Estimating Quality-Adjusted Life-Year Loss Due to Noncommunicable Diseases in Korean Adults through to the Year 2040

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ABSTRACT

Objectives: To estimate the loss in quality-adjusted life-years (QALYs) in Korean adults due to 13 noncommunicable diseases (NCDs) in 2010 and predict changes in QALY loss through to the year 2040. Methods: Thirteen NCDs (hypertension, diabetes mellitus, hyperlipidemia, stroke, myocardial infarction, angina, arthritis, osteoporosis, asthma, allergic rhinitis, atopic dermatitis, cataract, and depression) were selected from the Korean Community Health Survey 2010. The Euro-Qol five-dimensional questionnaire index from the Korean Community Health Survey 2010 and the Korean valuation set were used to estimate utility weights according to sex, age, and disease. Morbidity data were also obtained from the Korean Community Health Survey 2010. Mortality data according to disease and life expectancy were retrieved from the Korean Statistical Information Service. To predict future QALY loss, future population projection data from the Korean Statistical Information Service were used as substitutes for 2010 population size. Results: Among the assessed 13 NCDs, the largest total QALY loss was for hypertension (513,113 QALYs; units are omitted hereafter), followed by arthritis (509,317) and stroke (431,049). The largest QALY loss due to mortality was stroke (306,733), whereas the largest QALY loss due to morbidity was arthritis (502,513). By applying the middle estimate of future population, the largest increase in total QALY loss between 2010 and 2040 was for hypertension (840,582), followed by stroke (719,076) and diabetes mellitus (474,607). Conclusions: Hypertension, arthritis, and stroke are important in terms of total QALY loss, which will continue to increase because of aging. These results could be used to develop cost-effective interventions that reduce the burden of NCDs. Keywords: chronic disease, health-related quality of life, noncommunicable diseases, quality-adjusted life-year.

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Introduction

Although communicable diseases remain a global public health concern, the global disease profile has shifted from communicable diseases to noncommunicable diseases (NCDs), such as ischemic heart disease, cancer, and stroke [1]. NCDs have been problematic in developed countries, but they are now global pandemics with considerable effects in developing countries [2]. In 2010, NCDs accounted for 65% of total global deaths [3] and mortality due to NCDs is expected to continue to increase because of population growth and aging.

Measuring disease burden is the first step toward establishing health service and research priorities for NCDs [4]. There are various methods for measuring disease burden, from epidemiologic indicators (such as mortality) to summary measures that reflect both quantity and quality of life such as quality-adjusted life-year (QALY), quality-adjusted life expectancy (QALE), or disability-adjusted life-year (DALY) [5,6]. Among these, QALY can integrate the impact of disease on mortality and morbidity into a single index, thereby allowing comparisons between different disease areas [5]. Similar to life expectancy, QALY can be differentially expressed using QALE, which is the total QALYs throughout the remainder of the expected life at a certain age [7].

The National Institute for Health and Clinical Excellence of the United Kingdom uses QALY as a tool to determine whether the National Health Service should fund certain treatments [8]. In addition, several studies use QALY to investigate the burden of NCDs, such as stroke [9], diabetes [10], and cancer [11]. These studies, however, focus on the QALYs of particular diseases. For that reason, there is a certain limit for comparing the burden of NCDs in terms of QALYs. Annual QALY loss was estimated for 29 chronic conditions, but only due to morbidity [12]. Although
decreases in life expectancy and QALE due to only five diseases were calculated [13], in the future measuring and predicting QALY loss for various NCDs will be needed to establish health service and research priorities.

This study calculated QALY loss in Korean adults due to 13 NCDs. Furthermore, future changes in QALY loss were predicted according to predicted changes in the population structure of Korea.

