Using Disability Adjusted Life Years to Value the Treatment of Thirty Chronic Conditions in the U.S. from 1987-2010

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ABSTRACT

Health care spending in the U.S. grew two trillion dollars from 1987 to 2010, a 400% increase, but our understanding of the value of that increase is limited. In this paper we determine the net value of spending at the disease level by assigning a monetary value to changes in health outcomes and relating it to the costs of treating the disease. Changes in health outcomes in the U.S. are measured using newly-available time series of Disability Adjusted Life Years (DALYs) from the Institute for Health Metrics and Evaluation. Spending on treatments are determined using health care expenditure data from nationally representative surveys. We examine the data for thirty chronic diseases for the period 1987 – 2010. For several diseases, we find the net value of treatment has grown substantially, consistent with medical technology improving over time and leading to better health outcomes at a lower cost per patient. Overall, twenty of the 30 chronic diseases studied experienced an increase in health outcomes over the period, with 8 of those 20 showing a decrease in per-patient spending. Our estimates of net value are simple to apply and results are generally consistent with previous estimates of the value of spending on disease treatments, which usually involve onerous data collection methods to study only a single disease. However, challenges remain in applying these DALYs data to accurately measure the changing value of health care spending. We highlight some of these issues in this paper.

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INTRODUCTION

Health care spending in the U.S. grew over two trillion dollars from 1987 to 2010, a 400% increase, and currently accounts for over 17% of U.S. Gross Domestic Product (Centers for Medicare and Medicaid Services, 2013). Considering the vital role that the health sector plays in the overall U.S. economy, surprisingly few studies have tried to estimate the net value of health spending associated with the rapid growth and quality changes in the health sector. Net value refers to the difference between the monetized change in patient health outcomes and the change in treatment spending. Recently, health economists have advised federal agencies that produce health spending statistics to account for the improvements to the quality of delivered health care (National Research Council, 2010). Information on quality is useful for policymakers and stakeholders in the health care sector as they try to assess the value of spending on health services.

Chronic diseases affect almost half of the U.S. population and account for approximately 75% of overall health care spending (Roehrig, Miller, Lake, and Bryant, 2009; Centers for Disease Control and Prevention, 2009). Given the importance of chronic disease as a share of health expenditures, in this study we focus on the value of spending on chronic conditions. We calculate the net value of health care spending for thirty chronic diseases in the U.S. from 1987 to 2010. We determine the net value of spending for each disease by assigning a monetary value to changes in health outcomes and relating it to the increase (or decrease) in the cost of treating the disease. We employ a technique previously used to measure the value of spending from the treatment of diabetes (Eggleston, Shah, Smith, et al., 2011) to determine the value of spending for these thirty diseases. This method, a recommended approach to calculating value in health care (Porter,

2010), allows us to relate the change in health outcomes for an average patient to the change in the cost of treating the disease.

Health care expenditure data from nationally representative surveys are used to determine spending for the treatment of diseases. We calculate patient-level spending for the treatment of individual diseases with an accepted method used in previous research (American Diabetes Association, 2008).). The details of the data and calculations are described in the Methods section.

We use Disability Adjusted Life Years (DALYs), a newly-available time series from the Institute of Health Metrics and Evaluation (IHME), as a tool to measure the changes in health outcomes for the chosen diseases. The time series was developed by IHME in partnership with organizations such as the World Health Organization (WHO), Harvard University, University of Tokyo, and Imperial College London, as part of the 2010 Global Burden of Disease study (GBD 2010). It is based on the DALY measure originally created by the WHO. The data provide population health measures for almost three hundred diseases and injuries across multiple countries. It is the first consistent time series of its kind for the U.S. We focus our analysis on thirty chronic conditions that could be accurately matched to the health care expenditure data.

The DALYs fulfill the basic requirements for a national measure of health outcomes set forth by health economists (Stewart, Cutler, and Rosen, 2013), the Committee on National Statistics (2005) and by the Organization for Economic Co-operation and Development (OECD) (2010). Specifically, the DALYs account for both mortality and morbidity, including mental well-being; include entire populations; and represent a

comparable time series across different countries. To our knowledge, these DALYs are the only time series currently available that allow analysis of health outcomes across multiple diseases for the U.S.

The DALYs data may serve as a low-cost approach to measure the net value of health care spending. Previous methods often relied on onerous data collection and analysis methods to estimate the gains from spending for a single disease (Eggleston et al., 2011; Cutler, McClelland, Newhouse and Remler, 2001; Shapiro, Shapiro and Wilcox, 2001) or were only conducted at an overall population level (Cutler, Rosen and Vijan, 2006). Despite the low cost and ease of use, the DALYs data have drawbacks, which are discussed in detail below.

