Using Disability-Adjusted Life Years to Assess the Burden of Disease and Injury in Rhode Island

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ABSTRACT

Objectives. Disability-adjusted life years (DALYs) measure the burden of disease and injury in a population. We tested the feasibility of calculating DALYs to assess the burden of disease and injury in Rhode Island (RI).

Methods. We computed DALYs for the 2008 RI population using methods developed by the World Health Organization, Harvard University, and the World Bank. DALYs are a composite measure that sum years of life lost (YLLs) due to premature mortality with years lived with disability (YLDs). We calculated crude mortality, YLLs, YLDs, and DALYs for 90 major health conditions for RI and stratified them by gender and age. Calculations for YLLs and YLDs were based on five-year averages. We compared our results with U.S. and Los Angeles County, California, estimates.

Results. A DALYs ranking produces a different picture of RI's disease and injury burden than does mortality-based ranking. Of 90 major health conditions assessed for RI, six of the top 10 causes for mortality and DALYs were the same, but were ranked differently: ischemic heart disease, cerebrovascular disease, Alzheimer dementia and other dementias, trachea/bronchus/lung cancer, chronic obstructive pulmonary disease, and diabetes mellitus. These six conditions accounted for 59% of deaths but only 35% of DALYs. Causes and rank orders for DALYs differed between males and females and among age groups.

Conclusions. Including nonfatal health conditions in an assessment of population health provides a different picture than traditional mortality-based assessments. This study demonstrates the feasibility and constraints of using DALYs to assess the burden of disease and injury at the state level.

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Mortality data have been used traditionally to identify a population's most important health problems.¹ However, falling death rates often mean people are living longer but with years of illness and disability. Mortality measures provide incomplete information about overall population health, necessitating the development of alternate summary measures.^{1,2} The World Health Organization (WHO), Harvard University, and the World Bank introduced disability-adjusted life years (DALYs) in the Global Burden of Disease (GBD) study.^{3,4} DALYs reflect the years of life lost (YLLs) to premature death and the years spent in unhealthy states, combining the impacts of mortality and disability.

DALYs are a "health gap" measure that represents the gap between the current health status of a population and one in which everyone lives into old age free of disease and injury.^{5,6} It includes the impact of usually nonfatal conditions, such as alcohol use, mental disorders, arthritis, and injuries, and provides a different picture of population health than traditional mortality-based assessments.

Several studies have implemented DALYs and published disease and injury burden reports for countries and subnational entities,^{1-3,5,7} including for the United States² and for Los Angeles (LA) County, California.³ In this study, we applied DALYs to the Rhode Island (RI) population using the GBD study methods.⁴ We estimated DALYs for major health conditions, compared DALYs results with traditional mortality measures, and assessed the benefits and limitations of estimating DALYs at the state level. To our knowledge, RI is the first U.S. state to attempt the use of DALYs to evaluate the burden of disease and injury at the state level.

METHODS

We used methods developed by WHO, Harvard University, and the World Bank to compute DALYs⁴ for the 2008 RI population. DALYs are a composite measure of years of healthy life lost due to both fatal and non-fatal conditions. They are a summation of YLLs due to premature mortality and years lived with disability (YLDs), adjusted for duration and severity, due to specific conditions. One DALY equates to one year of healthy life lost.¹⁻³ Crude mortality, YLLs, YLDs, and DALYs for 90 major health conditions were calculated overall and stratified by gender and seven age groups. RI's small population size and low proportion of racial/ethnic minority groups prevented us from stratifying by race/ethnicity as other studies have done.

We calculated YLLs using RI mortality data for all conditions, while YLDs were calculated using RI cancer registry data, and disease and injury parameters

including incidence estimates, average duration, and disability severity weights developed by Harvard University,² the World Bank, and WHO.^{4,8} Denominators were based on 2008 RI census population estimates. The 90 health conditions used were disease and injury categories defined in the U.S. Burden of Disease and Injury (USBODI) study.²

Data sources

Reflecting RI's small population (about one million), the number of RI deaths for many causes is small and can fluctuate from year to year. To reduce error due to such variation, we used five years (2004–2008) of RI death registry data for estimates of deaths and five years (2004–2008) of RI cancer registry data for estimates of cancer incidence. We used 2008 census estimates for population denominators.

