Health Policy Analysis

The Effects of Diabetes, Hypertension, Asthma, Heart Disease, and Stroke on Quality-Adjusted Life Expectancy

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A B S T R A C T

Objective: Quality-adjusted life expectancy (QALE) is a summary measure that combines mortality and health-related quality of life across different stages of life. The objective of this study was to estimate QALE loss due to five chronic diseases—diabetes mellitus, hypertension, asthma, heart disease, and stroke. **Methods:** Health-related quality of life scores were from the 1993-2009 Behavioral Risk Factor Surveillance System. Using age-specific deaths from the Compressed Mortality File, this study constructed life tables to calculate losses in life expectancy and QALE due to each of the five diseases from 1993 through 2009 and for 50 US states and the District of Columbia. **Results:** In 2009, the individual-level QALE loss for diabetic people, compared with nondiabetic people, was 11.1 years; for those with hypertension, 6.3 years; for those with asthma, 7.0 years; for those with heart disease, 10.3 years; and for those with stroke, 12.4 years. At the population level, diabetes, hypertension, asthma, heart disease, and stroke contributed 1.9, 2.2, 0.8, 1.2, and 0.8 years of population QALE loss at age 18 years, respectively. **Conclusions:** Persons with each of the five diseases had significantly lower life expectancy and QALE. Because the prevalence of diabetes and hypertension has increased significantly in the United States in the last two decades, the burdens of these two conditions, measured by population QALE losses, had increased 83% and 29% from 1993 to 2009, respectively. Also, by examining changes in population QALE loss at different ages, policymakers can identify age groups most affected by particular diseases and develop the most cost-effective interventions by focusing on these groups.

Keywords: chronic diseases, health-related quality of life (HRQOL), life expectancy, quality-adjusted life expectancy (QALE).

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Introduction

The health impact of diseases, injuries, risk factors, or determinants includes premature mortality and long-term nonfatal morbidity [1–4]. There are many indexes used for measuring different health outcomes, such as attributable mortality, years of potential life lost, and diminished health-related quality of life (HRQOL) [1–4]. A summary score would be particularly useful in quantifying with a single-valued index lifetime burden or effects of diseases on both mortality and morbidity [5,6]. Burden of disease (BOD) measures take into account both the years of life lost and the relative severity of disease and make it possible to quantify the overall health outcomes for the population or affected patients [7]. BOD analyses are also particularly useful for evaluating the cost-effectiveness of health policies, intervention programs, and alternative treatments for disease [7].

Life expectancy is a summary measure of the age-specific mortality rates across the entire lifespan [8,9]. It measures expected years of life or average life years starting at a certain age. Because HRQOL differs across different stages of life, calculating life expectancy adjusted by HRQOL provides a more complete measure for assessing overall health [10,11]. Like life expectancy, quality-adjusted life expectancy (QALE) measures average quality-adjusted life-years (QALYs) or expected QALYs starting at a certain age. In addition to mortality data, QALE estimates use HRQOL health preference measures, which assess a person's perception of her or his health and how much a person values one health state versus another state. The HRQOL health preference measures capture respondents' perceived health for different health states by using a summary score (also called utility value) anchored at 0 (dead) and 1 (perfect health) [12,13]. Thus, 1 year of life lived at a utility value of 0.8 is equal to 0.8 QALYs [10,11]. QALE at a certain age is defined and calculated as the average number of QALYs throughout the remainder of the expected life [10,11].

QALE differs slightly from World Health Organization's BOD measures, disability-adjusted life-years or years lived with disability [5,7]. First, disability-adjusted life-years/years lived with disability use disability (i.e., loss of functioning) to weight the remaining years of life. QALE uses HRQOL to weight these life years and relies on the preference of different health states obtained from the general population. Second, disability-adjusted life-years sum the years of potential life lost because

of premature mortality and the years of productive life lost because of disability. QALE averages QALYs for a population, and similar to life expectancy, weights loss in QALYs more in the earlier stages of life [10,11].

Several studies have calculated the loss in QALE due to a disease/condition by following a cohort of patients prospectively [14,15]. For example, Hung et al. [15] followed 633 patients with prolonged mechanical ventilation from 1998 to 2007 to obtain their survival status. They calculated the probability of survival at each point of follow-up time adjusted by HRQOL scores and extrapolated to 300 months of follow-up to obtain the QALE. One of the weaknesses of this study was to assume a constant excess hazard for survival function extrapolation. This assumption may not be appropriate, especially for diseases that may not cause premature mortality. To deal with these weaknesses, some investigators have proposed estimating the survival function from National Death Index Linked health surveys to construct life tables of patients and then applying age-specific HRQOL scores for those who had the disease from a different data set to the life table to calculate QALE [11,16]. This method would provide more reliable estimates of QALE loss due to a disease or a risk factor [11]. A validation study of this method demonstrated small bias and good reliability of the estimation method [11].

Since 1993, the ongoing Behavioral Risk Factor Surveillance System (BRFSS) has included a set of questions to track population HRQOL [17]. The BRFSS also asked respondents whether they had any chronic conditions, such as diabetes mellitus, hypertension, asthma, heart diseases, and stroke [18,19]. The present study examined the impact on QALE for US adults for these five conditions. Specifically, this study calculated the QALE loss for patients with the disease and for the entire population due to each of these five diseases and examined recent trends and stated differences in these QALE losses.