The rest of the paper is organized as follows. The Methods section provides detailed descriptions of the data and calculations used in our study. In the Results section, we highlight trends in spending, health outcomes, and the value of treatment. The Discussion section provides potential explanations for our findings and includes an abbreviated review of past case studies. Limitations of the data and methods are also listed, followed by a summary of the main points and suggested future research.

METHODS

Data

Data from the Medical Expenditure Panel Survey (MEPS) were used to calculate disease expenditures in 2010 and its precursor, the National Medical Expenditure Survey

(NMES), provides disease spending figures for 1987[2]. These data, from nationally representative surveys conducted by federal agencies, detail healthcare coverage, utilization, and expenditures for the civilian non-institutionalized U.S. population. The surveys include event-level expenditure data for the following services: physician office, emergency room, inpatient and outpatient hospital, and prescription drugs. Expenditures represent spending from all sources, not just out-of-pocket spending from patients. Expenditures were converted into inflation-adjusted 2009 dollars using the overall Personal Consumption Expenditure deflator from the U.S .Bureau of Economic Analysis (Table 2.4.4).

DALYs data are available for 1990, 2005, and 2010 from IHME. The changes between 1990 and 2010 data were used to measure health outcomes. The 1990 data is the earliest available year for the DALYs data and will be used as a proxy for health outcomes in 1987 in the calculation of treatment value (explained below). Therefore, we may be underestimating the value of health improvements between 1987 and 1990 because we are not picking up any potential advances in technology that occurred during that period.

A DALY is formally defined as the sum of years of life lost (YLL) and years lived with disability (YLD):

$$\textbf{\textit{Formula 1}}.\ DALY = YLL + YLD$$

DALYs represent both a mortality measure and a morbidity, or health-related quality of life, measure. YLL were determined by multiplying the number of deaths at each

[2] We are grateful to Thorpe and Howard (2006) for their Stata code to create a consistent comparison of diseases over time.

age by the predicted life expectancy for that age, for each disease. These measure years of life prematurely lost due to a disease. YLD were found by multiplying prevalence of a disease by a disability weight. These measure years of a healthy life lost due to disability. In IHME's data, disability refers to any short- or long-term loss of health. The GBD 2010 group used population-based, random sample of over 30,000 respondents to determine the disability weights. The information was gathered using computer-assisted telephone interviews and also through an open internet survey. Taken together, a DALY is interpreted as a year of life in full health lost due to a disease. Therefore, a reduction in DALYs is interpreted as a gain in healthy life years. Prevalence for these diseases was also obtained from IHME to calculate per-patient DALYs.

A per-patient DALY can be interpreted as a year of life in full health lost for each person who has the disease or condition. Since this paper is interested in estimating the net value of spending on disease treatments, it is most appropriate to analyze DALYs at the patient-level. We are limited to chronic diseases for our computation of per-patient DALYs since the prevalence data from IHME are point-prevalence (which represents the number of people with a certain condition or disease at a specific point in time). Acute conditions and accidents require an incidence rate for the per-patient calculation, which were unavailable.

Calculations

Disease expenditures were calculated using a primary diagnosis method, which attributes spending from a medical encounter to the first diagnosis attached to each health care event. Once expenditures are allocated to a disease, the events are summed to an

annual level and divided by the number of people with that disease to find per-patient spending by disease. This method has been used in the past to calculate per-patient disease expenditures and tends to be the most transparent method for determining spending (Hall and Highfill, 2013; Aizcorbe, Bradley, Greenaway-McGrevy, et al., 2011). Per-patient spending was calculated using nationally-representative weights provided by MEPS.

Disease categories for the DALY and MEPS data were matched using 3-digit International Classification of Diseases (ICD-9) codes, the most detailed level at which the MEPS data are published. Because certain DALY conditions are only available at the 4- or 5-digit ICD9-level, those diseases were not included in this analysis because they could not be aggregated to the 3-digit level. Additionally, diseases with less than twenty-five people in the MEPS data or a prevalence of fewer than 6,000 in the DALYs data were excluded due to validity uncertainties. We end up with thirty separate diseases for our analysis, representing approximately 18% of all health care spending in the MEPS in 2010.[3]

The net value of spending associated with treating a disease is calculated using the definition offered by Eggleston et al. (2011) in their analysis of the value of spending related to treating diabetes. Specifically, we define the net value of treatment as the difference between the change in inflation-adjusted monetized health outcomes and the change in the inflation-adjusted treatment spending for each patient. For each disease, d:

***Formula* 2**.

$$Net\ Value\ of\ Treatment_d = \Delta Monetized\ Health\ Outcomes_d - \Delta Per\ Patient\ Spending_d$$

[3] See Tables 1 and 2 for a list of the thirty diseases and Appendix A for a table of excluded diseases

