Assessing the Burden of Disease and Injury in Los Angeles County Using Disability-Adjusted Life Years

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SYNOPSIS

Objective. This study was designed to assess the burden of disease and injury in the Los Angeles County population using Disability-Adjusted Life Years (DALYs), a composite measure of premature mortality and disability that equates to years of healthy life lost.

Methods. DALYs, stratified by gender and race/ethnicity, were calculated for 105 health conditions and aggregated groups of conditions for the Los Angeles County population for 1997. Years of Life Lost (YLLs) were calculated using 1997 county mortality statistics and published life tables. Years Lived with Disability (YLDs) were derived from age- and gender-specific disease incidence and disability data from the Global Burden of Disease Study.

Results. DALYs produced a substantially different ranking of disease and injury burden than did mortality rates alone. The leading five causes of DALYs for males in the county were ischemic heart disease, violence, alcohol dependence, drug overdose and other intoxications, and depression. For females, the leading five causes were ischemic heart disease, alcohol dependence, diabetes, depression, and osteoarthritis. Differences in the rank order were also observed by race/ethnicity. The age-adjusted rate of DALYs for all health conditions combined was highest in African Americans (190 per 1,000), followed by American Indians (149 per 1,000), whites (113 per 1,000), Latinos (94 per 1,000), and Asians/Pacific Islanders (77 per 1,000).

Conclusions. The DALYs measure is a promising new tool to improve the capacity of local health departments and other health agencies to assess population health and establish an evidence base for public health decisions.

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Historically, efforts to assess disease and injury burden have been hampered by the lack of a single measure of burden that accounts for both morbidity and mortality. To address this limitation at the international level, the Disability-Adjusted Life Years (DALYs) measure was developed a decade ago to assess global patterns of disease and injury burden and to project future trends.[1,2] DALYs combine the impacts of premature mortality and disability associated with various health conditions. One DALY equates to one year of healthy life lost. DALYs have been used to measure disease burden in both developed and developing countries[3–5] and to assess the allocation of National Institutes of Health (NIH) funding in the United States.[6]

In this report, we describe the use of DALYs to assess the burden of disease and injury in a large urban population, compare the results to those of more traditional measures of disease burden (crude mortality and premature mortality), and discuss the potential benefits and limitations of using the DALYs methodology at the local health department level to assess and prioritize population health needs.

METHODS

DALYs measure population-level disease burden based on mortality and disability rates. They represent the sum of (*a*) the number of Years of Life Lost (YLLs) to premature mortality, summed across a given population, and (*b*) the number of Years Lived with Disability (YLDs), adjusted for level of disability and summed across the given population. Because one purpose of our study was to demonstrate that DALYs can be used domestically for assessing disease burden, we calculated DALYs for the Los Angeles County population in 1997 using the same methods as in the Global Burden of Disease (GBD) Study.[2]

Calculation of YLLs

The YLL component was calculated using morality rates derived from publicly available death records. All 1997 deaths records for individuals residing in Los Angeles County (N = 60,072) were eligible for inclusion in the analysis. Two hundred eighty-six (0.5%) were excluded because of insufficient information on the death certificate. The remaining 59,786 reports were grouped by underlying cause of death into 105 disease and injury categories as defined in the GBD Study.[2] The underlying cause of death is denoted using International Classification of Diseases, Ninth Revision (ICD-9) codes.

