly, depressed moods.^{2–4} Smoking is disproportionately common, and associated with high injury risks in narcotics addicts.⁵ Addicts may have been disproportionately omitted from the employment or volunteer based populations in whom smoking related injury risks have previously been assessed.

Studies of smoking related injury risks lack 1990's data, nationally representative samples, and adjustment for risk taking behaviors such as non-use of seat belts.^{2–3} Therefore, we will assess the prospective association between smoking and injury death in the 1990s in a nationally representative sample of Americans, without and with adjustment for demographic factors and behavioral risk factors.

Methods

United States National Health Interview Survey (NHIS) adult (ages 18+) interviewees from 1990 and 1991 were followed up for vital status through 1995 using the National Death Index (NDI).⁶ The NHIS, NDI, and linkage methods have been described in previous studies.^{7–8} This provided an average of five years of virtually complete⁹ follow up on a nationally representative cohort of Americans. The lack of seat belt and alcohol use data precluded use of NHIS data from years other than 1990 and 1991.

Participants were classified as never smokers (fewer than 100 lifetime cigarettes), ex-smokers, and current smokers (smokers), by baseline self report. For smokers, cigarettes per day were recorded into 1–14, 15–24, and 25+ cigarettes/day categories.

Injury deaths include *International Classification of Diseases*, 9th revision (ICD-9) codes from E800–E999. Injury deaths were further categorized into unintentional injury (ICD-9 E800–E949), motor vehicle crash (ICD-9 E810–E825), suicides (ICD-9 E950–E959), and homicides (ICD-9 E960–E969).

We adjusted for several injury risk factors. Demographic risk factors included age (five year age groups), race (white, black, or other), and gender. Behavioral risk factors were education (0–11, 12, 13–15, or 16+ (college graduate or more) years), seat belt use (always, sometimes, or never), marital status, body mass index, and alcohol use (0, 0.01–4.9, 5.0–14.9,

Department of
Epidemiology and
Preventive Medicine,
University of
California, Davis,
California, USA
B N Leistikow
D C Martin
S J Samuels

Correspondence to:
Dr Bruce N Leistikow,
1 Shields Av, TB 168,
Department of Epidemiology
and Preventive Medicine,
University of California,
Davis, CA 95616–8638,
USA
(BNLeistikow@UCDavis.edu)

Table 1 Summary of injury associated risks across smoking categories

Characteristic	Total	Never smoker	Ex-smoker	Current smoker
No of persons	82 461	41 225	19 573	21 663
Deaths	4 372	1 729	1 498	1 145
Injury deaths	210	94	42	74
Person years	400 202	201 181	93 988	105 033
Mean age at baseline	46	45	52	42
Education (%)				
0–11 years	20	20	21	26
High school graduate	21	35	36	43
Some college	37	22	21	20
College graduate or higher	22	24	22	11
Marital status (%)				
Never married	20	24	11	20
Married	54	52	64	51
Widowed	11	13	12	7
Divorced/separated	15	11	14	22
Seat belt use (%)				
“Always”	69	74	72	58
“Sometimes” or “occasionally”	23	20	20	29
“Never”	8	6	8	13
Alcohol intake (g/day) (%)				
0	54	61	44	39
0.01–4.9	12	8	19	14
5.0–14.9	22	21	26	26
15.0–24.9	4	3	3	7
≥25	9	7	8	14

15.0–24.9, and >25 g/day of alcohol (given 13.4 g of alcohol/drink).

Stata software's Cox proportional hazards regression analysis was used to estimate relative risks of injury death among current smokers.¹⁰ NHIS final weights and primary sampling units were incorporated into the calculations. Sex was stratified in the demographic and fully

adjusted calculations. The test for trend was calculated using 0 cigarettes/day (never + ex-smokers), 1–14 cigarettes/day, 15–24 cigarettes/day, and 25+ cigarettes/day.

The smoking attributable fraction of injury death equals $((RR-1) \times \text{Prevalence}) / (1 + ((RR-1) \times \text{Prevalence}))$; RR = relative risk. The estimated smoking prevalences were 70% for the homeless^{11 12} and 24.7%¹³ for household members.