We used RI death data to calculate YLLs for all 90 conditions in our study. To calculate YLDs for 24 cancers, we used RI cancer registry data and obtained other parameters (e.g., disability weights, duration of disability, and age of onset of disability) from the USBODI study. Because reliable state disease incidence data—which are needed to calculate YLDs—were lacking for conditions other than cancer, we used U.S. incidence estimates and other needed parameters for 31 conditions from the USBODI study. However, the USBODI study did not provide incidence data or one of the other parameters needed to calculate YLDs for the remaining 35 conditions.² To address this problem, we adopted the method used by the USBODI study of applying age- and gender-specific YLD-to-YLL ratios for Established Market Economics countries provided in the GBD study⁴ to calculate YLDs. Figure 1 indicates the data sources used to calculate YLDs for the 90 conditions in our study.

Years of life lost (YLLs)

YLLs capture the loss of life associated with premature death due to a specific cause occurring at a particular age. One YLL is calculated as follows:

$$YLL = \frac{KCe^{ra}}{(r+\beta)^2} \left[e^{-(r+\beta)(L+a)} [-(r+\beta)(L+a)-1] - e^{-(r+\beta)a} [-(r+\beta)a-1] \right] + \frac{1-K}{r} (1-e^{-rL})^4$$

- K = age-weighting modulation factor
- C = a necessary adjustment constant due to unequal age weights
- r = discount rate
- a = age at death
- β = age-weighting parameter
- L = the standard expectation of life at age a

Figure 1. Rhode Island burden of disease and injury study (YLDs) data sources

Data source	Condition
Rhode Island Cancer Registry 2004–2008 (24 conditions) ^a	Mouth and oropharynx cancer; esophagus cancer; stomach cancer; colon and rectum cancer; liver cancer; pancreas cancer; trachea/bronchus/lung cancer; melanoma cancer; nonmelanoma skin cancer; breast cancer; cervix uteri cancer; corpus uteri cancer; ovary cancer; prostate cancer; bladder cancer; kidney and renal pelvis cancer; brain cancer; Hodgkin's disease; non-Hodgkin's lymphoma; multiple myeloma; lymphocytic (acute, chronic, and other) leukemias; myelocytic and monocytic leukemias; other leukemias; other neoplasms
U.S. Burden of Disease and Injury study (31 conditions) ^b	Tuberculosis, HIV/AIDS, diabetes mellitus, unipolar major depression, bipolar disorder, schizophrenia, epilepsy, alcohol use, Alzheimer dementia and other dementias, Parkinson's disease, multiple sclerosis, drug use, obsessive-compulsive disorders, panic disorder, ischemic heart disease, cerebrovascular disease, asthma, rheumatoid arthritis, osteoarthritis, anorectal atresia, oral clefts, oesophageal atresia, Down syndrome, congenital heart anomalies, spina bifida, road traffic accidents, poisonings, drownings, suicide and self-inflicted injuries, homicide and violence, posttraumatic stress disorder
YLD/YLL ratios from the Global Burden of Disease study (35 conditions) ^c	Sexually transmitted diseases excluding HIV, diarrheal diseases, childhood-cluster diseases, bacterial meningitis and meningococcaemia, hepatitis B and hepatitis C, septicemia, lower respiratory infections, upper respiratory infections, otitis media, perinatal conditions, protein-energy malnutrition, small intestine cancer, nutritional/endocrine disorders, sense organ diseases, rheumatic heart disease, inflammatory heart diseases, valvular disorders, aortic aneurysm, hypertension and hypertensive heart disease, pulmonary embolism, chronic obstructive pulmonary disease, oesophagus, peptic ulcer disease, cirrhosis of the liver, appendicitis, genitourinary diseases, skin diseases, anencephaly, renal agenesis, oral conditions, falls, fires, accidental firearms, other unintentional injuries, war

^aRhode Island Department of Health. Cancer registry [cited 2011 Dec 14]. Available from: URL: <http://www.health.ri.gov/data/cancer/index.php>

^bMichaud CM, McKenna MT, Begg S, Tomijima N, Majmudar M, Bulzacchelli MT, et al. The burden of disease and injury in the United States, 1996. *Popul Health Metr* 2006;4:11.

