Korea Institute for Health and Social Affairs

Working Paper 2013-02

Analysis of the Effects of Obesity Control on Life Expectancy and Healthy Life Expectancy

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KIHASA Korea Institute for Health and Social Affairs

Working Paper 2013-2

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ISBN: 978-89-6827-111-3 93510

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Chapter 1

Introduction

1 Introduction

Many advanced countries have set out national initiatives for improving their people's health and pursued strategies for nationwide health promotion since the 1980s. Examples of such initiatives include 'Healthy People' of the US, 'Our Healthier Nation' of the UK, 'Healthy Japan 21' of Japan, and 'Better Health Commission' of Australia. The goals of these plans is to help people have longer healthy lives and eliminate health disparities. South Korea's third national health promotion plan--'National Health Plan 2020' (HP 2020, '11~20)--intends to increase healthy life expectancy for Koreans to 75 by 2020. Healthy life expectancy, a basic health measure of HP 2020 is the number of years a person can expect to live without diseases or injuries, which is a measure of a population's health that focuses on how many years a person might live in a healthy state rather than just how many years they might be expected to live.

Such improvement in the quality of life cannot be achieved without a social environment that promotes good health for all. While infectious diseases took up a large portion of the global burden of disease in the past, rapidly increasing chronic diseases account for a larger portion these days. Therefore, it is

necessary to increase healthy life expectancy by reducing the burden of chronic diseases through prevention and appropriate management.

Of such health risk factors causing chronic illness as smoking, drinking and obesity, this research is about obesity. In the US, the cost of obesity-related diseases accounted for 5.5%--7.8% of the total medical expenditure (as of 1998)[1)]--while in Canada 2.5% (as of 1999) of the total medical cost is caused by a lack of exercise.[2)] In Korea, obesity makes up about 6% of the medical cost of adults 20 or older for the national health insurance plan.[3)]

This study intends to estimate the life expectancy and healthy life expectancy of the Korean people, and measure the effects of the control of obesity, a major health risk factor, thereby analyzing the relationship between chronic illness, life expectancy, and healthy life expectancy. Based on the results, this study explores the current state of Koreans' healthy life expectancy (2009) and the effects of obesity control, providing the basis for attaining the goals of Korea's national health promotion plan. This paper is composed of five chapters. Chapter 1 is the introduction, and Chapter 2 reviews existing literature

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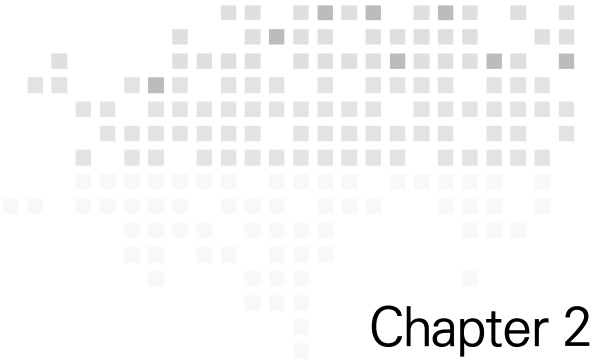
1) Kortt M. et al., "A review of cost-of-illness studies on obesity", *Clinical Therapeutics,* Vol.20, No.4, 1998.
2) Katzmarzyk et al., "The economic burden of physical inactivity in Canada", *CMAJ,* 2000; 163(11):1435 ~ 40.
3) Jung Young-ho et al., "Research for building a health-friendly fiscal policy," Korea Institute for Health and Social Affairs, 2010.

related to healthy life expectancy in to help the reader to understand the indicator. In Chapter 3, Koreans' life expectancy and healthy life expectancy as of 2009 are estimated. First, the number of deaths, population, and life table released by the Korean Statistical Information Service (KOSIS) are used to calculate life expectancy, and then the health-related quality of life data out of the nationwide survey, Korea Health Panel (KHP) is utilized to measure healthy life expectancy. Chapter 4 presents analysis of the effects of obesity control on life expectancy and healthy life expectancy. A multi-state simulation model and the Sullivan method are applied to estimate healthy life expectancy. The Sullivan method, a widely used method to calculate healthy life expectancy, is useful in estimating the average healthy life expectancy of the population, while the multi-state model is good for computing the healthy life expectancy of a specific age group or subgroup with a certain health status (Lee Seung-wook et al., 2007). Next, the Markov Model is used for dynamic analysis of the life expectancy and healthy life expectancy of those with obesity and those of normal weight. Chapter 5 is the conclusion and summarizes the results of the analyses of this study and discusses its limitations and research tasks for the future.



Chapter 2

Literature review of the methods and results of estimation of healthy life expectancy

2 Literature review of the methods and results of estimation of healthy life expectancy

1. Mathers et al. (2003)[4)]

Mathers et al. analyzed healthy life expectancy (HALE) in order to compare the health status of Australia and that of other OECD countries. For HALE analysis, estimates of mortality of OECD nations, 135 prevalence rates of 135 health conditions by country released by the GBD 2000 study, and 34 health surveys of OECD states were analyzed. The results showed that Japan ranked first with 73.6 as of 2001 and Australia recorded 71.6 (95% CI: 70.9 - 72.8).

According to the data, Korea's HALE was 67.4 years as of 2001, that of males was 64.5 years (63.8 - 65.6) and that for females was 70.3 years (69.6 - 71.8). All in all, Korea showed lower average HALE than the OECD average of 68.4 years and 66.6 years for males, but its female average was higher than that of the OECD average of 70.2 years.

4) Mathers C, Murray C, Slomon J, Lopez A et al. Healthy life expectancy: comparison of OECD countries in 2001, Aust NZ J public Health 2003;27:5-11

〈Table 2-1〉 Healthy life expectancy of OECD member states, 2001

Rank	Range	Nation	Healthy life expectancy			Life expectancy	
			Total	Male	Female	Male	Female
1	1-2	Japan	73.6	71.4	75.8	77.9	84.7
2	1-4	Switzerland	72.8	71.1	74.4	77.3	82.8
3	2-7	Sweden	71.8	70.5	73.2	77.7	82.3
:							
22	22-25	U.S.A.	67.6	66.4	68.8	74.4	79.6
23	**22-25**	**South Korea**	**67.4**	**64.5**	**70.3**	**71.2**	**78.7**
24	22-25	Portugal	66.8	64.3	69.4	72.7	80.1
25	23-25	Czech Republic	66.6	63.8	69.5	71.9	78.8
	OECD	Average	68.4	66.6	70.2	74.0	80.2

2. Loukine et al. (2011)[5)]

Hypertension might cause chronic illness such as cardiovascular diseases. In Canada, the impact of hypertension on premature death and life expectancy had been studied, but its impact on HALE (health adjusted life expectancy) had not been examined. That is why Loukine et al.(2011) analyzed the effects of high blood pressure on HALE.

The first report on hypertension in Canada, the Canadian Chronic Disease Surveillance System (CCDSS) published by the Public Health Agency of Canada standardized hypertension by

5) Loukine L, Waters C, Choi B, Ellsion J. Health-Adjusted Life Expectancy among Canadian Adults with and without Hypertension Cardiology Research and Practice 2011

age and found that the rate of the condition had risen 7% between 1998 and 2006 for adults, and it was expected to increase by 25% by the end of 2012. The report showed that the crude prevalence of hypertension was 22.7% for adult Canadians in 2006. In most cases, high blood pressure is likely to lead to premature death, thereby leading to a shorter life. Since mortality and life expectancy of hypertension is not enough to explain the burden of chronic disease due to its high morbidity rate, the burden was explored through HALE. While life expectancy (LE) is defined as the average number of years a person can expect to live, HALE is an indicator to reflect health levels related to quality of life. HALE consolidates morbidity rates and death rates into a single indicator to show the average years a person can live a healthy life. We can comprehensively understand how hypertension changes people's lives by measuring the difference between LE and HALE of those with and without high blood pressure and the rate of unhealthy days and years of potential life lost for the cohort.

The CCDSS (mortality data 2004-2006) and the Canadian Community Health Survey (CCHS) (Health Utilities Index data 2000-2005) were used for analysis. Mortality data from the CCDSS was used to measure mortality rates by age and sex. Mortality and census were enough to calculate LE, but health-related quality of life should be measured to estimate HALE. The method used for this analysis was Health Utilities

Index Mark 3 measured by the CCHS. HUI3 consists of eight attributes (vision, hearing, speech, ambulation, dexterity, emotion, cognition, and pain) with five to six levels per attribute. Single attribute is on a scale from 0.0 (lowest) to 1.0 (highest) and multi-attribute utility function is used to sum up eight attributes into a single score. HUI3's total score is on a scale from -0.36 to 1.0. A partly healthy state from a social activity perspective is regarded as worse than death, thereby generating a negative value. A difference of 0.03 or higher in HUI3 total score and difference of 0.05 or higher in single attribute are considered clinically significant.

Life table analysis was used to estimate LE and HALE. Chiang method created a life table classifying groups into specific disease-related populations and 14 age groups (20-24, 25-29, ... , 80-85, 85+ years) to generate the 2004-2006 period. The Gompertz function was used to accurately measure the LE of the 85+ age group. This method was explained by Hsieh. A modified Sullivan method was also used to measure HALE. According to the method, "life days" is adjusted by HUI.

$$L'x = Lx * HUIx$$

L′x means adjusted time lived by age section x,, Lx is life years by age section x, and HUIx is health utility index of age section x.

A study on Canadians of 20 years of age showed that LE of females and males without hypertension were 65.4 years and 61

years, respectively, and HALE for the age of 20 was 55 years and 52.8 years, and 24.7 years and 22.9 years, respectively, at the age of 55. HALE of those with hypertension was 48.9 years and 47.1 years for females and males, and 22.7 and 20.2 at the age of 55, respectively. High blood pressure was related more to the meaningful loss of HALE than to LE.

〈Table 2-2〉 LE and HALE with and without hypertension in Canada

(Unit: Year)

Age		LE(F)-LE(M)	HALE(F)-HALE(M)
20	With hypertension	5.2*	1.8**
	W/o hypertension	4.4*	2.2*
55	With hypertension	4.2*	2.5*
	W/o hypertension	3.6*	1.8*
85	With hypertension	2.0	0.9
	W/o hypertension	1.7	0.8

Note: * Statistically significant (P-value 〈 .0001).** Statistically significant (P-value 〈 .05). For 2004 - 2006.

