Multiple Sclerosis Rates Up 50%

Review Tracking Neurological Disorders Shows 1 in 1,000 Americans Have Multiple Sclerosis

By Miranda Hitti
WebMD Medical News

Reviewed By Louise Chang, MD
on Monday, January 29, 2007

Jan. 29, 2007 -- Multiple sclerosis (MS) may be 50% more common in the U.S. than previously thought, according to a new research review.

The review from the National Institute of Neurological Disorders and Stroke says almost one in 1,000 people in the U.S. have MS.

However, the National Multiple Sclerosis Society says that figure could still be low.

The society points out that the review's estimate of MS prevalence (the number of people with MS) works out to about 266,000 people.

But the society says it has "over 300,000 people" in its database who say they have MS.

The Review

The review's researchers included Deborah Hirtz, MD, of the National Institute of Neurological Disorders and Stroke, which is part of the National Institutes of Health (NIH).

They analyzed 500 studies published from 1990 to 2005 to track MS and 11 other neurological disorders. Their findings appear in the Jan. 30 issue of *Neurology*.

Since high-quality U.S. data on most disorders were lacking, the researchers often applied data from other countries to the U.S. population.

That approach isn't ideal, the researchers admit. They call for better studies to track neurological disorders in the U.S.

Still, they say their findings show "the burden of neurologic illness affects many millions of people in the United States."

Multiple Sclerosis Findings

"Our estimate of MS prevalence is about 50% higher than a comprehensive review from 1982," Hirtz says in an American Academy of Neurology news release.

"Whether this reflects improvement in diagnosis or whether incidence is actually increasing deserves further study," Hirtz says.

How Common Are Neurological Conditions?

In addition to MS, the researchers tracked the prevalence of the following conditions:

- **Migraine:** 121 in 1,000 people
- **Epilepsy:** 7.1 in 1,000 people
- **Alzheimer's disease:** 67 in 1,000 people 65 or older
- **Parkinson's disease:** 9.5 in 1,000 people 65 or older
- **Autism spectrum disorders:** 5.8 in 1,000 children
- **Cerebral palsy:** 2.4 in 1,000 children
- **Stroke:** 10 per 1,000 people
- **Traumatic brain injury:** No prevalence estimates available
- **MS:** 0.9 in 1,000 people
- **Spinal cord injury**: No prevalence estimates available
- **ALS** (amyotrophic lateral sclerosis, or Lou Gehrig's disease): 0.04 in 1,000 people
- **Tourette's syndrome:** No prevalence estimates

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How common are the "common" neurologic disorders?

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Abstract—*Objective:* To estimate the current incidence and prevalence in the United States of 12 neurologic disorders. *Methods:* We summarize the strongest evidence available, using data from the United States or from other developed countries when US data were insufficient. *Results:* For some disorders, prevalence is a better descriptor of impact; for others, incidence is preferable. Per 1,000 children, estimated prevalence was 5.8 for autism spectrum disorder and 2.4 for cerebral palsy; for Tourette syndrome, the data were insufficient. In the general population, per 1,000, the 1-year prevalence for migraine was 121, 7.1 for epilepsy, and 0.9 for multiple sclerosis. Among the elderly, the prevalence of Alzheimer disease was 67 and that of Parkinson disease was 9.5. For diseases best described by annual incidence per 100,000, the rate for stroke was 183, 101 for major traumatic brain injury, 4.5 for spinal cord injury, and 1.6 for ALS. *Conclusions:* Using the best available data, our survey of a limited number of disorders shows that the burden of neurologic illness affects many millions of people in the United States.

NEUROLOGY 2007;68:326–337

Current accurate estimates of the numbers of people affected by neurologic disorders are needed to understand the burden of these conditions, to plan research on their causes and treatment, and to assess preventive interventions. Estimating the incidence and prevalence of neurologic disorders can be challenging. For some diseases, there are few published data and for others, available estimates vary greatly.[1] We surveyed the literature to develop the best possible estimates of the incidence and prevalence in the United States of 12 neurologic disorders across the life span that are commonly seen by neurologists and have substantial morbidity or mortality. Our approach was similar to the American Academy of Neurology's process for evidence-based guidelines for clinical practice.[2] We defined four classes of evidence (table 1) and searched the literature for relevant studies. We based our estimates for incidence and prevalence on the strongest evidence available.

