



Clinical Study

Neurologic disorders, in-hospital deaths, and years of potential life lost in the USA, 1988–2011

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ABSTRACT

Premature mortality is a public health concern that can be quantified as years of potential life lost (YPLL). Studying premature mortality can help guide hospital initiatives and resource allocation. We investigated the categories of neurologic and neurosurgical conditions associated with in-hospital deaths that account for the highest YPLL and their trends over time. Using the Nationwide Inpatient Sample (NIS), we calculated YPLL for patients hospitalized in the USA from 1988 to 2011. Hospitalizations were categorized by related neurologic principal diagnoses. An estimated 2,355,673 in-hospital deaths accounted for an estimated 25,598,566 YPLL. The traumatic brain injury (TBI) category accounted for the highest annual mean YPLL at 361,748 (33.9% of total neurologic YPLL). Intracerebral hemorrhage, cerebral ischemia, subarachnoid hemorrhage, and anoxic brain damage completed the group of five diagnoses with the highest YPLL. TBI accounted for 12.1% of all inflation adjusted neurologic hospital charges and 22.4% of inflation adjusted charges among neurologic deaths. The in-hospital mortality rate has been stable or decreasing for all of these diagnoses except TBI, which rose from 5.1% in 1988 to 7.8% in 2011. Using YPLL, we provide a framework to compare the burden of premature in-hospital mortality on patients with neurologic disorders, which may prove useful for informing decisions related to allocation of health resources or research funding. Considering premature mortality alone, increased efforts should be focused on TBI, particularly in and related to the hospital setting.

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1. Introduction

Premature mortality, as defined by years of potential life lost (YPLL) and life expectancy, is a significant public health concern in the USA [1–3]. Diagnoses that account for the highest YPLL may be an area for increased public health attention, resource allocation, or quality improvement. A focused evaluation of YPLL among neurologic disorders has not been undertaken to our knowledge.

YPLL has been specifically studied in several discrete populations including unintentional child and adolescent injuries [4,5], some traumatic populations [6], and alcohol-related deaths [7]. Unintentional injuries are the leading cause of deaths in young people and contributes significantly to overall YPLL calculations [4,5]. Traumatic brain injury (TBI) and spinal cord injury as a result

of gunshot injury are estimated to shorten lifespan by 3.1 days in the USA [6]. Alcohol also contributes significantly to premature mortality, with an estimated 1,288,700 YPLL in the USA in 2005 [7].

Most recently, the Global Burden of Disease Study 2010 (GBD 2010) analyzed causes of death and premature mortality including YPLL in 1990 and 2010 on a large scale in multiple countries [8,9]. A variety of related analyses, including the USA Burden of Disease Collaborators, have been published more recently [10–13]. The GBD 2010 data demonstrated stroke as an important contributor to YPLL with 2,250,400 YPLL in 1990 and 1,945,300 YPLL in 2010 in the USA.

According to the National Center for Health Statistics (NCHS), in 2000 and 2010, approximately one-third of all USA deaths occurred in short-stay, general hospitals [13]. Given these facts, we evaluated the scale of premature mortality limited to USA in-hospital mortality of neurologic diagnoses using the YPLL framework. We sought to identify the neurologic diseases responsible for the greatest inpatient YPLL over a longitudinal timespan to

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Table 1
Neurologic principal diagnosis disease categories

Category	Number of diagnoses [*]	CCS categories ^{**}	ICD-9-CM diagnosis codes from partial CCS categories
Anoxic brain damage	1	85p	348.1
Brain tumor	15	35p, 95p	191.XX, 192, 192.1, 348.0, V10.85, V12.41
Cerebral edema and brain compression	2	95p	348.4, 348.5
Cerebral ischemia	46	109p, 110, 111p, 112	346.XX, 433.XX, 434.XX, 436, 437.XX (except 437.3)
CNS infection	124	76, 77, 78, 95p	V12.42
Cognitive deficit	42	95p, 653	331.83, 799.51, 799.52, 799.55, 799.59
Coma - unspecified	10	85p, 95p	348.3X, 348.82, 349.82, 780.XX
Congenital	29	82p, 216	343.XX
Degenerative spine	64	205p	All except 721.7, 723.4, 723.5
Demyelinating	5	80, 95p	341.XX
Epidural hematoma	1	109p	432.0
Epilepsy	31	83	
Headache	66	84	
Intracerebral hemorrhage	2	109p	431, 432.9
Neurologically degenerative	63	81p, 95p	330.XX, 331.XX, 333.XX-336.XX, 337.0, 348.2
Neuropathy and myopathy	96	81p, 95p, 205p	337.XX, 350.XX - 359.XX (except 353.2, 353.3, 353.4), 723.4, 723.5, 781.7
Paralysis	40	82p	All except 343.XX
Parkinson's disease	2	79, 95p	332.1
Spine trauma	80	205p, 227	721.7
Spine tumor	2	35p	192.2, 192.3
Subarachnoid hemorrhage	1	109p	430
Subdural hemorrhage (non-traumatic)	1	109p	432.1
Traumatic brain injury	494	228p, 233	800.XX, 801.XX, 802.0, 802.1, 803.XX, 804.XX, 905.0
Unruptured aneurysm	1	111p	437.3
CCS categories with excluded diagnoses	235	11, 35p, 95p, 113, 228p	