Results

Compared with never and ex-smokers, smokers were younger, less educated, less consistent users of seat belts, more often divorced, and consumed more alcohol (table 1). Compared with never smokers, smokers' crude RR of injury death was 1.86 (95% confidence interval (CI) 1.30 to 2.66) (table 2). After adjustment for sex, age, and race, the RR was 1.60 (CI 1.12 to 2.29). The fully adjusted smoker injury RR was 1.42 (CI 0.99 to 2.05) with a significant dose response trend ($p < 0.030$). The above crude, demographically, and fully adjusted RR correspond to smoking attributable fractions for injury death of 18%, 13%, and 9%, respectively, for the estimated 99.8% of Americans who have homes.¹⁴ The overall (homeless + housed) American smoking attributable fractions are

Table 2 Estimated relative risk* and dose response for injury, accident, motor vehicle accident, suicide, and homicide in current compared with never cigarette smokers

	No of cases	Crude	Demographically† adjusted	Fully adjusted‡
All external cause (ICD-9 E800–E999)				
Never smoker	94	1.00	1.00	1.00
Former smoker	42	0.92 (0.61 to 1.38)	0.73 (0.49 to 1.09)	0.70 (0.44 to 1.09)
Current smoker (cigarettes/day)	74	1.86 (1.30 to 2.66)	1.60 (1.12 to 2.29)	1.42 (0.99 to 2.05)
1–14	19	1.83 (1.09 to 3.08)	1.78 (1.06 to 3.01)	1.59 (0.92 to 2.77)
15–24	27	1.53 (0.91 to 2.59)	1.37 (0.81 to 2.32)	1.33 (0.77 to 2.28)
≥25	25	2.65 (1.56 to 4.52)	2.06 (1.21 to 3.49)	1.91 (1.06 to 3.45)
Test for trend§		$p < 0.000$	$p < 0.006$	$p < 0.030$
Unintentional injury (ICD-9 E800–E949)				
Never smoker	66	1.00	1.00	1.00
Former smoker	32	1.08 (0.67 to 1.73)	0.89 (0.56 to 1.41)	0.86 (0.51 to 1.44)
Current smoker (cigarettes/day)	43	1.87 (1.22 to 2.86)	1.66 (1.09 to 2.53)	1.56 (1.01 to 2.41)
1–14	12	1.99 (1.07 to 3.73)	1.97 (1.06 to 3.66)	1.87 (0.98 to 3.59)
15–24	20	1.87 (1.02 to 3.45)	1.75 (0.95 to 3.22)	1.92 (1.04 to 3.52)
≥25	8	1.52 (0.68 to 3.40)	1.29 (0.58 to 2.84)	1.18 (0.49 to 2.85)
Test for trend§		$p < 0.027$	$p < 0.081$	$p < 0.124$
Motor vehicle crash (ICD-9 E810–E825)				
Never smoker	27	1.00	1.00	1.00
Former smoker	15	1.14 (0.59 to 2.22)	0.99 (0.51 to 1.93)	0.89 (0.41 to 1.96)
Current smoker (cigarettes/day)	22	2.14 (1.12 to 4.11)	1.93 (1.00 to 3.73)	1.83 (0.97 to 3.44)
1–14	7	2.13 (0.83 to 5.48)	2.03 (0.83 to 4.99)	1.92 (0.79 to 4.66)
15–24	9	1.81 (0.77 to 4.27)	1.68 (0.69 to 4.10)	1.74 (0.76 to 4.03)
≥25	4	1.65 (0.55 to 4.91)	1.34 (0.43 to 4.12)	1.40 (0.42 to 4.68)
Test for trend§		$p < 0.135$	$p < 0.332$	$p < 0.422$
Suicide (ICD-9 E950–E959)				
Never smoker	16	1.00	1.00	1.00
Former smoker	9	0.81 (0.33 to 1.99)	0.55 (0.23 to 1.36)	0.49 (0.17 to 1.42)
Current smoker (cigarettes/day)	21	2.17 (1.02 to 4.62)	1.75 (0.80 to 3.81)	1.36 (0.60 to 3.12)
1–14	5	2.05 (0.67 to 6.24)	2.15 (0.71 to 6.51)	1.53 (0.46 to 5.10)
15–24	3	0.75 (0.17 to 3.36)	0.61 (0.13 to 2.79)	0.51 (0.11 to 2.42)
≥25	13	5.80 (2.30 to 14.62)	3.58 (1.32 to 9.69)	2.81 (0.95 to 8.31)
Test for trend§		$p < 0.005$	$p < 0.062$	$p < 0.195$
Homicide (ICD-9 E960–E969)				
Never smoker	10	1.00	1.00	1.00
Former smoker	1	0.16 (0.02 to 1.21)	0.13 (0.02 to 0.92)	0.16 (0.02 to 1.07)
Current smoker (cigarettes/day)	7	1.16 (0.41 to 3.30)	1.00 (0.36 to 2.75)	0.77 (0.34 to 1.74)
1–14	1	0.35 (0.04 to 2.87)	0.31 (0.04 to 2.60)	0.26 (0.03 to 1.98)
15–24	3	1.04 (0.25 to 4.29)	0.97 (0.23 to 4.10)	0.64 (0.12 to 3.36)
≥25	3	3.58 (1.05 to 12.28)	2.95 (0.83 to 10.49)	2.53 (0.79 to 8.14)
Test for trend§		$p < 0.203$	$p < 0.286$	$p < 0.374$