Monetized health outcomes were determined by multiplying the increase (or decrease) in per-patient DALYs (calculated by dividing aggregate DALYs by prevalence for each disease) between 1990 and 2010 by the value of a year of life in full health, calculated using the range $100,000 - $200,000, consistent with past research on the value of medical treatments (Eggleston, et al., 2011; Cutler, McClelland, Newhouse, and Remler, 2001). This means if patients lost an average of one DALY, i.e., gained one year in full health, this would be worth anywhere between $100,000 and $200,000 for each person with that disease. This translates to a day of healthy life being worth $258 and $517 per day in 2009 dollars. For simplicity, we will use the lower estimate ($100,000) as the value of a healthy life year in our subsequent discussion. Additionally, since most of the diseases studied showed relatively small changes in health outcomes, we use changes in healthy life days as our unit of analysis.

RESULTS

Gains in per capita health outcomes more than offset the average increase in per patient costs over the two decades, suggesting the net value for overall treatment spending was positive (Table 1, bottom row). However, only twelve of the 30 diseases studied realized a positive net value of spending. Spending per patient increased for two-thirds of the diseases. Some diseases showed either no discernable gains in health outcomes, or sometimes a decrease, between 1990 and 2010, while others saw significant increases in healthy life. The Results section will begin with a review of the spending results, followed by health outcomes, and end with an analysis of the estimated net value of treatment spending.

Spending

Using the primary diagnosis method, treatment for ischemic heart disease accounted for the greatest spending in both 1987 and 2010 ($15 billion and $50 billion, respectively), followed closely by diabetes. These results are generally consistent with the recent study by Roehrig, Miller, Lake, and Bryant (2009) on national health spending by medical condition. At the per-patient level, the disease with the highest costs in this study was trachea, bronchus, and lung cancers at $17,817 in 2010 (Table 1). Ischemic heart disease was a distant second, at $4,212. The largest increase in per-patient expenditures between 1987 and 2010 was for non-infective inflammatory bowel disease, where inflation-adjusted costs increased by $3,255, from $824 to $4,079. The second-largest increase in per-patient costs was for trachea, bronchus, and lung cancers ($2,423), followed by Parkinson's disease ($2,059). Prostate cancer showed the largest decrease in spending, where per-patient costs declined by $2,962, followed by benign prostatic hyperplasia and ischemic heart disease, both of which saw per-patient costs decrease over $1,000.

<Table 1>

Health Outcomes

The number of total DALYs lost increased almost 14% during the 20-year period, where the overall burden of disease in the U.S. was estimated to account for the loss of 81.8 million healthy life years in 2010 (left panel of Table 2). However, after taking into account population growth, the average person in the U.S. is estimated to have gained around nine days of healthy life during the period (change in per capita DALYs).

To make comparisons between per-patient costs and value of spending, we use per-patient DALYs (right panel of Table 2) rather than total DALYs. Examining DALYs at the patient level allows us to relate changes in health outcomes for diseases to changes in treatment costs for an average patient, which is necessary for the calculation of net value of spending (see Formula 2). Murray et al. (2013) provide an in-depth discussion of overall population disease trends and outcomes using total DALYs.

Of the thirty diseases in this study, the 5 diseases that accounted for the largest number of per-patient DALYs lost in 2010 were trachea, bronchus, and lung cancers; colon and rectum cancers; ischemic heart disease; Parkinson's disease; and Alzheimer's disease and other dementias. In terms of changes in health outcomes, of these five, trachea, bronchus, and lung cancers, showed the greatest improvements between 1990 and 2010, where the data suggests patients in 2010 had 593 more days of life in full health compared with patients in 1990. Colon and rectum cancers and ischemic heart disease also showed gains in health outcomes for the average patient. Alzheimer's and other dementias showed the largest declines in health, where patients are estimated to have lost fifty-six healthy days between 1990 and 2010. Twelve of the 30 conditions showed essentially no change in health outcomes over the 20-year period: benign prostatic hyperplasia, cataracts, dental caries, eczema, endometriosis, fungal skin diseases, gout, osteoarthritis, periodontal disease, pruritus, psoriasis, and urticaria.

<Table 2>

Net Value of Treatment

The net value of spending was positive for twelve of the 30 diseases, meaning the gain in monetized health outcomes for patients with those diseases was greater than the related increase in spending to treat the disease. The largest net value of treatment was for trachea, bronchus, and lung cancers, estimated to be $150,715 per patient (Table 1). This was followed by ischemic heart disease, colon and rectum cancers, prostate cancer, and breast cancer. Two of the 12 diseases, benign prostatic hyperplasia and osteoarthritis, have a positive value of treatment figure due solely to declines in per-patient spending (there was no change in health outcomes).

