A Review of the Types and Characteristics of Healthy Life Expectancy and Methodological Issues

Young-Eun Kim[1], Yoon-Sun Jung[2], Minsu Ock[3,4], Seok-Jun Yoon[5]

[1]Department of Big Data Strategy, National Health Insurance Service, Wonju, Korea; [2]Institute for Future Public Health, Graduate School of Public Health, Korea University, Seoul, Korea; [3]Department of Preventive Medicine, University of Ulsan College of Medicine, Seoul, Korea; [4]Department of Preventive Medicine, Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, Korea; [5]Department of Preventive Medicine, Korea University College of Medicine, Seoul, Korea

An index that evaluates the health level of a population group considering both death and loss of function due to disease is called a summary measure of population health (SMPH). SMPHs are broadly divided into *life year* indices and *life expectancy* indices, the latter of which comprise healthy life expectancy (HLE). HLE is included as a policy target in various national and regional level healthcare plans, and the term "HLE" is commonly used in academia and by the public. However, the overall level of understanding of HLE—such as the precise definition of HLE and methods of calculating HLE—still seems to be low. As discussed in this study, the types of HLE are classified into disability-free life expectancy, disease-free life expectancy, quality-adjusted life expectancy, self-rated HLE, and disability-adjusted life expectancy. Their characteristics are examined to facilitate a correct understanding and appropriate utilization of HLE. In addition, the Sullivan method, as a representative method for calculating HLE, is presented in detail, and major issues in the process of calculating HLE, such as selection of the population group and age group, estimation of death probability, calculation of life years, and incorporation of health weights, are reviewed. This study will help researchers to select an appropriate HLE type and evaluate the validity of HLE research results, and it is expected to contribute to the vitalization of HLE research.

Key words: Summary measure of population health, Healthy life expectancy, Life expectancy, Disability-adjusted life expectancy, Quality-adjusted life expectancy

INTRODUCTION

The health assessment of a given population group should consider not only the death rate, but also the incidence, prevalence, and consequent functional losses (or occurrence of disability) of various diseases. Thus, an index that evaluates the health level of a population group considering both death and loss of function due to disease is called a summary measure of population health (SMPH) [1]. SMPHs are useful for monitoring the changes in the health level of population groups and quantifying levels of inequality [2]. They may also be applied to compare the health levels of international population groups or evaluate the effects of a policy or intervention [3].

SMPHs are broadly divided into *life year* indices and *life ex-*

pectancy indices. The former category includes *disability-adjusted life-years* (DALYs) and *quality-adjusted life-years* (QALYs), while the latter includes disability-free life expectancy, disease-free life expectancy, disability-adjusted life expectancy (DALE) or health-adjusted life expectancy (HALE), and quality-adjusted life expectancy (QALE), which are collectively referred to as the *healthy life expectancy* (HLE). HLE is reflected in the policy goals of various national and regional public healthcare plans. For example, the Health Plan 2030 in Korea aimed to increase the HLE by 2.9 years, from 70.4 years in 2018 to 73.3 years in 2030 [4].

HLE is the life expectancy including disease-related disability or dysfunction and decreased health-related quality of life (QoL). Hence, HLE not only expresses how long an individual is likely to live, but also how healthy that individual's life might be. Compared to DALY and QALY, an advantage of HLE is that it can be easily understood by both the public and policymakers. Furthermore, the goals of HLE can be readily implemented on a quantitative level; thus, the utility of HLE has gradually increased. Nevertheless, the overall understanding of the precise definition of HLE and the methods used to estimate HLE still seems to be low compared to the extent to which the term "HLE" is used in academia and by the public. In addition, the various types of HLE are used without proper distinction, leading to misunderstanding and confusion.

For HLE to function appropriately as a policy goal, it must be accurately understood. Thus, this study reviews the various types of HLE and their characteristics and discusses issues in the methodology of HLE estimation through examples. Hence, a theoretical review of HLE may facilitate accurate estimations of HLE and promote a better understanding of HLE estimations and the utility of HLE in policy development.