3. Kaplan et al. (2007)[6)]

In 1996, the Department of Health and Human Services in the US announced the guidelines for assessment of the national health programs. Regarding common measures for health improvement, this report focused on involving quality of life that is known as quality of life-adjusted LE. Quality of life-adjusted

6) Kaplan R, Anderson J, Kaplan C. MODELING QUALITY-ADJUSTED LIFE EXPECTANCY LOSS RESULTING FROM TOBACCO USE IN THE UNITED STATES Social Indicator Research 2007; 81:51-64

LE can be used as an indicator to evaluate various activities of healthcare institutions and governmental health policies. Cost of healthcare programs and the rate of the cost of quality of life-adjusted LE are related to each other as a statistical indicator to compare social values invested in healthcare programs.

Kaplan et al. (2007) pointed out that most previous models were limited in combining the effects of morbidity and mortality and including the impact of the reduced smoking amount of smokers, creating a complicated model for health results. As for the effects of smoking on quality of life-adjusted LE, the model was used to measure them on the health of Americans ages 18 - 70.

NHIS's 1987, 1990-1994 data was utilized. This data includes information on restricted activity days, bed days, days absent from work, number of hospital visits over two weeks, and acute or chronic health conditions that restrict activities or cause medical treatments.

General concepts of health such as ‘‘disability,‘ "‘restricted activity days,’’ ‘‘bed days’’ can be seen as those of functional disability. Functional disability is defined as a functional impairment that limits a person's physical and social activities. A person's QWB (Quality of Well-being Scale) score on a specific day is calculated by giving 0 or 1 of symptom weight and is composed of functional disability of 0,1,2,3. Preference weight

is placed on health states based on how desirable a state is in a certain situation. Preference weight of symptom and functional disability are the basis of all QWB calculations. Quality of life-adjusted LE consolidates mortality and well-being index. This study suggests both mortality-adjusted QWB scores and unadjusted scores. All the scores range from 0 to 1.00. Mortality-adjusted QWB is calculated by multiplying the average QWB score by age by the survival rate of birth cohort. In this analysis, mortality-adjusted QWB was measured by multiplying the average QWB score by age by adjusted number of deaths before 1997 out of birth cohort.

Although the QWB methodology is widely applied, this study adopted a new method to measure QWB with NHIS data. Health effects of NHIS were derived from weights on symptoms and functional disabilities, and then this might be used for estimating QWB scores. The QWB score is a preference weight that combines symptom and functional levels.

In this study, NHIS data was used to create a new QWBX1 index. The QWB Social Activity Scale is related to NIHS' restricted activity scale. Questionnaires of the two measures are very similar. The physical activity domain of QWB is matched with NIHS' absence over two weeks. The self-care item of the QWB Social Activity Scale was based on the self-care scale of NIHS that was added in 1982. On the basis of such a method, QWB was designed to measure the levels of wellness on a con-

tinuum between death to optimum functioning, and adjust LE of quality of life based on health states.

As a result of the analysis, quality of well-being score classified smoking status into 6 stages: (1) non-smoker, (2) those who smoke 1 - 10 cigarettes a day, (3) those who smoke 11 - 20 cigarettes a day, (4) those who smoke 21 - 30 cigarettes a day, (5) those who smoke 31 - 40 cigarettes a day, and (6) those who smoke more than 40 cigarettes a day. Current smoking states were systematically correlated with quality of life by age group. Quality of life-adjusted LE is clearly and regularly divided by the number of smoking cigarettes a day. The difference in quality of life-adjusted LE until 70 years of age between those who smoke two packs of cigarettes a day and non-smokers was estimated to be 3.5 years. In summary, 1.2 years were caused by reduced LE and 2.3 years were caused by shortened health-related quality of life.

4. van Baal et al. (2006)[7)]

Obesity and smoking are major risk factors of chronic illness that affect LE and quality of life. The difference in LE between smokers and non-smokers was revealed to be 7.5 - 10 years. Recent studies found that obesity reduces LE by 6 - 7 years, but

7) van Baal P, Hoogenveen R, de Wit A, Boshuizen H Estimating health-adjusted life expectancy conditional on risk factors: results for smoking and obesity. Population Health Metrics 2006; 4:14

the single LE difference is not enough to prove the effects of chronic disease on an unhealthy lifestyle because it doesn't explain how it affects quality of life. Thus, van Baal et al. (2006) analyzed the effects of smoking and obesity on HALE by measuring HALE.

The dynamic population model, which calculates chronic disease rate by limiting dynamic risk factors, was used to estimate the LE and HALE of the cohort of smokers of normal weight in their 20s, that of obese non-smokers, and that of non-smokers of normal weight. Health states of cohorts were calculated based on the disease incidence data of Dutch Burden of Disease research. Health states were evaluated by multiplying life years for measuring HALE.

The analysis showed that the difference in HALE between smokers and non-smokers with obesity and those of normal weight was significant, and LE of the cohorts was similar. Estimated HALE was the highest for non-smokers of normal weight (males and females age 20 - 54.8 years and 55.4 years, respectively). The difference in HALE between the smoking group and obese group of the above male cohort was 7.8 years and 4.6 years, respectively. That for the female cohort was 6.0 years an 4.5 years for the smoking group and obese group, respectively.

〈Table 2-3〉 Difference in LE and HALE caused by smoking and obesity

(Unit: Year)

		Male			Female		
AGE	LE/ HALE	Non-smoker of normal weight	Smoker	Obese	Non-smoker of normal weight	Smoker	Obese
20	LE	63.1	55.4 (-7.7)	58.5 (-4.7)	65.7	59.4 (-6.3)	61.3 (-4.4)
	HALE	54.8	46.9 (-7.8)	50.2 (-4.6)	55.4	49.4 (-6.0)	50.8 (-4.5)
40	LE	44.6	37.1 (-7.5)	40.1 (-4.5)	47.0	40.8 (-6.2)	42.8 (-4.2)
	HALE	37.0	29.2 (-7.8)	32.5 (-4.5)	37.5	31.6 (-5.9)	33.1 (-4.4)
65	LE	21.0	15.4 (-5.6)	17.8 (-3.2)	23.2	18.2 (-5.0)	20.1 (-3.1)
	HALE	16.5	9.4 (-7.1)	12.5 (-4.0)	18.0	12.2 (-5.8)	14.0 (-4.0)

5. Manuel et al. (2004)[8)]

In Canada, diabetes affected 5.5% of the Canadian population in 2004 - 2005, increasing individual and social burden. According to the Canadian Diabetes Association, more than 2 million Canadians suffer from diabetes, and the number is expected to grow to 3 million by 2010. In Canada, diabetes has been considered a complicated health condition and national problem. Therefore, Manuel et al. (2004) researched on the burden of diabetes and analyzed the effects of the disease on health-related quality of life (HRQOL) of the diabetic.

8) Manuel D, Schultz S Diabetes and its impact on health-related quality of life: a life table analysis Population Health Metrics 2004;2:4

Health Utility Index (HUI) is a classification system for various health attributes based on utility and a useful index measuring HRQOL. For the cross-section data of HRQOL measurement, the 2003 CCHS Cycle 2.1 file was utilized. The overall HUI score system ranges from -0.36 to 1.00, where 0.00 means death, 1.0 means completely healthy, and negative values mean worse than death. Differences of more than 0.03 in total HUI average are regarded as clinically significant.

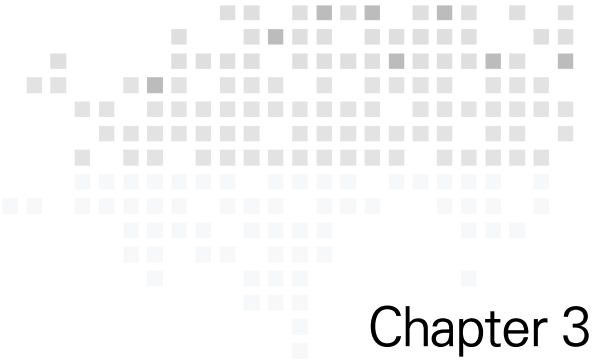
Based on the method for estimating LE, mortality without diabetes was used to calculate LE without diabetes, and the difference between HALE and HALE without diabetes was analyzed. Those with diabetes accounted for 6.8% of the total samples, and made up 14% of the causes of death in 2001 - 2005. LE of age 15 was 61.3 years and 66.7 for males and females, and of these, 53 years and 57 years are values for healthy life expectancy. If a person is not diabetic, his LE and HALE increase 1.3 years and 1.4 years and her LE and HALE increase 2.0 years and 1.7 years, respectively. Those with diabetes show statistically lower HRQOL than those without the condition.

〈Table 2-4〉 Difference in LE and HALE in Canada caused by diabetes

(Unit: Year)

Age	Life expectancy	LE without diabetes	Difference in LE	HALE	HALE without diabetes	Difference in HALE
Male						
15	61.3	62.6	1.3	53	54.3	1.4
35	32.6	34	1.4	27	28.3	1.3
65	15.6	16.8	1.2	12.4	13.5	1.1
85	4.9	5.6	0.7	3.7	4.1	0.4
Female						
15	66.7	68.6	2.0	57	58.7	1.7
35	37.4	39.3	1.9	30.5	32.2	1.7
65	19.5	21.3	1.8	15.1	16.6	1.5
85	6.9	8.1	1.2	4.4	5.2	0.8

Source: Manuel et al.(2004)



Chapter 3

Estimation of life expectancy and health life expectancy

3 Estimation of life expectancy and healthy life expectancy

1. Method and result of the analysis of healthy life expectancy

A life table is a statistical model that shows what would happen to a hypothetical cohort if they lived out their lives under a particular set of age-specific death rates. The Korean Statistical Information Service (KOSIS) constructs a time table based on mid-year population on the resident registration for a given year. The table shows the average remaining years of life, probability of death by age, and probability of a person of a specific age to survive until the next age on the assumption that the type and level of the history of death of a population of a specific age would remain the same. While a complete life table contains data for every single year of age, an abridged life table contains data by 5- or 10-year age intervals.