Additional material related to this article can be found on the *Neurology* Web site. Go to www.neurology.org and scroll down the Table of Contents for the January 30 issue to find the title link for this article.

Methods. For each disorder, we searched PubMed using the terms epidemiology, incidence, and prevalence; we restricted the search to English-language articles published between January 1, 1990, and January 31, 2005. We screened titles and abstracts and selected relevant articles, excluding case reports and small case series. We identified additional studies from reference lists and from recent reviews. Approximately 500 articles were reviewed.

Criteria for evaluating the strength of evidence considered time frame, case-finding strategy, case definition, and source of diagnosis (table 1):

- *Time frame.* Because rates of disease occurrence as well as methods of diagnosis or data collection often change over time, we gave our top rating (A) to studies in which some or all of the data were obtained from 1990 or later.
- *Case finding and sample size.* An A rating required either the great majority of cases in a population to be included or a representative population-based sample. Studies of exceptionally small samples with wide CIs (e.g., from less than one-half to more than twice the point estimate) were rated as C.
- *Case definition.* An A rating was reserved for studies with clearly defined and consistently applied diagnostic criteria reflecting currently accepted disease definitions.
- *Source of diagnosis.* An A rating required either an expert diagnostician who had applied the case criteria to each case or a validated source with known high predictive values.

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See also pages 338 and 384

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Disclosure: The authors report no conflicts of interest.

Received June 20, 2006. Accepted in final form November 6, 2006.

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Table 1 *Classes of evidence for studies on neurologic disorders*

Time frame

A. Data refer to time period that includes years from 1990 or later

B. Data refer to time period that includes years from 1970 to 1989 but not later

C. Data refer to 1969 or earlier

D. Data refer to an undisclosed time period

Case-finding and sample size

A. Evaluate all eligible population members (or adequate-sized random sample) or search of all relevant referral sources, with likelihood of identifying substantial majority of targeted cases

B. Some potentially relevant case-finding sources omitted

C. Case-finding strategy that may lead to an unrepresentative sample or significant over- or underascertainment

D. No information disclosed or sample size inadequate to provide confident estimate of incidence or prevalence

Case definition

A. Clearly defined and consistent with generally accepted clinical/laboratory criteria

B. Less precisely defined with minor deviations from generally accepted criteria

C. Modification or partial use of generally accepted criteria

D. Other or no criteria applied

Source of diagnosis

A. Specialist or fully validated source (including self-report) with known positive predictive values

B. Self-report with specified criteria or partially validated source

C. Nonvalidated but well-defined diagnostic source

D. Self-report without specified criteria or poorly defined source

Using these criteria, we categorized articles as Classes I through IV (table 2). At least two of the authors (D.H., D.J.T., K.G.H., R.Z.) independently reviewed each article and resolved any differences in classification with the rest of the authors. When four or more Class I articles were not available from the United States or Canada, we included data from other developed countries. Class III and IV evidence was reviewed but not included in determining estimates of incidence and prevalence, unless there was little or no Class I or II evidence.

We defined incidence as the number of new cases occurring in a specified population during a given interval and expressed it as new cases per 100,000 population per year. Prevalence was defined as the number of cases existing in a population at a specific time point. Prevalence includes all cases, whether of recent or remote onset, until such time as the condition fully resolves or death occurs, expressed as a proportion: existing cases per 1,000 population.

Table 2 *Determination of class of evidence*

Class	Distribution of criteria*
I	All A
II	One or more B; no C or D
III	One or more C; no D
IV	One or more D

* From table 1: time frame, case-finding strategy, case definition, and source of diagnosis.

Many authors did not adjust their data to the age distribution of a standard population. To improve comparisons across studies that reported incidence or prevalence data stratified by age, we recalculated summary rates standardized through direct adjustment to the age distribution of the US population in 2000.[3] We did not standardize rates from studies limited to children and we could not standardize rates if age-specific data were lacking. Where studies reported separate data from multiple time periods, we considered only the most recent data (see appendix E-1 on the *Neurology* Web site at www.neurology.org).

