Measuring the burden of major cancers due to smoking in Korea

Heeyoung Lee, Seok-Jun Yoon[1] and Hyeong-Sik Ahn

Department of Preventive Medicine, College of Medicine, Korea University, 126-1, 5-ka, Anam-dong Sungbuk-ku, Seoul 136-705, Korea

Morbidity and mortality are classically used to measure disease burden. However, the allocation of limited health-care resources demands an agreed rational allocation principle and, consequently, the setting of priorities is of considerable importance. We collected data from the national death certificate database, and the national health insurance claim database and life tables. Using this data, we calculated disability adjusted life year (DALY) and health life year (HeaLY) values for smoking-related cancer. The burden of cancer due to smoking was estimated by multiplying the population attributable risk due to smoking by the DALY and HeaLY results for cancers. The burden of cancer due to smoking for Korean men was 1930.1 person-years by DALY and 1681.3 person-years by HeaLY per 100 000 people. Similarly, the burden of cancer due to smoking for Korean women was 352.6 person-years for DALY and 313.6 person-years for HeaLY per 100 000 people. Priority rankings for cancer burden due to smoking was somewhat different by DALY and HeaLY. The largest health gap for men was stomach cancer by DALY and lung cancer by HeaLY, whereas for women it was lung cancer by both methods. This study provides a rational basis for national cancer policy planning by presenting the priority burden of cancers caused by smoking. (*Cancer Sci* 2006; 97: 530–534)

Cigarette smoking is the single major factor responsible for the elevated prevalence of cancer and, thus, the death rate due to cancer. Cigarette smoke is the single most important addressable cause of disease burden and contains some 4000 chemicals, many of which are toxins known to cause malignant tumors,[1–4] respiratory[5–7] and circulatory diseases,[8] and to increase the risk of miscarriage and birth deformities. Therefore, smoking is now widely regarded as the most unhealthy behavior engaged in by the general population.[9]

The Korean Association of Smoking and Health estimates that the number of deaths due to smoking-related diseases is approximately 35 000 per annum, and that the economic loss due to premature death caused by smoking-related diseases exceeded 3 trillion won (approximately US$ 2.5 billion) in Korea in the year 2000.[10] Unfortunately, the smoking rate among Korean men is one of the highest in the world.[11]

Of all cancer-related deaths, 35.1% (28.2% due to lung cancer and 6.9% to other cancers) are attributable to smoking.[12] Thus, one-third of all cancers that result in death are caused by smoking. Moreover, in 1999, the burden of premature death due to smoking was 57.7% in men and 11.4% in women in Korea.[9]

As for the classical methods of measuring population actual health status, the typical indices used are morbidity and mortality.[13] However, the allocation of limited health-care resources demands an agreed rational allocation principle, and consequently priority setting is of considerable importance.[13,14]

Recently, the World Health Organization (WHO) developed global burden of disease methodology and recommended that summary measure of population health indicators (SMPH) be used to measure burden of disease.[15] Major representative SMPH indicators consist of health gap indicators and health expectancy indicators. The representative health gap indicators used are disability adjusted life year (DALY) and health adjusted life year (HeaLY), and the representative health expectancy indicators are disability free life expectancy (DFLE), health adjusted life expectancy (HALE) and disability adjusted life expectancy (DALE).[15]

Given this background, the present study was carried out to measure the burden of major cancers attributable specifically to smoking using the health gap indicators (DALY and HeaLY) in Korea.

Materials and Methods

To estimate the disease burden of major cancers in Korea, we followed four steps. First, we selected smoking-related diseases by systematic review. Second, we estimated smoking-related attributable risks using relative risks and age-specific smoking rates. Third, we estimated some of the epidemiological indicators of major cancers, such as incidence and case fatality rates. Fourth, using the above results, we calculated the DALY and HeaLY values of major cancers in Korea.

Selection of smoking-related cancers
The selection of smoking-related diseases included for the Korean population was based on a systematic review according to level of evidence. For decision-making concerning the levels of evidence, we decided on inclusion criteria by consensus between three researchers and then reviewed the collected levels of evidence. Thus, we selected 12 smoking-related cancer diseases, and the Korean population aged 35 years and older was chosen as the study population, as the

[1]To whom correspondence should be addressed. E-mail: yoonsj02@korea.ac.kr

lag time of the effects of smoking is believed to be 20 or more years after initial exposure.[9]

Calculation of DALY for cancer

To estimate years of life lost due to premature death (YLL) in 2001, we developed estimates of population and deaths by each age group and sex. Estimates of cause-specific mortalities were based on vital registration data, maintained by the National Statistical Office (NSO). Age group-specific YLL was estimated using standard expected years of life lost (SEYLL), and the final burden of cancer due to premature death was estimated by applying the YLL function, as suggested by the Global Burden of Disease study group.[16]

To estimate years lived with disability (YLD), epidemiological parameters were estimated as follows. First, to estimate incidence rates, nationwide social health insurance claim data for the period 1998–2001 was converted to person-based health utilization data from claim-based data. Patients that sought health care for a particular cancer for the first time in 2001 were considered as incident cases. Incidence rates were calculated by dividing the number of incident cases by population size.