This study estimated LE as a precondition to calculate HALE. LE is a measure that estimates the average years of life that people aged x would expect to live and is calculated as follows: First, calculate probability of death that estimates the probability a person aged x will die before age $x+n$; second, estimate the number of deaths and the number of survivors by

subtracting the number of deaths from the total population. In other words, the number of survivors means the number of people surviving at exact age x. If 100,000 people born in the same year are assumed to die depending on mortality rate, the number of people expected to survive until exact age x is the number of survivors; third, calculate stationary population by estimating the probability of survival and stationary population by age, and then calculating stationary population after a given year, the sum of years of life survivors aged x are expected to live until age $x+n$. Lastly, calculate LE by dividing the sum of survival years survivors aged x are expected to live until their death by the number of survivals.

The 2009 LE estimated through the above method revealed that LE of age 0 was 80.67. The result was similar to the total 2009 LE provided by KOSIS of 80.55.

〈Table 3-1〉 Life table: Total

(Unit: person, year)

Age	Probability of death	No. of survivors	No. of deaths	Stationary population	Total years of life	LE
0	0.0034	100,000	1,500	99,712	8,067,147	80.67
1 - 4	0.0009	99,661	405	398,468	7,967,435	79.95
5 - 9	0.0007	99,573	384	497,684	7,568,967	76.01
10 - 14	0.0007	99,501	441	497,339	7,071,283	71.07
15 - 19	0.0015	99,435	1,073	496,792	6,573,944	66.11
20 - 24	0.0024	99,282	1,507	495,814	6,077,151	61.21
25 - 29	0.0033	99,044	2,544	494,410	5,581,338	56.35
30 - 34	0.0039	98,721	3,040	492,636	5,086,927	51.53
35 - 39	0.0052	98,334	4,718	490,384	4,594,291	46.72
40 - 44	0.0080	97,820	7,000	487,149	4,103,908	41.95
45 - 49	0.0125	97,040	10,970	482,164	3,616,758	37.27
50 - 54	0.0180	95,825	13,988	474,817	3,134,595	32.71
55 - 59	0.0249	94,102	13,394	464,648	2,659,777	28.26
60 - 64	0.0371	91,758	16,113	450,287	2,195,129	23.92
65 - 69	0.0608	88,357	24,020	428,347	1,744,841	19.75
70 - 74	0.1000	82,982	31,975	394,156	1,316,495	15.86
75 - 79	0.1652	74,681	34,553	342,552	922,338	12.35
80 - 84	0.2746	62,340	33,981	268,910	579,786	9.30
85 - 89	0.4318	45,224	27,439	177,301	310,876	6.87
90 or older	1.0000	25,696	17,934	133,575	133,575	5.20

By gender, LE of males aged 0 in 2009 was 76.99, that of males aged 40 was 38.21, and that of those aged 60 was 20.77. That of females was 83.77 at age 0, 44.01 at age 40, and 25.11 at age 60.

〈Table 3-2〉 Life table by sex: Male

(Unit: person, year)

Age		Probability of death	No. of survivors	No. of deaths	Stationary population	Total years of life	LE
Male	0	0.0036	100,000	361	99,693	7,680,474	76.80
	1 - 4	0.0009	99,639	86	398,382	7,580,781	76.08
	5 - 9	0.0009	99,552	89	497,541	7,182,399	72.15
	10 - 14	0.0008	99,464	76	497,130	6,684,858	67.21
	15 - 19	0.0019	99,388	190	496,467	6,187,728	62.26
	20 - 24	0.0029	99,198	283	495,285	5,691,261	57.37
	25 - 29	0.0038	98,915	377	493,635	5,195,977	52.53
	30 - 34	0.0047	98,539	463	491,535	4,702,342	47.72
	35 - 39	0.0067	98,075	657	488,736	4,210,807	42.93
	40 - 44	0.0111	97,419	1,085	484,380	3,722,072	38.21
	45 - 49	0.0181	96,333	1,739	477,318	3,237,692	33.61
	50 - 54	0.0267	94,594	2,522	466,665	2,760,373	29.18
	55 - 59	0.0368	92,072	3,384	451,899	2,293,709	24.91
	60 - 64	0.0542	88,688	4,811	431,414	1,841,809	20.77
	65 - 69	0.0893	83,877	7,493	400,655	1,410,396	16.81
	70 - 74	0.1434	76,385	10,956	354,534	1,009,740	13.22
	75 - 79	0.2262	65,429	14,802	290,139	655,207	10.01
	80 - 84	0.3618	50,627	18,314	207,348	365,068	7.21
	85 - 89	0.5238	32,312	16,925	119,250	157,720	4.88
	90 or older	1.0000	15,388	15,388	38,470	38,470	2.50

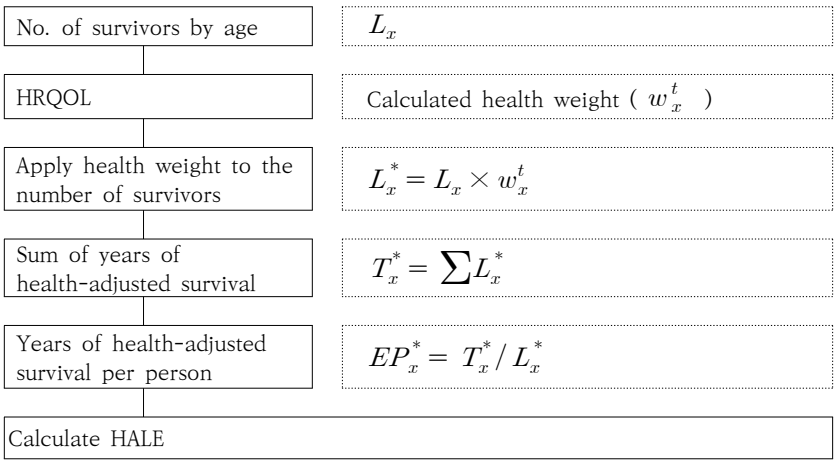
〈Table 3-3〉 Life table by sex: Female

Age		Probability of death	No. of survivors	No. of deaths	Stationary population	Total years of life	Life expectancy
Female	0	0.0031	100,000	314	99,733	8,292,273	82.92
	1 - 4	0.0009	99,686	91	398,560	8,192,540	82.18
	5 - 9	0.0005	99,594	54	497,838	7,793,980	78.26
	10 - 14	0.0006	99,541	55	497,566	7,296,142	73.30
	15 - 19	0.0011	99,486	111	497,150	6,798,576	68.34
	20 - 24	0.0019	99,375	189	496,399	6,301,425	63.41
	25 - 29	0.0027	99,185	266	495,261	5,805,026	58.53
	30 - 34	0.0031	98,919	307	493,828	5,309,765	53.68
	35 - 39	0.0037	98,612	365	492,149	4,815,937	48.84
	40 - 44	0.0047	98,247	460	490,087	4,323,789	44.01
	45 - 49	0.0067	97,787	659	487,289	3,833,702	39.20
	50 - 54	0.0091	97,128	886	483,428	3,346,412	34.45
	55 - 59	0.0130	96,243	1,253	478,081	2,862,985	29.75
	60 - 64	0.0204	94,990	1,938	470,105	2,384,904	25.11
	65 - 69	0.0360	93,052	3,348	456,892	1,914,799	20.58
	70 - 74	0.0665	89,705	5,967	433,606	1,457,907	16.25
	75 - 79	0.1282	83,738	10,733	391,856	1,024,302	12.23
	80 - 84	0.2326	73,005	16,982	322,569	632,446	8.66
	85 - 89	0.3937	56,023	22,059	224,967	309,877	5.53
	90 or older	1.0000	33,964	33,964	84,910	84,910	2.50

2. Method and result of HALE analysis

To calculate HALE, LE is estimated based on the afore-mentioned method, and HALE weight is derived to apply them to the number of survivors. HALE is calculated by dividing HRQOR-adjusted years of survival by the number of survivors.

[Figure 4-1] Method for analysis of HALE



3. Health-related Quality of Life

HRQOL should be applied to LE in order to derive HALE. To estimate HRQOL, this study obtained the 2009 data from the Korea Health Panel (KHP).

KHP is a collaborative survey of the Korea Institute for Health and Social Affairs (KIHASA) and the National Health Insurance Service, the first year survey in 2008 sampled 7,866 households, and since then data on the individual's health levels, medical treatments, and medical expenditures of the original sample has been generated every year. KHP includes information on emergency, hospitalization, outpatient service, chronic disease, smoking, drinking, physical activity, mental health, and quality of life.

KHP surveys EQ-5D, a tool to measure HRQOL. EQ-5D questionnaire consists of five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. And it is on three scales (no difficulty, somewhat difficult, very difficult).

To generate the EQ-5D index, the EQ-5D tariff needs to be developed. Korea has recently released the results of the researches on developing the EQ-5D tariff for calculating HRQOL as follows (Gang Eun-jeong et al., 2006[9]; Korea Centers for Disease Control and Prevention (KCDC), 2007; Jo Min-woo et al., 2008[10]):

〈Table 3-4〉 Korea's EQ-5D preference weight

		Gang Eun-jeong et al. (2006)	KCDC (2007)	Jo Min-woo et al. (2008)
Mobility	level 2	0.003*	0.096	0.056
	level 3	0.274	0.418	0.404
Self-care	level 2	0.058	0.046	0.081
	level 3	0.078	0.136	0.399
Usual activities	level 2	0.045	0.051	0.084
	level 3	0.134	0.208	0.301
Pain/discomfort	level 2	0.049	0.037	0.076
	level 3	0.132	0.151	0.297
Anxiety/depression	level 2	0.044	0.043	0.077
	level 3	0.102	0.158	0.391
Constant		0.164	0.050	0.019
N3		0.345	0.050	-0.242
I2sq[1)]		0.014	-	-
R-squared		0.4321	-	0.074

Note: 1) (number of level 2 - 1) squared
*) At 5% level, it is not statistically significant

9) Gang Eun-jeong et al., Research on the valuation of health levels using EQ-5D, KIHASA·Health Improvement Business Center, 2006

10) Jo et al. Estimating Quality weights for EQ-5D health states with the time trade-off method in South Korea, Value In Health, 2008: 11(7)

Set the utility weight calculated by the regression coefficient of the above table as a dependent variable and five values (levels 1 - 3) of health states as dummy variables and EQ-5D index, which applies weight to 243 combinations of health states that can be expressed using the formula

$$\text{Health state} = b0 + b1 \times \text{mobility\_level2} + b2 \times \text{mobility\_level3} + b3 \times \text{self-care\_level2} + b4 \times \text{self-care\_level3} + \ldots$$

The results of HRQOL of this study based on EQ-5D preference weight found that the EQ-5D index of the model 2 was the highest with 0.945, followed by model 3's EQ-5D index with 0.940, and model 1's 0.903. By sex, as in the following table, HRQOL index of males is generally lower than that of females.