Neurologic disorders with onset early in life. *1. Autism.* The autism spectrum disorders (ASD) are classified according to the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision* (DSM-IV-TR) as pervasive developmental disorders that include autistic disorder, Rett syndrome, childhood disintegrative disorder, and Asperger disorder as well as pervasive developmental disorder not otherwise specified.[4] Prevalence is reported in preference to incidence because the age at ascertainment is variable. We found no studies of prevalence in adults, although the disorder is lifelong.

There were seven Class I[5-11] (one from the United States) and seven Class II[12-18] (two from the United States) prevalence studies (see table E-1 on the *Neurology* Web site at www.neurology.org). From the Class I studies, the median prevalence of autistic disorder was 2.4 per 1,000 (range 0.7 to 4.1), and of ASD was 5.8 per 1,000 (range 1.3 to 6.7). The ratio of boys to girls was approximately 4:1.

These numbers are larger than have been previously reported, and there is widespread concern about an apparent increase in autism.[19,20] In light of current controversy, two articles (one US, one Canadian) published after completion of our literature search support the prevalence figure of approximately 6 per 1,000 for ASD.[21,22] There are major limitations in our ability to compare recent and older data; for example, diagnostic criteria have changed, public services are more available, societal attitudes have evolved, and case ascertainment methods have shifted to population screening.

2. Cerebral palsy (CP). CP is a nonprogressive impairment of movement or posture originating either perinatally or very early in life, usually in the first year.[23] Studies of prevalence have been performed in populations of children, although the disability is lifelong. Many studies include separate data for infants born preterm because their risk of CP is higher.

Eight European[24-31] and one US[32] Class I studies yielded a median prevalence of 2.4 per 1,000, and there was remarkable consistency (range 2.0 to 2.5 (table E-2a). Four European and two US Class II studies also yielded a median prevalence of 2.4 per 1,000 but with a broader range (1.2 to 3.2).[33-38]

For preterm infants, from nine Class I[24-27,29,31,32,39,40] and two Class II[41,42] studies the median prevalence of CP among survivors with birth weights of 1,500 to 2,499 grams was 11.2 per 1,000 (range 6.2 to 13.9); the corresponding median among those with birth weights less than 1,500 grams was 63.5 per 1,000

(range 28 to 185) (table E-2b). For infants weighing less than 600 grams at birth, in a single Class III study, of the 25% of infants who survived, 75% had CP.[43] In all studies, the lower the birth weight was and the younger the gestational age was, the higher the prevalence of CP. Infants born in multiples have a higher risk of developing CP than singletons, but this risk is largely related to the fact that they are more commonly preterm.[44] Estimates do not vary appreciably between studies from the 1980s and from 1990 or later. However, in the current decade, improved survival rates at earlier gestational ages as well as increased rates of prematurity and multiple births may be causing an increase in children with CP.[25,32,41,43-49]

3. Tourette syndrome. The diagnosis of Tourette syndrome (Gilles de la Tourette syndrome) is based on the presence of multiple vocal and motor tics present for at least 1 year with onset by age 18 years.[4] DSM-IV[50] criteria (published in 1994) required that there be some impairment or distress as a result of the symptoms, and in contrast, DSM-III-R[51] (published in 1987) and DSM-IV-TR[4] (2000) do not include that requirement. Study populations or samples are usually relatively small, resulting in wide estimated CIs. Symptoms vary in frequency and intensity and may go unrecognized by those who suffer them, their families, or their physicians.[52]

No Class I studies were found. Four Class II studies[53-56] (including one from the United States) yielded a median prevalence of 3.5 per 1,000 (range 0.4 to 11.0) (table E-3). The median prevalence in four Class III studies (two from the United States) was 7.2 per 1,000 (range 1.5 to 18.5).[54,57-59] Prevalence peaks between ages 7 and 16 years with a male predominance of about 5:1 (range 1.6 to 10:1).[52] The prevalence in special education students is much higher than in the general population.[59]

Difficulties in case identification make accurate estimates of prevalence challenging, and methods of case ascertainment differ considerably among studies. Correspondingly, estimates from Class II studies in several countries vary greatly (nearly 30-fold), and the validity of the median estimate of 3.5 per 1,000 is suspect.