Second, to estimate case fatality rates, numbers of deaths due to each cancer type were divided by the number of incident cases. In order to generate the case fatality rate, this study used a 2001 NSO statistical release in which the causes of death specified on death certificates were classified and totaled.[17] This NSO study divided the number of deaths in 2001 by the incidence cases in 2001 to calculate the case fatality rate associated with each of the diseases, which was then adjusted to the population, according to age groups.

Third, the DISMOD method developed by GBD researchers[16] was used to estimate the expected duration of disability and the average age at onset. The Global Burden of Disease (GBD) study emphasized the importance of internal consistency of epidemiological estimates for specific causes. The computer model called 'DISMOD' was developed to ensure internal consistency and to model the association among incidence, remission, fatality and prevalence. Under the DISMOD model, it is assumed that any individual or group that is susceptible to a specific disease at a certain point in time will trigger the incidence of the disease as they become infected. The model further explains that the YLD equals the burden of disease obtained by excluding remission rate, deaths from general mortality and cause-specific death rate or case fatality rate from incidence rate.

The final burden of disease due to disability caused by cancer was estimated using years lived with disability function supplied by the Global Burden of Disease study group.[16] Using YLL and YLD results, the DALY values of the major cancers in Korea were summed.

Calculation of HeaLY for cancers

To calculate HeaLY values, we estimated incidence rate, case fatality rate, average age at onset and death, expectation of life at age of onset and death, case disability ratio, extent of disability and duration of disability.[18]

To determine incidence and case fatality rates, we used the above estimated DALY results. Average ages at onset and death and expectation of life at age of onset and death were estimated using nationwide social health insurance claim, death certificate and life table data maintained by the National Statistical Office. To determine case disability ratios we used previous study results, for durations of disabilities we used formula described previously,[19] and for extent of disability we used disability weight determined by WHO.[16]

Estimation of Population Attributable Risk (PAR) of major cancers due to smoking

To calculate PAR values due to smoking, three parameters should be considered: (i) the number of deaths; (ii) the relative risks of smoking for different smoking-related cancers; and (iii) smoking rates. The number of deaths classified by age, gender and cause are published in the annual report of the National Statistical Office. The relative risks of smoking for selected cancers, with the exception of stomach and liver cancer, were obtained from a cancer prevention study carried out in the USA.[12]

Because the epidemiological characteristics of stomach and liver cancer in the Orient differ from in the Occident, the relative risks of smoking for stomach and liver cancer were obtained from the Hirayama Study carried out in Japan.[20,21] Smoking rates in the Korean population by age and sex were extracted from the results of the national health survey conducted by the Ministry of Health and Welfare in 2000.[22]

PAR values of smoking-related cancers of a chronic degenerative nature and an average lag time of 20 years were applied.[9] Finally, the PAR values of DALY and HeaLY due to smoking were calculated by multiplying PAR values by DALY and HeaLY results.

Results

Based on the DALY method per 100 000 people in the Korean population, cancer burden priorities due to smoking in Korean men were: stomach (497.8 person-years), trachea, lung and bronchus (480.9 person-years), liver (255.4 person-years), colorectal (225.9 person-years) and esophageal (182.9 person-years) (Table 1).

For Korean women, again based on the DALY method per 100 000 people in the Korean population, burden priorities were: trachea, lung and bronchus (96.9 person-years), esophageal (67.7 person-years), stomach (64.6 person-years), lip, oral cavity and pharynx (33.0 person-years) and cervical (29.9 person-years) (Table 1).

Based on the HeaLY method per 100 000 people in the Korean population, burden priorities for Korean men were: trachea, lung and bronchus (489.7 person-years), stomach (306.8 person-years), liver (227.7 person-years), esophageal (219.8 person-years) and colorectal (148.1 person-years) (Table 2).

