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The Cost of Epilepsy in the United States: An Estimate from Population-Based Clinical and Survey Data

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Summary: *Purpose:* To provide 1995 estimates of the lifetime and annual cost of epilepsy in the United States using data from patients with epilepsy, and adjusting for the effects of comorbidities and socioeconomic conditions.

Methods: Direct treatment-related costs of epilepsy from onset through 6 years were derived from billing and medical chart data for 608 population-based incident cases at two sites in different regions of the country. Indirect productivity-related costs were derived from a survey of 1,168 adult patients visiting regional treatment centers. Direct costs separate the effects of epilepsy and comorbidity conditions. Indirect costs account for the effects of other disabilities and socioeconomic conditions on foregone earnings and household activity. The estimates were applied to 1995 population figures to derive national projections of the lifetime and annual costs of the disorder.

Results: The lifetime cost of epilepsy for an estimated 181,000 people with onset in 1995 is projected at $11.1 billion, and the annual cost for the estimated 2.3 million prevalent cases is estimated at $12.5 billion. Indirect costs account for 85% of the total and, with direct costs, are concentrated in people with intractable epilepsy.

Conclusions: Direct costs attributable to epilepsy are below previous estimates. Indirect costs adjusted for the socioeconomic conditions of patients are above previous estimates. Findings indicate that epilepsy is unique in the large proportion of costs that are productivity-related, justifying further investment in the development of effective interventions. **Key Words:** Cost—Lifetime—United States—Direct—Indirect.

Epilepsy is a neurologic condition characterized by recurrent unprovoked seizures. It affects ~2.5 million people with 150- to 200,000 new cases a year in the United States (1). Most people with onset of seizures can achieve seizure control with existing medications. However, 20–25% have seizures that do not respond to treatment. Epilepsy is an economic burden on individuals and society because of increased health care cost as well as losses in employment, wages, and household work. Few studies have assessed the magnitude of the cost, because of difficulties in defining epilepsy, the limitations of national surveys, the problem of separating the cost of epilepsy from that of coexisting conditions, and the variability of the illness. The last comprehensive study was done in 1975. Accurate and up-to-date cost estimates are needed to provide insight into the potential opportunities for cost savings and for determining how to treat the disease cost-effectively.

The goal of this study was to provide current estimates of both the *lifetime and annual cost* of epilepsy, addressing some of the methodologic problems of estimation. Lifetime costs include costs incurred from onset until remission or death. Such estimates are needed to value the economic gains of interventions that may prevent new cases or ameliorate the effects of the disorder on existing cases. Annual costs include all costs in a base year of persons living with the disorder. Such estimates are useful for comparing the social burden of epilepsy with that of other illnesses.

BACKGROUND

The human capital approach is used to generate the estimates. Costs to society are defined as (a) the direct cost of medical resources devoted to diagnosing and

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treating persons with the disorder, and (b) the indirect cost from foregone earnings and reductions in household activities because of epilepsy-related morbidity and mortality (2).

Medical care costs for epilepsy begin with the effort to detect underlying causes for seizures, to document cortical electrical abnormalities, and to initiate therapy with an antiepilepsy drug (AED). This may involve emergency room visits, hospitalization, and the use of diagnostic evaluations such as EEGs, computer tomography (CT) scans, and magnetic resonance imaging (MRIs). Follow-up treatment involves regular physician visits to monitor blood levels and to assess any side effects of AEDs. If adequate control is not achieved with the first AED, usually additional agents are tried. A small percentage of individuals who do not respond to multiple drug treatment may be considered for surgery or other therapies such as the ketogenic diet or vagal nerve stimulation (3).

Morbidity-related indirect costs result when individuals are less productive because of the disorder. Such losses occur when epilepsy causes people to withdraw from or never enter the labor market, reduce the number of hours worked, and/or reduce productivity per hour. They also occur when people reduce the number of hours they devote to household work (i.e., time spent preparing meals, cleaning, caring for children) because of the disorder. Mortality-related indirect costs refer to losses in future earnings and household activity due to premature death caused by epilepsy.

National projections of the lifetime costs of epilepsy require that the number and survival of incident cases and the present value of lifetime direct and indirect costs for each case be estimated. Projections of the annual cost of epilepsy require that the number of prevalent cases and the annual direct and indirect cost per case be estimated.

Studies vary in terms of the measures of cost that are estimated, the methods used as a basis for the projections, and the representativeness of the samples on which estimates are based (4,5). Most studies rely on data from a variety of different sources, including other cost studies in the literature and expert panel opinions. The validity of such estimates is difficult to assess because they are based on assumptions that may not be verifiable and opinion that may be variable. The methods used in this study attempt to address some of the methodologic shortcomings of previous research by basing estimates on data from representative patients with epilepsy and identifying the costs that are directly attributable to epilepsy.