Standard life tables for males and females from the GBD study (indicating remaining life expectancy at each year of age) were then used to calculate YLLs.[2] These tables are based on different data sources for men and women. For women, the standard life tables use the maximum life expectancy observed internationally, i.e., 82.5 years for Japanese women. For men, the standard life tables are based on an ideal life expectancy (80.0 years) developed using models of the true biological male/female difference in life expectancy, controlling for other risk factors.[7]

YLLs were calculated for each disease and injury category as the difference between life expectancy and age at death in months, summed across the total county population, and by gender and race/ethnicity (i.e., African American, American Indian/Alaska Native, Asian/Pacific Islander, Latino, and white). We stratified our analyses according to race/ethnicity to examine potential disparities in disease burden. Data on race/ethnicity were obtained directly from the death records, which are subject to misclassification.[8]

Calculation of YLDs

Calculation of YLDs requires estimates of disease and injury incidence, the frequency of associated disabilities, and the average duration and severity of the disabilities.[7] For the GBD Study, disease and disability incidence and duration for a range of conditions were estimated based on an exhaustive review of the published and unpublished literature and input from experts in epidemiology.[2] The severity of disabilities was quantified in the GBD study using disability weights, ranging from 0 (perfect health) to 1 (death), developed by an international panel of health care providers.[2] For example, treated angina pectoris has a disability weight of 0.095 for all ages, whereas untreated unipolar major depression has a weight of 0.600 for all ages.

Because of the relative lack of disease incidence and disability data for the Los Angeles County population, we imputed disease and disability rates and assigned disability weights using the same methodology as in the GBD study, but with updated rates. To estimate YLDs in the county population,[2] we used updated age- and gender-specific YLD-to-YLL ratios and YLD rates for each disease and injury category for Established Market Economy (EME) countries obtained from the Harvard University School of Public Health Burden of Disease Unit (Personal communication, Catherine Michaud, MD, PhD, January 1999).

YLDs for each age/gender stratum in the county population were estimated in one of two ways: (1) if the EME YLD-to-YLL ratio was stable (defined as <10 in the GBD study), this ratio was multiplied by the county's YLLs to determine the county's YLDs; or (2) if

the EME YLD-to-YLL ratio was unstable because of low mortality (defined as ≥10 in the GBD study), the EME YLD rate was used to determine the county's YLDs by applying this rate to the county population estimated by the Census Bureau for 1997.[2] These YLD calculations were done for each age (<1, 1, 2–4, 5–9, 10–14, . . . 80–84, ≥85) and gender stratum and then summed across strata to obtain totals for each disease and injury category. We could not calculate separate YLDs by race/ethnicity because we did not have comprehensive data on disease and disability rates by race/ethnicity.

Calculation of DALYs

Prior to summing the YLLs and YLDs within each disease and injury category, we applied the same age-weighting and discounting factors used in the GBD study to each age and gender stratum.[2] Age-weighting quantifies the perception that a year of healthy life has greater social value during early adulthood than during earlier or later life. Therefore, younger and older age categories are weighted somewhat less than 1.0, while age categories during early working adulthood are weighted greater than 1.0. The discounting factors account for the perception that a current year is worth more than a future year of healthy life and that future years need to be expressed in present value terms. YLLs and YLDs that extended beyond the current year into the future, therefore, were discounted, i.e., divided by 1.03^n, where n is the number of years in the future, to produce a present value for YLLs and YLDs. This same calculation is used to calculate the present value of costs and benefits in cost-effectiveness studies.[9] We examined the sensitivity of our final results, as presented below, to removal of both age-weighting and discounting, and found no substantial differences in the findings.

After applying the age-weighting and discounting factors to each age and gender stratum, we summed the YLLs and YLDs within the 105 disease and injury categories to produce DALYs.

Rate calculations

Rates per 1,000 population were calculated for YLLs, YLDs, and DALYs by gender and race/ethnicity using

Table 1. Leading causes of crude mortality, YLLs, and DALYs, Los Angeles County, 1997