Methods

Data

We used data from the Korean Community Health Survey (KCHS) 2010, which is the largest cross-sectional health survey of the representative adult population (≥19 years old) of 253 regions in Korea [14]. A total of 229,229 people participated in the KCHS 2010, and the survey was conducted using computer-assisted personal interviews. The KCHS collected various health-related data, including self-reported morbidity (15 diseases), EuroQol five-dimensional questionnaire (EQ-5D), and EuroQol visual analogue scale. After excluding tuberculosis and hepatitis B viral infection, 13 diseases—hypertension, diabetes mellitus, hyperlipidemia, stroke, myocardial infarction, angina, arthritis, osteoporosis, asthma, allergic rhinitis, atopic dermatitis, cataract, and depression—were considered NCDs in this study.

To estimate utility weights by sex and age group, the EQ-5D index from the KCHS was used in conjunction with the Korean EQ-5D valuation set [15]. A control group was needed to confirm the decrease in health-related quality of life (HRQOL) in certain disease groups, and this decrease can be determined by comparisons with healthy or general population controls. In this study, we used healthy controls as the reference group, which were defined as persons with no self-reported morbidity and EQ-VAS scores of 70 or more according to the KCHS 2010.

Mortality data were obtained from the Korean Statistical Information Service from Statistic Korea. International Statistical Classification of Diseases, 10th Revision codes were used to link morbidity and mortality. Table 1 presents 13 NCDs from the KCHS 2010 and their related International Statistical Classification of Diseases, 10th Revision codes. In addition, the population of Korea, life expectancy, and the future population projection were obtained from the Korean Statistical Information Service.

### Table 1 – The 13 noncommunicable diseases assessed in this study and their ICD-10 codes

<table>
<thead>
<tr>
<th>Disease</th>
<th>ICD-10 codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>I10–I13</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>E10–E14</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>E780–E789</td>
</tr>
<tr>
<td>Stroke</td>
<td>I60–I69</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>I21–I25</td>
</tr>
<tr>
<td>Angina</td>
<td>I20</td>
</tr>
<tr>
<td>Arthritis</td>
<td>M000–M259</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>M80–M81</td>
</tr>
<tr>
<td>Asthma</td>
<td>J45–J46</td>
</tr>
<tr>
<td>Allergic rhinitis</td>
<td>J301–J304</td>
</tr>
<tr>
<td>Atopic dermatitis</td>
<td>L200, L208, L209</td>
</tr>
<tr>
<td>Cataract</td>
<td>H250–H269</td>
</tr>
<tr>
<td>Depression</td>
<td>F320–F329</td>
</tr>
</tbody>
</table>

ICD-10, International Statistical Classification of Diseases, 10th Revision.

Calculating QALY Loss

Total QALY loss due to a specific disease is the sum of QALY losses due to morbidity and mortality (Equation 1):

\[
\text{QALY loss}_\text{total} = \text{QALY loss}_\text{morbidity} + \text{QALY loss}_\text{mortality}
\]

(1) QALY loss due to morbidity is equal to the sum of the individual QALY losses due to morbidity and can be regarded as the difference in utility weights between healthy controls and diseased people (Equation 2).

\[
\text{QALY loss}_\text{morbidity} = \sum_{s=1}^{2} \sum_{n=1}^{13} \left( \text{Ps}_m \times \text{Morb}_{s,n} \times \left( \text{UWH}_s - \text{UD}_s \right) \right)
\]

(2) where \( \text{Ps}_m \) is the population of Korea in 2010 by sex and age group; \( \text{Morb}_{s,n} \) is the morbidity rate by sex and age group; \( \text{UWH}_s \) is the utility weight for healthy controls by sex and age group; \( \text{UD}_s \) is the utility weight for diseased people by sex and age group; \( n \) is the age group in 5-year intervals: 1 (20–24), 2 (25–29) … 12 (70–79), 13 (≥80); and \( s \) is sex: 1 (men) and 2 (women).