HEALTHY LIFE EXPECTANCY: TYPES AND CHARACTERISTICS

HLE has several types, which differ in the precise definition and estimation method used to assess the level of health or dysfunction. Figure 1 shows a hypothetical case that depicts the rate of survival by age for a certain population group; however, only half the population survives to the age of 100 years. Here, the life expectancy is obtained by dividing the sum of the areas of the survival rate by the population size (i.e., dividing the sum of the areas of A and B by 100 000 persons). If the level of dysfunction corresponds to the area of B in this population
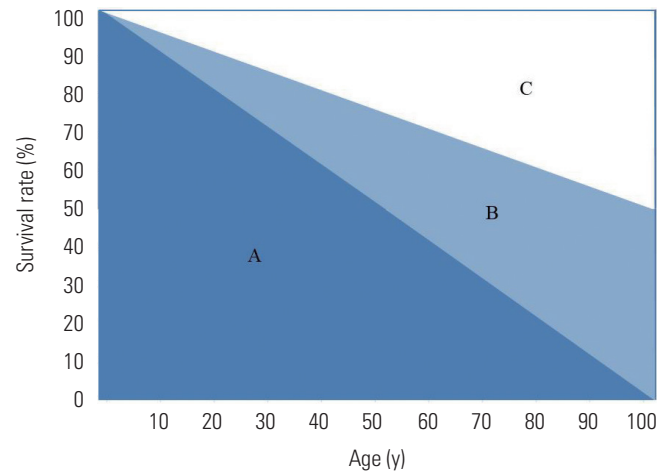

Figure 1. Hypothetical examples illustrating healthy life expectancy. A, B, and C represent the area of the same colored area.

group, then the HLE is estimated by dividing A by 100 000 persons. Thus, different types of HLE exist depending on the method used to quantify the weight of the level of dysfunction (B). The types and characteristics of HLE are reviewed further in the following sections.

Disability-free Life Expectancy

Disability-free life expectancy is a type of HLE that reflects the presence or absence of a disability. The weight of the level of dysfunction is classified as 0 (absence of disability) or 1 (presence of disability), wherein a disability is handled in the same manner as death. As the health level is assessed based on the presence or absence of a disability, an advantage is that it can be calculated even with insufficient data sources; thus, many early HLE studies used disability-free life expectancy [5,6]. However, as this type of HLE assesses the level of health on a binary scale of disability, it is not sensitive to differences in the health levels of a population group. It is also difficult to test the presence or absence of a disability, which is generally done using a measure of activity limitations [7]. It is therefore important for studies applying disability-free life expectancy to clearly define disability.

Disease-free Life Expectancy

Disease-free life expectancy is a type of HLE that reflects the level of reduced health caused by diseases, such as cancer, cardiovascular disease, and dementia, which have a high mortality rate and are highly prevalent. The advantage of this type of HLE is that the influence of a specific disease can be expressed

in a readily understandable form, which can increase the level of interest from the perspective of public health. As with disability-free life expectancy, disease-free life expectancy was utilized in early HLE studies [8,9], and the scope of research has recently extended to the estimation of the effect sizes of interventions aiming to improve the disease-free life expectancy [10]. However, similar to disability-free life expectancy, the level of health is assessed based on the presence or absence of a disease alone, which may lead to an overestimation of the disease-related burden. Although it is possible to estimate disease-free life expectancy in a way that simultaneously considers various diseases [11], there are limitations to the inclusive estimation of HLE within a population group.

Quality-adjusted Life Expectancy

QALE is a type of HLE that incorporates health-related QoL into health expectancy. Based on the definition of health-related QoL and its method of estimation, QALE may be further specified. Health-related QoL can comprehensively reflect the multiple dimensions of health [12]. In general, among the subcategories of physical, psychological, and social dimensions, those suitable for a given population group are combined within an instrument to evaluate the health-related QoL. The result of this evaluation is converted to an index expressed as a single quantitative value, which is used to estimate HLE [13]. Hence, this index acts as a utility weight representing the level of health-related QoL.