Crude mortality			*YLLs*			*DALYs*		
Rank	*Cause*	*Number of deaths*	*Rank*	*Cause*	*Number of deaths*	*Rank*	*Cause*	*Number of deaths*
1	Ischemic heart disease	14,378	1	Ischemic heart disease	66,494	1	Ischemic heart disease	72,886
2	Stroke	4,168	2	Homicide	35,572	2	Alcohol dependence	60,872
3	Lung cancer	3,772	3	Lung cancer	27,414	3	Homicide/other violence	45,548
4	Pneumonia	3,364	4	Stroke	21,601	4	Depression	43,449
5	COPD	2,671	5	Motor vehicle crashes	19,908	5	Diabetes	42,456
6	Diabetes	1,747	6	Suicide	15,339	6	Osteoarthritis	39,811
7	Colon cancer	1,483	7	HIV/AIDS	14,939	7	Stroke	33,351
8	Homicide	1,247	8	Cirrhosis	14,123	8	Lung cancer	29,875
9	Breast cancer	1,242	9	Breast cancer	13,288	9	COPD	29,333
10	Hypertension	1,241	10	Diabetes	13,262	10	Motor vehicle crashes	29,040
11	Cirrhosis	1,045	11	COPD	13,017	11	Drug overdose/other intoxications	28,508
12	Alzheimer's disease/ other dementias	1,000	12	Pneumonia	12,977	12	Alzheimer's disease/ other dementias	27,626
13	Inflammatory heart disease[a]	927	13	Inflammatory heart disease[a]	10,635	13	HIV/AIDS	20,649
14	Motor vehicle crashes	888	14	Drug overdose/other intoxications	10,631	14	Cirrhosis	18,263
15	Prostate cancer	841	15	Colon cancer	10,154	15	Endocrine and metabolic diseases	17,541

[a]Includes myocarditis and pericarditis

COPD = chronic obstructive pulmonary disease

DALYs = Disability-Adjusted Life Years

YLLs = Years of Life Lost

Table 2. Comparison of leading causes of DALYs by gender, Los Angeles County, 1997

Male		*Female*	
Cause	*Percent*[a]	*Cause*	*Percent*[a]
Ischemic heart disease	8.1	Ischemic heart disease	6.7
Homicide/other violence	5.8	Alcohol dependence	5.8
Alcohol dependence	6.6	Diabetes	5.2
Drug overdose/other intoxication	4.9	Depression	4.7
Depression	4.2	Osteoarthritis	4.4
Osteoarthritis	3.8	Stroke	3.9
Motor vehicle crashes	3.7	Alzheimer's disease/other dementias	3.8
Diabetes	3.6	Breast cancer	3.4
HIV/AIDS	3.3	COPD	3.3
Lung cancer	3.2	Lung cancer	2.9
Total	49.0	Total	44.2

[a]Percentage of the total number of DALYs in each population group

COPD = chronic obstructive pulmonary disease

DALYs = Disability-Adjusted Life Years

1997 county population projections based on the 1990 Census.[10] Rates were age-adjusted to the 1990 U.S. population.

RESULTS

Table 1 shows the 15 leading causes of disease and injury burden in the county population based on measures of crude mortality (number of deaths), premature mortality (YLLs), and DALYs. Although ischemic heart disease led the list for all three measures, there was considerable variation in the rank order of the other conditions. For example, alcohol dependence was 2nd on the DALYs list but only 29th based on YLLs and 39th based on crude mortality. Similarly, depression and osteoarthritis were among the leading causes of DALYs but accounted for very little burden based on crude mortality and YLLs. Conversely, pneumonia was 4th on the crude mortality list but dropped to 12th based on YLLs and 21st based on DALYs.

The 10 leading causes of DALYs by gender are shown in Table 2. Ischemic heart disease led the list in both males and females. However, homicide/other violence, drug overdose/other intoxication, motor vehicle crashes, and HIV/AIDS accounted for higher percentages of DALYs in males than females. Diabetes, stroke, Alzheimer's/other dementias, and breast cancer accounted for higher percentages in females than males. Alcohol dependence, depression, and osteoarthritis were among the leading causes of DALYs in both groups.