METHODS

The direct cost study

Medical care utilization was obtained from charts and billing data for 608 incident cases who were identified over the period 1987–1994 enrolled in a managed care plan served by the Kelsey–Seybold system in Houston, Texas (275), or were a resident of Rochester, Minnesota (333). Case ascertainment involved record review of all persons receiving medical care at both sites during the study period (6,7). Treatment costs were identified from epilepsy diagnosis or first unprovoked seizure if treatment began at that time. Epilepsy neurologists at Kelsey–Seybold and Rochester conducted final review to confirm incident cases.

The Houston cases are from a population of employees and dependents in the Houston area who were enrolled in managed care plans served by the Kelsey–Seybold multispecialty group of primary care and specialist physicians. Kelsey–Seybold maintains a comprehensive medical record and billing system on managed care enrollees that captures services of affiliated hospitals and in- and out-of-network providers. In 1994, the total enrollment of these plans was 118,817. The Rochester cases were drawn from the centralized medical record and billing system maintained by the Mayo Clinic for all Olmsted County residents. The Mayo Clinic is a large multispecialty group practice in Rochester. In 1990, the population of Olmsted County was 70,000.

The cases were followed from initial evaluation of seizures through the end of 1995, exit from the study population (migration in Rochester or withdrawal from the managed care population in Houston), or death. The centralized medical charts and billing data at Kelsey–Seybold were used to obtain complete, item-specific medical services of Kelsey–Seybold cases over the study period. The Olmsted County Utilization Database, which captures administrative and billing data for the Mayo Clinic, its affiliated hospitals, and the Olmsted Medical Center and its affiliated hospital, was used to obtain the same data for Rochester cases.

At each site, the record of each medical encounter was reviewed, and utilization items were classified for attribution to seizure disorder. For encounters caused only by seizures, all itemized services and procedures were counted. For encounters judged to be caused primarily by seizures but with underlying comorbidity, only those services and procedures that were related to the seizure disorder were counted. Hospital admission routine room and board costs were counted and epilepsy-specific procedures such as diagnostic tests and blood levels were counted, but non–epilepsy-related items such as treatment for hypertension were not counted. For encounters judged to be primarily due to comorbidity but with underlying seizure-related treatment, only the services or procedures performed during the encounter that related directly to the seizures or their complications were counted. The routine costs associated with the encounter (room and board costs for a hospital admission, physician visit cost for an outpatient visit) were not counted.

Finally, for encounters judged to be caused by a comorbidity unrelated to epilepsy that had no underlying seizure-related treatment, no services or procedures were attributed to epilepsy. In an interrater reliability test, data abstractors at both sites coded >300 items of 20 complicated cases with 98% agreement.

Medical care items captured in the study and the unit costs used to value them are presented in Table 1. As indicated in the last column of the table, nationally representative unit costs were used whenever possible (i.e., the national Medicare payment rate for physician visits, procedures, and laboratory tests, and the national wholesale drug price for AEDs). Hospital-based charges from Houston and Rochester hospitals were adjusted to costs using the cost-to-charge approach and were nationalized based on comparisons of AHA hospital expense data for Houston and Rochester hospitals compared with those of the nation. The direct-cost study included no people with epilepsy surgery. Therefore, unit costs of surgery evaluation and surgery were obtained from King et al. (11). Total costs were derived by multiplying the percentage of the cohort using a particular service by the amount of use, and summing across services.

To examine the variation in cost by severity, cases were divided into three broad groups based on prognosis. Group 1 consisted of persons with early remission, defined as cases with no additional seizures during follow-up after the first year. Group 2 were people with delayed remission (e.g., had seizures one or more years after onset but were seizure free for at least a year at last follow-up). Group 3, intractable epilepsy, included people still having seizures in the last year of follow-up.

The indirect cost study

Because of confidentiality issues, it was not possible to identify and survey the 608 incident cases used in the direct cost study to obtain information on indirect costs. Instead, a survey was conducted of 1,168 adult patients with active epilepsy who visited one of 18 epilepsy treatment centers in the United States in 1995 or 1996. Estimates of indirect costs attributable to epilepsy were calculated based on comparing the responses of the epilepsy sample on work status, annual earnings and hours if working, and hours spent in home production with similar information for the general population obtained from the March 1996 Current Population Survey (CPS) (12) and the 1992 Panel Study of Income Dynamics (PSID) (13).