For Korean women, the HeaLY method yielded: trachea, lung and bronchus (85.0 person-years), stomach (80.5 person-years), esophageal (58.1 person-years), liver (23.5 person-years) and cervical (22.0 person-years) (Table 2).

The DALY and HeaLY methods showed some differences in terms of these ranking priorities, and in particular these methods differed for Korean men, between stomach and trachea, lung and bronchial cancer, between colorectal

Table 1. Disability adjusted life year (DALY) results of major cancers due to smoking in Korea (2001)

Cancer	Men					Women				
	YLL		YLD		DALY	YLL		YLD		DALY
	n	%	n	%		n	%	n	%	
Lip, oral cavity, pharynx	23.6	23.5	76.9	76.5	100.5	1.6	4.9	31.3	95.1	33.0
Esophagus	62.2	34.0	120.7	66.0	182.9	3.3	4.9	64.4	95.1	67.7
Pancreas	32.4	61.5	20.3	38.5	52.7	6.3	90.1	0.7	9.9	7.0
Larynx	30.7	74.6	10.5	25.4	41.2	3.7	62.8	2.2	37.2	5.9
Trachea, lung, bronchus	409.5	85.2	71.4	14.8	480.9	71.0	73.5	25.6	26.5	96.6
Cervix uteri	NA		NA		NA	3.6	12.0	26.3	88.0	29.9
Urinary bladder	13.0	23.2	43.1	76.8	56.2	1.0	45.8	1.2	54.2	2.2
Kidney, other urinary	11.9	32.4	24.7	67.6	36.6	0.3	26.2	0.8	73.8	1.1
Stomach	251.1	50.4	246.7	49.6	497.8	37.4	57.8	27.3	42.2	64.6
Liver	132.3	51.8	123.1	48.2	255.4	5.5	20.0	22.0	80.0	27.5
Colorectal	35.5	15.7	190.4	84.3	225.9	4.1	25.2	12.2	74.8	16.3
Total	1000.2	51.8	927.8	48.2	1930.1	137.8	39.2	214.0	60.8	351.8

Units are person-years per 100 000 people. NA, not applicable; YLD, years lived with disability; YLL, years of life lost.

Table 2. Healthy life years lost (HeaLY) results of major cancers due to smoking in Korea (2001)

Cancer	Men					Women				
	YHLLpm		YHLLd		YHLL	YHLLpm		YHLLd		YHLL
	n	%	n	%		n	%	n	%	
Lip, oral cavity, pharynx	19.8	20.6	76.4	79.4	96.2	1.2	7.6	14.9	92.4	16.1
Esophagus	46.9	21.3	172.9	78.7	219.8	2.4	4.1	55.7	95.9	58.1
Pancreas	27.6	48.1	29.7	51.9	57.3	4.1	63.5	2.3	36.5	6.4
Larynx	22.7	43.1	29.9	56.9	52.5	2.7	48.9	2.8	51.1	5.5
Trachea, lung, bronchus	311.8	63.7	177.9	36.3	489.7	47.1	55.5	37.8	44.5	84.9
Cervix uteri	NA		NA		NA	2.7	12.3	19.3	87.7	22.0
Urinary bladder	0.0	0.0	28.9	100.0	39.7	0.6	38.7	1.0	61.3	1.6
Kidney, other urinary	10.8	20.0	34.5	80.0	43.5	0.2	18.6	0.7	81.4	0.9
Stomach	160.6	51.7	146.3	48.3	306.8	20.3	25.2	60.2	74.8	80.5
Liver	69.9	30.7	157.8	69.3	227.7	3.0	12.7	20.5	87.3	23.5
Colorectal	20.3	13.7	127.8	76.3	148.1	2.4	17.1	11.7	82.9	14.1
Total	699.3	41.6	982.0	58.4	1681.3	86.7	27.6	226.9	72.4	313.6

Units are person-years per 100 000 people. NA, not applicable; YHLL, years of healthy life lost; YHLLd, years of healthy life lost due to disability; YHLLpm, years of healthy life lost from premature mortality.

and esophageal cancer, and between cancer of the urinary bladder, pancreas and larynx (Table 3). In Korean women, the priorities differed between esophageal and stomach cancer, and between lip, oral cavity, pharyngeal and cervical cancer (Table 4).