Neurologic disorders with onset at any age. *4. Migraine.* Operational diagnostic criteria published by the International Headache Society (IHS) have helped standardize recent epidemiologic studies.[60] Many migraine sufferers do not seek medical care; thus, a study that relies on medical records is likely to substantially underestimate this problem. Population surveys are crucial in epidemiologic studies of migraine. Studies variously reported 1-year prevalence, annual incidence, and lifetime prevalence. The episodic nature of the disorder makes these susceptible to recall bias (e.g., people may forget an episode from decades earlier). Because the diagnosis of migraine headache is based on history rather than on physical examination, we considered studies that employed structured questionnaires using IHS criteria to be equivalent to having the diagnosis made by an expert without direct examination (table 1).

Four Class I[61-64] and eight Class II[65-70,72,73] studies (five from the United States) estimating the 1-year prevalence of migraine in adult populations yielded a median prevalence of 121 per 1,000 (range 50 to 158) (table E-4a). Studies including adults that compared rates by sex consistently reported lower 1-year rates for men, with a median man-to-woman rate ratio of 0.36. In adults, prevalence varies little by age (figure E-1). Two Class II studies found a prevalence in children of 70 and adolescents of 106 per 1,000 (median 88).[74,75]

There was a single Class II study that found an age-adjusted annual incidence of 370 per 100,000, with a man-to-woman rate ratio of 0.28.[73] From four Class I[64,71,76,77] (one US) and three Class II[65,68,73] (one US) studies, the median lifetime prevalence for men and women together was 159 per 1,000 (range 109 to 234) (table E-4b).

5. Epilepsy. The International League Against Epilepsy has defined epilepsy as recurrent nonprovoked seizures.[78] Excluded from this definition are a) acute symptomatic seizures provoked by known precipitants such as head trauma, b) febrile seizures in young children with no history of nonfebrile seizures, and c) neonatal seizures. Using these criteria, we excluded several studies with broader definitions.

In four Class I[79-82] (all European) and six Class II[83-88] studies of incidence (three from the United States), the median estimate was 46 per 100,000 per year (range 32 to 71; table E-5a). The subgroup of four studies including all age groups yielded a similar median estimate of 48 per 100,000.[81,82,86,87] The incidence of epilepsy is related to age; in studies restricted to children or adolescents, the median estimate was 57 per 100,000 per year (range 41 to 65). Higher incidence rates occurred among infants younger than 1 year and among people older than 60 years (figure E-2).[79-86,88,89] Most studies did not show significant differences by sex.

Six Class I[90-95] (all European) and seven Class II[81,85,87,89,96-98] (three from the United States) studies addressed prevalence (table E-5b). For the three Class I studies in children and adolescents up to age 19, the median value was 3.9 per 1,000 (range 3.6 to 5.1).[90,92,94] Among the Class II studies that included all age groups, the median estimate was 7.1 per 1,000 (range 4.0 to 8.9) (table E-5b).[81,87,96-98]

6. Multiple sclerosis (MS). Most of the studies that we reviewed relied on diagnostic criteria proposed by Poser et al. in 1983[99]; most included both definite and probable cases, with definite cases accounting for most. Epidemiologic studies of MS have been hampered by variability in clinical findings, lack of a single, accurate diagnostic test, and delays in diagnosis. In addition, changes in diagnostic tools and criteria may have altered observations of incidence and prevalence.

Earlier epidemiologic studies drew attention to variation in prevalence by latitude,[100] suggesting that climatic, environmental, or infectious exposures—or varying genetic predispositions—are involved in the pathogenesis of MS.[101] A systematic meta-analysis has found that the apparent relationship between MS and latitude diminishes when estimates are age and sex adjusted to a common standard population.[102]

Among all 22 Class I studies of incidence (one from the United States),[103-124] the median estimate of the annual incidence of MS was 4.2 per 100,000 (range 0.8 to 12.0) (table E-6a). The median estimate among Mediterranean countries (Greece,[103] Italy,[104-111] Malta,[112] and Spain[113-115]) was 3.7 (range 0.8 to 6.7) per 100,000, whereas the median among more northern European countries[116-123] was 4.6 (range 3.8 to 12.0). A study from North America (Minnesota)[124] using data from 1985 through 2000 reported 7.4 cases per 100,000 population per year.