TABLE 1. *Cost variables and data sources used to estimate direct costs*

Cost items	Cost measures	Unit cost	Source of cost
Physician and hospital services			
Emergency room visits	Routine cost per visit	233	Cost-to-charge[a]
Hospital admissions	Routine cost per hosp	2,385	Cost-to-charge
Inpatient physician visits	Cost per visit	65	MFS[b]
Outpatient physician visits	Cost per initial visit	63	MFS
	Cost per follow-up visit	48	MFS
Diagnostic procedures			
EEG	Cost per procedure	117	MFS
CT scan	Cost per procedure	249	MFS
MRI	Cost per procedure	643	MFS
Other radiologic procedure	Cost per procedure	54	MFS
Lumbar puncture	Cost per procedure	66	MFS
Neuropsychological testing	Cost per procedure	78	MFS
Laboratory tests			
AED blood levels	Cost per procedure	18	MFS[c]
Other diagnostic lab tests	Cost per procedure	10	MFS
Other			
Emergency transportation	Cost per trip	181	Tx Medicaid[d]
Other services and procedures	Cost per procedure	56	MFS
AED treatment			
AEDs	Cost per year	[e]	Red Book[f]
Surgery			
Initial outpatient evaluation	Cost for vis & proc	2,134	King et al.[g]
Inpatient surface monitoring	Cost per hospitalization	12,268	King et al.
Inpatient depth monitoring	Cost per hospitalization	55,364	King et al.
Surgery	Cost per hospitalization	17,652	King et al.

[a] Hospital-based charges were translated into cost by applying the cost-to-charge ratios from each hospital's Medicare cost report.
[b] Medicare Resource-Based Physician Fees for professional services (8).
[c] Based on average Medicare payments adjusted to 1995 dollars (9).
[d] Texas Medicaid Payment Rate (personal communication, Texas Medicaid officials).
[e] Varies with drug type and dosage.
[f] 1995 wholesale drug prices from the Drug Topics Red Book (10).
[g] Based on published data reported by King et al. (11), and updated to 1995.

The first step was to develop multivariate regression models of earnings and household production by combining data from the general population and epilepsy surveys. The multivariate regression models allow estimation of the independent effect of epilepsy, controlling for other factors known to be associated with earnings including ethnicity, age, region of the country, city size, and another disability. Expected earnings was calculated as the product of two components: the probability of working and expected earnings, conditional on working:

$$\text{E(earnings)} = \text{probability (working)} \times \text{E(earnings working)} \quad (1)$$

A probit regression model was used to estimate the probability of working, and a standard regression model was used to estimate expected earnings of workers.

A separate home-production model was estimated that had the same independent variables plus the current unemployment rate. The latter was added to control for the fact that the PSID comparison sample, which contains a question on home production that the CPS does not, was from 1992, a mild recession period, whereas the epilepsy sample was from 1995 to 1996, a period of economic expansion. The average wage paid in 1995 to individuals working in social service occupations ($8.83 per hour) was applied to the results of the regression model for home production to value the estimates of time spent in household work.

After the estimation of the earnings and home-production models, the second step was to calculate the effect of epilepsy as the difference in regression estimates of earnings and home production for each person with epilepsy as compared with imputed estimates for the same person, setting all seizure variables to zero. The sum of the differences in the regression estimates of earnings and home-production losses for each person with and without epilepsy provides an estimate of total *annual* indirect costs per person attributable to epilepsy, controlling for other disabilities, demographic, and geographic factors that affect these costs.

Indirect costs per person *over a lifetime* were derived by summing the regression estimates of annual losses of persons of different ages in the sample. The following calculations were made: (a) the survival of each sample person was estimated based on life expectancy from the literature; (b) for each person, losses were summed across years of projected survival to obtain the value of future lifetime costs; (c) the annual losses were increased to reflect a rate of real (inflation-adjusted) wage growth in the future of 0.65% per year; and (d) all future losses were discounted to 1995 dollars by using a discount rate of 3.6% (the real interest rate on 10-year Treasury bonds as of June 1997).

The indirect lifetime cost estimates assume that for those with onset after the age of 18, the lifetime productivity costs of epilepsy begin accruing at the time of onset of the disorder and end at age 65. For those with onset before the age of 18, indirect costs were assumed to begin accruing at age 18 and end at age 65.

1995 incidence and prevalence

The number and distribution of incident cases of epilepsy in the United States in 1995 were estimated by applying the age-, sex-, and prognostic group-specific rates from the direct cost study to the 1995 U.S. population. The number of 1995 prevalent cases was estimated by applying incidence, prognosis, and remission rates from the direct cost study, and survival probabilities from the literature (14), to the U.S. population over the period 1910–1995. A simulation model was developed in which these parameters were applied to annual age-specific population cohorts beginning in 1910 and continuing through 1995 to derive estimates of 1995 cases by prognostic group and years since onset of the disorder. Prevalent cases were defined as cases with AED treatment and/or seizures in the last 5 years.