〈Table 3-5〉 EQ-5D index of Korean adults

		mean	SD	min	max
Apply Korea's weight	Model 1	0.903	0.155	-1.3	1.0
	Model 2	0.945	0.098	-0.3	1.0
	Model 3	0.940	0.104	0.1	1.0

Note: Model 1 applied Gang Eung-jung et al. (2006)'s regression coefficient, model 2 applied KCDC (2007)'s regression coefficient, and model 3 applied Jo Min-woo et al. (2008)'s regression coefficient to KHP and targeted adults aged 18 and older.

〈Table 3-6〉 HRQOL of Korean adults by sex and age

		18-29	30-39	40-49	50-59	60-69	70 and older
Male	Mean	0.941	0.939	0.926	0.892	0.828	0.746
	S.D	0.106	0.105	0.119	0.133	0.187	0.235
Female	Mean	0.963	0.959	0.940	0.919	0.899	0.839
	S.D	0.088	0.093	0.120	0.146	0.153	0.202
Total	Mean	0.950	0.948	0.933	0.904	0.860	0.786
	S.D	0.100	0.100	0.119	0.140	0.176	0.226

Note: Kang Eun-jeong et al. (2006)'s regression coefficient was applied

Of the literature suggesting a regression coefficient for Korean adults, this study employed Gang Eun-jeong et al. (2008)'s regression coefficient to estimate HALE. Also, since KHP's EQ-5D questionnaire targeted those aged 18 and older, Manuel (2004)'s data was used for utility values for ages between 0 and 20.

〈Table 3-7〉 Utility weight for less than 20 years of age

Age	Male	Female	Total
0	0.97640	0.97460	0.97549
1 - 4	0.97640	0.97460	0.97549
5 - 9	0.97000	0.98570	0.97783
10 - 14	0.94780	0.94360	0.94574
15 - 19	0.93510	0.92870	0.93192

Note: Manuel DG, Schultz SE(2004)

4. Health-adjusted life expectancy

HRQOL-adjusted HALE for 2009 was 72.63 years. HALE of males was 71.38 and that of females was 73.37, and the difference in remaining years between men and women was 6.12 and

that in HALE between the two sexes was 1.99 years. The fact that the difference in remaining years of 6.12 was bigger than that of HALE of 1.99 can be interpreted that women are weaker than men in terms of years of a healthy life, although they live a relatively longer life than men.

〈Table 3-8〉 HRQOL-adjusted healthy life expectancy

(Unit: Year)

	Male	Female	Total
LE at age 0	76.80	82.92	80.67
HALE at age 0	71.38	73.37	72.63
	6.12		
Difference b/w HALE of males and females	1.99		

According to HALE by age, that of age 0 was 72.63 years, that of 30 was 44.74 years, and that of 60 was 18.88 years. The difference between HALE and LE was 8.04 for age 0, 6.79 years for age 30, and 5.04 for age 60.

When it comes to the ratio of HALE to LE, that of age 0 was 9.96%. In other words, the proportion of an unhealthy state is 9.96% of the total lifetime. Those aged 65 are likely to spend 23.45% of their remaining lives in a morbid state.

〈Table 3-9〉 HRQOL-adjusted HALE

(Unit: Year)

Age	LE	HALE	Difference between HALE and LE (year)	Difference between HALE and LE (%)
0	80.67	72.63	8.04	9.96
1	79.95	71.91	8.04	10.06
5	76.01	68.07	7.95	10.46
10	71.07	63.22	7.84	11.04
15	66.11	58.54	7.58	11.46
20	61.21	53.96	7.25	11.84
25	56.35	49.34	7.01	12.44
30	51.53	44.74	6.79	13.17
35	46.72	40.16	6.56	14.05
40	41.95	35.64	6.32	15.06
45	37.27	31.21	6.06	16.27
50	32.71	26.94	5.77	17.64
55	28.26	22.82	5.45	19.27
60	23.92	18.88	5.04	21.08
65	19.75	15.12	4.63	23.45
70	15.86	11.77	4.09	25.79
75	12.35	8.84	3.51	28.39
80	9.30	6.33	2.97	31.98
85	6.87	4.03	2.84	41.32
90	5.20	2.13	3.07	58.99

HALE of males aged 0 is 71.38 and LE was 76.80, so the difference between the two indicators was 5.42 years. And the ratio of HALE to LE was 7.06%, meaning that 7.06% lives in an unhealthy state. HALE of males aged 45 was 34.34 years, and the difference between HALE and LE was 3.64 years. HALE of males aged 65 was 14.35 years, and the difference between the two was 2.46 years.

〈Table 3-10〉 HALE: Male

Age	LE	HALE	Difference between HALE and LE (year)	Difference between HALE and LE (%)
0	76.80	71.38	5.42	7.06
5	72.15	66.82	5.33	7.39
10	67.21	62.03	5.18	7.71
15	62.26	57.33	4.93	7.91
20	57.37	52.76	4.61	8.04
25	52.53	48.13	4.40	8.37
30	47.72	43.52	4.20	8.80
35	42.93	38.88	4.05	9.44
40	38.21	34.34	3.87	10.13
45	33.61	29.97	3.64	10.82
50	29.18	25.78	3.40	11.66
55	24.91	21.78	3.13	12.57
60	20.77	18.02	2.75	13.24
65	16.81	14.35	2.46	14.63
70	13.22	11.10	2.11	16.00
75	10.01	8.44	1.58	15.74
80	7.21	6.13	1.08	15.03
85	4.88	4.30	0.58	11.88
90	2.50	2.17	0.33	13.20

HALE of females aged 0 was 73.37 years and the difference between HALE and LE was 9.55 years. The ratio of HALE to LE was 11.52%, which was higher than males' 7.06%. This means that females spend a longer time in ill and unhealthy states.

Given that HALE of females aged 45 was 31.82 years and that of males of the same age group was 34.34 years, the health state of a female aged 24 is worse than that of her male counterpart. However, HALE of women aged 65 was 15.10 years, a little bit higher than men's 14.35 years. It can be said that a woman reaches the age of 65, she is likely to spend

about 26.63% of her LE in an unhealthy state.

〈Table 3-11〉 HALE: Female

Age	LE	HALE	Difference between HALE and LE (year)	Difference between HALE and LE (%)
0	82.92	73.37	9.55	11.52
5	78.26	68.79	9.47	12.10
10	73.30	63.90	9.40	12.82
15	68.34	59.21	9.12	13.35
20	63.41	54.63	8.78	13.84
25	58.53	50.01	8.51	14.55
30	53.68	45.41	8.27	15.41
35	48.84	40.85	7.99	16.36
40	44.01	36.33	7.68	17.45
45	39.20	31.82	7.39	18.85
50	34.45	27.45	7.01	20.33
55	29.75	23.16	6.59	22.15
60	25.11	19.01	6.09	24.27
65	20.58	15.10	5.48	26.63
70	16.25	11.60	4.65	28.64
75	12.23	8.40	3.84	31.35
80	8.66	5.67	3.00	34.60
85	5.53	3.03	2.50	45.21
90	2.50	0.60	1.90	76.10

Chapter 4

Expected effects of obesity control on life expectancy and healthy life expectancy

4 Expected effects of obesity control on life expectancy and healthy life expectancy

The prevalence of obesity in Korea has continuously increased. According to HP 2020, the obesity prevalence of males aged 19 and older with a body mass index (BMI) of 25㎏/㎡ and higher has rapidly risen from 26.0% in 1998 to 30.7% in 2008. The obesity prevalence of females seems to be stagnant, but that of those aged 60 and older is on a steady increase. In terms of income level, the lower a female's income is, the higher her obesity prevalence is. On the contrary, the higher a male's income level is, the higher his obesity prevalence is.

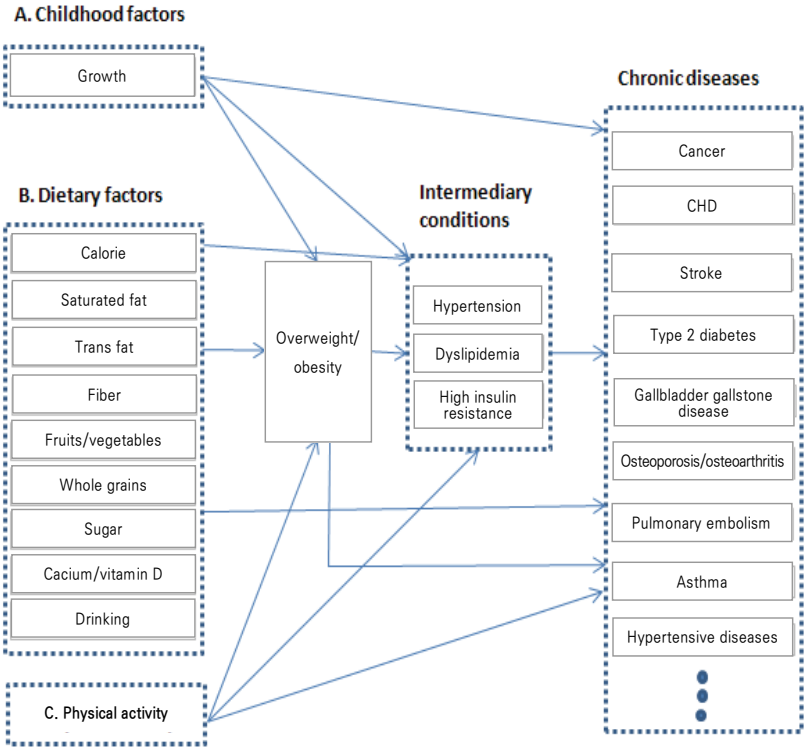
Such phenomena have emerged as a serious health issue as the number of obese people has increased rapidly across the world. In the US, 31% (〉BMI 30) of the total population is obese, 34% is overweight (BMI 20 - 29.9) (Jeon Yong-gwan·Park Ji-hye, 2005), and obesity prevalence has more than tripled in two to three decades in Spain, UK, Italy, Australia, Canada, Japan and China as well as the US (Baek Seol-hyang, 2008).

