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Disease burden estimates for lung cancer in Japan

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Objective: Prioritization within the healthcare policy system requires illness-specific data on disease burden, and decisions on future policies must be made in light of current and future assessments of disease burden. The present study aimed to clarify issues and challenges for disease burden predictions by analyzing disability-adjusted life years (DALY) data from Japan in a lung cancer model.
Methods: After extracting data from existing resources, we used sex- and age group-specific data for total death rates, lung cancer death and prevalence rates, disease duration, and recovery rates to calculate disease burden according to DALY for patients in the year 2000. We then used the Poisson regression method to estimate disease prevalence rate through 2037.
Results: Estimated DALY for lung cancer in males showed a gradual increase that leveled off by 2035, whereas that for women showed a constant increase through 2035. The proportion of DALY that comprised years of life with disability (YLD) gradually increased in both sexes, but both the absolute proportion and rate of increase were higher for women (9.97% and 12.63% in males and females, respectively, in 2000, and 13.70% and 21.84%, respectively, in 2035).
Conclusions: The present report used a model of patients with lung cancer, a disease for which the data are relatively organized, as a way to estimate future disease burden according to DALY. The results show that the estimated values are relatively compatible with previous estimates using a structural model, although the YLD accounts for a higher proportion. Future studies should clarify and compare estimated disease burdens for various illnesses to contribute to healthcare policy construction and implementation.

Key words: global burden of disease (GBD), estimates, disease burden, disability-adjusted life years (DALY), lung cancer

Introduction

Policymakers require data on disease burden as they work to prioritize within the medical care policy system. In 1996, Murray[1] conducted research on global burden of disease (GBD), using 1990 data for disability-adjusted life years (DALY) as an index of disease burden for various diseases worldwide, and to estimate disease burden for 2000, 2010, and 2020. Many studies[2-5] since then have referred to Murray's results, which estimated that HIV/AIDS, depression, and ischemic heart disease would be the top three diseases worldwide in terms of DALY. The effects of these findings are also reflected in various publications and policies that have been published or constructed since then. Murray's estimates were made using regression methods with smoking rate, income, and human capital as explanatory variables. Death rate predictions could thus be made by geographical region, sex, and disease. In 2006, Lopez and Mathers[2] expounded upon Murray's methods, adding new data to make similar estimates through 2030. Both methods of analyses effectively determined GBD estimates, for which the epidemiological data for death rate and disease prevalence are limited. However, for estimates pertaining to regions where specific epidemiological data are available, in our opinion, Murray's methods, or those of Lopez and Mathers, may not necessarily be the most appropriate. In order to determine future medical care cost estimates for Australia, Vos[6] used a Poisson regression model to calculate disease and morbidity prevalence estimates.

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To contribute to prioritization of healthcare measures and policies, we surmised that disease burden for nonfatal illnesses should also be included in calculations of future disease burden for various diseases. By making the calculations in this manner, we hope to estimate illness-specific disease burden in Japan according to DALY. In the present study, we aimed to investigate the possibility and challenges of accurately estimating DALY in Japan by using an epidemiological model.

Methods

Estimated lung cancer DALY for 2000

Our DALY calculations mostly followed Murray's methods,[1] but we also referred to an Australian study on disease burden published by the Public Health Division, Victorian Government Department of Human Services[7] for specifics. We also obtained an Excel worksheet to calculate DALY values from a collaborator at Queensland University, which allowed a careful analysis of the methodology involved. After determining the data required for DALY calculations, we collected the available data in Japan.

Construction of the epidemiologic model

We created an epidemiologic model for lung cancer. The Australian studies had established 9 conditions for lung cancer such as those shown in Table 1, and had established mean disease duration for each stage. Radiation therapy was not included in the model because one of the objectives of this study was to compare the estimate using an epidemiologic model with that of a structural model as of the year 2000. Their model differentiated between non-small cell lung carcinomas and small cell lung carcinomas, a delineation which is fairly consistent with data published in Japan. However, duration for diagnosis and chemotherapy for small cell lung carcinoma are typically set at 3-6 month cycles in Japan.[8] We felt that the 2-month cycles in their model were too short and changed them to 6-month cycles in the present study (Figure 1).