Lifetime costs of incident cohort

Direct costs from onset to death for each incident case were projected based on per case cost estimates from the direct cost study and expected survival. Direct costs for the incidence cohort for each year past onset was the sum of discounted costs (with a discount rate of 3.6%) per case for all medical services multiplied by the number of persons that survive to that year and receive the service. The present-value model of the total lifetime costs of incident cases in each group can be summarized as

$$\text{PVLC} = \sum_{t=0}^{99} N_a^t \sum_{i=1}^{15} P_{a,i}^t \times Y_{a,i}^t \times \text{UC}_i \times (1+r)^{-t} \quad (2)$$

where N_a^t is the number of people of prognostic group a who survive to time t past onset; $P_{a,i}^t$ is the probability that a person will use a service i in time t; $Y_{a,i}^t$ is the mean utilization of service i in time t; UC_i is the unit cost of the service in 1995 dollars; and r is the real discount rate.

Future surgery costs were projected separately based on rates of occurrence and unit cost reported by King et al. (11). It was assumed that 3,500 group 3 incident cases (persons with intractable epilepsy) would be evaluated for surgery 5 years after diagnosis and 2,000 (1% of all cases) would receive surgery. It was further assumed that 60% of the candidates for surgery would undergo initial outpatient evaluation followed by inpatient surface video-EEG monitoring. The other 40% would receive inpatient depth electrode video-EEG monitoring after their initial evaluations. Repeated surgeries and other therapies such as the ketogenic diet or vagal nerve stimulation were not considered.

Morbidity-related indirect cost estimates involved ap-

plying the per case estimates of productivity losses based on the epilepsy sample to the portion of incident cases in prognostic group 2 who are expected to have to continue AED therapy for their lifetime to control their seizures and prognostic group 3, expected to have intractable seizures. Indirect cost estimates for group 2 were based on the regression results for the subsample who had been seizure free for at least a year but were still taking AEDs. Group 3 indirect costs were based on the regression estimates for the remaining portion of the sample having seizures. Indirect costs for group 1 individuals (persons with early remitting epilepsy) and the proportion of group 2 individuals (persons with late remission) who discontinue AED treatment could not be estimated because the sample survey included too few people with these characteristics.

Mortality-related losses for the 1995 incident cohort were projected in three steps. First, age-specific premature deaths among incident cases were projected based on life expectancy from the literature (14). Second, regression estimates of future earnings and household production of persons in the epilepsy sample were derived by applying the regression models with epilepsy characteristics set at zero. Third, the number of deaths were multipled by the age- and sex-specific estimates of future lifetime earnings, discounted to 1995. The assumption is that people will be working and productive during their expected lifetimes in accordance with the current pattern of work experience.

Annual costs of prevalent cases

The per-case utilization and unit costs from the direct cost study were applied to 1995 prevalent cases to project annual direct costs. Direct cost estimates for study cases t years past onset were multipled by the estimated number of active cases in 1995 who were t years past onset (see section on prevalence estimates). The calculation for each group is summarized as:

$$AC = \sum_{t=0}^{99} N_a^t \sum_{i=1}^{15} P_{a,i}^t \times Y_{a,i}^t \times UC_i \qquad (3)$$

where N_a^t is the number of people of prognostic group a with onset at t years ago; $P_{a,i}^t$ is the probability a person with onset t years ago will use service i; $Y_{a,i}^t$ is the mean utilization of that service or procedure by a person with onset t years ago; and UC_i is the unit cost in 1995 dollars. Again, surgery costs were added based on the data reported by King et al. (11). It was assumed that in 1995, 3,500 prevalent cases from group 3 were evaluated for surgery and 2,000 received surgery, with unit costs reported in Table 1.

To estimate annual morbidity-related indirect costs for prevalent cases in 1995, the regression estimates developed from the survey were applied to the proportion of prevalent cases in prognostic group 2 on AEDs and all group 3 cases. Three calculations were involved. The number of premature deaths was estimated based on age- and sex-specific annual death rates drawn from the literature (8). Using the regression models, age-specific expected earnings and home production were derived for those people in the epilepsy sample had they not had epilepsy. The number of deaths was multiplied by the age-specific expected lifetime earnings and home production.

RESULTS

Direct cost per case

The epilepsy cases from Kelsey–Seybold were multiethnic and of all ages, but included few elderly. The Rochester cases were 96% white, but 35% were 65 or older. The combined cohort represents the spectrum of epilepsy in terms of etiology (63% idiopathic, 37% nonidiopathic), age (49% age 0–24, 31% age 25–64, 20% age 65+), and race (81% white, 11% black, 8% Hispanic, and other). About half the cases were identified at first unprovoked seizure. The remainder began with a diagnosis of epilepsy. About half of those identified at first unprovoked seizure had not received an epilepsy diagnosis before the end of the study period (25% of the cohort). The number of years of follow-up averaged 2.8 years; all 608 cases used to derive costs were followed up for a minimum of 2 years, 3 years of follow-up data were available for 413 cases, and 134 cases had ≥6 years of follow-up.