Among the 39 Class I studies of MS prevalence (table E-6b),[103-106,108-115,118-141] the median was 0.9 per 1,000 (range 0.2 to 2.3). Studies in Mediterranean countries[103-115,131-133,135-138] yielded a median prevalence per thousand of 0.6 (range 0.2 to 1.6), and other European countries[101,116-123,125,126,129,130,139,140] of 1.2 (range 0.7 to 1.8). The four studies from North America covering populations in Alberta[127,128] and Minnesota[124,141] provided a median estimate of 2.0 per 1,000 (range 1.7 to 2.3). The peak age of MS onset is approximately 30 years (figure E-3), and few cases are diagnosed before age 15 or after 50. Both incidence and prevalence are approximately twice as high among women as in men.

7. *Stroke.* Stroke includes both ischemic and nontraumatic hemorrhagic insults to the brain. We did not include studies of asymptomatic cerebral infarctions diagnosed only from brain imaging procedures, studies of perinatal stroke, or data on TIAs. Most studies of incidence addressed only first strokes.

We identified 11 Class I[142-152] (two from the United States) and 14 Class II (seven from the United States) studies[153-165a] that reported combined incidence of ischemic and hemorrhagic stroke (table E-7a). Overall rates varied greatly by age range. The median annual incidence of first stroke in studies encompassing all ages was 183 per 100,000. The median value in studies excluding older ages (upper bounds from 15 to 49 years) was 10 per 100,000 per year. Data from Class I[142-148,150,151] and Class II[153,156-163] studies suggest that the risk of stroke roughly doubles with each decade of age during adulthood (figure E-4). The lowest risk is seen among children after 1 year of age[153-155]; the highest is among persons aged 85 years or older, with a median annual rate exceeding 2,000 per 100,000.

The summary rate ratios by sex (table E-7a) do not show a consistent difference; however, most studies show somewhat higher age-specific rates among men. Nine studies of US communities focused on disparities in incidence by race or ethnicity.[152,154,155,164,165a,165b,166-168] These studies suggest higher risk among Hispanics and African Americans; in the latter group, rates appear to be roughly twice those of whites (table E-7b).

Most studies attributed 80% or more of all strokes to ischemia (median 81%). Lower figures were seen in studies focused on children or populations younger than 50 years of age (median 51%),[142,153-155] and populations in Japan (median 62%).[148,158,162] In one Class I and two Class II studies addressing prevalence (ever having a stroke), results varied by age range (table E-7c).[161,169,170] A study in Rochester, MN, suggests a prevalence of 1% in the white population of all ages[161]; a national survey suggests a prevalence of nearly 2% for US adults aged 25 to 74 years.[170] As predicted by results for incidence, older populations have a much higher prevalence, as demonstrated by an Italian study.[171]

8. *Traumatic brain injury.* The Centers for Disease Control and Prevention (CDC) defines traumatic brain injury (TBI) as craniocerebral trauma associated with decreased level of consciousness, amnesia, other neurologic or neuropsychological abnormalities, skull fracture, intracranial lesions, or death.[172] The majority of studies in the United States are focused on injuries that lead to hospital admission or result in death.

Of six Class I studies in the United States,[173-178] four[173,175-177] addressed the combined incidence of fatal and hospitalized TBI among all age groups (table E-8) with a median annual incidence of 101 per 100,000 (range 91 to 105 per 100,000). Rates among men were approximately twice those of women; rates were higher among adolescents and young adults as well as among seniors (figure E-5). The proportion of TBIs resulting in death either immediately or during acute hospital care varied from 18 to 23%. The Class I study of hospitalized patients with nonfatal TBIs found an incidence rate of 70 per 100,000.,[178] and the Class I study that addressed TBI hospitalizations and deaths only among children younger than 20 years found a rate of 74 per 100,000.[174]

The estimated annual rates of presumed mild TBIs treated only in outpatient facilities or hospital emergency departments (EDs) from two Class II studies in the United States were 392 TBI-related ED visits per 100,000 population[179] and 540 combined ED or outpatient visits per 100,000.[180]

We found no Class I, II, or III studies that directly measured the prevalence of TBI-related disability in general populations. One Class II study[181] reported a prevalence of disability of 37% in a population-based sample of patients followed 1 or more years after hospitalization for TBIs. Based on this figure and taking account of temporal trends in TBI incidence rates, the CDC has estimated that nearly 2% of the entire US population has TBI-related disabilities.[177] Because it is a proportion derived using assumptions of long-term survival and mathematical models, we

cannot classify the level of this evidence, although it clearly indicates a high prevalence.