The cost of treating Alzheimer's disease and other dementias returned the lowest net value, estimated at -$15,123. This was followed closely by Parkinson's disease (-$14,753), and non-infective inflammatory bowel disease (-$4,906). All three of these diseases saw decreases in health during the time period according to the DALYs data, while the cost of treatment increased.

DISCUSSION

The gains in population health outcomes between 1990 and 2010 more than offset the increase in average spending on medical treatments during this period. Our simple method of calculating net value found that average per patient costs increased approximately $550, but the monetized improvement in health was valued to be at least $2,406, suggesting a net value from spending of $1,852 for the average American. However, changes in health outcomes and costs of treatments varied widely by type of condition, discussed in more detail below.

Ischemic heart disease, the disease responsible for the most overall health care spending in the U.S., realized the second-highest net value of treatment in this study. Taking into account both improved health outcomes and a decrease in per-patient spending, we estimate that improvements in the treatment of ischemic heart disease are worth at least $37,639 per patient. Our findings are consistent with past research on the treatment of heart attacks, a component of ischemic heart disease, which suggested that better medical treatments have substantially increased the quality of life for heart attack patients and any associated increase in costs were justified (Cutler, McClellan, Newhouse, and Remler, 2001).

The greatest net value from spending on the treatment of disease was found to be for patients with trachea, bronchus, and lung cancers. Most of the value is attributed to the increase in health outcomes for those patients, estimated to be worth at least $153,137 per patient during the study period. This corresponds with current research on trends in cancer, which shows that rates of lung and bronchus cancers (trachea data was unavailable) declined significantly between 1990 and 2008 (Siegel, Naishadham, and Jemal, 2012). Although that study attributes screenings and earlier diagnosis as key drivers of reducing mortality rates for many cancers, they note the improvements seen in lung cancer are most likely due to the decrease in smoking. Therefore, the value attributed to treatment of the disease is likely overstated in our study, since individual behaviors are identified as a primary cause of the decrease in mortality for lung cancer.

The five diseases that showed the greatest value for spending were also among the diseases with the highest per-patient costs of treatment (Table 2). Four of these diseases

(ischemic heart disease, colon and rectum cancers, prostate cancer, and breast cancer) saw an increase in health outcomes and a decrease in inflation-adjusted per-patient spending. This may suggest the treatment of those diseases has indeed been cost-effective, despite the relatively high per-patient spending. These results are particularly significant for ischemic heart disease, which was responsible for the most medical care spending and loss of healthy life in the U.S. between 1990 and 2010, as a means to justify the enormous expenditures.

The poorest net value for the spending was for patients with Alzheimer's disease and other dementias, where the data show both a decrease in health outcomes and an increase in the cost of treatment. These results are supported by a recent study from the Alzheimer's Association (2011) that states:

> "Although other major causes of death have been on the decrease, deaths because of [Alzheimer's disease] have been rising dramatically. Between 2000 and 2008 (preliminary data), heart disease deaths decreased by 13%, stroke deaths by 20%, and prostate cancer-related deaths by 8%, whereas deaths because of [Alzheimer's disease] increased by 66%" (p.208).

The authors cite an aging population and the lack of a cure as explanations for the rise in mortality rates. Currently, treatments for Alzheimer's disease include prescription medications that slow the worsening of symptoms for six to twelve months, and for only about half of patients (Alzheimer's Association, 2011). When viewing our results in terms of net value of spending, the negative estimate suggests the increased spending on these

conditions has not returned gains in health outcomes for an average Alzheimer's patient. However, another possible factor in the estimated decline in outcomes might be better awareness of Alzheimer's as a fatal disease, translating to an increase in attributing cause-of-death to Alzheimer's on death certificates. These records serve as the chief source of the YLL data, so their accuracy is essential for a correct interpretation of changes in the DALYs data. In fact, a recent study highlighted the potential issues with using death certifications to identify causes of mortality, arguing this method greatly understates the role of Alzheimer's diseases (James, Leurgans, Hebert, et al., 2014). If the estimated decrease in health outcomes is driven by better reporting of causes of mortality, our results may overstate the decline in health outcomes for Alzheimer's patients and, therefore, understate the net value from the increased spending on treatments.

Parkinson's disease, another degenerative disease of the central nervous system, was the other outlier disease in terms of poorest value of treatment. The average cost of treating the disease increased by over 250% (from $1,467 to $3,536), but outcomes were shown to decrease. As with Alzheimer's disease, this may be due to the types of treatments available for this disease, which only temporarily address the symptoms but do not cure or stop the progression of it (Fasano, Daniele, and Albanese, 2012; Olazaran, Reisberg, Clare, et al., 2010). For example, a common treatment of advanced Parkinson's disease is deep brain stimulation, an expensive surgical technique that is able to reduce major tremors and other debilitating traits of the disease, but does not stop the disease and is accompanied by potentially severe side effects (Deuschl, Schade-Brittinger, Krack, et al., 2006). As with Alzheimer's disease, our results may suggest that the increase in spending on these new

treatments is not returning value in terms of outcomes. Future research should investigate additional factors that might be contributing to these results.