Similarly, QALY loss due to mortality is equal to the sum of individual QALY losses due to mortality (Equation 3) and can be regarded as the total loss of life expectancy and a reflection of HRQOL (Equation 4). Utility weight averages over 10-year intervals were used as the utility weights for each age group. We assumed that the life expectancy of the median age was representative of each age group. For the last age group (≥90 years), however, we used the life expectancy value for those who were 92 years old. Life expectancy was based on the general population—rather than healthy control—because it is hard to determine the life expectancies of healthy controls. We introduced the term “\( \alpha_{s,m} \)” to adjust life expectancy by sex and age group when calculating QALY loss due to mortality. This correction value was used to fine-tune the life expectancy at the start and end of the age group on the basis of the assumption of age linearity adjustment [16].

\[
\text{QALY loss}_\text{mortality} = \sum_{s=1}^{2} \sum_{n=1}^{13} \left( \frac{Q_{s,n}}{C_0} - \frac{Q_{s,n}}{C_1} \right) - \sum_{m=1}^{15} \left( \frac{Q_{s,m,n}}{C_2} - \frac{Q_{s,m,n}}{C_3} \right)
\]

(3)

\[
Q_{s,m,n} = \frac{\text{UWH}_{s,m,n,v} \times \left( \text{LE}_{s,m,n,v} + \alpha_{s,m} \right)}{\text{mortality rate} \times \text{death size in Korea} \times \text{age group} \times \text{sex}}
\]

(4)

\( Q_{s,m,n} \) is the representative QALY loss due to mortality by sex and age group; \( \text{mortality rate} \times \text{death size in Korea} \times \text{age group} \times \text{sex} \) is the utility weight for healthy control by sex and age group; \( \text{LE}_{s,m,n,v} \) is the life expectancy by sex and age group; \( \alpha_{s,m} \) is the correction value for life expectancy by sex and age group; \( n \) is the age group in 5-year intervals: 1 (20–24), 2 (25–29) … 14 (85–89), 15 (≥90); \( m \) is the age group in 10-year intervals: 1 (20–29), 2 (30–39) … 6 (70–79), 7 (≥80); and \( s \) is sex: 1 (men) and 2 (women).

Predicted QALY Loss through to 2040

Future changes in QALY loss were also investigated. We replaced the population size of 2010 with the future population projections for 2015–2040 (at 5-year intervals) to calculate QALY loss. Future population projection data reflect changes in the population structure by age and include three main scenarios: low, middle, and high estimates. These scenarios were determined by considering variable factors, such as birth rate, mortality, and international migration. We assumed that other factors that would affect the estimated QALY loss values, such as mortality and utility weight, would stay at the same levels determined for 2010. SPSS (version 19.0) software was used for all statistical analyses. This study was approved by
the institutional review board of Asan Medical Center (S2014-0047-0001).

Results

A total of 229,229 respondents participated in the KCHS 2010, including 104,575 men (45.6%) and 124,654 women (54.4%). There were 112,439 (49.1%) respondents who reported having 1 or more of the 13 NCDs. Appendix Table 1 in Supplemental Materials found at http://dx.doi.org/10.1016/j.jval.2014.09.008 provides the number of respondents who reported NCDs according to sex and age. In men, the most common morbidity was hypertension (20.2%), followed by diabetes mellitus (8.5%) and hyperlipidemia (8.2%). In women, the most common morbidity was hypertension (22.4%), followed by arthritis (19.5%) and osteoporosis (13.0%).

The utility weights for the 13 diseases by sex and age group are shown in Figure 1 A,B. As the age of the respondents increased, the utility weights for each disease tended to decrease. In some cases, however, the utility weights did not decrease as age increased. For example, in men with osteoporosis, the utility weight at age 20 to 24 years (0.7907) was lower than that at age 30 to 39 years (0.9208); in women with myocardial infarction, the utility weight at age 40 to 49 years (0.8331) was lower than that at age 50 to 59 years (0.8670).