As in the figure below, obesity causes metabolism and endocrine disorders such as hypertension, dyslipidemia, high insulin resistance, ultimately transferring to cancer, cardio-cerebrovascular diseases, and diabetes. In particular, obesity of adults causes high blood pressure and metabolic complica-

tions, leading to cancer, cardio-cerebrovascular diseases, and diabetes, ultimately raising mortality.

Must et al. (1999) suggested that obesity-related diseases such as type 2 diabetes, gallbladder diseases, hypertension, and coronary artery disease increased as the BMI of the participants aged 25 and older for the third National Health and Nutrition Examination Survey (NHANES Ⅲ) rose. Asia Pacific Cohort Studies Collaboration (2007) conducted a study on the population attributable fraction (PAF) of being overweight and obesity for deaths caused by cardiovascular diseases in 14 Asia-Pacific countries. In the study, PAF for deaths caused by obesity and overweight (BMI≥25kg/m^2)-related coronary artery disease in each Asia-Pacific country was 0.8 - 9.2%, that for deaths caused cerebral hemorrhage was 0.2 - 2.9%, and that for deaths caused by cerebral infarction was 0.9 - 10.2%.

[Figure 4-1] Major path of onset of obesity-related chronic diseases



Source: Popkin BM et al.(2006) was revised·supplemented.

Since the burden of disease from obesity and being overweight is presumed to be significant in Korea, the importance of obesity prevention and the severity of the condition has become the focus of public attention. Jeong Baek-geun et al. (2002) estimated the socioeconomic cost of the obesity of adults aged 20 and older as of 1998 to be 205 - 422.5 billion won. Medical expenditure amounted to 141.8 billion won, about 0.55% of the total national medical cost in 1998. In a

study on Korea's burden of disease, Jeong Young-ho et al. (2006) assumed that the burden of being overweight and obesity stood at 2 trillion and 161.9 billion won or 6.63% of the total burden of disease, ranking the two as the third largest health risk factors after smoking and drinking.

Therefore, the Korean government enforces health policies for reducing obesity-related diseases and deaths caused by obesity through obesity control, thereby alleviating the socio-economic burden and helping citizens live healthy lives.

This chapter intends to use the multi-state simulation model to explore the effects of obesity reduction through obesity prevention and control on HALE. While the Sullivan method is a generally used method to compute the average HALE of a population, the multi-state model has the advantage to calculate HALE of subgroups of specific age or health states (Lee Seung-wook et al., 2007).

〈Table 4-1〉 Comparison of multi-state model and Sullivan method

	Multi-state model	Sullivan Method
	- Able to measure transition from one state to another such as survival to death, healthy to unhealthy, and unhealthy to recovery - Able to research changing aspects of health states of an individual's lifetime - Easy to express and identify the difference and effects by explanatory variable for progression of disease such as sex and smoking status	- Calculation method is relatively simple - Only prevalence or data on the observed health state is needed for calculation
Weakness	- Needs repetitive measurement for measuring health states - Recovery data is required as well as incidence and prevalence rates of diseases and disabilities - Significant amount of cost and time is required for calculation	- Only the average HALE of the total population is calculated, HALE of a specific population at a specific point in time cannot be calculated - Bias is created if prevalence is rapidly changed with the passage of time - Prevalence data for estimation is based on experiences in the past

Source: Lee Seung-wook et al., 2007

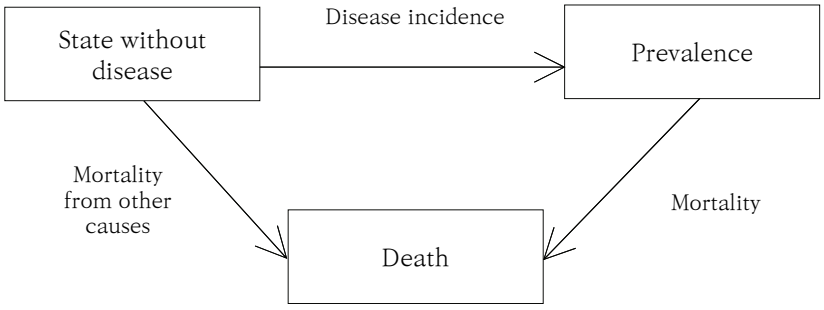
1. Analysis method

Multi-state model is a method to measure HALE. This model takes health states and transition to more than one disability or disease state. It is composed of two major parts. First, population module reflects the process of the shift of population structure depending on the change of population by sex and age and on that with risk factors. Second, as in the figure be-

low, the disease module reflects the change of the prevalence of risk factors, incidence and progression of diseases, and mortality with the passage of time into modeling.

Major variables inputted for the modeling are the structure and changing trends of population, the level and change of the observed population's exposure to risk factors, incidence and prevalence of diseases, mortality, prevalence of risk factors, and relative risk of specific diseases, and excess mortality.

[Figure 4-2] Causal chain path of disease incidence



The model of this study was constructed to compare the HALE of cohorts with different lifestyles such as that of people of normal weight or who are overweight. Since the cohort of normal weight, obese cohort, and seriously obese cohort may generate different health-related indicators at transitional phases of life, HALE of the three groups are compared on heart disease, stroke and diabetes, which are the conditions that are affected by obesity the most. In other words, HALE of the co-

hort of normal weight (BMI <25㎏/㎡), obese cohort (BMI 25㎏/㎡ - 30㎏/㎡), and seriously obese cohort (BMI≥30㎏/㎡) until they are expected to die was analyzed.

HALE of each cohort can be expressed using the formula

$$HALE = \frac{\sum_{t} HS(t) \times N(t)}{N(0)}$$

where HS(t): health state weight by cohort at t stage

N(t): number of cohort survivors at t stage

N(0): size of the initial cohort at t=0 stage

1) Disease module

Obesity-related diseases include heart diseases, stroke and diabetes, and their incidence, prevalence and mortality by age and sex were estimated using the three-state transition model.

Because incidence of each condition differs from one risk factor to another, the relative risk of each cohort was calculated using the formula. The incidence rate of disease d for cohort j (normal weight, obese, seriously obese, $i \quad (d|s_j)$ was also calculated based on the formula

$$i(d|s_j) = i(d)_0 \times \mathrm{RR}(d|s_j)$$

where $i(d)_0$ = incidence rate of disease d for normal weight cohort

$\mathrm{RR}(d|s_j)$ = relative risk of cohort j to disease d

The incidence rate of disease d for normal weight cohort $i(d)_0$, was calculated such that

$$i(d_0) = \frac{i(d)}{\sum_j (RR(d|s_j) \times S_j)}$$

$i(d)$ = incidence rate of disease d for the total population

s_j = percentage of cohort j

Mortality by cohort was calculated as

$m(tot|s_j) = m(tot)_0 \times \mathrm{RR}(tot|s_j)$

$m(tot|s_j)$ = mortality of disease d of cohort j (normal weight, obese, seriously obese)

$m(tot)_0$ = mortality of normal weight cohort

$\mathrm{RR}(tot|s_j)$ = relative risk of cohort j to disease d

Mortality of normal weight cohort was calculated using the formula

$$m(d)_0 = \frac{m(d)}{\sum_j (RR(d|s_j) \times s_j)}$$

where $m(d)$ is mortality of the cause of death of disease d

2) Population module

A population consisting of cohort of normal weight, obese and seriously obese cohorts by risk factor changes as follows. Change of population of prevalence of a particular disease at the next stage $PREV_{t+1}$ is calculated by adding the population of incidence to the population of prevalence of the stage and then subtracting the population of prevalence of those who died of the disease.

$$PREV_{t+1} = PREV_t + INC_t - MORT_{d,t}$$

where $PREV_{t+1}$ is population of prevalence at t+1 stage

$PREV_t$ is population of prevalence at t stage

INC_t is incidence at t stage

$MORT_{d,t}$ is mortality at t stage

In this case, deaths caused by diseases other than those included in this model or accidents need to be reflected. Thus, the cases can be divided into those from disease d and those from other causes.

$$MORT_{d,t} = MORT_d + MORT_{other}$$

where $MORT_{d,t}$ is mortality at t stage

$MORT_d$ is mortality from disease d at t stage

$MORT_{other}$ is mortality from other causes than disease d at t stage

2. Analysis variables

Diseases included in this model are ischaemic heart disease (I20~I25), stroke (I60~I69), and diabetes, which are major chronic diseases that are affected by obesity. Major variables inputted to construct the model are the incidence, prevalence, mortality of these conditions and relative risk of obesity for them. The source and basic statistics of the variables are as follows:

1) Incidence rate

In order to calculate the incidence of ischaemic heart disease (I20~I25), stroke (I60~I69), and diabetes, which are chronic diseases highly correlated with obesity, review and assessment of data from the Health Insurance Review & Assessment Service (HIRA) for the year 2008 was conducted. To estimate the incidence of the observed patients, this study targeted patients who had not claimed insurance benefits for a disease as a main or sub disease code before 2008. Those who claimed benefits for such conditions more than once in 2008 but had not claimed benefits for the same condition from 2006 to 2007 can be included in the analysis.

· $Incidence\,by\,disease = \frac{I_{ijd}}{N_{ij}}$

$i = sex,$
$j = age,$
$d = disease,$
$I = mid-year\,population\,on\,the\,resident\,registration$

When it comes to the stroke incidence in 2008, that of males aged 20 - 24 was 0.0009 and 0.0012 for females, and that of males aged 30 - 34 was 0.0020 and 0.0021 for females. That of the 40 - 44 male group was 0.0048 and female group was 0.0049, and that of 60 - 64 males was 0.0231 and 0.0257 for females, indicating that the incidence of stroke constantly increases with age.