Comparison to Case Studies

A few case studies offer a comparison to the results of our analysis. Cutler and colleagues found that the price of treating heart attacks between 1984 and 1994, after taking into account increases in quality of life, showed only a slight increase in price (Cutler, McClellan, Newhouse, and Remler, 2001). Additionally, they found that heart attack patients gained around nine months of a healthy life during that time. Though we are studying different time periods, these results are consistent with our results for ischemic heart disease, which show that patients with ischemic heart disease gained about five months of healthy life years between 1990 and 2010. Since ischemic heart disease includes heart attacks along with other less-acute heart conditions, our lower estimate is consistent with what we would expect for diseases with lower acuity (i.e., diseases with relatively low rates of mortality and morbidity by definition account for less DALYs than more severe diseases). The authors concluded that the increase in spending on treating heart attacks was more than worth the price considering the increases in quality of life. This is also consistent with results from our study, which found the cost of treating ischemic heart disease declined by $1,018 per patient (from $5,230 in 1987 to $4,212 in 2010).

Another study was recently published on the value of increased spending for patients with diabetes between 1999 and 2009 (Eggleston et al., 2011). While the time period differs from our study, the results showed a similar trend. Specifically, the authors

found that the per-patient cost of treating diabetes was essentially constant when taking into account health outcomes. In our analysis, we found that the price of treating diabetes between 1987 and 2010 changed very little (a decrease of less than $100), and this corresponded to a negligible change in health outcomes (a decrease of 1.5 days of healthy life).

Although these studies do not represent an apples-to-apples comparison to this analysis, the results nonetheless show similar trends. Considering the resource-intensive nature of these case studies, which often involve onerous methods of collecting data, including needing access to medical claims data, patient surveys, and clinical coders, the comparability between the findings suggests the DALYs data may serve as a promising alternative to the resource-consuming methods used in the past.

Comparison to Population DALYs

Analyzing the impact of diseases on patients using patient-level DALYs tells a somewhat different story about the burden of disease than analyzing the data for the overall population. Trachea, bronchus, and lung cancers showed the strongest negative impact on health for patients of the diseases studied, which contrasts with an analysis of aggregate DALYs, where ischemic heart disease represents the most significant health burden to the U.S. and lung cancer is ranked fourth (Table 2; see also Murray, et al., 2013). The difference between the two measures suggests that trachea, bronchus, and lung cancers are related to a greater loss of healthy life for individual patients than for the overall population. For those interested in studying health outcomes, it is important to

consider the appropriate figure given the different interpretations of per-patient and population-level DALYs.

Caveats

This paper provides a simple method to calculate the net value of spending for certain diseases, however there are potential factors that may complicate the interpretations of this study. First, the DALYs data capture changes in health outcomes not directly related to the treatment of diseases, such as the increase in obesity and various environmental factors. Therefore, the change in DALYs over the time series cannot be attributed solely to advances in the health sector. However, research suggests that the increases in life expectancy and quality of life that have occurred since the mid-twentieth century are mainly attributable to advancements in medical care (Bunker, 2001). Nonetheless, our results indicate that attributing trends in DALYs solely to changes in treatment may not be appropriate for certain diseases. For example, if more people are being diagnosed with prostate cancer in its early stages, prevalence of prostate cancer will increase. Even with no changes in the quality of treatments for prostate cancer patients, it will appear as if they are living longer with the disease, when it really reflects a change in reporting. In this case, the net value of treatments will be overstated. But, considering the correspondence of our results with other quality of care studies, the DALYs data appear to be a useful, low-cost tool to measure changes in health outcomes for diseases in which medical treatments have been shown to have a major impact on patient health.

Second, data coverage issues exist in both the MEPS and DALYs data. The MEPS data cover only the non-institutionalized population; those in the armed forces, prisons,

and nursing homes are not represented in the data. Nonetheless, MEPS data has been used in numerous studies related to health care spending in the United States (Aizcorbe, et al., 2011; Roehrig, Miller, Lake, and Bryant, 2009) and is the only viable option for analyzing total health care expenditures by disease at this time. Additionally, the MEPS time series only goes back to 1996 and its precursor, NMES, only has data available for 1987. Unfortunately, we had no other choice but to use 1987 expenditure data for use in the analysis with 1990 DALYs data, though it seems reasonable to believe health outcomes for 1990 and 1987 are comparable. However, there is no way to know what impact this may have had on the analysis.