Disability weight

To calculate DALY values, the degree of disability must be specified as disability weight (DW), which ranges from 0 to 1, where death is 1 and complete health is 0. Original data from Japan were not available for DW, so we referred to the Australian research, and used Dutch

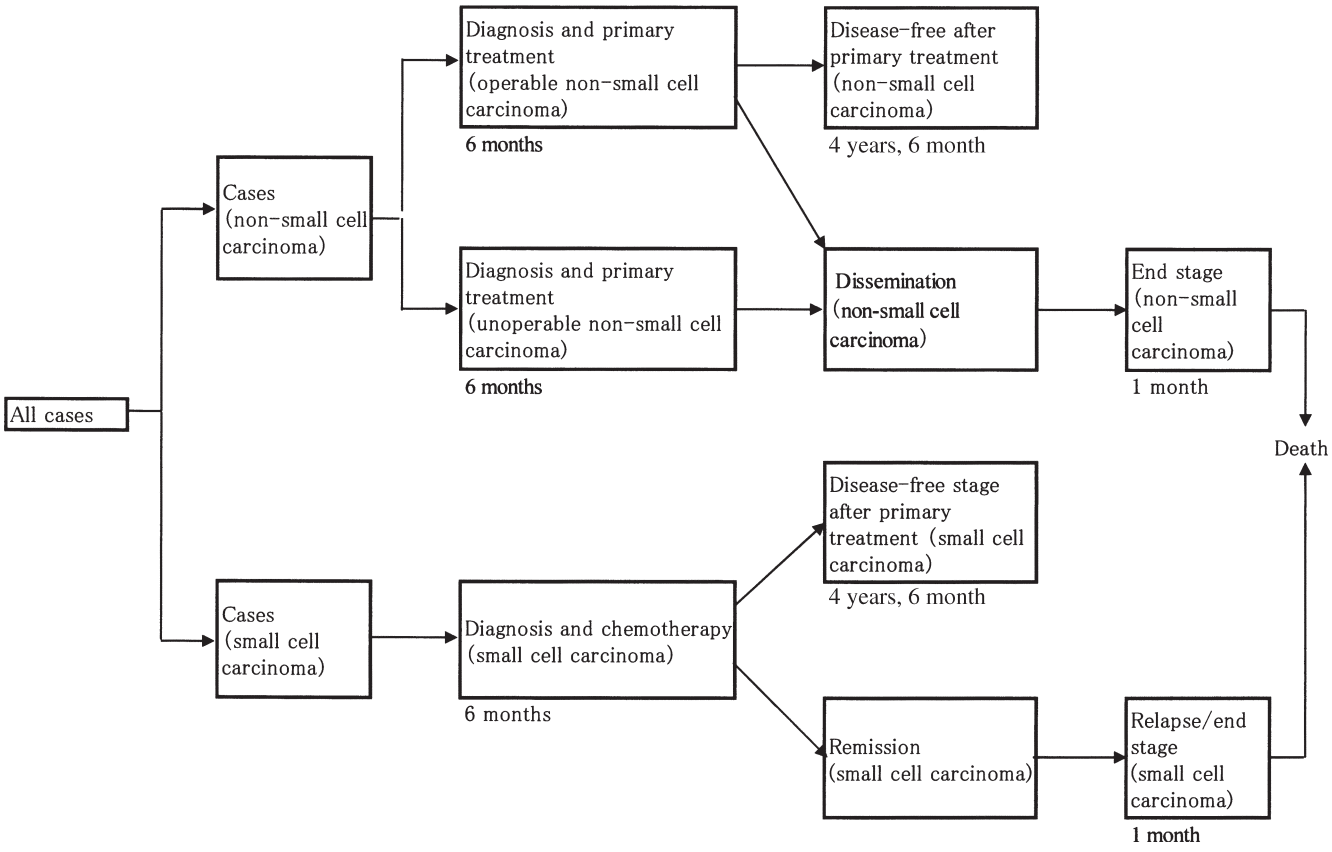


Figure 1. Epidemiologic model of lung cancer

DW values[9] to characterize the 9 conditions used in the present study (Table 1).

Data collection and specification

The years of life with disability (YLD) values for each of the 9 conditions were calculated using data from existing databases on the following items: sex- and 5-year incremental age group-specific disease prevalence, mean age at disease onset, mean disease duration, proportion of operable patients, proportion with small cell lung cancer, mean recovery rate for non-small cell lung cancer, and mean recovery rate for small cell lung cancer. We obtained data on lung cancer disease prevalence (Table 2) and death rates from the National Cancer Center homepage,[10] and extracted rates of small cell lung cancer (Table 3) from the literature.[11] Total death rates and population values were extracted from the Population Survey Report (year 2000)[12] and population census (year 2000). Finally, mean disease duration (Table 4) and mean age at onset (Table 5) were estimated using the epidemiologic software DisMoD II.[13] Data from Japan on average remission rates, which mean the percentage of recovery in 1 year, for non-small cell lung cancer (Table 6) and small cell lung cancer (Table 7) and the proportion of operable patients were unavailable; therefore, we used data from the Australian study.