〈Table 4-2〉 Stroke incidence: 2008

Age	No. of new cases		Incidence	
	Male	Female	Male	Female
20-24	1,514	1,830	0.0009	0.0012
25-35	2,609	2,855	0.0013	0.0014
30-34	3,966	4,022	0.0020	0.0021
35-39	7,072	6,566	0.0030	0.0029
40-44	10,587	10,314	0.0048	0.0049
45-49	17,641	18,756	0.0079	0.0087
50-54	21,589	24,078	0.0118	0.0134
55-59	21,353	24,374	0.0171	0.0192
60-64	22,833	27,021	0.0231	0.0257
65-69	27,419	36,367	0.0312	0.0348
70-74	24,083	36,707	0.0397	0.0440
75-79	15,482	29,509	0.0485	0.0515
80-84	8,638	18,836	0.0570	0.0557
85+	4,871	13,155	0.0535	0.0518

Source: HIRA data

Regarding the incidence of ischaemic heart disease in 2008, that of 20 - 24 males and females was 0.0016 and 0.0013, and that of 30 - 34 males and females was 0.0033 and 0.0021, respectively. That of 40 - 44 men and women was 0.0068 and 0.0045, respectively, meaning the incidence of the condition of males is higher than that of their female counterparts.

〈Table 4-3〉 Incidence of ischaemic heart disease: 2008

Age	No. of new cases		Incidence rate	
	Male	Female	Male	Female
20-24	2,646	1,992	0.0016	0.0013
25-35	4,350	2,972	0.0021	0.0015
30-34	6,591	3,969	0.0033	0.0021
35-39	10,724	6,253	0.0046	0.0028
40-44	14,897	9,401	0.0068	0.0045
45-49	22,468	17,626	0.0101	0.0082
50-54	25,142	23,103	0.0137	0.0129
55-59	22,897	22,535	0.0183	0.0178
60-64	21,978	23,325	0.0222	0.0222
65-69	21,951	27,717	0.0250	0.0265
70-74	16,289	24,283	0.0269	0.0291
75-79	9,230	17,346	0.0289	0.0303
80-84	4,576	9,922	0.0302	0.0293
85+	2,377	6,383	0.0261	0.0251

Source: HIRA data

As for the 2008 diabetes incidence rate, that of males and females aged 20 - 24 was 0.0015 and 0.0019, respectively, and that of 30 - 34 was 0.0047 for men and 0.0047 for women. That of 40 - 44 was 0.0115 for men and 0.0077 for women, and that of 60 - 64 was 0.0282 for men and 0.0280 for women.

〈Table 4-4〉 Incidence of diabetes: 2008

Age	No. of new cases		Incidence rate	
	Male	Female	Male	Female
20-24	2,441	2,928	0.0015	0.0019
25-35	5,296	6,235	0.0025	0.0031
30-34	9,414	8,899	0.0047	0.0047
35-39	17,535	12,124	0.0075	0.0054
40-44	25,056	16,294	0.0115	0.0077
45-49	36,453	25,703	0.0164	0.0119
50-54	37,581	31,671	0.0205	0.0176
55-59	31,352	29,967	0.0251	0.0237
60-64	27,867	29,393	0.0282	0.0280
65-69	27,548	35,084	0.0313	0.0336
70-74	18,968	28,838	0.0313	0.0346
75-79	10,449	19,571	0.0327	0.0341
80-84	4,752	10,312	0.0314	0.0305
85+	2,411	5,920	0.0265	0.0233

Source: HIRA data

2) Prevalence rate

To estimate the prevalence rate of ischaemic heart disease (I20~I25), stroke (I60~I69), and diabetes, the review data for the year 2008 from the Health Insurance Review & Assessment Service (HIRA) was used. Patients who claimed insurance benefits for the observed disease in 2008 was the target of the estimation.

· $\mathrm{P}revalence\,by\;disease = \dfrac{P_{ijd}}{N_{ij}}$

$i = sex,\ j = age,\ d = disease,\ P = prevalence\,\nu mber,$
$N = mid-year\,population\,on\,the\,resident\,registration$

The number of stroke patients as of 2008 was 5,543 for males aged 30 - 34, and that of their female counterparts was 5,193. The figure of males aged 40 - 44 was 19,195 and that of females of the same age group was 15,509, with 60 - 64 men at 68,722 and that of 60 - 64 women at 69,572, indicating that the number of patients, prevalence population, and prevalence rate increase with age.

〈Table 6-5〉 Prevalence of stroke: 2008

Age	Prevalence number		Prevalence rate	
	Male	Female	Male	Female
20-24	1,984	2,196	0.0012	0.0014
25-35	3,491	3,560	0.0017	0.0018
30-34	5,543	5,193	0.0028	0.0027
35-39	11,032	9,036	0.0047	0.0040
40-44	19,195	15,509	0.0088	0.0074
45-49	36,983	32,259	0.0166	0.0150
50-54	51,931	48,086	0.0284	0.0268
55-59	58,935	56,246	0.0472	0.0444
60-64	68,722	69,572	0.0694	0.0662
65-69	86,265	103,678	0.0981	0.0993
70-74	78,978	111,605	0.1303	0.1337
75-79	54,030	92,489	0.1692	0.1614
80-84	29,207	56,843	0.1927	0.1681
85+	14,945	35,022	0.1640	0.1378

Source: HIRA data

As of 2008, the number of patients with ischaemic heart disease was 8,349 for 30 - 34 males, and 4,725 for 30 -34 females. The number was 26,584 for men ages 40 - 44 and 14,200 for women ages 40 - 44, and that for males ages 60 - 64 was 75,405 and that for their female counterparts was 67,284, proving that prevalence population and prevalence rate increase with age,

and that prevalence rate is higher for men than women.

〈Table 4-6〉 Prevalence of ischaemic heart disease: 2008

Age	Prevalence number		Prevalence rate	
	Male	Female	Male	Female
20-24	2,986	2,154	0.0018	0.0014
25-35	5,079	3,369	0.0024	0.0017
30-34	8,349	4,725	0.0042	0.0025
35-39	16,029	8,118	0.0069	0.0036
40-44	26,584	14,200	0.0122	0.0067
45-49	48,537	31,153	0.0218	0.0144
50-54	65,423	48,537	0.0358	0.0270
55-59	69,238	56,957	0.0554	0.0450
60-64	75,405	67,284	0.0762	0.0640
65-69	80,963	89,606	0.0921	0.0858
70-74	64,359	85,452	0.1062	0.1024
75-79	38,317	62,335	0.1200	0.1088
80-84	18,047	34,364	0.1191	0.1016
85+	8,398	18,577	0.0922	0.0731

Source: HIRA data

Prevalence rate of diabetes in 2008 was 0.0102 for males ages 30 - 34 and 0.0086 for the same female age group. That for 40 - 44 men was 0.0404 and that for 40 - 44 women was 0.0220, and the rate for men ages 60 - 64 was 0.1710 and that for the same female age group was 0.1528, indicating that prevalence rate increases with age, and females shows higher prevalence rate than men.

〈Table 4-7〉 Prevalence of diabetes: 2008

Age	Prevalence number		Prevalence rate	
	Male	Female	Male	Female
20-24	4,815	4,764	0.0029	0.0031
25-35	9,440	10,167	0.0045	0.0051
30-34	20,407	16,430	0.0102	0.0086
35-39	48,770	27,332	0.0210	0.0122
40-44	88,143	46,359	0.0404	0.0220
45-49	153,812	82,914	0.0691	0.0385
50-54	188,742	117,256	0.1032	0.0653
55-59	178,230	141,502	0.1427	0.1117
60-64	169,232	160,652	0.1710	0.1528
65-69	171,676	208,218	0.1952	0.1994
70-74	122,408	183,605	0.2019	0.2200
75-79	61,963	122,632	0.1941	0.2140
80-84	26,101	60,643	0.1722	0.1793
85+	11,090	26,654	0.1217	0.1049

Source: HIRA data

3) Relative risk of obesity

Relative risk (RR) of obesity to stroke, heart diseases and diabetes in this research is derived from Wilson et al. (2002), IOTF (1999), and this analysis model utilized the following results. For prevalence of obesity, the 2008 National Health and Nutrition Examination Survey (NHANES) was used.

〈Table 6-8〉 Relative risk of obesity

	Stroke		Heart disease		Diabetes	
	Male	Female	Male	Female	Male	Female
Overweight	1.21	1.20	1.40	1.40	5.32	5.32
Obesity	1.46	1.64	2.33	2.33	26.29	26.29

Note: Age-adjusted results.
Source: Wilson et al. (2002), IOTF (1999)

4) Mortality

Mortality by cause of death is released by KOSIS based on the formula. This study used the data to estimate mortality and excess mortality by cause of death.

$$Mortality = \frac{Mort_{ijd}}{N_{ij}}$$

where $Mort_{ijd}$ is number of deaths caused by particular causes by sex and age

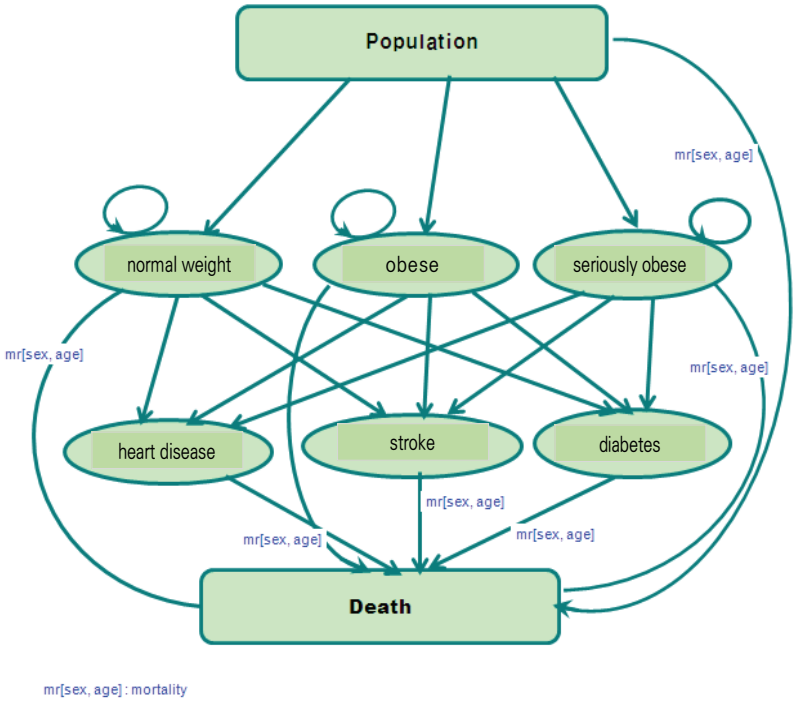
〈Table 4-9〉 Mortality of obesity-related diseases: 2009