QALE can be estimated when data are available to estimate the life expectancy and there are responses to a health-related QoL instrument that can be converted to an index. For example, several previous studies have attempted to estimate QALE using index values obtained from representative health-related QoL instruments, such as the EuroQoL 5-Dimension (EQ-5D) and Short Form Six Dimensions [14,15]. However, QALE inevitably shares the limitations of the instruments used to measure health-related QoL. An inherent feature of health-related QoL measurement is that the state of health is assessed by the respondent; thus, the result is often unreliable for children and illiterate or mentally challenged individuals, who find it difficult to properly assess their health-related QoL. Therefore, in the estimation of QALE, estimated values are substituted for the health-related QoL of these participants who have difficulty responding appropriately. For example, the health-related QoL of a child is presumed to be based solely on a healthy state, for which a weight of 1 is given [16]. Due to this methodological limitation, interpretations of QALE should consider the potential of overestimation.

Nevertheless, QALE is advantageous for certain population groups, as it can be more comprehensively assessed than disability-free or disease-free life expectancy. In addition, this type of HLE is unambiguous if data on health-related QoL are available, enabling relatively easy comparisons of HLE among different population groups or monitoring of changes in the annual trends of HLE. Another notable advantage of QALE is that the HLE of small-scale regions can be easily estimated on a level similar to that for districts, cities, or provinces.

Self-rated Healthy Life Expectancy

Self-rated HLE is a broader form of QALE, since the HLE estimation is based on self-rated health as a way of measuring health-related QoL. Self-rated health is also referred to as self-reported health, self-assessed health, or perceived health and, despite slight differences in phrasing, it is generally defined as the collection of responses to the question "How do you rate your health?" on a 5-point scale (very good, good, moderate, bad, or very bad) [17]. Individuals who respond "bad" or "very bad" on self-rated health surveys are considered to have an "unhealthy" status, for which a health weight of 0 is assigned in the estimation of self-rated HLE [18]. Thus, self-rated HLE resembles QALE and disability-free life expectancy.

Compared to health-related QoL, instruments measuring self-rated health involve a more subjective assessment of an individual's state of health. While these instruments are frequently used to achieve a highly facilitated assessment of health, the results of which can be used to estimate HLE, caution is required as self-rated HLE has similar drawbacks to those of self-rated health. As with instruments used to measure health-related QoL, self-rated health cannot be measured in individuals with cognitive impairment. In addition, while self-rated health requires the respondents to comprehensively consider the physical and psychological aspects of their health, the substantial influence of external factors such as income level and race could lead to a measure of life expectancy that reflects overall and not specifically health-related QoL [19]. Thus, compared to other HLE types, self-rated health poses a risk of underestimation.

Disability-adjusted Life Expectancy

DALE is an HLE index that reflects disability measurements in terms of DALYs. The term "HALE" has recently been used to

describe the same concept as DALE [20]. However, HALE may lead to a misguided perception that it is the only index of HLE. Therefore, to clearly differentiate this from other HLE indices, the term DALE appears more reasonable than HALE.

DALYs are calculated using the sum of the years of life lost and the years lost due to disability (YLD), and YLD is regarded as the parameter that incorporates the level of disability in DALE [21]. Moreover, YLD is an expression of the summed levels of disabilities caused by various diseases in terms of years. The disability level for each disease is evaluated using disability weights, which are quantified for a specific health status or disease-related disability level on a scale between 0 (completely healthy, no disability) and 1 (disability equivalent to death) [22]. For example, in a study evaluating the disability weight of 289 causes of disease, the highest weight (0.906) was given to trachea, bronchus, and lung cancers (stage 4) and the lowest weight (0.049) to acne vulgaris. Thus, compared to disease-free and disability-free life expectancy, which rate the level of disability as 0 or 1, DALE allows HLE to be estimated with a more accurate consideration of disability levels.

Furthermore, DALE also allows a more objective and nuanced evaluation of levels of disability than QALE or self-rated HLE. Notably, a survey of individuals including children in whom health-related QoL is difficult to assess found that DALE enabled a more valid reflection of disability levels. Thus, the use of DALE should be prioritized over other methods of HLE estimation, specifically for children and handicapped or vulnerable populations.