^cMurray CJL, Lopez AD, editors. The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Vol 10. Cambridge (MA): Harvard University Press; 1996.

YLDs = years lived with disability

YLLs = years of life lost

HIV = human immunodeficiency virus

AIDS = acquired immunodeficiency syndrome

For standard YLLs used in the GBD study,³ $K=1$, $C=0.1658$, $r=0.03$, and $\beta=0.04$.

Standard life tables representing the maximum remaining life expectancy at each age, for males and females, were adopted from the GBD study.⁴ These standard life tables have been used by others calculating DALYs for the U.S. population.^{1–3}

To calculate the number of YLLs associated with a condition, the number of YLLs per death at each age and gender must be multiplied by the number of deaths at each age and gender, and then summed across all ages and genders.

$$\text{Total YLLs} = \sum[(\text{Number of deaths due to cause } i \text{ by age and gender}) \times \text{YLL}]^4$$

Causes of death during 2004–2008 for all people who had their usual place of residence in RI were grouped into 90 disease and injury categories. The underlying cause of death was denoted using the International Classification of Diseases, 10th Revision codes.⁹

Years lived with disability (YLDs)

The calculation of YLDs requires estimates of disease and injury incidence, average duration of associated disability, and disability weight.^{4,10} A disability weight indicates the average severity of any mental or physical disability associated with each disease or injury.^{1,3} Disability weights are expressed as a number on a scale from 0 to 1, with 0 representing ideal health and 1 representing death. Estimation of disability weights were based on the person trade-off method, which is explained in detail elsewhere. Duration estimates are the average duration for each disabling sequelae associated with each disease or injury.⁴ One YLD is calculated as follows:

$$YLD = D \left\{ \frac{KCe^{ra}}{(r + \beta)^2} \left[e^{-(r + \beta)(L + a)} \left[-(r + \beta)(L + a) - 1 \right] - e^{-(r + \beta)a} \left[-(r + \beta)a - 1 \right] \right] + \frac{1 - K}{r} (1 - e^{-rL}) \right\}^4$$

- D = disability weight
- K = age-weighting modulation factor

- C = a necessary adjustment constant due to unequal age weights
- r = discount rate
- a = age of onset of the disability
- β = age-weighting parameter
- L = duration of disability

For standard YLDs used in the GBD study,⁴ $K=1$, $C=0.1658$, $r=0.03$, and $\beta=0.04$.

To calculate the number of YLDs associated with a condition, the number of YLDs lost per incident at each age and gender must be multiplied by the number of incidents at each age and gender, and then summed across all ages and genders.

Total YLDs = $\Sigma[(\text{Number of incidents due to cause } i \text{ by age and gender}) \times \text{YLD}]^4$

Disability-adjusted life years (DALYs)

DALYs are a composite measure of mortality and disability attributed to a specific cause equal to the summation of YLLs due to premature death and YLDs due to the specific cause.^{1-4,6} We calculated DALYs for each of 90 health conditions, and for each condition stratified by gender and seven age groups, based on the formula:

$$\text{DALYs} = \text{YLLs} + \text{YLDs}^{10}$$

All calculations were performed using Microsoft® Excel and SAS® version 9.1.¹¹

RESULTS

Table 1 displays the 10 leading causes of DALYs, deaths, YLLs, and YLDs. The RI estimated burden in 2008 due to 90 disease and injury categories was 95,395 DALYs and 8,108 deaths. When DALYs were compared with mortality as a measure of disease and injury burden, the top 10 DALYs accounted for 51% of all DALYs, while the top 10 causes of death accounted for 69% of all deaths. Six causes of DALYs and death were the same, though their ranking and proportion of burden differed (e.g., ischemic heart disease [IHD] was the leading cause of both death and DALYs but accounted for a greater proportion of deaths than of DALYs [28% vs. 12%]). Alzheimer dementia and other dementias, trachea/bronchus/lung cancer, chronic obstructive pulmonary disease (COPD), and diabetes mellitus decreased in rank when going from cause of death to cause of DALYs, while cerebrovascular disease increased in rank. Cerebrovascular disease, dementia, and COPD also appeared among the top 10 causes of YLLs and YLDs.

Patterns by gender

Table 2 presents the leading causes of DALYs by gender. Males had a higher number of DALYs from all causes (48,562) than did females (46,833). However, the burden for the top 10 DALYs for females (26,769 or 57% of total female DALYs) exceeded that for males (23,891 or 49% of total male DALYs). IHD, the leading cause of DALYs for both genders, accounted for about 13% of DALYs for males and 10% of DALYs for females. Cerebrovascular disease, lung cancer, dementia, depression, osteoarthritis, and COPD dominated the list of major causes in both groups, though they were ranked differently and each was a higher proportion of all DALYs for females than for males, with the exception of lung cancer. Breast cancer, genitourinary diseases, and asthma were among the top 10 leading causes of DALYs for females but not for males. Drug use, road traffic accidents, and alcohol use were among the top 10 leading causes of DALYs for males but not for females.

Patterns by age group

Table 3 presents the leading causes of DALYs by age group. More than half (66%) of the total number of DALYs occurred in adults aged 45 years and older. Most of the remaining burden was distributed between those aged 15–24 years (11%) and 25–44 years (17%), while the younger age groups—those aged 0–4 years and 5–14 years—accounted for only 4% and 2% of the total burden, respectively (data not shown).

Leading causes of DALYs varied by age group. For the three oldest age groups (45–64, 65–74, and ≥ 75 years of age), leading causes were primarily chronic disease conditions. IHD, the leading cause of DALYs, accounted for 15% of DALYs for those aged 45–64 years, 16% of DALYs for those aged 65–74 years, and 20% of DALYs for those ≥ 75 years of age. Five other chronic conditions were common to the three age groups, though they were ranked differently: lung cancer, cerebrovascular disease, osteoarthritis, COPD, and nutritional/endocrine disorders. The leading causes of DALYs for those aged 15–24 and 25–44 years were primarily mental and behavior-related conditions. Depression, drug use, and alcohol use were common to both age groups. Road traffic accidents, panic disorder, homicide, and obsessive-compulsive disorder were among the leading causes of DALYs for those aged 15–24 years, while posttraumatic stress disorder, poisonings, suicide, and human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) were among the leading causes of DALYs for those aged 25–44 years. Due to the small number of deaths and hospitalizations among children, only the top

Table 1. Ten leading causes of disease and injury, based on various measures: Rhode Island, 2008