Finally, the MEPS data are only available with 3-digit ICD-9 codes, making analysis of diseases at a finer-level of disaggregation impossible for this time period. For researchers with access to health expenditure data at the 5-digit ICD-9 level, such as medical claims data, there is potential to study changes in health outcomes for a much greater number of diseases.

Conclusion

Health care spending in the United States topped almost three trillion dollars in 2012, yet there has been no systematic way to measure the value of this spending. The DALYs data provides the potential to measure health outcomes for multiple diseases, which in the past has involved onerous data collection methods. This analysis found that the net value of treatment spending grew substantially for several diseases between 1990-2010. Overall gains in health outcomes for the population more than offset the increase in the average cost of treatment, suggesting a positive net value for medical spending. Future research is needed to validate the DALYs data as a useful tool for measuring patient health

outcomes and value of spending. Our findings suggest the data may be appropriate for diseases in which medical treatments are the principal drivers of health outcomes. For these diseases, the DALYs data, when combined with health care expenditure data, may be a cost-effective way to determine net value for health care spending for specific diseases. This research is a step towards answering the increasingly important question: "Is health care spending worth it?"

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Table 1. U.S. Medical Spending and Net Value by Condition, 1987-2010												
		Total Spending ($000)					Per-Patient Spending ($)			Per-Patient	
	Condition	1987	2010	Average Growth Rate	Percent of Condition Spending in 2010	Percent of U.S. Medical Spending in 2010	1987	2010	Average Growth Rate	Value of Change in Health Outcomes[1] ($)	Net Value of Treatment Spending[1] ($)
1	Ischemic heart disease	15,720,338	50,610,755	9.6%	25.8%	4.6%	5,230	4,212	-0.8%	36,622 - 73,243	37,639 - 74,261
2	Diabetes mellitus	12,949,723	39,599,610	8.9%	20.2%	3.6%	2,007	1,909	-0.2%	-400 - -801	-302 - -702
3	Asthma	3,832,929	15,407,611	13.1%	7.8%	1.4%	922	1,026	0.5%	311 - 621	207 - 518
4	Chronic obstructive pulmonary disease	4,495,922	11,126,864	6.4%	5.7%	1.0%	531	1,064	4.4%	-71 - -142	-604 - -675
5	Trachea, bronchus, and lung cancers	3,967,109	9,679,247	6.3%	4.9%	0.9%	15,394	17,817	0.7%	153,137 - 306,275	150,715 - 303,852
6	Osteoarthritis	580,404	9,575,688	67.4%	4.9%	0.9%	1,477	1,067	-1.2%	-3 - -7	407 - 404
7	Breast cancer	2,617,991	8,989,425	10.6%	4.6%	0.8%	5,763	4,837	-0.7%	11,104 - 22,207	12,029 - 23,133
8	Cataracts	5,868,689	6,682,196	0.6%	3.4%	0.6%	2,274	1,859	-0.8%	7 - 13	422 - 429
9	Rheumatoid arthritis	1,004,764	6,231,057	22.6%	3.2%	0.6%	2,642	1,846	-1.3%	244 - 488	1,040 - 1,284
10	Non-infective inflammatory bowel disease	1,447,076	5,806,319	13.1%	3.0%	0.5%	824	4,079	17.2%	-1,651 - -3,302	-4,906 - -6,557
11	Prostate cancer	1,261,312	5,058,590	13.1%	2.6%	0.5%	6,795	3,833	-1.9%	16,860 - 33,720	19,822 - 36,683
12	Non-melanoma skin cancer	1,019,924	3,836,646	12.0%	2.0%	0.4%	814	1,003	1.0%	3,885 - 7,769	3,696 - 7,580
13	Glaucoma	1,135,344	3,551,605	9.3%	1.8%	0.3%	620	1,092	3.3%	1,461 - 2,921	989 - 2,450
14	Colon and rectum cancers	1,167,795	2,134,272	3.6%	1.1%	0.2%	4,843	3,959	-0.8%	32,064 - 64,128	32,947 - 65,011
15	Alzheimer's disease and other dementias	437,323	2,095,621	16.5%	1.1%	0.2%	2,692	3,290	1.0%	-14,525 - -29,049	-15,123 - -29,648
16	Benign prostatic hyperplasia	532,029	1,772,786	10.1%	0.9%	0.2%	2,324	886	-2.7%	-10 - -21	1,428 - 1,417
17	Parkinson's disease	436,395	1,714,394	12.7%	0.9%	0.2%	1,467	3,526	6.1%	-12,694 - -25,388	-14,753 - -27,447
18	Psoriasis	223,787	1,635,636	27.4%	0.8%	0.2%	306	1,273	13.7%	3 - 6	-964 - -961
19	Periodontal disease	80,415	1,539,893	78.9%	0.8%	0.1%	67	1,449	89.6%	2 - 4	-1,380 - -1,378
20	Peptic ulcer disease	2,509,574	1,456,090	-1.8%	0.7%	0.1%	1,669	1,646	-0.1%	652 - 1,304	676 - 1,328
21	Epilepsy	1,131,840	1,451,162	1.2%	0.7%	0.1%	1,227	1,937	2.5%	826 - 1,651	115 - 941
22	Refraction and accommodation disorders	691,679	1,409,411	4.5%	0.7%	0.1%	205	354	3.2%	324 - 649	175 - 499
23	Gastritis and duodenitis	688,363	1,071,170	2.4%	0.5%	0.1%	971	995	0.1%	-1,788 - -3,577	-1,812 - -3,601
24	Eczema	665,330	952,419	1.9%	0.5%	0.1%	128	220	3.1%	6 - 11	-86 - -81
25	Endometriosis	746,907	867,238	0.7%	0.4%	0.1%	1,668	2,192	1.4%	-12 - -24	-537 - -549
26	Gout	473,731	669,543	1.8%	0.3%	0.1%	288	287	0.0%	3 - 7	4 - 8
27	Fungal skin diseases	170,874	500,157	8.4%	0.3%	0.1%	140	275	4.2%	1 - 1	-134 - -133
28	Dental caries	295,439	493,152	2.9%	0.3%	0.0%	86	184	5.0%	-1 - -2	-99 - -100
29	Urticaria	88,369	374,399	14.1%	0.2%	0.0%	164	658	13.1%	7 - 14	-487 - -480
30	Pruritus	41,531	154,511	11.8%	0.1%	0.0%	73	341	16.0%	2 - 4	-266 - -264
	All Causes	444,259,592	1,100,952,639	6.4%		100%	3,724*	4,278*	0.6%	2,406 - 4,813	1,852 - 4,259