*Relative risk estimated by Cox hazard proportion models (see methods).

†Sex stratified and adjusted for age and race.

‡Stratified for sex and adjusted for age, race, education, marital status, alcohol use, and seat belt use.

§Trend test using non-smokers (never + ex), 1–14, 15–24, and 25+ cigarettes/day.

the same as the above housed smoking attributable fractions, unless smoker injury death RRs are higher for homeless (*v* housed) Americans and/or there is a 13-fold higher injury death risk averaged across the homeless compared with the housed. Assuming the homeless and housed have the same crude and adjusted injury mortality RR, the smoking attributable fractions of homeless injury deaths are 38%, 30%, and 23%, respectively.

Table 2 shows a crude increased risk of death among smokers for unintentional injury, motor vehicle crashes (crashes), and suicide. In the fully adjusted analysis smoker RRs of unintentional injury, crash, and suicide were 1.56 (CI 1.01 to 2.41), 1.83 (CI 0.97 to 3.44), and 1.36 (CI 0.60 to 3.12), respectively.

Discussion

We find that in the early 1990s, smokers in the United States had dose-response excesses of injury death, independent of smokers' excesses of divorce and heavy alcohol use and deficits of education and seat belt use. Smokers also had significantly raised unadjusted RRs of fatal unintentional injury, crash, and suicide, though the adjusted RR were not statistically significant due to low numbers of cases studied, due to lack of association, or confounding. These associations are consistent with published suggestive ($p=0.10$ to $p<0.20$) associations between smoking and injury, unintentional injury, and suicide death seen in randomized trial data.³

In this national sample, smokers' risks of injury death are similar to the relatively high RRs seen in Norwegian or Swedish general population samples.^{2 15 16} Those injury risks are modestly higher than smokers' injury, suicide, or violence death RR seen in socioeconomically advantaged populations such as the United States Cancer Prevention Study-I (CPS-I) volunteers,¹⁷ British physicians, nurses in the United States, or Northern California Kaiser Permanente health examinees.² It seems possible that smoking confers a higher injury death RR in poor or addicted⁵ people included in general population samples. The NHIS may underestimate the United States smoking/injury RR since the NHIS is based on households and thus omits homeless people who may be very prone to smoking and injury.^{18 19} Correctly estimating national and global RR of injury caused by smoking is important since each 0.25 added to the global smoking attributable injury RR, means an additional about 1% of the global burden of disease is due to smoking.²

This study has strengths. Inference from this study is strengthened by the multiple demographic and behavioral factors we adjusted for, and the recent data representative of households of a large and diverse nation.