The average direct cost per case was $6,429 over the 6-year follow-up period, declining from $2,642 in the first 3 months to $329 for year 6 (Fig. 1). The high cost at onset reflects the intense service use for diagnostic evaluation and initial treatment for this condition. During the initial 3 months, 96% of the cohort had an outpatient physician visit, 58% visited an emergency room, and 40% were hospitalized at least once. The downward

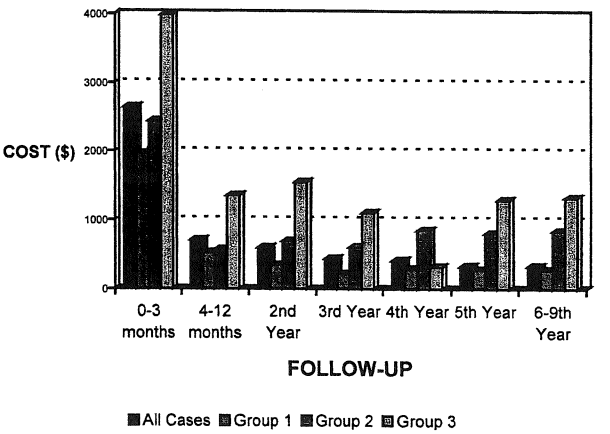

FIG. 1. Direct cost estimates per person by prognostic category.

trend over time reflects both the decreased service use by those whose seizures continue and the large number of persons who achieve remission with initial treatment and, after 1–3 years, discontinue services including use of AEDs. During the first 3 months, 68% of followed cases were taking AEDs, but only 45% were taking AEDs by year 6.

Differences in direct cost by prognostic group also are reflected in Fig. 1.[1] The differences reflect the additional resources, particularly hospital admissions and inpatient physician visits, as a consequence of ongoing seizures in group 3. Many people with early remission (group 1) are no longer treated 2–3 years after onset; by year 6, only 17% of group 1 were still taking AEDs compared with 61% for group 2 and 89% for group 3.

Indirect costs per case

Lifetime and annual indirect costs per case are provided in Table 2 based on 1,168 surveyed patients, 77% of those who agreed to participate and were successfully contacted and supplied required information by telephone. Based on the regression models, indirect costs due to epilepsy for adult men (aged 18–64) in the sample with intractable epilepsy (group 3) were 56% higher on an annual basis compared with those in group 2, and 50% higher on a lifetime basis. For adult women in the sample with intractable epilepsy, losses were 83% higher on an annual basis compared with those in remission, and 71% higher on a lifetime basis. Men with epilepsy actually increase the number of hours spent in home production compared with those without, resulting in an increase in output at home that offsets some of the losses in job-related earnings. However, the survey suggests that women have reduced numbers of hours devoted to home production, as well as reduced earnings due to their epilepsy. The lifetime losses represent about a 34% decline in the typical man's expected future productivity (earnings plus home production with epilepsy versus without), and a 25% decline in the average woman's expected productivity.

Lifetime costs for 1995 incident cases

The estimated number of 1995 incident cases of epilepsy is 181,000 (Table 3). Of these, 61% are expected to respond to initial medication, become seizure free, and discontinue AED therapy within 5 years, 15% respond to treatment after 2–5 years, and 25% are expected to continue to have seizures even with AED therapy. Applying the direct cost patterns for these prognostic groups and adding the cost of surgery for group 3, leads to an estimate of total lifetime direct costs of $1.8 billion for all persons with onset in 1995 (Table 4). The cost of AED therapy accounts for the highest portion of direct costs (29.2%), followed by inpatient hospital care (21.8%) and the cost of physician visits (12.2%).

Applying the indirect costs to group 2 cases who are expected to continue on AEDs, and all group 3 cases, results in an estimatged $9.3 billion in lifetime indirect costs (Table 5). Morbidity-related indirect costs for group 3 compose 71% ($6.6 billion) of total indirect costs for the cohort.

Combining direct and indirect costs yields a present value estimate of $11.1 billion for the total future lifetime cost of epilepsy for 1995 incident cases in the United States (Table 6). The cost of group 3 cases, representing only 25% of all cases (see Table 3), accounts for 79% ($8.8 billion) of the projected costs, $1.1 billion in direct and $7.7 billion in indirect. Group 1, with 61% of all cases, accounted for <3.5% of total projected costs for the cohort.