9. Spinal cord injury. Most studies of the incidence of spinal cord injury (SCI) include traumatic lesions that result in complete or incomplete functional interruption of spinal pathways and varying degrees of paraparesis or tetraparesis, consistent with American Spinal Injury Association criteria.[182] Both transient and permanent manifestations are included. Some studies of incidence are limited to acute injuries that result in hospital admission; a few also include immediate fatalities not admitted to hospitals. Prevalence is defined as the proportion of a population with persisting neurologic sequelae as a result of SCI.

Four Class I[183-186] and one Class II[187] studies from North America yielded a median annual incidence rate of 4.5 per 100,000 (range 3.9 to 7.7) (table E-9). Rates are approximately four times greater among men and relatively higher among adolescents and young adults (figure E-6). Analysis by level of lesion showed that a slight majority of injuries resulted in quadriplegia or quadreparesis.[185,186,188]

Prevalence data are scant; one Class III study that surveyed a sample of the US population estimated that 0.72 people per 1,000 had a history of traumatic SCI.[189]

Disorders with onset later in life. *10. Alzheimer disease (AD).* We limited our review to studies that specifically addressed the incidence and prevalence of AD rather than dementia generally. Most studies used the clinical diagnostic criteria of the National Institute of Neurological and Communicative Diseases and Stroke/Alzheimer's Disease and Related Disorders Association,[190] the Cambridge Examination for Mental Disorders of the Elderly,[191] or the DSM-III-R criteria.[51] Although some of these criteria distinguish between probable and possible cases of AD, most of the studies did not. Nursing home placement is typical in end-stage AD, and so we did not use studies excluding long-term care residents.

Age ranges varied substantially across studies. Because AD rates increase with age, it was difficult to compare studies including younger ages with those limited to older ages. Therefore, among studies including younger age groups that had age-specific data available, we recalculated the overall rates to include only older populations (usually aged 65 or older).

Eight Class I studies (three from the United States) yielded a median annual incidence of AD of 1,178 per 100,000 population aged 65 years or older (range 1,005 to 3,554)[192-199] (table E-10a). Combining these studies with six Class II studies[200-205] (five from the United States) increased the median to 1,275. Between the seventh and ninth decades of life, the incidence of AD increases steeply with age (figure E-7). Most studies reporting rates by sex indicated a higher risk for women with a median men-to-women rate ratio of 0.54.[182,194-197,202,203]

Five Class I studies of AD prevalence (one from the United States) in both sexes yielded a median estimate of 48 per 1,000 population (range 31 to 122) for seniors (variously defined as 65 years or older, 70 years of older, or 75 years or older)[198,206-209] (table E-10b). With the addition of data from three Class II studies[210-212] (one from the United States), the median prevalence became 67 (range 31 to 130).

11. Parkinson disease (PD). We limited our review to studies using widely accepted diagnostic criteria.[213,214] The studies evaluated PD occurrence using differing age breakdowns, making cross-study comparisons difficult. To improve the comparability of studies that provided age-specific rates, we recalculated the rates provided to include only persons 65 years or older or 70 years or older, depending on the age strata reported (tables E-11a and E-11b). Although in all cases the final diagnosis was confirmed by physical examination, variations in screening methods among Class I articles may have contributed to variations in findings.