Age	Stroke		Heart disease		Diabetes	
	Male	Female	Male	Female	Male	Female
20-24	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000
25-35	0.00001	0.00001	0.00001	0.00000	0.00000	0.00001
30-34	0.00002	0.00002	0.00002	0.00000	0.00001	0.00001
35-39	0.00006	0.00002	0.00005	0.00001	0.00002	0.00001
40-44	0.00012	0.00006	0.00010	0.00002	0.00004	0.00002
45-49	0.00021	0.00009	0.00017	0.00002	0.00011	0.00003
50-54	0.00032	0.00017	0.00029	0.00005	0.00019	0.00005
55-59	0.00053	0.00020	0.00045	0.00008	0.00031	0.00011
60-64	0.00092	0.00043	0.00062	0.00018	0.00048	0.00019
65-69	0.00183	0.00087	0.00102	0.00035	0.00080	0.00049
70-74	0.00368	0.00206	0.00176	0.00091	0.00153	0.00098
75-79	0.00679	0.00465	0.00307	0.00206	0.00252	0.00183
80-84	0.01239	0.00867	0.00546	0.00395	0.00348	0.00305
85+	0.00174	0.00250	0.00081	0.00125	0.00041	0.00059

3) Result of analysis

The results of the analysis of LE and HALE of the obese group (25≤BMI〈30), seriously obese group (BMI≥30), and group of normal weight (BMI〈25) are in the table below. Each cohort was composed of 100,000 subjects on the assumption that they are expected to live until the age of 90.

[Figure 4-3] Concept map of analysis model



If a 30-year-old man of normal weight survives until 90, his LE is 53.48 years. If an obese man of the same age survives until 90, his LE is 52.06. And if the same is true for a seriously obese man of the same age, his LE is 50.58 years.

Assuming that a 40-year-old man of normal weight survives until 90 years old, his LE is 43.94 years. That of an obese man of the same age is 42.60 and that of a seriously obese man of the same age is 41.15 years.

If a 40-year-old woman of normal weight survives until 90,

her LE is 48.11. That of an obese female of the same age is 48.03, and that of a seriously obese female of the same age is 47.95.

〈Table 4-10〉 Life expectancy by cohort

Age	Normal weight		Obese		Seriously obese	
	Male	Female	Male	Female	Male	Female
30	53.48	57.96	52.06	57.85	50.58	57.65
40	43.94	48.11	42.60	48.03	41.15	47.95
50	34.91	38.32	33.71	38.26	32.29	38.25
60	26.19	28.59	25.20	28.47	23.80	28.43

The difference in LE between a 30-year-old man of normal weight and obese men of the same age was 2.90 years. 30-year-old men of normal weight had LE 1.42 years longer than that of obese men of the same age. The difference in LE between seriously obese 30-year-old men and obese men of the same age was 1.48 years.

〈Table 6-11〉 Difference in life expectancy between cohorts: Males

Age	Normal weight vs. seriously obese	Normal weight vs. obese	Obese vs. seriously obese
30	-2.90	-1.42	-1.48
40	-2.79	-1.35	-1.45
50	-2.62	-1.20	-1.43
60	-2.39	-1.00	-1.39

The LE difference between 30-year-old women of normal weight and seriously obese women of the same age was 0.32

year, showing that LE of those of normal weight was longer than that of seriously obese women The difference in LE between men of normal weight and seriously obese men at 30 years of age was 2.90 years compared to that of women of normal weight and seriously obese women of the same age with 0.32 year. This indicates that obesity affects patient's life expectancy more seriously in males than females.

〈Table 4-12〉 Difference in life expectancy between cohorts: Females

Age	Normal weight vs. seriously obese	Normal weight vs. obese	Obese vs. seriously obese
30	-0.32	-0.11	-0.20
40	-0.16	-0.08	-0.08
50	-0.07	-0.07	-0.01
60	-0.17	-0.12	-0.04

If a 40-year-old man is expected to live to 90, his HALE is 38.84 years for normal weight, 36.72 years for an obese state, and 34.10 for a seriously obese state.

HALE of a 40-year-old woman who is expected to live to 90 is 42.29 years if she is of normal weight, 40.83 years if she is obese, and 39.01 if she is seriously obese.

〈Table 6-13〉 Healthy life expectancy by cohort

Age	Normal weight		Obese		Seriously obese	
	Male	Female	Male	Female	Male	Female
30	48.06	51.77	45.90	50.30	43.01	48.16
40	38.84	42.29	36.72	40.83	34.10	39.01
50	30.26	33.06	28.24	31.62	25.78	29.97
60	22.27	24.23	20.14	22.52	17.84	20.93

When comparing HALE of 30-year-old males of normal weight with seriously obese males of the same age, that of seriously obese was 5.05 years shorter than that of normal weight. When it comes to that of those of normal weight and the obese from the same age group, the former showed HALE 2.16 years longer than the obese. The difference in HALE between seriously obese 30-year-old men and obese men was 2.89 years.

〈Table 6-14〉 Difference in healthy life expectancy between cohorts: Males

Age	Normal weight vs. seriously obese	Normal weight vs. obese	Obese vs. seriously obese
30	-5.05	-2.16	-2.89
40	-4.74	-2.12	-2.62
50	-4.48	-2.01	-2.46
60	-4.43	-2.13	-2.31

HALE of females at the age of 30 normal weight was 3.61 years longer than that of the seriously obese. Difference in HALE between 30-year-old males of normal weight and seriously obese of the same age was 5.05 years compared to 3.61

years between females of normal weight and seriously obese from the same age group. This means that obesity affects men more seriously than women in terms of HALE.

〈Table 6-15〉 Difference in healthy life expectancy between cohorts: Females

Age	Normal weight vs. seriously obese	Normal weight vs. obese	Obese vs. seriously obese
30	-3.61	-1.47	-2.14
40	-3.28	-1.46	-1.82
50	-3.10	-1.44	-1.66
60	-3.29	-1.70	-1.59

4) Results of simulation

To examine the effects of dynamic disease changes on the LE and HALE of the three cohorts, scenario analysis was conducted. The effects can be translated into the benefits HP 2020 would bring by reducing disease incidence and prevalence through continuous control of risk factors related to chronic illness such as cardio-cerebrovascular diseases.

(1) If disease incidence drops 20% within the model

Simulation on LE and HALE was conducted under the assumption that the incidence rate of the diseases in the model (stroke, diabetes, and ischaemic heart disease) decreased by 20%.

With the 20% decrease in the incidence of the three conditions, 40-year-old males of normal weight showed a 0.28 year increase in LE, the figure increased 0.49 year for obese males, and was 0.89 year for seriously obese males from the same age group.

〈Table 6-16〉 Life expectancy of males by cohort: 20% reduction in obesity-related diseases

Age	Normal weight			Obese			Seriously obese		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
30	53.48	53.79	0.31	52.06	52.59	0.53	50.58	51.54	0.96
40	43.94	44.22	0.28	42.60	43.08	0.49	41.15	42.03	0.89
50	34.91	35.14	0.23	33.71	34.10	0.39	32.29	33.01	0.72
60	26.19	26.34	0.14	25.20	25.45	0.25	23.80	24.30	0.50

When it comes to HALE, that of 40-year-old males of normal weight increased 0.23 year with a 20% reduction in the incidence rate of the three diseases. Under the same assumption, HALE of obese 40-year-old males rose by 0.35 year and that of the seriously obese from the same age group increased by 0.61 year.

〈Table 6-17〉 Healthy life expectancy of males by cohort: 20% reduction in obesity-related disease

Age	Normal weight			Obese			Seriously obese		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
30	48.06	48.31	0.25	45.90	46.29	0.39	43.01	43.67	0.66
40	38.84	39.07	0.23	36.72	37.07	0.35	34.10	34.71	0.61
50	30.26	30.44	0.18	28.24	28.52	0.28	25.78	26.26	0.48
60	22.27	22.39	0.12	20.14	20.32	0.18	17.84	18.16	0.32

Under the same assumption, 40-year-old females of normal weight showed a 0.22 year increase in LE, and that of the obese and the seriously obese rose by 0.27 year and 0.24 year, respectively.

〈Table 6-18〉 Life expectancy of females by cohort: 20% reduction in obesity-related diseases

Age	Normal weight			Obese			Seriously obese		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
30	57.96	58.19	0.23	57.85	58.13	0.28	57.65	57.90	0.26
40	48.11	48.33	0.22	48.03	48.30	0.27	47.95	48.20	0.24
50	38.32	38.52	0.20	38.26	38.50	0.24	38.25	38.48	0.23
60	28.59	28.75	0.15	28.47	28.67	0.20	28.43	28.64	0.21

Regarding 40-year-old females, HALE increased 0.18 year for those of normal weight, 0.20 year for the obese, and 0.18 year for the seriously obese from the same age group if the same assumption was valid.

〈Table 6-19〉 Healthy life expectancy of females by cohort: 20% reduction in obesity-related disease

Age	Normal weight			Obese			Seriously obese		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
30	51.77	51.96	0.19	50.30	50.50	0.20	48.16	48.35	0.19
40	42.29	42.47	0.18	40.83	41.03	0.20	39.01	39.19	0.18
50	33.06	33.22	0.16	31.62	31.80	0.18	29.97	30.13	0.16
60	24.23	24.35	0.12	22.52	22.67	0.14	20.93	21.07	0.14

(2) If disease incidence drops 50% within the model

Simulation on LE and HALE was conducted under the assumption that the incidence rate of the diseases in the model (stroke, diabetes, and ischaemic heart disease) decreased by 50%.

