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State Estimates of Medicaid Expenditures Attributable to Cigarette Smoking, Fiscal Year 1993

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SYNOPSIS

Objective. To develop estimates of state Medicaid expenditures attributable to smoking for fiscal year 1993.

Methods. The smoking-attributable fractions (SAFs) of state Medicaid expenditures were estimated using a national model that describes the relationship between smoking and medical expenditures, controlling for a variety of sociodemographic, economic, and behavioral factors.

Results. In fiscal year 1993, the SAF for all states (all types of expenditures) was 14.4%, with a range from 8.6% in Washington DC to 19.2% in Nevada. On average, SAFs ranged from a low of 7.9% for home health services expenditures to 21.7% for hospital expenditures. An estimated total of $12.9 billion of fiscal year 1993 Medicaid expenditures was attributable to smoking. The relative error of this estimate was 40.3%.

Conclusions. Cigarette smoking accounts for a substantial portion of annual state Medicaid expenditures, with considerable variation among states. The range in expenditures among the states is due to differences in smoking prevalence, health status, other socioeconomic variables used in the model, and the level and scope of the Medicaid program.

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Cigarette smoking, the leading cause of preventable mortality in the United States, causes approximately 430,000 deaths annually in this country.[1] Cigarette smokers use medical care at higher rates than nonsmokers,[2] and they accumulate substantial medical bills in the process. The Centers for Disease Control and Prevention (CDC) reported that medical care expenditures attributable to smoking amounted to $50 billion in 1993, with more than 40% of that amount publicly funded (that is, through Medicaid, Medicare, and other government programs).[3]

As of June 20, 1997, the day the proposed settlement between the state Attorneys General and the tobacco industry was announced, 39 states, Puerto Rico, the city of New York, and several counties in California had filed suits against the tobacco industry to try to recover monies spent on medical care for smoking-related illnesses among their citizens. Instead of employing the argument made in product liability cases that tobacco companies should be held responsible for damages incurred by individual smokers, these plaintiffs argued that the tobacco industry deliberately and systematically suppressed information about the adverse effects of smoking and the industry's awareness that nicotine was an addictive drug that resulted in loss of lives. The plaintiffs further argued that the states and other municipalities had no choice in providing health care to citizens suffering from smoking-related illnesses who relied on public programs for their health care. The plaintiffs may thus be entitled to recovery of the enormous health care costs created by the tobacco industry.[4-7]

Many states have estimated their *total* costs of medical care attributable to smoking by entering state-specific data into the widely used Smoking-Attributable Mortality, Morbidity, and Economic Costs computer software package (SAMMEC), a spreadsheet-based tool that uses calculations of attributable risks stratified by age and sex.[8-11] SAMMEC calculates medical expenditures using data from the 1987 National Health Interview Survey, including the prevalence of current and former cigarette smoking and the rates of utilization of hospital care and physician services for smokers and former smokers relative to never smokers. Because of the limitations of the data used to estimate relative rates of medical care utilization, however, SAMMEC can not explicitly control for such variables as access to health insurance, certain sociodemographic factors, and behavioral risk factors.

Another method of estimating total medical care expenditures attributable to smoking was based on a more extensive dataset, the 1987 National Medical Expenditure Survey (NMES); the authors, Bartlett et al., developed a national model that permitted control of numerous confounding variables.[3]

We subsequently developed a model for estimating state-level smoking-attributable fractions (SAFs) of Medicaid expenditures and state-level smoking-attributable Medicaid expenditures (SAEs). In this paper, we briefly describe the structure and specifications of the model we used to generate these estimates and present our results. A detailed description of the model, including regression equations, is available from the authors.

METHODS

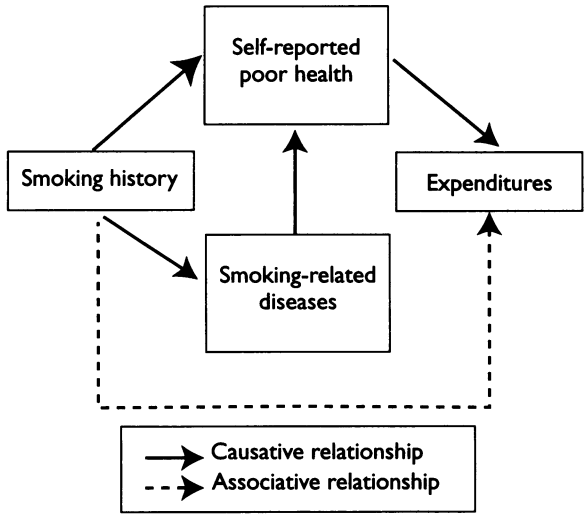
The national model on which we base the state estimates reported in this paper is an improvement on the model described by Bartlett et al. in 1993.[3] Both use data from NMES, a population-based survey of the civilian noninstitutionalized U.S. population.[12]

NMES is a national survey that links population characteristics with medical expenditures. For NMES, a cohort of 35,000 people from 14,000 households participated in four face-to-face interviews between February 1987 and May 1988. Respondents answered questions about sociodemographic factors, health insurance coverage, health status, specific health risk behaviors (smoking, not using a seat belt, and obesity), use of all types of medical care services (except nursing home care), and medical expenditures for those services. A supplemental survey, administered by mail to all respondents, included additional questions about health risk behaviors and history of smoking-related diseases.

We classified as "ever smokers" those who said they had smoked 100 or more cigarettes in their lifetimes. Ever smokers who were still smoking at the time of the survey were classified as "current smokers"; ever smokers who were not smoking at the time of the survey or for whom some smoking history information was missing were classified as "former smokers."