All utility weights for each disease according to age group were lower than those of similarly aged healthy controls, except women aged between 20 and 29 years with myocardial infarction. Differences in utility weights between healthy controls and diseased people tended to increase with age. In men with stroke, the difference in utility weights between age 20 and 29 years was 0.0867, but for men 80 years or older was 0.3374. In addition, in women with depression, the difference in utility weights at age 20 to 29 years was 0.0822, but among women 80 years or older was 0.3461.

Among the 13 investigated NCDs, the largest total QALY loss was for hypertension (513,113 QALYs; units omitted hereafter; see Appendix Table 2 in Supplemental Materials found at http://dx.doi.org/10.1016/j.jval.2014.09.008). The next largest total QALY loss was for arthritis (509,317), followed by stroke (431,049) and diabetes mellitus (337,424). Estimates of QALY loss by sex are shown in Figure 2. In men, the largest total QALY loss was for stroke (219,923), followed by hypertension (155,254) and diabetes mellitus (144,515). In women, the largest total QALY loss was for arthritis (415,957), followed by hypertension (357,859) and osteoporosis (261,246). QALY loss due to mortality was largest due to stroke among men (159,715), followed by myocardial infarction (76,880) and diabetes mellitus (73,272). QALY loss due to mortality was largest for stroke among women (147,018), followed by diabetes mellitus (57,925) and myocardial infarction (42,672).
QALY loss due to morbidity was largest due to hypertension among men (139,565), followed by arthritis (91,921) and diabetes mellitus (71,244). QALY loss due to morbidity was largest for arthritis among women (410,592), followed by hypertension (333,378) and osteoporosis (257,174).

According to future population projections by the Korean Statistical Information Service, the population of Korea will increase through 2040 (according to the high estimate) (Fig. 3), and the total population in 2040 will be 57,147,183. According to the middle estimate, the Korean population will peak in 2030, with a total population of 51,091,352 in 2040. According to the lowest estimate, the Korean population will decline after 2015 to a total population of 45,167,201 by 2040.

When these three estimates were used as substitutes for 2010 population, the total QALY loss demonstrated a continual increase through to 2040 in all cases (Fig. 3). When the middle estimate of the future Korean population was applied, the difference in the total QALY loss between 2010 and 2040 was greatest for hypertension (840,582), followed by stroke (719,076) and diabetes mellitus (474,607). In terms of increase in ratio, however, asthma was greatest (2.82 times bigger than 2010), followed by stroke (2.67 times) and hypertension (2.64 times).

**Discussion**

This study was performed to estimate QALY loss in Korean adults according to 13 NCDs in 2010 and predict changes in future QALY loss through to 2040. In 2010, the largest total QALY loss was due to hypertension, followed by arthritis, stroke, and diabetes mellitus. Furthermore, it is expected that the QALY loss due to NCDs will continue to grow by 2040 given the future population projections.
We used the EQ-SD to estimate utility weights according to sex and age group. The most frequently used HRQOL instrument for calculating QALY is the EQ-SD [17], but there are concerns about the ability of the EQ-SD to discriminate the HRQOL of health states [18]. This limitation, however, might be mainly limited to mild health states [19], and so it may not be a major problem in this study because we primarily focused on major NCDs, which will further decrease the HRQOL in comparison with mild diseases. Furthermore, the use of the EQ-SD is also a concern, in that it is considered a problematic outcome measure of psychotic disorders [20]. Although there is a study that reports the EQ-SD as suitable for calculating QALY in patients with anxiety disorders [21], QALY loss due to depression may have been underestimated in this study.

By reviewing the utility weights for 13 NCDs according to sex and age, we found that in some cases the utility weights of the respondents did not decrease as age increased. For example, the utility weight of women aged 20 to 29 years with myocardial infarction was higher than that of healthy controls aged between 20 and 29 years. These results might be due to the characteristics of the disease—which is very rare in young people—because only two women respondents aged between 20 and 29 years developed myocardial infarction.