With the 50% decrease in the incidence of the three conditions, 40-year-old males of normal weight showed 0.67 year increase in LE, and the figure increased 1.13 years for obese males and 1.94 years for seriously obese males from the same age group.

〈Table 6-20〉 Life expectancy of males by cohort: 50% reduction in obesity-related diseases

Age	Normal weight			Obese			Seriously obese		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
30	53.48	54.21	0.73	52.06	53.29	1.23	50.58	52.68	2.10
40	43.94	44.61	0.67	42.60	43.72	1.13	41.15	43.09	1.94
50	34.91	35.45	0.54	33.71	34.62	0.90	32.29	33.89	1.61
60	26.19	26.54	0.35	25.20	25.79	0.59	23.80	24.93	1.13

When it comes to HALE, that of 40-year-old males of normal weight increased 0.54 year with 50% reduction in the incidence rate of the three diseases. Under the same assumption, HALE of obese 40-year-old males rose 0.82 year and that of the seriously obese from the same age group increased 1.34 years.

〈Table 6-21〉 Healthy life expectancy of males by cohort: 50% reduction in obesity-related disease

Age	Normal weight			Obese			Seriously obese		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
30	48.06	48.65	0.60	45.90	46.80	0.90	43.01	44.47	1.46
40	38.84	39.39	0.54	36.72	37.54	0.82	34.10	35.44	1.34
50	30.26	30.69	0.43	28.24	28.89	0.65	25.78	26.86	1.08
60	22.27	22.55	0.28	20.14	20.56	0.42	17.84	18.56	0.73

Under the same assumption, 40-year-old females of normal weight showed a 0.48 year increase in LE, and that of the obese and the seriously obese rose by 0.55 year and 0.48 year, respectively.

〈Table 6-22〉 Life expectancy of females by cohort: 50% reduction in obesity-related disease

Age	Normal weight			Obese			Seriously obese		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
30	57.96	58.46	0.49	57.85	58.42	0.57	57.65	58.16	0.51
40	48.11	48.59	0.48	48.03	48.59	0.55	47.95	48.44	0.48
50	38.32	38.75	0.43	38.26	38.76	0.50	38.25	38.70	0.45
60	28.59	28.93	0.33	28.47	28.90	0.43	28.43	28.85	0.42

Regarding 40-year-old females, HALE increased by 0.39 year for those of normal weight, 0.41 year for the obese, and 0.35 year for the seriously obese from the same age group if the same assumption was valid.

〈Table 6-23〉 Healthy life expectancy of females by cohort: 50% reduction in obesity-related disease

Age	Normal weight			Obese			Seriously obese		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
30	51.77	52.17	0.40	50.30	50.72	0.42	48.16	48.54	0.38
40	42.29	42.68	0.39	40.83	41.24	0.41	39.01	39.36	0.35
50	33.06	33.41	0.35	31.62	32.00	0.37	29.97	30.28	0.32
60	24.23	24.49	0.27	22.52	22.83	0.30	20.93	21.21	0.28

Chapter 5

Conclusion

5 Conclusion

1. Results of the estimation of life expectancy and healthy life expectancy

This study estimated life expectancy using the mortality and population data from the Korean Statistical Information Service, and calculated healthy life expectancy based on health-related quality of life (HRQOL) suggested by the Korea Health Panel (KHP). These analyses found that the life expectancy of Koreans born in 2009 was 80.67 years, and by gender, that of males was 76.99 and that of females was 83.77 years. More details are provided in the following table.

〈Table 10-1〉 Life expectancy of Koreans by sex and age

Sex	Male			Female		
Age	0	40	60	0	40	60
LE	76.80	38.21	20.77	82.92	44.01	25.11

Meanwhile, the health-adjusted life expectancy (HALE) of the Korean people based on the HRQOL data of the KHP was found to be 72.63 years in 2009. Again by sex, that of men was 71.38 and that of women was 73.37. While the difference in LE between sexes was 6.12 years, that in HALE was 1.99 years.

〈Table 10-2〉 Difference in life expectancy and healthy life expectancy between sexes

	Male	Female	Total
LE at age 0	76.80	82.92	80.67
HALE at age 0	71.38	73.37	72.63
Difference in LE b/w sexes	6.12		
Difference in HALE b/w sexes	1.99		

When it comes to the proportion of HALE to LE, the ratio was 09.96% at age 0, meaning that about 10% of one's lifetime is undergone in an ill status. For those aged 65, 23.45% of their LE is in a morbid state. The difference between LE and HALE of Koreans is summarized in the following table.

〈Table 10-3〉 Difference between life expectancy and healthy life expectancy

Total	LE	HALE	LE - HALE (year)	LE - HALE (%)
0	80.67	72.63	8.04	9.96
40	41.95	35.64	6.32	15.06
65	19.75	15.12	4.63	23.45
Male	LE	HALE	LE - HALE (year)	LE - HALE (year)(%)
0	76.80	71.38	5.42	7.06
40	38.21	34.34	3.87	10.13
65	16.81	14.35	2.46	14.63
Female	LE	HALE	LE - HALE (year)	LE - HALE (year)(%)
0	82.92	73.37	9.55	11.52
40	44.01	36.33	7.68	17.45
65	20.58	15.10	5.48	26.63

The HALE of seriously obese males age 30 was 5.05 years shorter than that of those of normal weight from the same age group. While the difference in HALE between males of normal

weight and seriously obese ones at the age of 30 was 5.05 years, that between their female counterparts was 3.61 years, indicating that men are hit harder by obesity than women are.

〈Table 10-5〉 Difference in healthy life expectancy

		Normal weight vs. seriously obese	Normal weight vs. obese	Obese vs. seriously obese
Male	30	-5.05	-2.16	-2.89
	40	-4.74	-2.12	-2.62
	50	-4.48	-2.01	-2.46
	60	-4.43	-2.13	-2.31
Female	30	-3.61	-1.47	-2.14
	40	-3.28	-1.46	-1.82
	50	-3.10	-1.44	-1.66
	60	-3.29	-1.70	-1.59

2. Changes in healthy life expectancy depending on variations in incidence rates

Scenario analysis was conducted to examine the effects of the dynamic changes in diseases of this study (stroke, ischaemic heart disease, diabetes) on the life expectancy and healthy life expectancy of the three cohorts (normal weight, obese, seriously obese). These can be translated into the effects of continuous control of risk factors related to chronic diseases such as cardio-cerebrovascular disease through HP 2020 on the incidence and mortality of such diseases.

In the case of males of normal weight aged 40, a 20% reduction in stroke, diabetes and ischaemic heart disease led to a

0.23 year increase in HALE. A 50% reduction in such diseases for the same cohort resulted in increasing HALE by 0.54 year.

〈Table 10-6〉 Healthy life expectancy of males: 20% reduction in stroke, diabetes and heart diseases

	Age	Normal weight			Obese			Seriously obese		
		Before	After	Difference	Before	After	Difference	Before	After	Difference
20% reduction	30	48.06	48.31	0.25	45.90	46.29	0.39	43.01	43.67	0.66
	40	38.84	39.07	0.23	36.72	37.07	0.35	34.10	34.71	0.61
	50	30.26	30.44	0.18	28.24	28.52	0.28	25.78	26.26	0.48
	60	22.27	22.39	0.12	20.14	20.32	0.18	17.84	18.16	0.32
50% reduction	30	48.06	48.65	0.60	45.90	46.80	0.90	43.01	44.47	1.46
	40	38.84	39.39	0.54	36.72	37.54	0.82	34.10	35.44	1.34
	50	30.26	30.69	0.43	28.24	28.89	0.65	25.78	26.86	1.08
	60	22.27	22.55	0.28	20.14	20.56	0.42	17.84	18.56	0.73

Korea has achieved remarkable growth in terms of health in a short period of time, but diseases caused by unhealthy life-styles have had a significant impact on the quality of life, pre-mature death, and medical cost as other OECD countries have experienced. Under the current circumstances, Korea's health policies have prioritized the expansion of after-the-fact medi-cal coverage, but now the Korean government recognizes the importance of prevention and health improvement, thereby making progress in the area. OECD member states are also known to aggressively push for health promotion policies to suit their needs.[11)]

11) Regarding the current state of the health improvement policy of OECD

Korea enacted the National Health Promotion Act in 1995, laying the foundation for the government to take the responsibility for safeguarding the health of its people. In addition, based on the understanding of the importance of lifestyle (behavior) elements of health promotion, the government adopted "healthy lifestyles" as an overarching goal, and “change of individual behaviors" and preventive health service" as major strategies.[12] To motivate healthy lifestyles that are affected by various factors, what is needed is a holistic approach that encompasses the creation of social environments as well as the offering and promotion of accurate information, aggressive pricing and appropriate controls (non-pricing), and formation of a system for maintaining and managing healthy lifestyles.

However, there is a time gap between the benefits from turning to healthy lifestyles and the costs currently invested in health promotion. Therefore, a variety of conditions for national health promotion and determinants of health should be taken into account in order to set the strategic framework of national health improvement with long-term visions and goals. To do this, the implications, proportion and effect assessment of the national health promotion policy need to be comprehensively considered because the efficiency of national health

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members, Choi Yun-jeong et al., Research on the health improvement policy of major OECD nations, Asia Social Policy Center, 2006 was referred to

12) In 2000, National Health Plan 2010 was established to develop detailed tasks and strategies, and in 2010, Health 2020 was set up.

promotion programs should also be achieved through effect analysis from a macroscopic point of view for appropriate allocation of limited resources. It is required to develop a systematic forecast model for a strategic health promotion project where the benefits of health promotion policies are predicted, assessed and analyzed based on a comprehensive framework.

In recognition of these needs, this study sought to measure the effects of health improvement through life expectancy and healthy life expectancy to use them as the basis for policy-making. It is hoped that the results of this study in which the benefits of health improvement were measured by quantifying the increase of life expectancy and healthy life expectancy when particular causes of death or health risk factors were eliminated will help set the priorities of prevention and health improvement.

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