The national model. We developed a national model that relates smoking to medical expenditures in terms of biological causation (expenditures as a function of health status) and in terms of the association between smoking and expenditures, controlling for health. The model describes the decrease in health status caused by smoking as portrayed in the 1989 Surgeon General's report[13] and relates it to history of smoking-related diseases and self-reported poor health status. (See Figure.)

Figure. The national model



The model consisted of a set of equations describing the relationships among smoking history (current, former, ever smoker with missing information, or never smoker), a history of five specific smoking-related diseases (cancer, emphysema, arteriosclerosis, heart attack, and stroke), self-reported poor health status, and use of medical care in each of four categories (ambulatory care, prescription drugs, hospital care, and home health services).

Causative relationship. The first set of equations relate smoking to health and health to expenditures, controlling for age, "race/ethnicity," marital status, education level, region of residence, not using seat belts, and obesity ("the control variables").

Specifically, the first equation describes propensity (tendency) to have a past history of the specified tobacco-related diseases as a function of smoking history, adjusting for the control variables and sample selection bias. (The adjustment for sample selection bias is described in more detail below.) The second equation describes propensity to self-report poor health as a function of the propensity to have a past history of the tobacco-related diseases, adjusting for whether the individual reported a past history of a tobacco-related disease, the control variables, and sample selection bias.

Propensities differ from actual past disease status and health status. Two people who have emphysema might differ in their propensities to have had emphysema. For example, the difference in propensity would result from one being a smoker and the other being a nonsmoker if they were alike in all other characteristics.

Associative relationship. The associative relationship, as described in the third and fourth equations in the national model, is the direct effect of smoking on medical expenditures, controlling for self-reported health status.

We estimated the propensity to have medical expenditures as a probit model[14] that predicts the probability of having any medical expenditures during the study year. Thus the third equation describes the likelihood of having medical expenditures in each of four categories as a function of the propensity to self-report poor health, adjusting for self-reported health status, the control variables, sample selection bias, income level, and public health insurance status (receipt of Medicaid and other publicly funded health services for low-income people, excluding Medicare, veterans', and military benefits). The fourth equation, which yields the magnitude of expenditures, is a linear model of the logarithm of positive annual expenditures; given that the person has expenditures, it predicts the magnitude of those expenditures.[15]

The associative relationship reflects several ways that smoking, controlling for poor health, can affect expenditures: (*a*) NMES respondents reported their health status in month 5 of the survey; expenditures may be related to changes in health status that occurred after that time. (*b*) These equations take into account smoking-related expenditures for conditions not usually reported as affecting health status. For example, while pregnancy can be associated with smoking-related medical expenditures,[16] women do not normally report their health status as poorer due to pregnancy. (*c*) The associative relationship incorporates demand effects. For example, if smokers are less likely to visit physicians because they do not pursue preventive health services, their demand for health services is lower.

Analyses by age, sex, and expenditure category. In fact, there are 24 separately specified models: six defined by age and sex (males and females in each of the following age categories: 19–34 years old, 35–64 years old, and 65 years and older) and four by medical expenditure category. We used age 19 as the lower bound because smoking-related expenditures usually do not occur before this age. And, for the same reason, we did not include the relationship between smoking and a history of smoking-related diseases in the analyses for 19- to 34-year-olds.

Because information on smoking history was obtained through the supplemental questionnaire, and not every NMES respondent returned the questionnaire, we attempted to correct for any selection bias inherent in the sample of NMES respondents who reported a smoking

history. For example, frail individuals were less likely to participate in the survey. We estimated an equation predicting survey participation for each of the six age/sex group models. The participation equation for each group yielded a selection bias correction term, which was included in all of the other equations in the national model.[17,18]

NMES does not include expenditures for nursing homes. We estimated smoking-attributable expenditures (SAEs) for nursing home care by applying the smoking-attributable fractions (SAFs) for hospital expenditures for people ages 65 and older to total nursing expenditures reported by the Health Care Financing Administration (HCFA) in its quarterly reports. This reflects the fact that a large proportion of elderly nursing home residents (39% in 1985[19]) are admitted to nursing homes from short-stay hospitals and that many of these people suffer from smoking-related diseases.

Applying the national model to the states. We used the national model to estimate SAFs for populations whose health care is funded by public monies at the state level. (See Appendix.)

Using data from the Current Population Survey (CPS), conducted by the Bureau of the Census, and the Behavioral Risk Factor Surveillance System (BRFSS), an annual telephone survey conducted by state health departments in collaboration with the Centers for Disease Control and Prevention, we developed a sample of state residents likely to receive publicly funded medical care. (See the Appendix for the method used to define low-income people. Low-income people are likely to receive publicly funded medical care, including Medicaid.) We generated average SAFs for each of the 24 age/sex/expenditure categories for each of the 50 states and the District of Columbia. We then multiplied these average SAFs by adjusted Medicaid expenditures (using two Medicaid databases) to obtain point estimates of SAEs for each type of expenditure, as described below. Finally, we estimated interval estimates of total smoking-attributable expenditures by type for the nation and applied the relative errors from this analysis to each state.

The two Medicaid databases we used in estimating smoking-attributable expenditures for the states were: claims data as reported on the HCFA 2082 form and HCFA form 64 quarterly financial reports.

The HCFA 2082 forms contain claims-level data by age, sex, and type of expenditure. However, certain program-level adjustments are not captured on this form because they can not be assigned to an individual claim. These adjustments, including disproportionate share hospital payments (additional Medicaid payments to hospitals that serve a disproportionate share of low-income patients), are recorded on the HCFA 64 quarterly financial reports submitted by the states to HCFA.