Substantial variation in the DALYs rankings was observed by race/ethnicity (Table 3). For example, ischemic heart disease was the leading cause of DALYs in whites, homicide/other violence the leading cause in African Americans, and alcohol dependence the leading cause in both Latinos and Asians/Pacific Islanders. HIV/AIDS and asthma were among the leading 10 causes of DALYs in African Americans but were not among the leading causes in the other racial/ethnic groups.

For all conditions combined, the age-adjusted DALYs rate was higher in males (119 per 1,000) than females (94 per 1,000) (Table 4). This difference was attributable to a 50% higher rate of YLLs in males (67 per 1,000) than in females (44 per 1,000). The DALYs rate also varied by race/ethnicity and was highest in African Americans (190 per 1,000), followed by American Indians/Alaska Natives (149 per 1,000), whites (113 per 1,000), Latinos (94 per 1,000), and Asians/Pacific Islanders (77 per 1,000).

DISCUSSION

This study is the first that we are aware of to use DALYs to assess the burden of disease and injury in the United States at a local or regional population level. The findings suggest that DALYs produce a substantially different ranking of disease and injury burden from that produced by mortality rates alone. For example, alcohol and other drug dependence, depression, and arthritis impose a substantial burden in the Los Angeles County population not reflected in county mortality statistics. In addition, the findings highlight the

Table 3. Comparison of leading causes of DALYs by race/ethnicity,[a] Los Angeles County, 1997

Asian/Pacific Islander		*Black*		*Latino*		*White*	
Cause	*Percent[b]*	*Cause*	*Percent[b]*	*Cause*	*Percent[b]*	*Cause*	*Percent[b]*
Alcohol dependence	8.9	Homicide/other violence	8.7	Alcohol dependence	8.5	Ischemic heart disease	10.5
Depression	6.6	Ischemic heart disease	7.0	Homicide/other violence	7.2	COPD	4.9
Osteoarthritis	6.1	Diabetes	6.0	Depression	5.6	Alcohol dependence	4.8
Ischemic heart disease	5.6	Alcohol dependence	4.3	Diabetes	4.6	Lung cancer	4.6
Stroke	4.6	Stroke	4.3	Osteoarthritis	4.5	Alzheimer' disease/ other dementias	4.4
Diabetes	4.4	Lung cancer	3.4	Motor vehicle crashes	4.3	Diabetes	3.7
Alzheimer's disease/ other dementias	4.1	HIV/AIDS	3.4	Ischemic heart disease	3.7	Osteoarthritis	3.6
COPD	3.2	Asthma	2.9	Drug overdose/other intoxication	2.9	Stroke	3.6
Motor vehicle crashes	2.9	COPD	2.7	Stroke	2.7	Depression	3.4
Unintended firearm injury	2.7	Depression	2.5	Cirrhosis	2.4	Drug overdose/other intoxication	3.4
Total	49.1	Total	45.0	Total	46.4	Total	46.8

[a]American Indians/Alaska Natives were not included in this analysis because of insufficient numbers.

[b]Percentage of the total number of DALYs in each population group

COPD = chronic obstructive pulmonary disease

DALYs = Disability-Adjusted Life Years

importance of violence as a leading cause of both YLLs and DALYs among males in the county, and also highlight the importance of heart disease and diabetes in all population groups. The results further document the considerable disparities in disease burden across population groups in the county as reflected, for example, in the finding that the DALYs rate for the African American population was more than twice as high as the rate for either the Latino or Asian/Pacific Islander population.