Methods

The 1993-2009 BRFSS survey was used to estimate population HRQOL scores by age categories (18–24, 25–34,..., >85 years), sex, state of residence, and the statuses of the five chronic conditions. The BRFSS is a state-based survey of noninstitutionalized civilian adult residents from each of the 50 states and the District of Columbia [18,19]. The BRFSS asked respondents to rank their general health from 1 (excellent) to 5 (poor) and to report the number of physically unhealthy days, mentally unhealthy days, and days with activity limitation during the past 30 days [17]. This study applied a previously constructed algorithm to obtain values for the EuroQol five-dimensional questionnaire index, a preference-based HRQOL measure, for respondents in the BRFSS, based on their age and answers to these four questions [12,20]. This algorithm provides valid estimates of EuroQol five-dimensional questionnaire scores of the US population by some demographic subgroups and common health conditions from the BRFSS [12,20], and the bias of estimated QALE from these scores has been estimated to be less than 1% of that using the actual EuroQol five-dimensional questionnaire questions [11].

The BRFSS includes a set of core questions asked in all 50 states and the District of Columbia and a set of modular questions asked in a subset of states. We used only the core questions to estimate QALE for the entire United States and by state. The BRFSS asked respondents whether they had ever been told they had diabetes, hypertension, asthma, heart diseases (myocardial infarction or coronary heart disease), or stroke by a doctor. Women told that they had diabetes or hypertension or both only during pregnancy were excluded. The core diabetes questions were asked annually, and the core hypertension question was asked every 2 years. The core asthma questions were

asked annually since 2000, and the core heart disease and stroke questions were asked annually since 2005.

The Centers for Disease Control and Prevention has compiled state-level death summary statistics and makes them available to the pubic (available from: http://wonder.cdc.gov). The U.S. Census Bureau provides annual population estimates (available from: http://www.census.gov/popest/states/asrh/). Both data are available by state, age, gender, and other basic demographics. For the years 2007-2009, death data are not available. Because the national and state death rates were relatively stable across the time period we analyzed, we estimated the death rate for these three missing years by using a time-series autoregressive moving-average model based on the 1993-2006 death rates [21].

The age-specific death rate (m) was obtained by dividing the number of deaths (d) by the population size (N). Death rates for those with the disease (m_1) and those without the disease (m_0) were estimated by using the hazard ratio (h) between diseased and nondiseased and the disease prevalence (p) by

$$m_1 = \frac{hm}{hp+(1-p)} \quad \text{and} \quad m_0 = \frac{m}{hp+(1-p)}$$

respectively. The hazard ratio was estimated from the National Health Interview Survey–linked mortality files (available from: http://www.cdc.gov/nchs/data_access/data_linkage/mortality/nhis_linkage.htm) by using the Cox proportional hazards model [22]. The proportion of the population who had a specific disease was estimated from the BRFSS.

QALE and QALE Loss

Formulas to calculate QALE and their standard errors were provided by Jia et al. [11], and there is a summary. The QALE at age x is calculated by summarizing QALYs throughout the remaining of expected life starting at age x over the population surviving to age x [10,11]. Let A_i be the number of hypothetical population surviving to age i and D_i be the total life years for the age interval i. The probability of dying in an n_i-year interval is estimated by $q_i = 1 - e^{-n_i m_i}$ [23,24]. Assume that those who died during the interval for ages x less than 85 years lived an average $n_i/2$ years, that is,

$$D_i = A_i\left(1 - \frac{n_i q_i}{2}\right)$$

and for the last age interval (85+ years), assume a constant death rate (m_{85}), so that the average years of life at age 85 years is $D_{85} = A_{85}/m_{85}$ [11,22–25]. If y_i is the mean HRQOL score, the QALY for this age interval is $D_i y_i$ Therefore, QALE for those at age x is

$$Q(x) = \frac{\sum_{i \geq x} D_i y_i}{A_x}$$

Let $Q(x, z)$ be the QALE at age x, conditional on a population characteristic, z; for example, $z = 1$ for diseased persons and $z = 0$ for nondiseased persons. Thus, the QALE loss contributed by a disease for diseased persons (i.e., the "individual" QALE loss) is the difference in QALE between those without the disease and those with the disease: $\Delta(x) = Q(x, 0) - Q(x, 1)$ [25]. This index quantifies the effect of the disease for a person who has the disease. This study examined each of the five diseases individually. For example, the QALE loss to diabetes was the difference in QALE between those who did not have diabetes and those who had diabetes. This analysis did not estimate the impact on QALE by multiple diseases.

Suppose $Q(x)$ is the QALE for the total population (both diseased and nondiseased). The difference in QALE between nondiseased and the total population, $\Delta_p(x) = Q(x, 0) - Q(x)$, is the disease-related QALE loss to the population. This "population" QALE loss is similar to the "population-attributable risk" in epidemiology. It quantifies the burden of the disease for the