We estimated state-specific SAFs by age/sex/medical expenditure group and applied these estimates to fiscal year 1993 Medicaid expenditures for the 50 states and the District of Columbia, as reported on the HCFA 2082 forms.

We aggregated the state-specific age/sex groups and then multiplied these aggregate SAFs by type of expenditure as reported on the HCFA 64 forms. Before doing so, we reduced the total expenditures by the amount spent for care of people under 19 years old, assuming that the relative lack of smoking-related chronic diseases in this age group would make these costs largely irrelevant. We also adjusted Medicaid expenditures to eliminate several types of expenditures that are not likely to be smoking-related, including expenditures for family planning, mental hospitals, mental retardation services, and dental services.

RESULTS

Table 1 shows the estimated SAFs for publicly funded health care for the 50 states and the District of Columbia for fiscal year 1993. The estimated total smoking-attributable Medicaid expenditures for each state for fiscal year 1993 are shown in Table 2. In both tables, the data are presented by type of expenditure: ambulatory care, prescription drugs, hospital care, home health services, nursing homes, and total.

The combined SAF for all states and Washington DC was 14.4%; Washington DC had the lowest SAF (8.6%), and Nevada the highest (19.2%). The lowest SAF (7.9%) was for home health care, while the highest (21.7%) was for hospital care. For each type of expenditure, there was considerable variation by state. For ambulatory care, the highest-ranking state, Minnesota, had a value more than twice that of the lowest, Washington DC. Prescription drugs had a similar range (from 8.0% in Washington DC to 18.3% in Nevada). For hospital care, SAFs ranged from a low of 13.1% in Washington DC to a high of 26.6% in Colorado. The SAFs for home health care were generally lower than those for other expenditure categories; these ranged from 3.6% in Utah to 13.7% in New York. The variation in these estimates is due to differences in smoking prevalence and history, health status, smoking-related diseases, and the sociodemographic factors that are included in the model (for example, older people use

Table 1. Smoking-attributable fractions (SAFs) of publicly funded medical expenditures, by state and type of expenditure, 1993

State	Ambulatory care	Prescription drugs	Hospital care	Home health services	Nursing home	Total
Alabama	7.15	9.56	15.62	7.16	7.52	9.01
Alaska	12.98	17.26	26.24	7.71	17.46	16.85
Arizona	8.47	12.76	18.65	7.43	14.87	14.25
Arkansas	11.74	11.77	21.20	12.13	12.81	13.61
California	12.73	14.67	20.27	4.73	14.72	16.22
Colorado	13.36	15.43	26.59	6.26	16.52	16.57
Connecticut	11.92	12.45	18.18	8.26	12.66	12.56
Delaware	12.94	12.83	21.48	10.49	15.43	15.59
District of Columbia	5.76	8.02	13.09	4.62	6.86	8.57
Florida	12.50	13.72	21.78	8.24	14.80	15.56
Georgia	11.06	12.10	18.94	8.98	10.03	12.84
Hawaii	11.08	14.25	21.05	7.47	13.46	14.33
Idaho	11.71	14.29	22.34	8.49	13.15	14.35
Illinois	11.01	15.36	24.29	7.45	16.24	18.13
Indiana	12.30	14.76	24.99	7.04	11.84	15.08
Iowa	11.01	12.86	21.26	6.59	13.56	14.17
Kansas	11.98	13.63	22.46	5.60	13.71	14.51
Kentucky	12.38	15.06	22.85	8.21	15.72	15.40
Louisiana	11.91	13.20	21.41	7.69	14.66	16.58
Maine	13.57	15.50	23.26	8.21	14.35	16.00
Maryland	11.67	12.82	20.10	9.49	13.14	14.79
Massachusetts	12.57	14.87	19.94	8.29	13.84	14.33
Michigan	13.37	15.52	25.79	7.47	14.53	16.43
Minnesota	13.60	13.56	26.20	6.34	10.06	12.52
Mississippi	10.85	11.85	18.16	6.85	13.91	13.62
Missouri	12.84	12.64	20.64	10.45	13.01	14.13
Montana	10.60	12.65	19.01	8.23	12.39	12.89
Nebraska	10.62	11.88	19.44	7.07	10.75	12.14
Nevada	12.16	18.31	25.57	8.65	22.60	19.24
New Hampshire	13.02	14.17	22.43	6.69	13.80	12.71
New Jersey	11.46	13.72	20.16	10.28	16.51	15.80
New Mexico	10.07	14.04	23.94	7.65	12.33	14.58
New York	11.95	14.34	23.14	13.67	13.74	15.83
North Carolina	10.44	12.68	21.69	9.95	10.86	13.27
North Dakota	10.52	11.74	19.90	6.32	9.82	10.93
Ohio	12.33	16.10	24.03	10.92	16.90	16.95
Oklahoma	11.12	11.15	23.31	6.07	10.14	12.72
Oregon	12.35	14.10	22.15	8.12	16.02	13.40
Pennsylvania	12.11	14.52	22.79	6.39	14.92	16.36
Rhode Island	13.50	13.72	22.58	8.59	12.96	14.52
South Carolina	11.18	12.07	19.87	8.48	10.89	13.63
South Dakota	10.16	11.92	21.76	5.02	12.60	12.57
Tennessee	11.20	15.12	22.69	7.21	14.26	14.81
Texas	10.37	12.69	22.04	13.55	13.69	15.05
Utah	9.05	10.83	20.09	3.61	9.30	11.92
Vermont	12.07	16.27	25.12	6.41	15.22	14.43
Virginia	11.57	13.49	19.15	10.65	13.85	14.18
Washington	12.85	14.30	21.66	7.27	16.92	16.29
West Virginia	10.89	13.84	23.38	7.13	13.62	14.07
Wisconsin	11.34	12.80	20.92	9.67	13.40	13.93
Wyoming[a]	11.80	12.54	22.70	4.59	12.84	14.33
Mean	11.51	13.52	21.69	7.92	13.51	14.36

NOTE: SAFs are expressed as percentages of Medicaid expenditures, reduced by amounts spent for people under 19 years old and for family planning, mental hospitals, mental retardation services, and dental services. State SAFs are evaluated for the poor and low-income population with weights equal to BRFSS individual weights.