We identified three Class I[215-217] (one from the United States) and five Class II[218-222] (two from the United States) studies of incidence. For the two studies that reported all age groups, the median incidence was 14 per 100,000 (range 12 to 15). The median estimate from studies restricted to populations aged 65 or older or 70 years or older was much higher: 160 (range 62 to 332).[216-219,221,222] Controversy exists about whether incidence plateaus around age 80 or keeps increasing, but data are too meager to draw firm conclusions (figure E-8). PD appears to be more common in men than women, with a median rate ratio of 1.8 (range 1.4 to 2.0).[215-219,221]

There were six Class I[215,223-227] (all European) and six Class II[220,222,228-231] (one from the United States) studies of prevalence. Eleven reported a median prevalence of 9.5 per 1,000 population for persons aged at least 65 or 70 years (range 7.0 to 43.8).

12. ALS. Most studies of ALS published since the mid-1990s used the El Escorial criteria for case definitions.[232] We included other studies if they used similar criteria, although a few Class II studies addressed the broader category of motor neuron disease. We excluded studies of spinal muscular atrophy of infancy and childhood.

Nine Class I[233-241] (one from the United States) and 10 Class II[242-251] (one from the United States) studies of ALS incidence (table E-12a) were found. Most of these studies identified cases from a combination of hospital and clinic administrative data, neurologist practices, or vital records; in all cases, a neurologist made or reviewed the diagnosis. The median annual rate of incidence among studies that included all ages was 1.6 per 100,000 (range 0.7 to 2.5). From Class I studies, only the median annual rate (all ages) was 2.1 per 100,000 (range 0.7 to 2.5). Most studies showed somewhat lower rates among women, and the median rate ratio of men to women was 1.3.

The distribution of reported age-specific rates is shown in figure E-9. In general, the data show an

acceleration in the upward trend for rates after age 40. Estimated rates in the seventh decade of life are broadly distributed around five per 100,000. Beyond this age, wide disparities in reported rates do not allow confident generalizations.

We identified one Class I[236] (Italy) and seven Class II[242,244,245,247,248,251,252] (one United States) studies addressing ALS prevalence (table E-12b). Results did not vary widely, with a median reported prevalence of 0.04 per 1,000 for all ages. Consistent with the limited survival with this condition, prevalence is quite low. ALS is weakly associated with male sex and strongly associated with older age.

Discussion. The disorders included here are not the only causes of neurologic morbidity and mortality nor are they necessarily the most common. We selected a limited number of disorders of the CNS that neurologists are likely to diagnose and treat and that are generally presumed to have a high burden of illness. We did not address other frequent and burdensome conditions, such as chronic pain, mental retardation, peripheral neuropathies, or sleep disorders, some of which lack well-established diagnostic criteria or are treated primarily by non-neurologists. We considered disorders that are primarily psychiatric to be beyond our scope. A few disorders originally considered, such as muscular dystrophy, were omitted because of insufficient studies. Some disorders, such as CNS neoplasms, are systematically tracked and their incidence is summarized in other sources.[253] Other important disorders, such as essential tremor, restless legs syndrome, and vascular dementia, were not included but may merit future reviews.

Comparisons with an earlier review[1] of the epidemiology of a range of similar disorders may be informative. The previous review did not evaluate the quality of available evidence and often used broader inclusion criteria. Adding to the difficulty of inferring real changes, case definitions, and methods of case ascertainment have since evolved. We are unable to make age-adjusted comparisons between this and the earlier report, and the recent shift in the distribution of the US population toward older ages could result in somewhat higher crude rates for conditions that mainly arise late in life. Given these limitations, the current and previous results for epilepsy and migraine prevalence are very similar. For CP, the data also appear consistent, taking age into account. For Tourette syndrome and autism, there were no earlier estimates given, which may reflect recently increased recognition of these conditions. Our estimate of MS prevalence rate is approximately 50% higher than the earlier estimate. Whether this reflects improvements in diagnosis or whether the incidence is actually increasing deserves further study. The reported incidence of hospitalized TBI has decreased about 50%. It is likely that this reflects more restrictive hospital admission criteria, although improvements in motor vehicle safety may also contribute.[254] Data are too sparse to support conclusions regarding an apparent increase in SCI incidence rate. The incidence rates of ALS appear similar in both reviews, as do the incidence rates of PD, considering that the earlier review encompassed broader categories of parkinsonism and that there have been changes in the age distribution of the population.