Rank	DALYs		Crude mortality		YLLs		YLDs	
	Cause	DALYs N (percent)	Cause	Death N (percent)	Cause	YLLs N (percent)	Cause	YLDs N (percent)
1	Ischemic heart disease	11,267 (11.8)	Ischemic heart disease	2,256 (27.8)	Ischemic heart disease	9,971 (20.9)	Unipolar major depression	5,992 (12.5)
2	Unipolar major depression	6,001 (6.3)	Alzheimer dementia and other dementias	702 (8.7)	Trachea/bronchus/lung cancer	4,248 (8.9)	Osteoarthritis	4,207 (8.8)
3	Cerebrovascular disease	5,653 (5.9)	Trachea/bronchus/lung cancer	639 (7.9)	COPD	2,079 (4.4)	Cerebrovascular disease	3,637 (7.6)
4	Alzheimer dementia and other dementias	5,402 (5.7)	Cerebrovascular disease	469 (5.8)	Cerebrovascular disease	2,016 (4.2)	Alzheimer dementia and other dementias	3,526 (7.4)
5	Trachea/bronchus/lung cancer	4,540 (4.8)	COPD	451 (5.6)	Alzheimer dementia and other dementias	1,876 (3.9)	Drug use	2,363 (4.9)
6	COPD	4,281 (4.5)	Genitourinary diseases	260 (3.2)	Road traffic accidents	1,780 (3.7)	Asthma	2,212 (4.6)
7	Osteoarthritis	4,218 (4.4)	Lower respiratory infections	251 (3.1)	Suicide and self-inflicted injuries	1,699 (3.6)	COPD	2,202 (4.6)
8	Drug use	2,435 (2.6)	Diabetes mellitus	239 (2.9)	Poisonings	1,616 (3.4)	Bipolar disorder	1,488 (3.1)
9	Road traffic accidents	2,315 (2.4)	Colon and rectum cancer	205 (2.5)	Diabetes mellitus	1,489 (3.1)	Alcohol use	1,325 (2.8)
10	Diabetes mellitus	2,315 (2.4)	Breast cancer	157 (1.9)	Breast cancer	1,288 (2.7)	Schizophrenia	1,313 (2.8)
Total from the top 10 causes		48,426 (50.8)	5,629 (69.4)		28,061 (58.9)		28,265 (59.2)	
Total from the 90 causes		95,395 (100.0)	8,108 (100.0)		47,643 (100.0)		47,752 (100.0)	

DALYs = disability-adjusted life years

YLLs = years of life lost

YLDs = years lived with disability

COPD = chronic obstructive pulmonary disease

Table 2. Ten leading causes of burden of disease and injury, by gender: Rhode Island, 2008

Rank	Males		Females	
	Cause	DALYs N (percent)	Cause	DALYs N (percent)
1	Ischemic heart disease	6,381 (13.1)	Ischemic heart disease	4,886 (10.4)
2	Cerebrovascular disease	2,472 (5.1)	Unipolar major depression	4,039 (8.6)
3	Trachea/bronchus/lung cancer	2,327 (4.8)	Alzheimer dementia and other dementias	3,394 (7.2)
4	Alzheimer dementia and other dementias	2,008 (4.1)	Cerebrovascular disease	3,181 (6.8)
5	Unipolar major depression	1,962 (4.0)	COPD	2,639 (5.6)
6	Osteoarthritis	1,926 (4.0)	Osteoarthritis	2,292 (4.9)
7	Drug use	1,878 (3.9)	Trachea/bronchus/lung cancer	2,213 (4.7)
8	Road traffic accidents	1,787 (3.7)	Breast cancer	1,659 (3.5)
9	COPD	1,642 (3.4)	Genitourinary diseases	1,241 (2.7)
10	Alcohol use	1,508 (3.1)	Asthma	1,226 (2.6)
Total from the top 10 causes		23,891 (49.2)	26,769 (57.2)	
Total from the 90 causes		48,562 (100.0)	46,833 (100.0)	

DALYs = disability-adjusted life years

COPD = chronic obstructive pulmonary disease

four causes of DALYs could be estimated for children aged 0–4 and 5–14 years. Perinatal conditions, which are unique to infants, accounted for 32% of DALYs, while congenital heart anomalies accounted for 30% of DALYs in children aged 0–4 years. For children aged 5–14 years, asthma accounted for 40%, and road traffic accidents accounted for 12% of all DALYs.

DISCUSSION

The 10 leading causes of DALYs for RI in 2008 were compared with published DALYs assessments for the U.S. in 1996² and LA County in 1997.³ Despite the 10-year gap between the calculation of DALYs for these U.S. entities, there were several commonalities (Figure 2). IHD was the leading cause of DALYs for each of these entities, and seven conditions appeared in the top 10 causes of DALYs for each, though in different rank order: depression, cerebrovascular disease, lung cancer, COPD, osteoarthritis, road traffic accidents, and diabetes mellitus. RI's top 10 causes of DALYs also included dementia and drug use, the U.S. top 10 causes of DALYs included alcohol use and HIV, and the LA County top 10 causes of DALYs included alcohol use and homicide/violence.