[a]Wyoming has no BRFSS dataset. The Wyoming SAFs were computed as the mean of the SAFs of its contiguous states: Montana, Idaho, Utah, Colorado, South Dakota, and Nebraska.

Table 2. Smoking-attributable Medicaid expenditures by state and type of expenditure, fiscal year 1993 (in thousands)

State	Ambulatory care	Prescription drugs	Hospital care	Home health services	Nursing home	Total
Alabama	$17,273	$10,083	$56,404	$1,172	$22,372	$107,304
Alaska	7,823	1,782	8,195	29	5,789	23,617
Arizona	31,516	779	79,931	254	9,366	121,846
Arkansas	21,294	6,051	22,924	687	27,500	78,456
California	272,240	139,845	1,078,348	716	241,600	1,732,749
Colorado	29,001	7,981	75,849	764	37,904	151,500
Connecticut	32,539	8,840	61,231	4,099	75,046	181,755
Delaware	5,888	1,262	7,176	816	7,703	22,845
District of Columbia	3,490	1,433	22,587	472	7,848	35,830
Florida	118,297	42,579	204,648	5,356	146,101	516,980
Georgia	59,712	18,508	125,056	2,600	46,060	251,936
Hawaii	8,037	2,782	20,409	103	12,728	44,059
Idaho	6,943	2,344	7,983	109	7,965	25,343
Illinois	60,083	38,420	317,997	721	143,408	560,629
Indiana	50,101	25,333	96,600	1,876	80,982	254,892
Iowa	14,954	7,778	27,743	1,027	27,882	79,384
Kansas	13,292	7,231	27,424	379	23,975	72,300
Kentucky	53,354	21,252	77,126	4,145	44,863	200,740
Louisiana	55,817	24,732	259,635	1,297	75,544	417,026
Maine	18,082	6,621	41,820	717	28,623	95,862
Maryland	44,766	11,240	102,440	3,196	50,662	212,304
Massachusetts	71,662	23,350	163,184	5,267	142,481	405,943
Michigan	111,036	29,652	257,278	1,890	132,723	532,580
Minnesota	49,473	10,667	52,176	1,327	73,203	186,846
Mississippi	19,540	10,828	53,620	437	26,704	111,130
Missouri	33,777	18,995	101,701	565	51,884	206,923
Montana	8,844	2,221	6,335	145	10,519	28,065
Nebraska	9,810	4,142	12,142	616	16,724	43,434
Nevada	7,222	1,852	27,748	367	12,947	50,137
New Hampshire	11,507	2,760	61,795	145	18,325	94,531
New Jersey	70,594	31,090	284,444	9,174	149,405	544,708
New Mexico	12,965	3,395	21,772	304	9,877	48,314
New York	309,407	75,606	961,369	60,260	444,050	1,850,692
North Carolina	48,558	16,580	80,511	4,209	55,742	205,600
North Dakota	4,445	1,282	5,292	128	7,910	19,056
Ohio	73,167	45,673	243,456	2,566	232,356	597,217
Oklahoma	19,948	6,833	32,675	28	20,621	80,105
Oregon	37,608	7,719	20,091	123	23,690	89,231
Pennsylvania	77,016	53,056	210,607	1,717	263,119	605,516
Rhode Island	18,955	3,572	49,188	242	24,927	96,884
South Carolina	24,023	8,889	88,870	523	19,740	142,044
South Dakota	4,398	1,272	5,959	73	9,038	20,740
Tennessee	47,326	25,079	159,051	965	67,459	299,880
Texas	122,706	32,608	370,230	2,242	126,216	654,003
Utah	7,516	2,583	18,287	89	5,737	34,211
Vermont	8,112	2,854	8,572	213	9,274	29,025
Virginia	39,539	17,787	59,422	954	44,862	162,564
Washington	58,490	14,936	95,810	619	67,304	237,159
West Virginia	31,164	9,089	52,185	982	25,815	119,235
Wisconsin	45,166	17,058	44,992	3,875	86,836	197,927
Wyoming[a]	3,634	744	4,031	44	2,995	11,449
Total	$2,312,108	$869,047	$6,274,322	$130,624	$3,306,405	$12,892,507

NOTE: Smoking-attributable Medicaid expenditures (SAEs) include the Federal share of Medicaid expenditures. State SAEs are evaluated with state SAFs for the poor and low-income population with weights equal to BRFSS individual weights.

[a]Wyoming has no BRFSS dataset. The Wyoming SAFs were computed as the mean of the SAFs of its contiguous states: Montana, Idaho, Utah, Colorado, South Dakota, and Nebraska.

more medical care on average than younger people).