Another significant advantage of DALE is that it can be estimated using DALYs to evaluate the priority of the disease burden [23]. Although HLE is a reliable index that represents the health of the overall population, interventions to improve HLE should be designed based on the individual measure of disease burden, which is expressed as DALYs. Hence, synergistic effects are anticipated from applying DALYs in setting priorities for public health policies or projects and DALE when setting goals for the health of the overall population.

HEALTHY LIFE EXPECTANCY: ESTIMATION METHODS AND CURRENT ISSUES

The most well-known method of HLE estimation is the Sullivan method, which is used by the World Health Organization and the Global Burden of Disease study [24]. In this method, the HLE is estimated based on the life expectancy calculated using a life table that incorporates weights for the levels of disability or dysfunction. The only requirement for this estimate is the availability of weight data on the level of disability or dysfunction by age and data on mortality (or death probability) by age. Table 1 shows an example of how the DALE is estimated. The following sections examine the methods of HLE estimation in detail and discuss the issues for each.

Selection of Population and Age Groups

The initial steps of HLE estimation are identical to those of life expectancy estimation. Table 1 describes an example of a simulated population group (E) with 100 000 persons at age 0, for which the age group (A) was determined. Instead of selecting a simulated population group, the age structure of an actual population group requiring HLE estimation could be used, in which the population size of the simulated group also remains flexible. If data are available with units of 1 year, a complete life table can also be used. In the given example, the age group was set to a unit of 5 years, and the group of 0-5 years was divided into 0 and 1-4 years (B). However, no group was set for those aged above 100 years.

Estimation of Death Probability

The death probability is a key data source for estimating the life expectancy and HLE. It is estimated using the death rate, which is calculated based on the number of population members and deaths in each age group. The methods that apply the death rate to estimate death probability by age vary according to the assumptions underlying the mortality and population distributions [25]. Well-known methods include the Chiang method, which assumes a linear increase in mortality in each age group; the Greville method, wherein the probability of death is calculated assuming a proportional relationship between age and the log-transformed death rate; and the Keyfitz method, which estimates the probability of death using the death rate by assuming that the age-dependent mortality distribution follows a quadratic function [25].

Statistics Korea provides data on the probability of death alongside the mortality for each age group, which may be directly applied or, if mortality data are available, the probability of death can be estimated. However, there seems to be a lack of clear agreement on the most appropriate method to use for death probability, which may reflect unique patterns in each