Alcohol use was the 19th leading cause of DALYs in RI (data not shown). Although alcohol use rates in RI are high,¹² RI's alcohol use mortality rate during 2004–2008 was almost half the national rate in 1996

(1.43 per 100,000 population vs. 2.52 per 100,000 population²). This figure may explain why alcohol use is not among the top 10 causes of DALYs for RI as it is in the U.S.

HIV was not a leading cause of DALYs in RI as it was in the U.S.² (HIV was the 33rd leading cause of DALYs in RI [data not shown].) This RI vs. U.S. comparison must take into account the advances that have been made during the past 20 years in clinical therapy and antiretroviral medications¹³ in the treatment of HIV/AIDS. Our DALYs calculations used RI HIV/AIDS mortality data for 2004–2008, while the U.S. HIV/AIDS DALYs calculations were based on mortality data for the U.S. in 1996.^{1,2} Starting in 1994, the number of RI AIDS deaths declined steadily and stabilized in 1998.¹³ National HIV/AIDS deaths began declining in 1996 and stabilized in 1998.¹⁴ The RI HIV/AIDS mortality rate for 2004–2008 (2.38 per 100,000 population) was much lower than that for the U.S. in 1996 (7.99 per 100,000 population²). RI's low HIV/AIDS mortality rate during the period 2004–2008 can explain why HIV was not among the top 10 causes of DALYs for RI.

Seven causes of DALYs for males and females were the same, while three differed between the genders (Table 2). Alcohol use, a major cause of cirrhosis,^{15,16} accounted for 3% of DALYs for males. The more common use of alcohol among men has been documented by others.^{16,17} Depression was the second leading cause of DALYs among women. Women are much more likely

Table 3. Ten leading causes of burden of disease and injury, by age group: Rhode Island, 2008

Rank	0–4 years		5–14 years		15–24 years		25–44 years	
	Cause	DALYs N (percent)	Cause	DALYs N (percent)	Cause	DALYs N (percent)	Cause	DALYs N (percent)
1	Perinatal conditions	1,133 (32.2)	Asthma	806 (39.9)	Drug use	1,577 (14.6)	Unipolar major depression	3,341 (20.5)
2	Congenital heart anomalies	1,069 (30.4)	Road traffic accidents	238 (11.8)	Road traffic accidents	1,177 (10.9)	Poisonings	899 (5.5)
3	Down syndrome	283 (8.0)	Schizophrenia	142 (7.0)	Schizophrenia	1,042 (9.6)	Ischemic heart disease	857 (5.3)
4	Asthma	263 (7.5)	Epilepsy	140 (6.9)	Unipolar major depression	985 (9.1)	Suicide and self-inflicted injuries	752 (4.6)
5	NC ^a		NC ^a		Bipolar disorder	974 (9.0)	Drug use	729 (4.5)
6	NC ^a		NC ^a		Alcohol use	710 (6.6)	Cerebrovascular disease	625 (3.8)
7	NC ^a		NC ^a		Panic disorder	691 (6.4)	HIV/AIDS	620 (3.8)
8	NC ^a		NC ^a		Asthma	650 (6.0)	Alcohol use	560 (3.4)
9	NC ^a		NC ^a		Homicide and violence	545 (5.0)	Posttraumatic stress disorder	541 (3.3)
10	NC ^a		NC ^a		Obsessive-compulsive disorders	399 (3.7)	Osteoarthritis	534 (3.3)
Total from the top four causes		2,747 (78.1)	Total from the top four causes	1,326 (65.6)	Total from the top 10 causes	8,749 (80.9)	Total from the top 10 causes	9,458 (58.0)
Total from the 90 causes		3,515 (100.0)	Total from the 90 causes	2,020 (100.0)	Total from the 90 causes	10,816 (100.0)	Total from the 90 causes	16,319 (100.0)