When we applied these SAFs to adjusted Medicaid spending, we estimated that $12.9 billion could be attributed to smoking in the United States in fiscal year 1993. Of this total, $6.3 billion was for hospital care, $3.3 billion was for nursing home care, $2.3 billion was for ambulatory care, $869 million was for prescriptions, and $131 million was for home health care. New York had the highest estimated Medicaid expenditures attributed to smoking—$1.9 billion or 14.4% of the $12.9 billion total.

The substantial variation among the states in smoking-attributable Medicaid expenditures was due both to differences in estimated SAFs and to differences in total Medicaid expenditures—reflecting differences in the proportion of the population that received Medicaid, the level of per-person spending on the program, and the distribution of expenditures by category. The totals shown in Table 2 include both the state and Federal shares of Medicaid expenditures; in fiscal year 1994 the Federal share ranged from 50% in 12 states (Alaska, Connecticut, Delaware, District of Columbia, Hawaii, Illinois, Maryland, Massachusetts, New Hampshire, New Jersey, New York, and Virginia) to 79% in Mississippi.[20]

We estimated interval estimates of the overall U.S. SAEs by type of expenditure using the jackknife method (see Appendix). The relative error of the $12.9 billion U.S. total SAE was 40.3%. Relative errors by type of expenditure were: ambulatory care 16.2%, prescriptions 14.9%, hospital care 59.2%, home health services 16.2%, and nursing home care 19.9%. Table 3 shows the point estimates for each state, plus and minus one standard deviation (40.3%).

DISCUSSION

Our study indicates that, on average, the states and the District of Columbia spend 14.4% of their Medicaid budgets (adjusted to eliminate expenditures that are not likely to be smoking-related) on medical care related to smoking—with a range from 8.6% in the District of Columbia to 19.2% in Nevada. Our findings are conservative, however, as they omit the following: (*a*) complications associated with health problems of newborns caused by mother's smoking, including low birth weight;[21,22] (*b*) illnesses caused by environmental tobacco smoke exposure of children and adults, such as asthma and otitis media.[21,23]

The models we developed can be applied to publicly funded expenditures focused on the poor other than Medicaid and can also be used to obtain multi-year estimates of smoking-attributable expenditures. It should be recognized, however, that medical practice changes over time. Since we estimated SAFs by type of medical expenditure, our model allows for the substitution of one type of service for another, for example, ambulatory care for hospital care. Our model does not allow for changes in practices within specific types of expenditures. Accordingly, the exercise should be repeated every 10 years or so.

Our estimates have several other limitations: (*a*) No single state dataset includes sufficient numbers to make accurate estimates of the number of people receiving publicly funded medical care (Medicaid and other programs for low-income people). (*b*) NMES did not record information on alcohol consumption, a potential smoking-related confounder. (*c*) Because expenditures for nursing homes comprise 25% to 40% of total Medicaid outlays in many states, it is extremely important that estimates of SAFs for this category be carefully estimated. As the national model is based on a survey of the noninstitutionalized population, it was impossible to estimate smoking-attributable expenditures for nursing home care directly. For the purpose of this analysis, we assumed that the SAFs for nursing homes equaled the SAFs for hospitals for people ages 65 and older. We are currently exploring the use of other datasets that we hope will provide more definitive estimates of smoking-attributable nursing home expenditures. (*d*) The samples used in developing the national model are heterogeneous. They include people currently being treated for tobacco-related diseases, who have relatively high medical costs, and people without such diseases, whose costs are much lower on average. These groups can be separated in later-released NMES data[24]; developing separate models for each would improve SAF estimates. (*e*) In our model, we relate smoking to medical expenditures in terms of biological causation (expenditures as a function of health status) and in terms of the association between smoking and expenditures, controlling for health. The interval estimates shown in Table 3 reflect the combined effects of the causative and associative relationships among smoking, disease, health status, and expenditures. Given that research has demonstrated a strong relationship between smoking and disease, the causative portion of the model should predict a positive and relatively certain relationship between smoking and health expenditures. Estimates based on the direct association between smoking and expenditures, controlling for health status, are likely to be weaker; it is not clear what their effect on expenditures should be, and therefore we should expect less stability in their statistical estimates. A further analysis of

Table 3. Interval estimates of smoking-attributable expenditures by state, fiscal year 1993 (in thousands)

State	Point estimates	Minus one standard deviation	Plus one standard deviation
Alabama	$107,304	$43,244	$150,548
Alaska	23,617	9,518	33,135
Arizona	121,846	49,104	170,950
Arkansas	78,456	31,618	110,074
California	1,732,749	698,298	2,431,047
Colorado	151,500	61,055	212,555
Connecticut	181,755	73,247	255,002
Delaware	22,845	9,207	32,052
District of Columbia	35,830	14,439	50,269
Florida	516,980	208,343	725,323
Georgia	251,936	101,530	353,466
Hawaii	44,059	17,756	61,815
Idaho	25,343	10,213	35,556
Illinois	560,629	225,933	786,562
Indiana	254,892	102,721	357,613
Iowa	79,384	31,992	111,376
Kansas	72,300	29,137	101,437
Kentucky	200,740	80,898	281,638
Louisiana	417,026	168,061	585,087
Maine	95,862	38,632	134,494
Maryland	212,304	85,559	297,863
Massachusetts	405,943	163,595	569,538
Michigan	532,580	214,630	747,210
Minnesota	186,846	75,299	262,145
Mississippi	111,130	44,785	155,915
Missouri	206,923	83,390	290,313
Montana	28,065	11,310	39,375
Nebraska	43,434	17,504	60,938
Nevada	50,137	20,205	70,342
New Hampshire	94,531	38,096	132,627
New Jersey	544,708	219,517	764,225
New Mexico	48,314	19,471	67,785
New York	1,850,692	745,829	2,596,521
North Carolina	205,600	82,857	288,457
North Dakota	19,056	7,680	26,736
Ohio	597,217	240,678	837,895
Oklahoma	80,105	32,282	112,387
Oregon	89,231	35,960	125,191
Pennsylvania	605,516	244,023	849,539
Rhode Island	96,884	39,044	135,928
South Carolina	142,044	57,244	199,288
South Dakota	20,740	8,358	29,098
Tennessee	299,880	120,852	420,732
Texas	654,003	263,563	917,566
Utah	34,211	13,787	47,998
Vermont	29,025	11,697	40,722
Virginia	162,564	65,513	228,077
Washington	237,159	95,575	332,734
West Virginia	119,235	48,052	167,287
Wisconsin	197,927	79,765	277,692
Wyoming	11,449	4,614	16,063
Total	$12,892,507	$5,195,680	$18,088,186