1995 annual costs for prevalent cases

There were an estimated 2.3 million prevalent cases of epilepsy in the United States in 1995 (Table 3). Total annual direct costs, applying the direct cost study findings to prevalent cases, was $1.7 billion (Table 4). AED therapy accounted for the highest portion (31.0%), followed by hospital admissions (23.9%) and physician visits (10.9%).

[1] The group costs are composite estimates based on multiplying the number of persons in a cohort with a service by the amount of service and its unit cost. Consequently, within-group variability was not addressed.

TABLE 2. *Indirect costs of epilepsy per person: all ages by sex and prognostic group*

	Women		Men	
	Group 2	Group 3	Group 2	Group 3
Lifetime per person losses in labor market earnings and household production	$104,350	$178,279	$196,678	$295,988
Reduction in labor market earnings	$59,157	$140,178	$209,727	$316,583
Reduction in household productivity	$45,193	$38,101	$–13,049[a]	$–20,595
Annual per person losses in labor market earnings and household production	$4,289	$7,869	$8,747	$13,617
Reduction in labor market earnings	$2,412	$6,266	$9,321	$14,518
Reduction in household productivity	$1,877	$1,603	$–574[a]	$–901
Sample size	144	523	98	403

[a] Men with epilepsy actually increase the number of hours spent in home production compared with those without. Women, on the other hand, have reduced number of hours devoted to home production.

TABLE 3. *Estimated number of incident and prevalent cases of epilepsy in the United States in 1995 by age and prognostic group*[a]

Prognostic group	Age 0–14 yr N	Age 0–14 yr % of overall total	Age 15–64 yr N	Age 15–64 yr ± of overall total	Age 65+ yr N	Age 65+ yr % of overall total	All ages N	All ages % of overall total
Incidence								
1	27,689	15.3	44,836	24.8	37,324	20.6	109,849	60.7
2	7,169	4.0	11,724	6.5	7,877	4.4	26,770	14.8
3	10,722	5.9	17,866	9.9	15,755	8.7	44,343	24.5
Total	45,580	25.2	74,426	41.1	60,956	33.7	180,962	100.0
Prevalence								
1	166,859	7.2	354,340	15.2	220,672	9.5	741,871	31.9
2	60,039	2.6	380,860	16.4	127,095	5.5	567,994	24.4
3	88,845	3.8	726,260	31.2	201,543	8.7	1,016,648	43.7
Total	315,743	13.6	1,461,460	62.8	549,310	23.6	2,326,513	100.0

[a] Estimated by applying the age-, sex-, and prognostic group–specific rates in the cohort study to the corresponding distribution of the U.S. population.

The morbidity- and mortality-related indirect costs for 1995 prevalent cases was $10.8 billion (Table 5). These costs were concentrated in Group 3 (86%). Lost productivity from premature death accounted for only 13% ($1.4 billion) of the total. The remainder was morbidity related.

Total annual costs in 1995 for all prevalent cases was $12.5 billion, with direct costs accounting for 14% and indirect costs 86% (Table 6). About 80% of 1995 annual costs for all prevalent cases were concentrated in group 3.

SUMMARY AND DISCUSSION

Based on a summation of epilepsy-attributable services used over time by two population-based incident cohorts in Houston, Texas, and Rochester, Minnesota, and regression estimates of productivity losses of people visiting epilepsy treatment centers throughout the United States, the 1995 lifetime cost of epilepsy for incident cases and the annual costs of prevalent cases is estimated at $11.1 and $12.5 billion, respectively.

TABLE 4. *Projected lifetime and annual direct costs for 1995 by cost item*

Cost items	Lifetime cost (in thousand dollars)	% of total cost	Annual cost (in thousand dollars)	% of total cost
Physician and hospital services				
Emergency room visits	73,657	4.2	72,696	4.3
Hospital admissions	381,891	21.8	403,045	23.9
Inpatient physician visits	48,982	2.8	54,036	3.2
Outpatient physician visits	164,861	9.4	129,211	7.7
Subtotal	669,391	38.2	658,988	39.1
Diagnostic procedures				
EEG	83,367	4.8	53,890	3.2
CT scan	70,211	4.0	60,586	3.6
MRI	64,203	3.7	50,356	3.0
Other diagnostic procedures	16,923	1.0	18,369	1.1
Lumbar puncture	1,314	0.1	1,381	0.1
Neuropsychological exams	1,156	0.1	1,277	0.1
Subtotal	237,174	13.7	185,859	13.1
Laboratory tests				
AED blood levels	67,912	3.9	56,579	3.4
Other diagnostic lab tests	72,550	4.1	70,024	4.2
Subtotal	140,462	8.0	126,603	7.6
Other				
Emergency transportation	23,201	1.3	26,505	1.6
Other services and procedures	47,167	2.7	59,675	3.5
Subtotal	70,368	5.0	86,180	5.1
Drug treatment				
AEDs	512,710	29.2	522,586	31.0
Subtotal	512,710	29.2	522,586	31.0
Surgery				
Evaluation	92,728	5.3	79,910	4.7
treatment	31,046	1.8	26,478	1.6
Subtotal	123,774	7.1	106,388	6.3
Total direct cost (in thousand dollars)	1,753,879	100.0	1,686,605	100.0