Table 1. An example of DALE estimation using the Sullivan method

Age (A)	Years in interval (B)	Linearity adjustment (C)	Probability of dying (D)	Individuals surviving (E)	Deaths in interval (F)	Years lived in (G)	Cumulative years lived (H)	Life expectancy at age (I)	YLD rate (J)	Disability adjusted years lived (K)	Cumulative disability adjusted years lived (L)	DALE at age (M)
0	1	0.1	0.00306	100 000	306	99 725	7 850 753	78.5	0.925	92 225	6 757 036	67.6
1-4	4	0.4	0.00082	99 694	82	398 580	7 751 028	77.7	0.899	358 496	6 664 810	66.9
5-9	5	0.5	0.00064	99 612	64	497 902	7 352 448	73.8	0.939	467 587	6 306 314	63.3
10-14	5	0.5	0.00060	99 548	60	497 593	6 854 546	68.9	0.955	475 119	5 838 727	58.7
15-19	5	0.5	0.00150	99 489	149	497 071	6 356 953	63.9	0.931	462 752	5 363 607	53.9
20-24	5	0.5	0.00237	99 340	235	496 109	5 859 882	59.0	0.933	462 884	4 900 855	49.3
25-29	5	0.5	0.00307	99 104	304	494 760	5 363 773	54.1	0.912	451 042	4 437 971	44.8
30-34	5	0.5	0.00418	98 800	413	492 967	4 869 013	49.3	0.897	442 054	3 986 928	40.4
35-39	5	0.5	0.00578	98 387	569	490 513	4 376 047	44.5	0.878	430 549	3 544 875	36.0
40-44	5	0.5	0.00932	97 818	912	486 812	3 885 534	39.7	0.861	419 057	3 114 326	31.8
45-49	5	0.5	0.01491	96 907	1445	480 920	3 398 722	35.1	0.839	403 461	2 695 269	27.8
50-54	5	0.5	0.02297	95 462	2193	471 826	2 917 802	30.6	0.809	381 714	2 291 808	24.0
55-59	5	0.5	0.03311	93 269	3088	458 624	2 445 975	26.2	0.778	356 873	1 910 094	20.5
60-64	5	0.5	0.04785	90 181	4315	440 116	1 987 351	22.0	0.752	331 028	1 553 220	17.2
65-69	5	0.5	0.07182	85 866	6167	413 911	1 547 235	18.0	0.746	308 596	1 222 192	14.2
70-74	5	0.5	0.12433	79 699	9909	373 721	1 133 324	14.2	0.771	288 175	913 596	11.5
75-79	5	0.5	0.20975	69 790	14 638	312 353	759 603	10.9	0.801	250 091	625 422	9.0
80-84	5	0.5	0.33821	55 151	18 653	229 125	447 250	8.1	0.831	190 501	375 331	6.8
85-89	5	0.5	0.50302	36 499	18 360	136 594	218 125	6.0	0.886	121 054	184 830	5.1
90-94	5	0.5	0.66734	18 139	12 105	60 433	81 531	4.5	0.782	47 273	63 776	3.5
95-99	5	0.5	0.80073	6034	4832	18 091	21 098	3.5	0.782	14 152	16 503	2.7
≤100	5	0.5	1.00000	1202	1202	3006	3006	2.5	0.782	2351	2351	2.0

DALE, disability-adjusted life expectancy; YLD, years lost due to disability.

country. In Korea, the results of different methods of estimating the death probability did not vary significantly using a complete life table; however, the variation became more distinct when an abridged life table was used [25]. Thus, a life table with 1-year units (i.e., a complete life table) is preferable for the direct estimation of the probability of death to provide a more valid estimation of life expectancy or HLE.

Once data on the probability of death have been collected for each age group (D), the mortality in each age group of a hypothetical population can be calculated (F). For example, if the death probability for an age of 0 is 0.00306, then the mortality in the respective age group would be 306, with 99,694 persons surviving to enter the age group of 1-4 years. Next, applying the death probability for the 1-4 years age group (0.00082), the mortality can be calculated, and so on until the last group (100+ years). For the 100+ years age group, it is assumed that the probability is 1.

Estimation of Healthy Life Expectancy With Life-year Calculations

Having estimated the mortality in each age group, life-years by age (G) is then calculated. For example, if 99 612 individuals survive up to 5-9 years of age and 64 deaths occur, then 99 548 individuals will survive to enter the age group of 10-14 years; thus, each of these 99 548 individuals is likely to have survived for 5 years. Although the precise time of death of the 64 individuals cannot be identified, assuming that the time is evenly distributed, the mean life-years of the 64 individuals can be estimated as 2.5 years. This can be expressed as "(99 612*5)+ (64*5*0.5)," where the number of life-years is 497 902 for the 5-9 years age group.

Here, the linearity adjustment (C), a concept for assuming the mortality distribution by age, is applied. It is set to 0.5 for most age groups to indicate an even distribution of mortality. However, as the probability for early deaths is higher in the age groups of 0 and 1-4 years, the linearity adjustments for

these groups are set to 0.1 and 0.4, respectively. Using the estimated life-years in each age group, the cumulative life-years (H) can be calculated. For example, the cumulative life-years at the age of 0 is the sum of the life-years from 0 to 100+ years of age (7 850 753), while the cumulative life-years for the next age group (1-4 years) is the sum of the life-years from 1-4 years to 100+ years (7 751 028). Hence, the cumulative life-years for a given age group is the sum of the life-years from that age group to the following group. If the goal is to calculate only the life expectancy, then the cumulative life-years (H) can be divided by the population (E) for that age group. For example, the life expectancy for the 0-year age group is 78.5 years, which is obtained by dividing 7 850 753 by 100 000.