NOTE: Interval estimates are estimated at 40.3% of the point estimates.

these separate effects is needed. (*f*) The interval estimations, described in the Appendix, are likely to take into account the strongly significant biologically determined smoking-attributable expenditures but probably undercount the interval estimates of the smoking-attributable expenditures from the associative portion of the model because we removed sets of variables from the model that were not statistically significant at the maximum *P* value of 0.15. Accordingly, the variation in the SAE estimates in Table 2 and their uncertainty as shown in Table 3 are quite conservative. More research is needed on this issue.

This research is important because it provides important information to policy makers and voters who may otherwise be uninformed in their decision-making. As the state lawsuits to recover Medicaid costs and other public and private expenditures attributable to smoking evolve in the next several years, they may prove to be an important public health intervention for two reasons: (*a*) They may help to strengthen acceptance of the concept that economic sanctions may be appropriately applied against the tobacco industry, which has caused measurable harm to the public health. (*b*) The monies awarded may be substantial, thereby helping the states to provide prevention and educational services to discourage teenage smoking. It might also be appropriate for these monies to be applied against the medical costs of smoking-related chronic conditions because these costs comprise a significant share of the bill for chronic care. Clearly, the economic burden of caring for the chronically ill, including those with illnesses caused by smoking, will be enormous through the foreseeable future, which provides still further argument for renewing efforts to prevent smoking among young people, to support cessation interventions among current smokers, and to protect nonsmokers from the adverse effects of environmental smoke. Due in part to the aging of the postwar generation in the next century, almost 150 million people are projected to suffer from chronic conditions in the United States in the year 2030, at an estimated medical care cost of almost $800 billion (in 1990 dollars).[25,26] A significant portion of this total is directly attributable to cigarette smoking and therefore preventable. Further, if current smoking patterns continue, an estimated 25 million people alive today will die from smoking-related diseases, including five million younger than 18 years of age.[1]

In conclusion, the expenditures attributable to smoking and the estimates of uncertainty presented here provide a picture of smoking's economic burden on state Medicaid expenditures. Although the tobacco industry often argues that smoking cigarettes is a matter of individual choice,[27] these estimates show that this harmful product imposes significant economic burdens on state taxpayers, who have no choice but to bear them.

This research was sponsored by the Robert Wood Johnson Foundation Tobacco Policy Research and Evaluation Program and the Office on Smoking and Health, Centers for Disease Control and Prevention (CDC). The authors thank Michael Schooley, MPH, and Ann Malarcher, PhD, of CDC and an anonymous reviewer.

References

1. Smoking-attributable mortality and years of potential life lost—United States, 1984. MMWR Morb Mortal Wkly Rep 1997;46:444–51.
2. Rice DP, Hodgson TA, Sinsheimer P, Browner W, Kopstein AN. The economic costs of the health effects of smoking, 1984. Milbank Q 1986;4:489–547.
3. Bartlett JC, Miller LS, Rice DP, Max W. Medical care expenditures attributable to cigarette smoking—United States, 1993. MMWR Morb Mortal Wkly Rep 1994;43:469–72.
4. Skolnick AA. Spate of lawsuits may finally find chink in tobacco industry's "impenetrable armor." JAMA 1996;273:1060–1.
5. Moore MC, Mikhail CJ. A new attack on smoking using an old-time remedy. Public Health Rep 1996;111:192–203.
6. Glantz SA, Fox BF, Lightwood JM. Tobacco litigation: issues for public health and public policy. JAMA 1997;277:751–2.
7. Humphrey HH III. Winning against big tobacco: let's take the time to get it right. Public Health Rep 1997; 112:378–85.
8. Schultz JM, Novotny TE, Rice DP. SAMMEC 2.1: smoking-attributable mortality, morbidity, and economic costs [computer software and documentation]. Atlanta: Centers for Disease Control and Prevention, Office of Smoking and Health (US); 1992.
9. Max W, Rice DP. The cost of smoking in California, 1993. Tobacco Control 1995;4 Suppl 1:S29–46.
10. Williams AF, Franklin J. Annual economic costs attributable to cigarette smoking in Texas. Tex Med 1993: 89(11): 56–60.
11. Cohen BB, Connolly GN, Lederman RI, Danley RA. Smoking: death, disease and dollars. Boston: Massachusetts Department of Public Health; 1991.
12. National Center for Health Services Research and Health Technology Assessment (US). National Medical Expenditure Survey: methods 2: questionnaires and data collection methods for the Household Survey and the Survey of American Indians and Alaska Natives. Rockville (MD): The Center; 1989. DHHS Pub. No.: PHS 89-3450.
13. Centers for Disease Control, Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health (US). Reducing the health consequences of smoking: 25 years of progress: a report of the Surgeon General. Washington: Department of Health and Human Services; 1989. DHHS Pub. No.: 89-8411.
14. Maddala GS. Limited-dependent and qualitative variables in econometrics. Cambridge (UK): Cambridge University Press; 1983.
15. Duan N, Manning WG, Morris CN, Newhouse JP. A comparison of alternative models for the demand for medical care. J Econ Bus Stat 1983;1:115–26.
16. Adams EK, Solanki G, Miller LS, Program Services and Development Branch, Division of Reproductive Health, National Center for Chronic Disease Prevention and Health Promotion (US). Medical care expenditures attributable to cigarette smoking during pregnancy—United