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Table 3 (continued). Ten leading causes of burden of disease and injury, by age group: Rhode Island, 2008

Rank	45–64 years		65–74 years		≥75 years	
	Cause	DALYs N (percent)	Cause	DALYs N (percent)	Cause	DALYs N (percent)
1	Ischemic heart disease	4,328 (14.7)	Ischemic heart disease	2,078 (15.6)	Ischemic heart disease	3,995 (20.0)
2	Trachea/bronchus/lung cancer	2,304 (7.8)	COPD	1,302 (9.8)	Alzheimer dementia and other dementias	3,495 (17.5)
3	Cerebrovascular disease	2,103 (7.2)	Trachea/bronchus/lung cancer	1,246 (9.4)	Cerebrovascular disease	1,658 (8.3)
4	Osteoarthritis	1,832 (6.2)	Cerebrovascular disease	1,080 (8.1)	COPD	1,502 (7.5)
5	COPD	1,419 (4.8)	Osteoarthritis	979 (7.4)	Lower respiratory infections	1,011 (5.0)
6	Unipolar major depression	1,384 (4.7)	Alzheimer dementia and other dementias	959 (7.2)	Genitourinary diseases	996 (5.0)
7	Diabetes mellitus	1,145 (9.3)	Genitourinary diseases	409 (3.1)	Osteoarthritis	873 (4.4)
8	Breast cancer	913 (3.1)	Colon and rectum cancer	360 (2.7)	Trachea/bronchus/lung cancer	744 (3.7)
9	Cirrhosis of the liver	812 (2.8)	Diabetes mellitus	339 (2.5)	Falls	484 (2.4)
10	Nutritional/endocrine disorders	710 (2.4)	Nutritional/endocrine disorders	315 (2.4)	Nutritional/endocrine disorders	444 (2.2)
Total from the top 10 causes		16,951 (57.7)			15,202 (75.9)	
Total from the 90 causes		29,401 (100.0)			20,019 (100.0)	

*As small numbers are not reliable or stable, we excluded any disease or injury category with a DALYs <100, resulting in four categories for those aged 0–4 years and four categories for those aged 5–14 years.

DALYs = disability-adjusted life years

COPD = chronic obstructive pulmonary disease

NC = not calculable

HIV/AIDS = human immunodeficiency virus/acquired immunodeficiency syndrome

Figure 2. Ten leading causes of DALYs for Rhode Island (2008), the U.S. (1996), and Los Angeles County, California (1997)

Rank	Rhode Island, 2008	U.S., 1996 ^a	Los Angeles County, 1997 ^b
1	Ischemic heart disease	Ischemic heart disease	Ischemic heart disease
2	Unipolar major depression	Cerebrovascular disease	Alcohol use
3	Cerebrovascular disease	Road traffic accidents	Homicide/violence
4	Alzheimer dementia and other dementias	Unipolar major depression	Depression
5	Trachea/bronchus/lung cancer	Trachea/bronchus/lung cancer	Diabetes mellitus
6	COPD	COPD	Osteoarthritis
7	Osteoarthritis	Alcohol use	Cerebrovascular disease
8	Drug use	Human immunodeficiency virus	Trachea/bronchus/lung cancer
9	Road traffic accidents	Diabetes mellitus	COPD
10	Diabetes mellitus	Osteoarthritis	Road traffic accidents

^aMichaud CM, McKenna MT, Begg S, Tomijima N, Majmudar M, Bulzacchelli MT, et al. The burden of disease and injury in the United States, 1996. *Popul Health Metr* 2006;4:11.

^bKominski GF, Simon PA, Ho A, Luck J, Lim YW, Fielding JE. Assessing the burden of disease and injury in Los Angeles County using disability-adjusted life years. *Public Health Rep* 2002;117:185-91.