Although stroke mortality has decreased,[149] the comparison of our data with the earlier review suggests a possible increase in stroke incidence, despite studies showing an earlier decline over several decades.[255,256] Possible explanations might include more sensitive diagnostic methods using neuroimaging and a significant increase in the proportion of older adults in the population. Finally, although the earlier review included all types of dementia, in comparison, the current rates of AD alone are substantially higher. Factors cited earlier such as an increase in the proportion of older people in the population and better case ascertainment may be important, but the possibility of a real increase in the incidence of dementia merits further research.

For most disorders, insufficient Class I evidence from the United States is available. Additional high-quality data are often available from non-US developed countries, perhaps in part because more centralized health care systems facilitate case ascertainment and study. With caution, findings obtained from one population may be generalized to others to the extent that the demographic, cultural, and environmental characteristics of the populations are similar. We recognize, however, that even among developed countries, differences in culture, age distribution, organization of health care and record keeping, genetic susceptibility, environmental exposures, and the socioeconomic composition of populations might influence the occurrence and detection of the conditions that we reviewed.

Although essential to any consideration of disease burden, neither incidence nor prevalence captures the full impact of disorders in human and economic dimensions. These broader consequences are encompassed by the term *burden of illness*. Estimates of human burden must consider not only the frequency of a disease but also the years of life lost and the duration, character, and degree of disability and suffering as well as the impact on family and society. Various summary measures that incorporate these considerations have been devised, including disability–adjusted life-years[257] and quality-adjusted life-years.[258] Such measures require data on age at onset, age at death, and some quantitative metric of disability and suffering. On the economic side, direct costs of treatment must be included, as well as lost wages and productivity both of patients and their caregivers.

Conclusions. Table 3 summarizes the results for the 12 disorders that we reviewed. For each disorder, consideration of incidence and prevalence immediately raises second-order questions that are critical

Table 3 *Summary of evidence: Incidence and prevalence of 12 neurologic disorders*

Disorder	Class of evidence	Range of ages included (y)	Median estimates: Annual incidence Rate/ 100,000	Annual incidence No.*	Prevalence Rate/ 1,000	Prevalence No.*	Rate ratio, M/F†	Age(s), y, of peak incidence
Autism spectrum disorders	I, II	2–15	—	—	5.8	500,000‡	4.2	—
Cerebral palsy	I, II	3–13	—	—	2.4	207,000‡	1.3	—
Tourette syndrome	II	7–17	—	—	3.5§	301,000	4.8	—
Migraine	I, II	12–65	—	—	121	35,461,000	0.4	—
Epilepsy	I, II	All	48	142,000	7.1	2,098,000	1	<1, ≥80
Multiple sclerosis	I	All	4.2	12,000	0.9	266,000	0.5	30
Traumatic brain injury	I	All	101	298,000	—	—	2.1	20, ≥80
Spinal cord injury	I,II	All	4.5	13,000	—	—	4.2	20
ALS	I, II	All	1.6	5,000	0.04	12,000	1.3	≥60
Stroke	I, II	All	183	541,000	10	2,956,000	1.1	≥80
		≥65	1,093	401,000	—	—	—	
Alzheimer disease	I,II	≥65	1,275	468,000	67	2,459,000	0.5	≥80
Parkinson disease	I,II	≥65	160	59,000	9.5	349,000	1.8	≥70

* Estimated number of cases in United States in 2005, rounded to nearest 1,000.
† Ratio of rates among males to rates among females.
‡ Estimated number of cases among children younger than 21 years of age only.
§ Data inadequate for firm estimate.

to understanding the disease and its impact on public health. For many neurologic disorders, we need better studies of incidence and prevalence to improve the accuracy of estimates, to enable more confident generalizations to broader populations, and to assess trends. Beyond incidence and prevalence, additional research is needed to allow a more complete estimate of burden of illness that includes potential years of life lost, productive years lost to disability, impact on caregivers, and economic costs.

Acknowledgment

The authors appreciate the assistance of Dallas W. Anderson, PhD, Lynda Anderson, PhD, Colleen Boyle, PhD, Gary Franklin, MD, MPH, Gary Friday, MD, MPH, Kurt Greenlund, PhD, Gary Gronseth, MD, MPH, and Paul Scherr, PhD, who provided critical advice in the preparation of this manuscript.

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