States, 1995. MMWR Morb Mortal Wkly Rep 1997;46:1048–50.
17. Heckman J. Sample selection bias as a specification error. Econometrica 1979;47:153–61.
18. Lee LF. Estimation of limited dependent variable models by two-stage methods [dissertation]. Rochester (NY): Univ. of Rochester; 1976.
19. Hing E, Sekscenski E, Strahan G. The National Nursing Home Survey: 1985 summary for the United States. Vital Health Stat 13;97.
20. Health Care Financing Administration (US). 1996 data compendium. Baltimore (MD): Department of Health and Human Services, Bureau of Data Management and Strategy (US); 1996. DHHS Pub. No.: 03388.
21. Environmental Protection Agency (US). Respiratory health effects of passive smoking: lung cancer and other disorders. Smoking and Tobacco Control, Monograph 4. Washington: EPA; 1993. NIH Pub. No.: 93-3605.
22. McIntosh ID. Smoking and pregnancy: attributable risks and public health implications. Can J Public Health 1984;75:141–8.
23. Department of Health and Human Services (US). The health consequences of involuntary smoking: a report of the Surgeon General. Rockville (MD): Public Health Service (US); 1986. DHHS Pub. No.: CDC 87-8398.
24. Agency for Health Care Policy and Research (US). National Medical Expenditure Survey. Public use tape 29. Household survey: disability days and medical conditions, calendar year 1987 [CD-ROM]. 1985 Feb 8.
25. Hoffman C, Rice DP, Sung, HY. Persons with chronic conditions: their prevalence and costs. JAMA 1996; 276:1473–9.
26. Robert Wood Johnson Foundation. Chronic care in America: a 21st century challenge. Princeton (NJ): Robert Wood Johnson Foundation; 1996.
27. Glantz SA, Slade J, Bero LA, Hanauer P, Barnes DE. The cigarette papers. Berkeley (CA): University of California Press; 1996.
28. Centers for Disease Control. State Behavioral Risk Factor Surveillance System, 1993 [data tapes]. Atlanta: Centers for Disease Control and Prevention, Office of Smoking Prevention (US); 1993.
29. Gentry EM, Kalsbeek WD, Hogelin GC, Jones JT, Gaines KL, Forman MR, et al. The Behavioral Risk Factor Surveys: Part II: design, methods, and estimates from combined state data. Am J Prev Med 1985;1:9–14.
30. Remington PL, Smith MY, Williamson DF, Anda F, Gentry EM, Hogelin GC. Design, characteristics, and usefulness of state-based behavioral risk factor surveillance: 1981–1987. Public Health Rep 1988;103: 366–75.
31. Bureau of the Census (US). Current population survey, March 1993 [machine-readable data file]. Washington: The Bureau; 1993.
32. Agency for Health Care Policy and Research (US). National Medical Expenditure Survey: sample design of the 1987 Household Survey. Methods 3. Rockville (MD): The Agency; 1991. AHCPR Pub. No.: 91-0037.
33. Rao JNK, Wu CFJ, Yue K. Some recent work on resampling methods for complex surveys. Survey Methodology 1992;18:209–17. ■

APPENDIX

POINT ESTIMATES OF SMOKING-ATTRIBUTABLE EXPENDITURES

The medical care utilization of poor residents of each state was predicted with the national model using state-collected Behavioral Risk Factor Surveillance System (BRFSS) data.[28–30] We obtained a sample of poor residents as follows: (*a*) Since BRFSS does not contain relative income, we used the Current Population Survey (CPS) Household Survey[31] to describe state residents with "poor" income (less than 125% of the poverty level) or "low income" (between 125% and 200% of the poverty level). We then used the CPS to model relative income status in each state. (*b*) We used the state's CPS-based model to predict the likelihood of poor or low-income status for each BRFSS interviewee in a state. (*c*) We selected the BRFSS interviewees with the highest probability of poor or low-income status until the reported CPS percentage of poor and low-income residents was achieved. (*d*) The probability of being poor or having low income for the chosen sample were reweighted to reflect their proportion of the poor/low-income sample.

While we would have liked to also weight each of these poor and low-income BRFSS interviewees by their probability of receiving publicly financed medical services in 1993, the number of individuals in the state CPS datasets receiving publicly funded services was too small to yield reliable estimates. Accordingly, for each of the 24 age/sex/medical expenditure categories in a state, we estimated a SAF for the poor/ low-income sample as a ratio. The numerator, smoking-attributable expenditures (SAE), is the product of BRFSS weighted differences between expected expenditures for the various smoking groups and their expected expenditures considered as never smokers. The denominator of the ratio, the total expenditures, is the BRFSS weighted expected expenditures for all sample members (that is, with all possible smoking histories).