Notes: Ranked by total spending in 2010; 2009 dollars (source: Personal Consumption Expenditures deflator, U.S. Bureau of Economic Analysis)

[1]Monetized value of healthy life year: $100,000-$200,000

*Average Per-Patient Spending

Table 2. U.S. Health Outcomes using DALYs, 1990-2010							
		Total DALYs Lost		Per-Patient DALYs Lost			
	Condition	**1990**	**2010**	**1990**	**2010**	**Change in DALYs (number of days)**	**Change in Rank**
1	Ischemic heart disease	9,537,448	7,849,544	1.271	0.882	141.7	-
2	Chronic obstructive pulmonary disease	2,720,177	3,658,529	0.112	0.113	-0.3	-
3	Diabetes mellitus	1,945,861	3,107,533	0.107	0.111	-1.5	-
4	Trachea, bronchus, and lung cancers	2,909,698	3,032,874	12.086	10.463	592.5	-
5	Alzheimer's disease and other dementias	789,589	2,022,332	0.239	0.393	-56.2	↑5
6	Colon and rectum cancers	1,076,239	1,146,834	1.775	1.436	124.1	-
7	Breast cancer	1,069,242	1,052,949	0.389	0.271	43	↓3
8	Asthma	901,831	1,032,196	0.056	0.052	1.2	↓1
9	Osteoarthritis	637,581	994,030	0.038	0.038	0	-
10	Prostate cancer	478,870	592,430	0.338	0.160	65.2	↑1
11	Rheumatoid arthritis	345,194	441,713	0.254	0.252	0.9	-
12	Benign prostatic hyperplasia	258,399	396,843	0.032	0.032	0	-
13	Eczema	303,835	390,233	0.038	0.038	0	-
14	Epilepsy	278,578	338,127	0.300	0.292	3.2	↑1
15	Parkinson's disease	129,760	255,395	0.493	0.628	-49.1	-
16	Non-melanoma skin cancer	112,150	230,918	0.181	0.140	15	-
17	Non-infective inflammatory bowel disease	215,625	209,190	0.219	0.237	-6.4	↑1
18	Periodontal disease	139,659	194,685	0.007	0.007	0	-
19	Pruritus	101,953	134,569	0.008	0.007	0	-
20	Urticaria	91,167	112,683	0.031	0.031	0	-
21	Peptic ulcer disease	137,142	76,432	0.388	0.381	2.5	-
22	Fungal skin diseases	55,773	70,655	0.002	0.002	0	-
23	Psoriasis	50,217	64,342	0.053	0.053	0	↑1
24	Cataracts	68,969	56,754	0.064	0.064	0	-
25	Dental caries	46,404	56,187	0.001	0.001	0	-
26	Gastritis and duodenitis	77,944	52,194	0.088	0.107	-6.9	↓1
27	Refraction and accommodation disorders	32,199	42,716	0.075	0.071	1.3	-
28	Glaucoma	13,936	22,092	0.104	0.088	5.7	↑1
29	Gout	15,253	21,941	0.023	0.023	0	-
30	Endometriosis	22,355	21,792	0.033	0.033	0	-
	All Causes	71,906,551	81,834,582	0.289^	0.265^	8.8	