TABLE 5. *Projected lifetime and annual indirect costs for 1995 by prognostic group*

Prognostic group	Morbidity-related		Total cost (in thousand dollars)	Mortality-related		Total cost (in thousand dollars)	Total indirect cost (in thousand dollars)
	No. cases	Cost per case (in dollars)		No. deaths	Cost per case (in dollars)		
Lifetime							
1	0[a]	0	0	0	0	0	0
2	10,581[b]	143,158	1,514,753	8,069	19,742	159,306	1,674,059
3	28,588[c]	231,432	6,616,183	16,253	65,137	1,058,673	7,674,856
Total	39,169	207,586	8,130,936	24,322	50,077	1,217,979	9,348,915
Annual							
1	0[a]	0	0	0	0	0	0
2	213,282[b]	6,740	1,437,713	212	328,929	69,733	1,507,446
3	726,260[c]	11,031	8,011,665	4,066	317,877	1,292,486	9,304,151
Total	939,542	10,057	9,449,378	4,278	318,424	1,362,219	10,811,597

[a] Morbidity-related indirect costs for group 1 individuals could not be estimated, because there were no individuals in the epilepsy sample with these characteristics.
[b] Group 2 individuals who continue on AED treatment and are under age 65.
[c] Group 3 individuals under age 65.

The similarity of the cost projections reflects the steady-state assumptions built into the method for estimating lifetime costs (15). The lifetime cost projections assume the medical technology, treatment patterns, the relative value of medical resources, and productivity effects of epilepsy that exist in the mid-1990s. Innovation in medical technology and changes in the future course of the disorder will undoubtedly have significant effects on the real value of future follow-on direct and indirect costs and thus the present value of those costs. In addition to shifts in the pattern of health resource utilization in the future, changes in the impairment-related productivity losses occurring over an affected person's lifetime are virtually impossible to predict with any accuracy.

The estimates are conservative because important cost items were not included. The direct costs are based on the medical treatment patterns of persons with epilepsy through the mid-1990s. New medical and other therapies that have recently become available in the United States, such as vagal nerve stimulation, are not reflected in the estimates. Social service and family care costs, such as special education, child care, transportation, and the cost of a family caregiver's time devoted to accessing care or providing care were not included. Patient time costs in accessing services also were not captured. A major indirect cost that was not addressed was household activity losses of those older than 65 years. Although only a small portion of those older than 65 are still working, they still have household chores and self-care responsibilities that might be affected. Given the high incidence of epilepsy in this age grouup, these indirect costs may be significant. The indirect costs of persons with early remitting epilepsy and those with late remission who are able to discontinue AED therapy also were not captured. These costs may be significant because one seizure may cause significant job-related problems for people.

The cost estimates include some patients who had no additional seizures during the follow-up period and would not meet the medical definition of epilepsy (about 25% of group 1). Including these cases is necessary because early diagnosis of epilepsy can be difficult, delayed, or may never occur. Substantial costs occur with an initial seizure as part of the evaluation to detect underlying causes, and these costs would be missed if cases were identified at diagnosis (4). This inclusive case definition leads to higher total costs and lower costs per case.

The only existing U.S. study used data from a variety of sources to estimate the national annual cost of epi-

TABLE 6. *Projected lifetime and annual direct and indirect costs for 1995 by prognostic group and type*

Prognostic group	Direct cost (in thousand dollars)	% of overall total	Indirect cost (in thousand dollars)	% of overall total	Total direct and indirect cost (in thousand dollars)	% of overall total
Lifetime						
1	383,910	3.4	0	0.0	383,910	3.4
2	287,055	2.6	1,674,059	15.1	1,961,114	17.7
3	1,082,914	9.8	7,674,856	69.1	8,757,770	78.9
Total	1,753,879	15.8	9,348,915	84.2	11,102,794	100.0
Annual						
1	593,554	4.7	0	0	593,554	4.7
2	457,564	3.7	1,507,446	12.1	1,965,010	15.7
3	635,487	5.1	9,304,151	74.4	9,939,638	79.5
Total	1,686,605	13.5	10,811,597	86.5	12,498,202	100.0

lepsy in 1995 for 2.1 million prevalent cases at $3.6 billion, 49% direct and 51% indirect (16). By comparison, the current projection of the annual direct cost of epilepsy is about 22% of the 1995 estimate (annual cost of $1.7 billion vs. $7.8 billion for the 1975 study when adjusted to 1995 dollars), and the estimate of indirect costs is 32% higher (annual cost of $10.8 billion vs. $8.2 billion when adjusted to 1995 dollars).