The propensity for previous treatment and for self-reported poor health status, as independent variables, are a function of (conditioned by) reported prior treatment and poor health status. Prior treatment and health

Table A. Estimates of NMES inflation factors required by state SAF estimates, by age, gender, and type of medical expenditure

Group	NMES evaluated SAF with conditional measures	NMES evaluated SAF with unconditional measures	Inflation factor ratio of conditional SAF to unconditional SAF	BRFSS evaluated SAF with unconditional measures	Inflated BRFSS SAF
Females 19–34					
Ambulatory	4.81	2.81	171.22	2.34	4.01
Prescription	5.53	3.21	172.67	2.62	4.53
Hospital	0	0	0	0	0
Home health	2.32	1.50	154.45	1.03	1.60
Males 19–34					
Ambulatory	9.74	6.43	151.60	3.69	5.59
Prescription	14.19	11.30	125.61	8.09	10.16
Hospital	61.07	60.98	100.14	48.46	48.53
Home health	0	0	0	0	0
Females 35–64					
Ambulatory	21.13	15.32	137.92	14.88	20.52
Prescription	12.53	4.08	307.09	4.69	14.41
Hospital	14.79	5.09	290.72	6.80	19.77
Home health	5.04	2.03	248.11	2.16	05.37
Males 35–64					
Ambulatory	14.73	5.08	289.94	5.28	15.32
Prescription	25.20	7.56	333.36	9.33	31.11
Hospital	42.97	13.58	316.41	11.75	37.17
Home health	7.72	3.11	247.96	3.19	07.92
Females ≥65					
Ambulatory	6.97	2.51	277.48	1.87	5.18
Prescription	10.74	3.46	310.62	3.00	9.31
Hospital	14.29	4.48	318.68	4.70	14.99
Home health	12.70	10.37	122.56	13.75	16.85
Males ≥65					
Ambulatory	14.29	5.91	241.75	5.06	12.24
Prescription	17.06	6.80	250.79	5.66	14.19
Hospital	9.54	4.85	196.71	6.11	12.02
Home health	11.84	5.24	226.09	5.79	13.09

NOTE: Smoking-attributable fractions (SAFs) are expressed as percentages.

status are known for smokers. However, since one can't know the treatment status or self-reported health status of smokers considered as never smokers, the estimate should be made without using reported data. We call these SAEs conditional estimates. Due to two inconsistencies between the NMES and 1993 BRFSS datasets, these conditional calculations were not feasible at the state level. First, BRFSS did not contain information about whether individuals had a history of tobacco-related diseases. Second, the BRFSS question on self-

reported health status included one additional possible answer, which changed the distribution of the way people self-reported poor health status.

Due to the limitations in the BRFSS, state SAF calculations had to be based on unconditional measures, that is, the SAF was based on the predicted propensities for previous treatment of tobacco-related diseases and for self-reported poor heath status, unadjusted with reported data. This calculation underestimates state SAFs and SAEs. To adjust for this underestimation, we estimated SAFs with the national model using the NMES poor/low-income sample for each age/sex/expenditure group with both conditional and unconditional indices. The ratio of the conditional to the unconditional SAF estimates for each age/sex/expenditure group established the required inflation factor. The unconditional state estimates were then inflated by these factors. Table A contains estimates of these inflation factors by age/sex/expenditure group. The inflation factors show how much undercounting would occur if the difference between conditional and unconditional SAFs were not appropriately considered. Table A also shows how similar the unconditional national SAFs based on BRFSS are to the unconditional national SAFs based on NMES. That is, BRFSS yields national unconditional estimates quite close to the unconditional national estimates based on NMES data. Table B describes the NMES-based national point estimates by type of medical expenditure obtained by aggregating the age/sex groups.

We estimated SAFs by age/sex/expenditure group and applied them to the 1993 state-specific HCFA 2082 Medicaid expenditures. The state SAFs were aggregated by age and sex, and applied, by type, to state HCFA 64 expenditures, yielding SAE estimates for each state.

Interval estimates. A "jackknife" estimation of the national model was used to make interval estimates of the SAE for the national model. The sampling design of NMES has 101 primary sampling units (PSUs) with two strata per PSU.[32] The jackknife estimate with this sampling design has 202 separate estimates of the parameters of the 24 models. For each jackknife estimate, the observations in one stratum of one of its 101 PSUs are deleted. The sample weights are doubled in the observations of the included stratum of the PSU containing the deleted stratum.[33]

The specification used for our point estimates was determined as follows: (*a*) The mean of each equation was specified as described above. (*b*) The variance of the poor health status equation was specified as a function of the smoking history variables, and the variance of the log level of positive expenditure equation was specified as a function of interactions between smoking history and insurance status. (*c*) After an initial estimation, sets of variables were removed when no variable within the set differed from zero by at least 15% by chance alone. The specification resulting from this algorithm was employed in each of the 202 jackknife estimates. This jackknife resulted in a distribution of national SAEs. The relative error of a SAE estimate is the ratio of the standard error of the jackknife SAE distribution to the original SAE estimate. The relative error is a statistic reporting the percentage increase or decrease in the national point SAE estimate containing approximately two-thirds of the probable SAE values. These estimates are reported in Table 3.

Table B. Point estimate of national model and relative errors

Type of Expenditures	*Point estimate of national SAFs*	*Relative error of SAEs*	*Relative error of SAFs*
Ambulatory care	12.25	16.23	13.46
Prescription drugs	15.78	14.93	8.93
Hospital care	18.74	59.22	49.99
Home health services	10.54	32.88	25.85
Nursing homes	12.22	22.96	19.89
Total	16.18	40.31	34.51

NOTE: Relative errors are expressed as percentages.
SAF = smoking-attributable fraction
SAE = smoking-attributable expenditure