This study has weaknesses. A modest number of injury deaths, and even lower numbers of suicide, unintentional, and homicide deaths were available for study. Our methods may substantially overestimate smoking's real injury risks due to our lack of adjustment for

drug use, biochemically determined alcohol use, binge or similarly risky patterns of alcohol use, personality, and other possible explanations for the smoking/injury association. However previously reviewed forensic,²⁰ randomized trial, challenge-rechallenge, animal, and some cohort and cotwin control evidence suggests a smoking/injury association is likely to exist, independent of those factors.^{2 3 21}

Alternatively, we may have substantially underestimated United States smoking attributable injury risks. That could result from omitting the homeless from our sample, counting baseline smokers who quit during follow up as smokers; adjusting for divorce and possible effects of nicotine addiction, and ignoring smoking's roles in fires,²² massive explosions,²³ crashes,²⁴ and other threats to bystander never smokers. Given the high levels of substance abuse seen in the homeless,²⁵ their smoking injury death RR could be over 2.5, as was seen in substance addicts.⁵

Additional research is merited. The various smoking/injury associations should be assessed in other nations, especially from Asia, Latin America, and Africa, at other stages of the tobacco epidemic. The smoking/injury association may be assessed in the homeless and then included in national estimates of smoking/injury associations. The role of smoking's fires, crashes, and stressors (illnesses from second-hand smoke and smoking attributable bereavements) in injuries in never smokers may be assessed. Smoking involved crashes may be studied in the same manner as alcohol involved crashes.²⁶ The contributions of smoking or nicotine addiction to behavioral risk factors for injury such as alcohol use,²⁷ drug use,^{5 28} social isolation,²⁹ and inability to advance in school³⁰ may be assessed. This would help assess whether it is appropriate to adjust the smoking/injury association for such possible effects of tobacco use.

Implications for prevention

In summary, there is a very substantial risk that smoking is contributing to many injuries and resulting costs in the United States and globally. Taxes, cigarette pack graphic warnings,³¹ and other methods of reducing smoking may be highly cost effective³² or possibly cost saving^{20 33} ways of reducing injury. Further studies and warnings of smoking's injury risks are merited. Smokers, physicians, policy makers, taxpayers, and non-smoking bystanders may benefit from warnings about the risks of injury associated with smoking.

We wish to thank the editor and three anonymous reviewers for helpful comments. The study was supported by the University of California-Davis, Department of Epidemiology and Preventive Medicine.

- 1 Murray CJL, Lopez AD. *The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020*. Cambridge, MA: Harvard School of Public Health, World Health Organization, World Bank, 1996: xxxii, 990.
- 2 Leistikow BN, Martin DC, Jacobs J, et al. Smoking risk factor for injury death: a meta-analysis of cohort studies. *Prev Med* 1998;27:871-8.
- 3 Leistikow BN, Shipley MJ. Might stopping smoking reduce injury death risks? A meta-analysis of randomized, controlled trials. *Prev Med* 1999;28:255-9.