Note: Ranked by total DALYs lost in 2010

^Per-capita

Appendix A: DALYs Conditions Not Included in Study			
Abortion	Drowning	Mechanical forces (other)	Pneumococcal pneumonia
Abscess, impetigo, and other bacterial skin diseases	Dysthymia	Meningococcal infection	Pneumoconiosis
Acne vulgaris	Eating disorders	Migraine	Poisonings
Acute glomerulonephritis	Edentulism	Motorized vehicle with three or more wheels	Polycystic ovarian syndrome
Acute hepatitis A	Encephalitis	Motorized vehicle with two wheels	Premenstrual syndrome
Acute hepatitis B	Enteropathogenic E coli infection	Neck pain	Preterm birth complications
Acute hepatitis C	Enterotoxigenic E coli infection	Neonatal encephalopathy (birth asphyxia and birth trauma)	Rabies
Adverse effects of medical treatment	Exposure to mechanical forces	Neural tube defects	Respiratory syncytial virus pneumonia
Alcohol use disorders	Falls	Obstructed labor	Rheumatic heart disease
Alopecia areata	Fire, heat and hot substances	Opioid use disorders	Road injury
Amoebiasis	G6PD deficiency	Other cardiovascular and circulatory diseases	Road injury other
Amphetamine use disorders	Gall bladder and bile duct disease	Other cirrhosis of the liver	Rotaviral enteritis
Animal contact (non-venomous)	Gonococcal infection	Other congenital anomalies	Scabies
Animal contact (venomous)	H influenzae type B meningitis	Other diarrheal diseases	Schizophrenia
Anxiety disorders	H influenzae type B pneumonia	Other endocrine, nutritional, blood, and immune disorders	Self-harm
Appendicitis	Hemorrhagic and other non-ischemic stroke	Other hemoglobinopathies and hemolytic anemias	Sepsis and other infectious disorders of the newborn baby
Asperger's syndrome	HIV disease resulting in mycobacterial infection	Other infectious diseases	Sexually transmitted chlamydial diseases
Assault by firearm	HIV disease resulting in other specified or unspecified diseases	Other liver cancer	Shigellosis
Assault by other means	Influenza	Other lower respiratory infections	Sickle cell disorders
Assault by sharp object	Inguinal or femoral hernia	Other meningitis	Syphilis
Atrial fibrillation and flutter	Interpersonal violence	Other mental and behavioral disorders	Tension-type headache
Attention-deficit hyperactivity disorder	Interstitial lung disease and pulmonary sarcoidosis	Other musculoskeletal disorders	Tetanus
Autism	Iodine deficiency	Other neoplasms	Thalassemias
Bipolar affective disorder	Iron-deficiency anemia	Other neurological disorders	Trichomoniasis
Campylobacter enteritis	Ischemic stroke	Other salmonella infections	Tuberculosis
Cannabis use disorders	Kidney and other urinary organ cancers	Other sense organ diseases	Tubulointerstitial nephritis, pyelonephritis, and urinary tract infections
Cellulitis	Leprosy	Other sexually transmitted diseases	Typhoid and paratyphoid fevers
Chronic kidney disease due to diabetes mellitus	Liver cancer secondary to alcohol use	Other skin and subcutaneous diseases	Unintentional injuries not classified elsewhere
Cirrhosis of the liver secondary to alcohol use	Liver cancer secondary to hepatitis B	Other transport injury	Upper respiratory infections
Cirrhosis of the liver secondary to hepatitis B	Liver cancer secondary to hepatitis C	Other vision loss	Urolithiasis
Cirrhosis of the liver secondary to hepatitis C	Low back pain	Otitis media	Uterine cancer
Cocaine use disorders	Macular degeneration	Ovarian cancer	Uterine fibroids
Cryptosporidiosis	Major depressive disorder	Pancreatic cancer	Varicella
Cysticercosis	Malaria	Paralytic ileus and intestinal obstruction without hernia	Vascular disorders of intestine
Decubitus ulcer	Maternal hemorrhage	Pedal cycle vehicle	Viral skin diseases
Dengue	Maternal sepsis	Pedestrian injury by road vehicle	Whooping cough
Diphtheria	Measles	Peripheral vascular disease	
Down's syndrome	Mechanical forces (firearm)	Pneumococcal meningitis	