Because the total QALY loss is the sum of QALY losses due to morbidity and mortality, the 13 NCDs included in this study could be divided into two groups according to the composition of QALY loss. For example, in the case of atopic dermatitis and allergic rhinitis, there was no QALY loss due to mortality. Likewise, NCDs that mainly affect QALY loss due to morbidity include cataract, hyperlipidemia, and depression. Myocardial infarction and stroke, however, largely affect QALY loss due to mortality. To reduce the QALY loss due to each disease, it is necessary to consider the composition of QALY loss and, in particular, assess the needs of people with a range of disorders that mainly cause disability [22].

Among the 13 assessed NCDs, the burden of hypertension was greatest with respect to QALY loss, followed by arthritis, stroke, and diabetes mellitus. Similar to the results of a previous study [13], these results were mainly attributed to high prevalence among Koreans, although the utility weight for hypertension was not especially low compared with those of other NCDs. The next largest total QALY loss in this study was for arthritis; in particular, the largest QALY loss due to morbidity was also for arthritis. These results are similar to those of a previous study in which arthrosis of the hip and knee was on top of the annual QALY loss using the EQ-SD [12]. Arthritis, of which osteoarthritis is the most common type, affects quality of life through various health dimensions, such as physical activity and pain, and is associated with other risk factors for chronic diseases [23]. In terms of QALY loss due to mortality, stroke was the most important. These results are similar to those of another study that reported QALE loss due to stroke as the highest among five major NCDs [13]. Furthermore, stroke demonstrated not only the largest DALY but also the greatest years of life lost in Korea in 1990 and 2010 [24]. Therefore, establishing interventions that reduce the stroke burden are urgently required.

It might be meaningful to compare these results with the findings of Korea from the Global Burden of Disease 2010 study [24]. First, in terms of mortality, these two estimates are generally similar because they are based on the same vital registration data. Differences, however, might be due to disease classification between the two estimates and reflect the HRQOL values of healthy control used to calculate QALY loss [25]. Second, in terms of morbidity, the ranks of depression and diabetes mellitus were relatively higher for DALY than for QALY loss, whereas those of stroke and cataract were relatively higher in terms of QALY over DALY. These discrepancies might result from the difference in the valuation methods and target populations used to elicit utility and disability weights [26,27]. Because cultural difference can affect valuation tasks [28], local country-specific HRQOL data might be more appropriate than disability weights when estimating QALY loss to morbidity.

When applying the three future population estimates, total QALY loss due to the 13 NCDs continued to increase through to 2040 in all cases. These results were mostly attributed to population aging, although given that the low population estimate will decline after 2015, the total QALY loss according to the low population estimate will also continue to increase through to 2040. NCDs will predominately in an aging society, and susceptibility to NCDs also increases due to aging [29]. Therefore, given the problem of the aging Korean population [30], the health care system of Korea will need to address the needs of elderly with NCDs.

This study has several limitations. First, not all NCDs were included in this study. For example, cancer, a classic NCD, was omitted. This is because the KCHS 2010 did not collect data on cancer-related morbidity. Second, the possible effects of comorbidities were not considered when calculating QALY loss. Estimates of QALY loss will change according to the manner of dealing with comorbidities, such as by combining utility weight with various combinations of NCDs. Third, we considered only the future population projections when predicting changes in QALY losses. If there are changes in the values of other factors that would affect QALY loss, such as mortality and morbidity rates and utility weight, the value of future QALY loss will also change.

Conclusions

In terms of total QALY loss, arthritis, hypertension, stroke, and diabetes mellitus are the most important NCDs. It is expected that QALY loss due to NCDs will continue to grow given the future population projection. Policymakers could develop cost-effective interventions to reduce disease burden by examining the estimates of QALY loss presented in this study.

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Supplemental Materials

Supplemental material accompanying this article can be found in the online version as a hyperlink at http://dx.doi.org/10.1016/j.jval.2014.09.008 or, if a hard copy of article, at www.valueinhealthjournal.com/issues (select volume, issue, and article).

REFERENCES