- 4 Wu LT, Anthony JC. Tobacco smoking and depressed mood in late childhood and early adolescence. *Am J Public Health* 1999;89:1837-40.
- 5 Hser YI, McCarthy WJ, Anglin MD. Tobacco use as a distal predictor of mortality among long-term narcotics addicts. *Prev Med* 1994;23:61-9.
- 6 National Center for Health Statistics. *NHIS, multiple cause of death CD-ROM, follow-up through 1995*. Hyattsville, MD: National Center for Health Statistics, 1997.
- 7 Massey JT. Overview of the National Health Interview Survey and its sample design. *Vital Health Stat* 2 1989; 105(110):1-5.
- 8 Liao Y, Cooper RS, Cao G, et al. Mortality from coronary heart disease and cardiovascular disease among adult US Hispanics: findings from the National Health Interview Survey (1986 to 1994). *J Am Coll Cardiol* 1997;30:1200-5.
- 9 Rich-Edwards JW, Corsano KA, Stampfer MJ. Test of the National Death Index and Equifax Nationwide Death Search. *Am J Epidemiol* 1994;140:1016-9.
- 10 StataCorp. *Stata statistical software*. College Station, TX: Stata Corporation, 1999.
- 11 Heffron WA, Skipper BJ, Lambert L. Health and lifestyle issues as risk factors for homelessness (see comments). *J Am Board Fam Pract* 1997;10:6-12.
- 12 Kermodie M, Crofts N, Miller P, et al. Health indicators and risks among people experiencing homelessness in Melbourne, 1995-1996. *Aust N Z J Public Health* 1998;22:464-70.
- 13 Centers for Disease Control and Prevention. *Percentage of adults* who were current, former, or never smokers, + overall and by sex, race, Hispanic origin, age, and education, National Health Interview Surveys, selected years—United States, 1965-1995*. <http://www.cdc.gov/tobacco/adstat1.htm>. Atlanta, GA: CDC, 1999.
- 14 Burt MR, Cohen BE. *America's homeless: numbers, characteristics, and programs that serve them*. Urban Institute report 89-3 0897-7399. Washington, DC: Urban Institute Press, 1989: 176.
- 15 Tverdal A, Thelle D, Stensvold I, et al. Mortality in relation to smoking history: 13 years' follow-up of 68,000 Norwegian men and women 35-49 years. *J Clin Epidemiol* 1993;46:475-87.
- 16 Friberg L, Cederlo FR, Lorich U, et al. Mortality in twins in relation to smoking habits and alcohol problems. *Arch Environ Health* 1973;27:294-304.
- 17 Burns DM, Shanks TG, Choi W, et al. The American Cancer Society Cancer Prevention Study I: 12-year followup of 1 million men and women. In: David LG, Burns M, Samet JM, eds. *Changes in cigarette-related disease risks and their implication for prevention and control. NIH publication; No 97-4213, Smoking and tobacco control monograph*. Bethesda, MD: National Cancer Institute, NIH, PHS, DHHS, 1997: 113-304.
- 18 Hwang SW. Mortality among men using homeless shelters in Toronto, Ontario (in process citation). *JAMA* 2000;283: 2152-7.
- 19 Sachs-Ericsson N, Wise E, Debrody CP, et al. Health problems and service utilization in the homeless. *J Health Care Poor Underserved* 1999;10:443-52.
- 20 Leistikow BN, Martin DC, Milano CE. Fire injuries, disasters, and costs from cigarettes and cigarette lights: a global overview. *Prev Med* 2000 (in press).
- 21 Leistikow BN, Martin DC, Jacobs J, et al. Smoking as a risk factor for accident death. A meta-analysis of cohort studies. *Accid Anal Prev* 2000;32:296-301.
- 22 Mierley MC, Baker SP. Fatal house fires in an urban population. *JAMA* 1983;249:1466-8.
- 23 Stephens HW. *The Texas City disaster, 1947*. 1st Ed. Austin: University of Texas Press, 1997: xvi, 141.
- 24 Waller JA. On smoking and drinking and crashing (editorial). *N Y State J Med* 1986;86:459-60.
- 25 Caton CLM. *Homeless in America*. New York: Oxford University Press, 1990: 236.
- 26 Alcohol involvement in fatal motor-vehicle crashes—United States, 1997-1998. *MMWR Morb Mortal Wkly Rep* 1999; 48(47):1086-7.
- 27 Dee TS. The complementarity of teen smoking and drinking. *J Health Econ* 1999;18:769-93.
- 28 Henningfield JE, Clayton R, Pollin W. Involvement of tobacco in alcoholism and illicit drug use. *Br J Addict* 1990;85:279-91.
- 29 Hines D. Nonsmoking college students' attitudes toward smokers and smoking. *Psychol Rep* 1996;78(3 pt 1):860-2.
- 30 Levine PB, Gustafson TA, Velenchik AD. *More bad news for smokers? The effects of cigarette smoking on labor market outcomes*. Cambridge, MA: National Bureau of Economic Research, 1995.
- 31 Health Canada. *Qualitative (focus group) report regarding health warning labels and images on cigarette packages*. Final report. Ottawa, Ontario: Health Canada, Health Protection Branch, Office of Tobacco Control, 1999.
- 32 Cummings SR, Rubin SM, Oster G. The cost-effectiveness of counseling smokers to quit. *JAMA* 1989;261:75-9.
- 33 Jha P, Chaloupka FJ. *Curbing the epidemic: governments and the economics of tobacco control*. Washington, DC: World Bank, 1999: xii, 122.