Estimation of Healthy Life Expectancy Considering Health Weights

The estimate of HLE uses life-years that reflect the health weights of the level of disability or dysfunction. Hence, the HLE calculation comprises the adjusted life-years (K) as the product of health weight (J) and life-years by age (G). Here, the health weight may vary according to the type of HLE. For instance, in the example of HLE with disability adjustment

shown in Table 1, the YLD rate was used as the weight. In the case of QALE, the utility weight can be used instead of the YLD rate.

The YLD rate is the difference between 1 and the per-person YLD obtained by dividing the sum of the YLD in each age group by the population of the target age group. The problem of comorbidities, which does not pose a significant problem in comparing the magnitude of disease burden, should be considered in the YLD rate calculation. Simply put, if the YLD rate does not consider comorbidities, the per-person YLD will be overestimated, leading to an underestimation of the HLE. Thus, the YLD in each age group must be adjusted by the reduced extent of YLD according to comorbidities, while the YLD rate used in DALE is the comorbidity-adjusted YLD rate.

Next, the adjusted cumulative life-years (L) can be calculated using the adjusted life-years (K). Hence, as in the case of cumulative life-years (H), which serves as the denominator for life expectancy, the adjusted cumulative life-years in each age group can be calculated. The adjusted cumulative life-year at age 0 is the sum of the adjusted life-years from 0 to 100+ years, which is 6 757 036. The HLE is obtained by dividing the adjusted cumulative life-years (L) by the population in the age

Table 2. Summary of healthy life expectancy research in Korea

Study	Title	Type of healthy life expectancy	Main findings
Kwon et al., 2002 [7]	A study of disability adjusted life expectancy (DALE) using national health interview survey in Korea	Disability-free life expectancy	The disability-free life expectancy for 1999 was 72.5, 69.5, and 75.3 y in total, for men, and for women, respectively
Kang et al., 2008 [26]	An estimation of health-adjusted life expectancy (HALE) for Koreans	Quality-adjusted life expectancy	The quality-adjusted life expectancy of men and women was 67.49 and 69.61 in 2005, respectively
Lee et al., 2016 [27]	Health-adjusted life expectancy (HALE) in Korea: 2005-2011	Disability-adjusted life expectancy	The disability-adjusted life expectancy at age 0 between 2005 and 2011 increased by 1.4 and 1.2 y for men (from 64.4 to 65.8 y) and women (from 67.7 to 68.9 y), respectively
Kim et al., 2017 [11]	Chronic disease-free life expectancy of middle-aged and elderly Koreans between 2005 and 2010	Disease-free life expectancy	The life expectancy at age 40 in 2005 was 39 y; Out of 39 y, about 19 y (about half of the remaining years) are expected to be lived without suffering from chronic diseases
Kwon et al., 2017 [30]	Health life expectancy in Korea based on sample cohort database of National Health Insurance Services	Disease-free life expectancy	Based on the mortality and morbidity estimated from the sample cohort database, men and women in Korea are expected to live a 'healthy life (disease-free life)' for 61 and 60 y in 2013, respectively
Jo et al., 2018 [15]	The trends in health life expectancy in Korea according to age, gender, education level, and subregion: using quality-adjusted life expectancy method	Quality-adjusted life expectancy	From 2005 to 2013, the quality-adjusted life expectancy of Koreans tended to steadily increase; the annual percent changes of quality-adjusted life expectancy in men and women were 0.73 and 0.71, respectively
Lim et al., 2020 [29]	Income-related inequality in quality-adjusted life expectancy in Korea at the national and district levels	Quality-adjusted life expectancy	The life expectancy of Koreans increased from 79.86 to 82.10 (a 2.2 y increase), while quality-adjusted life expectancy increased from 75.19 to 76.09 (a 0.9 y increase) between 2008 and 2014
Kim et al., 2021 [28]	The gaps in health-adjusted life years (HALE) by income and region in Korea: a national representative big data analysis	Disability-adjusted life expectancy	The disability-adjusted life expectancy in Korea was 68.89 y in 2008, increasing to 70.43 y in 2018, an increase of 1.54 y over 10 y (average 0.15 y per year)

group (E). For example, the HLE at age 0 is 67.6 years, which is obtained by dividing L (6 757 036) by E (100 000).