DALYs = disability-adjusted life years

COPD = chronic obstructive pulmonary disease

than men to develop depression and depression-related disorders during their lifetime, according to several studies.^{18,19}

Smoking has been estimated to cause one-third of all cancer deaths in many Western countries and to be responsible for about 11% of all deaths due to cardiovascular disease.²⁰ Because lung cancer and IHD were both leading causes of DALYs, tobacco use could be considered a significant contributor to RI's overall disease burden.

Osteoarthritis was the seventh leading cause of DALYs in RI, the 10th leading cause of DALYs in the U.S., and the sixth leading cause of DALYs in LA County (Figure 2).^{2,3} Osteoarthritis is an important public health problem affecting mostly older adults and is one of the most rapidly growing causes of disability.⁶ Researchers have estimated that the 40 million prevalent cases in the U.S. in 1996 will increase 150%—to 60 million cases—by 2020.²

Comparison of the causes and rank orders of DALYs, deaths, YLLs, and YLDs, overall and by gender and age, highlights the way nonfatal but disabling chronic and mental health conditions compromise quality of life, and indicates the significant impact of behavioral and mental health conditions on teens and young adults, of asthma on children, and of disparities by gender.

The relative contribution of premature death vs. disability to the estimation of DALYs becomes evident when the causes and rank order of deaths, YLLs, and YLDs are compared with one another. For example, IHD, the number one cause of DALYs, deaths, and

YLLs, did not appear in the top 10 causes of YLDs. Conversely, depression and osteoarthritis, both leading causes of DALYs, were not leading causes of death or of YLLs but were the two leading causes of YLDs.

Limitations

Estimating DALYs adds a new dimension to assessing the health of RI's population. However, some limitations need to be noted. For one, DALYs calculations require detailed epidemiologic information for many different conditions. Incidence data for most conditions are lacking at the state level, and the use of U.S. incidence estimates may not accurately represent RI's population. Second, we could not assess racial/ethnic disparities in RI because we did not have enough cases to calculate the YLLs by race/ethnicity. Third, numerous decisions and assumptions were made during the calculation process,¹ and these assumptions introduced some uncertainty into the calculations that requires caution when interpreting rankings for causes with small differences in the number of DALYs.

Fourth, the DALY method itself has some limitations. A critique by Grosse et al. notes that disability weights are assigned based on experts' judgments and clinical experience, and by people without disabilities whose judgments are likely to reflect their perception of the undesirability of a disabling condition. These disability weights also did not consider patients' medical treatment, disease stages, and complications. Further, Grosse et al. argue that in the future, DALYs and YLDs estimates should be based on measures of

activity limitations rather than perceived desirability. They also raised an ethics issue, as these weights imply that one year of living in good health is more valuable than living two years in poor health.²¹ These criticisms are legitimate and we support refinement of the disability weights that are currently being used in DALYs calculations. However, we believe that the existing disability weights, although imperfect, provide value in enabling the calculation of DALYs, and that DALYs add a much needed dimension to the estimation of disease burden in a population.

Finally, the influence of age weighting on the ranking of conditions is small and has been criticized by some researchers.^{3,22} While the use of a discounting rate remains controversial,⁷ a comparison study found that the discounting rate made little difference in the end results.^{3,5}

Despite these data and methodologic limitations, DALYs, reflecting years of healthy life lost, provide a useful tool for identifying conditions that exact large health burdens in RI's population, as well as for identifying health disparities among age and gender subgroups.

CONCLUSIONS

This study demonstrates the feasibility of using DALYs to assess the burden of disease and injury at the state level. Assessment of RI DALYs for age and gender subgroups indicated disparities in the causes and significance of conditions, indicating the need for targeted interventions. For example, alcohol and drug use are of particular concern for males, depression and asthma are concerning for females, mental disorders and injuries are concerning for younger adults, road traffic accidents and asthma are a concern for children and young adults, and congenital and perinatal conditions primarily affect infants. Using DALYs to assess the burden of disease and injury at the state or local level can help state and local government decision makers set public health priorities and allocate health resources.²³

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