A major difference between the two studies is in the treatment of the attribution problem. This is particularly evident with respect to residential care costs of institutionalized patients with epilepsy. The 1975 study attributed 70% of the direct costs of epilepsy to residential care even though they reflect the care of institutionalized people with seizures secondary to other disabilities. In the current study, 69 (11%) of the 608 individuals in the dirct cost study were in a nursing home or assisted living situation. Although the epilepsy-related medical treatment for these people was counted, none of the cost of their residential care was included because it could not be attributed to their epilepsy. Additional research is needed to identify the proportion of cost of institutionalized people attributable to epilepsy or to another disability.

The difference in indirect cost estimates between the two studies may also reflect methodologic differences. The 1975 study estimated indirect costs of epilepsy based on a 14.5% excess unemployment rate for noninstitutionalized persons with epilepsy. This figure was derived by comparing unemployment of persons with epilepsy with that of the general population. In making the same comparison, the current estimates reflect methods that explicitly control for education, geographic location, age, another disability, and other differences that exist between the epilepsy and the general population.

Based on a hypothetical model of treatment and productivity-related costs, Begley et al. (17) estimated the lifetime cost of epilepsy for 186,000 incident cases in 1990 at $3 billion. The current study's estimate of the lifetime direct cost of epilepsy is similar to that reported by Begley et al. ($9,593 vs. $9,692). However, the indirect cost estimate is substantially higher ($51,662 vs. $12,634). The estimates of Begley et al. of the effect of epilepsy on employment and earnings was obtained by comparing the unemployment rates among patients with epilepsy to national averages for the labor force. A much higher figure is obtained in this study after accounting for differences in the characteristics of patients with epilepsy and the general labor force with which they are compared.

Compared with those of other major chronic diseases, such as heart disease and cancer, epilepsy costs are relatively small both in the aggregate and on a per-case basis, accounting for only a small portion of the estimated $659 billion in the total cost of all chronic diseases in 1990 (18). However, on a per-case basis, it is a costly disorder for people with intractable seizures. The average cost of all chronic conditions was estimated at $7,355 in 1990, compared with the 1995 estimate of $9,939 for group 3 people with epilepsy in this study. Epilepsy also is unique among chronic conditions in terms of the relatively high percentage of indirect morbidity-related costs, 70% for persons with intractable epilepsy (i.e., prognostic group 3) compared with an average of 11% for all persons with chronic disease. This is because epilepsy strikes all ages, including the young, who are disabled during the most productive periods of their lives.

The high concentration of costs among intractable patients emphasizes the importance of seizure control in determining the economic burden of epilepsy, and the cost-saving potential of effective interventions that increase seizure control. Recent developments of new medical, surgical, and vagal nerve stimulation therapies hold promise for reducing the frequency and severity of seizures in people with refractory epilepsy. Although these procedures are expected to cause a substantial increase in the cost of treatment for persons with epilepsy, they may ultimately reduce costs by leading to lower indirect costs.

The impact of epilepsy on the direct costs of care should not be underestimated, however, particularly among the elderly. Indirect costs among persons aged 65 and older are low because of shortened life expectancy, low labor force participation rates, and low earnings. However, the over-65 population accounts for a disproportionate share of direct costs. The average cost per person over the follow-up of the direct cost study was $10,612, compared with $6,674 for persons aged 18–64, and $4,967 for children aged 0–17. Older people had greater use of hospital care and a higher percentage who continue AEDs. Given current projections of the growing proportion of the population over age 65, and the problems with Medicare coverage and payment for this population, the direct costs of care for the elderly also pose a major area of concern.

Limitations of this study should be considered in interpreting the results. Perhaps the most important is the fact the samples of patients used in estimating direct and indirect costs, although drawn from various treatment settings, may not be representative of epilepsy patients throughout the country. Data from patients in other regions of the country and treatment settings are needed to confirm or contradict the results reported here. Another limitation is the failure to address nonmedical direct costs and indirect costs for the elderly and persons with remitting epilepsy. Although difficult to obtain, it is possible that their omission may lead to substantial underestimates of the economic burden of this disorder. The relatively short follow-up period poses another limitation that affects the lifetime cost projections. The implicit

assumption is that the lifetime pattern of care is established in 6 years. Despite these limitations, the results represent reasonable updates of the cost of the disorder based on data from community-based patients and adjusted for attribution, socioeconomic conditions, and the effects of comorbidities.

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