Discussion

The present study measured the burden of major cancers due to smoking using DALY and HeaLY indicators in Korea. These two indicators, which are composite measures of the summation of time lost due to premature death and time lived with disability, have positively influenced health policy making in developing countries since the introduction of these indicators.[23]

Some potential applications of these indicators are indicated below.[15,16] First, comparisons of population health are possible for different health systems. Second, these indicators can

Table 3. Comparison of burden of major cancers due to smoking in Korean men (2001)

Cancer	DALY	DALY rank	HeaLY	HeaLY rank
Stomach	497.8	1	306.8	2
Trachea, lung, bronchus	480.9	2	489.7	1
Liver	255.4	3	227.7	3
Colorectal	225.9	4	148.1	5
Esophagus	182.9	5	219.8	4
Lip, oral cavity, pharynx	100.5	6	96.2	6
Urinary bladder	56.2	7	43.5	9
Pancreas	52.7	8	57.3	7
Larynx	41.2	9	52.5	8
Kidney, other urinary	36.6	10	39.7	10

Units are person-years per 100 000 people. DALY, disability adjusted life years; HeaLY, healthy life years lost.

Table 4. Comparison of burden of major cancers due to smoking in Korean women (2001)

Cancer	DALY	DALY rank	HeaLY	HeaLY rank
Trachea, lung, bronchus	96.6	1	85.0	1
Esophagus	67.7	2	58.1	3
Stomach	64.6	3	80.5	2
Lip, oral cavity, pharynx	33.0	4	16.1	6
Cervix uteri	29.9	5	22.0	5
Liver	27.5	6	23.5	4
Colorectal	16.3	7	14.1	7
Pancreas	7.0	8	6.4	8
Larynx	5.9	9	5.5	9
Urinary bladder	2.2	10	1.7	10
Kidney, other urinary	1.1	11	0.9	11

Units are person-years per 100 000 people. DALY, disability adjusted life years; HeaLY, healthy life years lost.

monitor changes in population health. Third, they facilitate appropriate and balanced consideration of the effects of non-fatal health outcomes on overall population health. Fourth, they provide information on priorities for health service delivery and planning.

The results of the present study show that the rankings of major cancer burdens due to smoking as assessed by DALY and HeaLY differ. For example, the burden ranking of cancers due to smoking in Korean men per 100 000 people using DALY (expressed in person-years) was stomach cancer (497.8), lung (480.9), liver (255.4), colorectal (225.9) and esophageal (182.9), whereas by HeaLY it was lung (489.7), stomach (306.8), liver (227.7), esophageal (219.8) and colorectal (148.1). Of these cancers, the burdens of stomach and lung cancer were particularly high, and exceeded 300 person-years per 100 000 people (Tables 3,4). These results indicate that cancer burden due to lung and stomach cancer caused by smoking is higher than the burden attributable to smoking for other cancers in Korea.

Although DALY and HeaLY were used to determine the burden of disease, these indicators have some differences.[18,24] First, diseases that afflict the young receive more weight in DALY than in HeaLY. Second, in HeaLY, healthy life lost is based on all disease with an onset in a given year, and on-going life lost due to disability and death thereafter in accordance with the natural history of a disease. However, in DALY, disability is calculated in an equivalent fashion but termed 'life years lived with disability', whereas mortality is considered for all deaths in the current year regardless of the date of onset.

The present study shows that disease burden by HeaLY is less than burden by DALY except for cancers of the pancreas, larynx and kidney. This phenomenon seems to be derived from the above differences. The present study also shows that mortality and prevalence rate rankings differ from burden of disease rankings in Korea. This phenomenon can be explained by the process of adjusting smoking rates and relative risks.[22]

The present study has the following limitations. First, some anomalies associated with the data used in this study should be mentioned, for example, the fact that the medical electronic data used to estimate incidence and the number of patients affected may not be in accordance with actual named diagnoses because they are based on insurance data. However, compared to the results of previous studies on estimated incidence,[13,26] the estimated incidences used in the present study showed similar rates in terms of major types of cancer in Korea. The current tendency to document cases at a more severe level due to the need to claim medical insurance by providers raises the possibility that incidences could have been overestimated according to the medical data utilized.[13]

The computerized causes of death data system is not entirely accurate because death certification is only issued by physicians in approximately 50–60% of cases,[17] and even when a diagnosis is made by a physician there is sometimes a discrepancy between recorded and actual cause of death.[27] In addition, because the relative risks of smoking have not been thoroughly investigated in Korea, relative risk data used in the present study were derived from previous studies carried out in the USA and Japan, and thus, may not accurately represent the Korean situation.[9]

However, despite limitations of the data sources used in the present study, the results indicate that lung, liver and stomach cancer in Korean men and lung, esophageal and stomach cancer in Korean women show particularly high disease burdens due to smoking.

Acknowledgments

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