Table 4. Age-adjusted rates per 1,000 population of YLLs, YLDs, and DALYs, by gender and race/ethnicity, Los Angeles County, 1997

Variable	*YLLs*	*YLDs*	*DALYs*
Gender			
Male	66.6	52.2	118.8
Female	44.1	52.7	93.8
Race/ethnicity			
African American	106.4	83.9	190.3
American Indian or Alaska Native	67.4	81.7	149.2
Asian/Pacific Islander	28.5	48.5	76.9
Latino	43.4	50.7	94.0
White	55.8	56.7	112.5

DALYs = Disability-Adjusted Life Years

YLDs = Years Lived with Disability

YLLs = Years of Life Lost

Although the DALYs measure represents a potential advance in population health assessment because it addresses the impacts of disease and injury on both the quantity and quality of life, it is important to note that the measure has been the subject of some debate.[11,12] For example, the use of age-weighting and discounting has been criticized by some researchers.[13] To address this concern, we conducted our analyses with and without the age-weighting and discounting adjustments and found only minimal differences in the results. Others have questioned the validity and universality of the disability weights because of the value judgments inherent in the process, e.g., the fact that the determination of weights in the GBD Study was done exclusively by health care providers.[14,15] A more recent study examined variation in disability rankings across 14 countries and several different informant groups, including individuals with disabilities.[16] This study found significant variation in disability rankings by country and informant group, although the rankings for all groups combined was nearly identical to that found in the GBD Study.

Our analysis was further limited because the county YLD estimates were based on gender- and age-specific YLD/YLL ratios and YLD rates for a broad geographic

area (including the United States, Canada, Japan, Western Europe, and Australia) rather than data for the county population. If the actual ratios and rates in the county population were significantly different from those used in our analysis, the YLDs and DALYs reported here may be overstated or understated for specific health conditions. For example, we believe that YLL rates may vary substantially across ethnic groups within the U.S. and Los Angeles county, but our results do not reflect these possible differences. Efforts are underway at the Centers for Disease Control and Prevention (CDC) to compile U.S. incidence and disability data for DALYs calculations (Personal communication, Matthew McKenna, MD, MPH, Division of HIV/AIDS Prevention, National Center for HIV, STD and TB Prevention, CDC, November 2000). Future efforts by state and local health departments to use DALYs to assess disease burden should incorporate these CDC data as well as state and local data where available.

Because the analysis was based on mutually exclusive categories of disease and injury, we could not assess the impact of interactions among disease states. In addition, because DALYs focus on health outcomes coded using the ICD-9, they do not measure attributable risk.[17] For example, an estimated one-third of all deaths in the United States in 1990 were attributable to smoking, poor nutrition, or physical inactivity.[18] Although DALYs are not exposure-specific, these types of attributable health risks are important to consider in identifying and prioritizing opportunities for prevention. For example, chronic obstructive pulmonary disease and lung cancer were only the 9th and 10th leading causes of DALYs among women, but if combined they would approach the leading cause, ischemic heart disease, highlighting the importance of developing interventions to reduce smoking among women in the county.

Despite these methodologic and data limitations, we believe that DALYs provide important information on which to base decisions on public health priorities, as long as information on disease burden is combined with a range of other data in the priority-setting process. For example, information on the preventable fraction and cost-effectiveness of available interventions is important to consider.

These findings have played a key role in the county health department's efforts to inform and, in some cases, persuade policy makers and community constituencies of the disproportionate health impacts of violence and chronic non-infectious diseases in the county population. The results have been helpful in bridging the divide between those in public health and those who provide mental health and drug and alcohol treatment and prevention services. In disseminating the findings in local forums, we have found that "years of healthy life lost" is the most understandable conceptualization of the DALYs measure and an extremely compelling construct among both professional and lay audiences.

These data have also been used to support successful requests for external funding, including a physical activity promotion campaign funded by the CDC and a community-based nutrition intervention supported by the California Department of Health Services. In addition, the data have been used to lobby successfully for a portion of the Master Tobacco Settlement funds to be reserved for chronic disease prevention programs.

In summary, the DALYs measure represents a promising new tool for improving the capacity of local health departments and other health agencies to assess and prioritize population health needs. To increase the validity of the measure at the local and regional levels, efforts will be needed to refine the YLD calculations by incorporating local estimates of disease incidence and applying disability weights that are specific to the U.S. population and important subpopulations.

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