CHARACTERISTICS AND FUTURE OF RESEARCH ON HEALTHY LIFE EXPECTANCY IN KOREA

Table 2 [7,11,15,26-30] summarizes the main findings of HLE studies conducted in Korea. Since the first HLE study by Kwon et al. [7], numerous studies have investigated various HLE types, indicating a steadily increasing scope of research.

An examination of the methodological characteristics of the main HLE studies shows that several did not clearly establish the concept or methodology of HLE. One of the first studies presented results for the estimation of DALE [7], while the estimation method used appears to be for disability-free life expectancy. Although Kang et al. [26] claimed to have estimated the HALE, which is considered to be identical to the DALE, they instead estimated the QALE based on the EQ-5D of the Korea National Health and Nutrition and Examination Survey (KNHANES).

More recent studies have shown a trend of using various HLE indices that comprehensively assess or reflect the level of disability or dysfunction, such as QALE or DALE. Furthermore, for the estimation of QALE or DALE, the scale of data was greater than in previous studies; thus, the validity of the estimated health weight can be predicted to be higher. For example, Lee et al. [27] obtained the YLD rate based on KNHANES data, while Kim et al. [28] used data provided by National Health Insurance to improve the validity of the finding. In addition, Lim et al. [29] used utility weights obtained using the EQ-5D of the Korean Community Health Survey, which features the largest sample size in the field of public health.

Nonetheless, compared to the growing interest and expectations regarding HLE, the number of studies on HLE is rather small. Despite recent advances in HLE estimation methodologies, studies have only identified trends in HLE. Considering the advantages and disadvantages of each HLE type, the scope of disease-free life expectancy, which allows the influence of each disease to be analyzed, should include a greater number of diseases, while QALE and DALE should enable a more comprehensive assessment of the level of disability or dysfunction. Furthermore, as HLE has been recently applied in setting the goals of public health projects on both national and regional levels, more studies should investigate the estimation of HLE on regional and sub-regional levels, as well as HLE variation according to socio-demographic characteristics such as income and education. Moreover, factors related to HLE should be identified to provide supporting evidence for the development of policies and interventions to improve HLE.

CONCLUSION

We reviewed various types of HLE and their characteristics in this study. Since each HLE type has advantages and disadvantages, it is important to select an appropriate HLE type in consideration of the purpose and application of HLE, as well as the availability of data sources. In addition, we provided an example of calculating HLE and discussed points to be noted in the process of calculating HLE. Recognizing the methodological issues of HLE calculation will be important for evaluating the validity of HLE study results. Contrary to the expectation that the academic interest in HLE and its utilization will increase, research on HLE in Korea is still lacking both quantitatively and qualitatively. Research using various HLE indices needs to be further conducted, and the scope of the research topics needs to be expanded, such as HLE research targeting sub-regional levels and vulnerable populations, as well as research that reveals factors related to HLE.

CONFLICT OF INTEREST

The authors have no conflicts of interest associated with the material presented in this paper.

AUTHOR CONTRIBUTIONS

Conceptualization: Kim YE, Jung YS, Ock M, Yoon SJ. Data curation: Kim YE, Ock M. Funding acquisition: Yoon SJ. Methodology: Kim YE, Jung YS, Ock M, Yoon SJ. Project administration: Jung YS. Visualization: Ock M. Writing – original draft: Kim YE, Ock M. Writing – review & editing: Kim YE, Jung YS, Ock M, Yoon SJ.

ORCID

Young-Eun Kim   *https://orcid.org/0000-0003-0694-6844*
Yoon-Sun Jung   *https://orcid.org/0000-0002-9379-4908*
Minsu Ock   *https://orcid.org/0000-0001-9949-9224*
Seok-Jun Yoon   *https://orcid.org/0000-0003-3297-0071*

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