CCS = clinical classification software, CNS = central nervous system, ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification.

^{*} The number of diagnoses within a category represents coding nomenclature and does not necessarily indicate an increased likelihood of admissions being assigned to the category.

^{**} p = only part of the CCS category diseases included; explained in next column.

understand the hospital contribution to YPLL in patients afflicted with neurologic conditions.

2. Methods

2.1. Study design

We examined all in-patient hospitalizations from 1988 to 2011 using hospital discharge data from the Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality (Rockville, MD, USA). The NIS is the largest publicly available, all-payer inpatient care database of non-federal hospitals in the USA. The NIS contains data from approximately 5 to 8 million hospital stays each year and represents an approximately 20% stratified sample of USA community (non-federal) hospitals. NIS data are represented by diagnosis and procedure codes from the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). Hospitalizations were categorized by principal diagnoses using 24 custom category

definitions. Categories were initially identified by selecting the 24 neurologic-related HCUP Clinical Classification Software (CCS) categories. Because CCS categories are not completely aligned with clinical neurologic diseases, we re-classified some of the diagnoses in CCS categories according to clinical disease states (Table 1). Some diagnoses contained within the CCS categories were excluded (for example, pain or sleep disorders, or diagnoses lacking specificity; Table 1). Constituent ICD-9-CM codes in each CCS category are readily available (see <http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp>). Hospitalizations with a missing or invalid age were excluded (0.08%; 131,108 of the total NIS sample of 171,998,419).

NIS discharge weight was used to extrapolate to estimates of annual USA volume (NIS variable DISCWTL). Corrected discharge weight data for years 1988 to 1997, as suggested and published by HCUP, were used (see <http://www.hcup-us.ahrq.gov/db/nation/nis/trendwghts.jsp>). Total hospitalization charges were corrected for inflation to the 2011 value using the USA Bureau of Labor Statistics Consumer Price Index Inflation Calculator [14].

Table 2

Ten neurologic principal diagnosis categories causing the highest years of potential life lost as a result of in-hospital death between 1988 and 2011

Principal diagnosis disease category	Rank	Annual mean YPLL ± SD [*]	% of total neurologic YPLL	Annual mean deaths [*]	Mortality rate	Mean inflation adjusted total charges among deaths	Inflation adjusted total charges of deaths per YPLL ^{**}
Traumatic brain injury	1	361,748 ± 39,569	33.9%	15,051	7.5%	\$ 62,252	\$ 2,590
Intracerebral hemorrhage	2	184,819 ± 14,582	17.3%	21,116	30.4%	\$ 31,274	\$ 3,538
Cerebral ischemia	3	151,034 ± 14,038	14.2%	35,365	4.3%	\$ 33,768	\$ 7,741
Subarachnoid hemorrhage	4	103,229 ± 10,722	9.7%	6,317	25.5%	\$ 61,851	\$ 3,757
Anoxic brain damage	5	47,158 ± 8,888	4.4%	2,533	52.1%	\$ 41,734	\$ 2,257
CNS infection	6	44,693 ± 12,958	4.2%	3,163	2.0%	\$ 58,522	\$ 4,150
Brain tumor	7	42,425 ± 9,821	4.0%	1,963	5.5%	\$ 52,370	\$ 2,429
Epilepsy	8	35,457 ± 7,634	3.3%	2,595	1.0%	\$ 51,693	\$ 3,752
Subdural hemorrhage (non-traumatic)	9	16,332 ± 4,527	1.5%	2,354	12.5%	\$ 50,772	\$ 7,256
Coma - unspecified	10	15,444 ± 6,081	1.4%	1,697	4.3%	\$ 42,039	\$ 4,660

Monetary values are in USD.

CNS = central nervous system, SD = standard deviation, YPLL = years of potential life lost.

^{*} National values are estimated using Nationwide Inpatient Sample discharge weight.

^{**} In hospitalizations where the patient died, this represents the total inflation adjusted in-hospital charges per total YPLL.

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