Table 1. Disability weigh

Condition	Weight	Sources
Diagnosis and primary treatment (operable non-small cell carcinoma)	0.440	Dutch disability weight
Disease-free stage after primary treatment (non-small cell carcinoma)	0.470	Dutch disability weight
Diagnosis and primary treatment (unoperable non-small cell carcinoma)	0.760	Dutch disability weight
Dissemination（non-small cell carcinoma）	0.910	Dutch disability weight
End stage（non-small cell carcinoma）	0.930	Dutch weight for end stage disease
Diagnosis and chemotherapy （non-small cell carcinoma）	0.680	Dutch disability weight
Disease-free stage after primary treatment (small cell carcinoma)	0.470	Dutch disability weight
Remission（small cell carcinoma）	0.540	Dutch disability weight
Replase/end stage (small cell carcinoma)	0.930	Dutch weight for end stage disease

Table 2. Incidence of lung Cancer (1998)

	Males	Females
0-4	0.0	0.0
5-9	0.0	0.1
10-14	0.0	0.1
15-19	0.1	0.1
20-24	0.1	0.1
25-29	0.2	0.6
30-34	0.9	1.2
35-39	4.1	2.7
40-44	9.8	5.1
45-49	20.4	11.4
50-54	34.8	18.4
55-59	67.4	32.9
60-64	120.9	40.5
65-69	246.1	64.5
70-74	397.1	88.3
75-79	491.0	121.9
80-84	611.5	156.5
85+	601.0	177.9

Source: National Cancer Center
Source: Jpn J Clin Oncol 2003: 33; 241-5.

Table 3. Proportion of small cell carcinoma (1988-97)

	Males	Females
0-9	0.0%	0.0%
10-19	33.3%	0.0%
20-29	24.0%	11.8%
30-39	12.4%	9.0%
0-39	14.0%	9.2%
40-49	14.9%	6.5%
50-59	19.3%	9.3%
60-69	21.2%	15.1%
70-79	20.0%	18.5%
80-89	18.5%	11.8%
90-	18.3%	6.5%

Source: Jpn J Cancer Res 2002: 93; 15-23.

Table 4. Average duration (years)

Condition	Duration
Diagnosis and primary treatment (operable non-small cell carcinoma)	0.500
Disease-free stage after primary treatment (non-small cell carcinoma)	4.500
Diagnosis and primary treatment (unoperable non-small cell carcinoma)	0.500
Dissemination (non-small cell carcinoma)	variable
End stage (non-small cell carcinoma)	0.083
Diagnosis and chemotherapy (non-small cell carcinoma)	0.500
Disease-free stage after primary treatment (small cell carcinoma)	4.500
Remission (small cell carcinoma)	variable
Replase/end stage (small cell carcinoma)	0.083

Table 4-2. Average duration of non-small cell carcinoma (years)

	Age			
	0-54	55-64	65-74	75+
Males	0.50	0.72	0.58	0.14
Females	0.75	1.10	0.83	0.18

Table 4-3. Average duration of remission of small cell carcinoma (years)

	0-54	55-64	65-74	75+
Males	0.30	0.27	0.09	0.00
Females	0.47	0.49	0.20	0.00

Table 5. Average age at onset

	Males	Females
0-4	2.2	2.8
5-9	8.8	7.8
10-14	13.2	12.6
15-19	17.9	17.5
20-24	22.8	22.9
25-29	27.9	27.9
30-34	33.0	32.8
35-39	37.9	37.8
40-44	42.8	42.8
45-49	47.8	47.8
50-54	52.7	52.7
55-59	57.7	57.7
60-64	62.8	62.6
65-69	67.7	67.7
70-74	72.6	72.6
75-79	77.6	77.6
80-84	82.6	82.6
85+	88.5	88.8

Estimated with DisMoD II

Table 6. Average remisson rate of small cell carcinoma

	Males	Females
0-4	6.7%	6.8%
5-9	6.7%	6.8%
10-14	6.7%	6.8%
15-19	6.7%	6.8%
20-24	6.7%	6.8%
25-29	6.7%	6.8%
30-34	6.7%	6.8%
35-39	6.7%	6.8%
40-44	6.7%	6.8%
45-49	6.7%	6.8%
50-54	6.7%	6.8%
55-59	4.9%	5.2%
60-64	4.9%	5.2%
65-69	2.9%	3.2%
70-74	2.9%	3.2%
75-79	1.8%	2.0%
80-84	1.8%	2.0%
85+	1.8%	2.0%

Source: Australian National Burden of Disease Study

Table 7. Average remission rate of non-small cell carcinoma

	Males	Females
0-4	13.6%	17.7%
5-9	13.6%	17.7%
10-14	13.6%	17.7%
15-19	13.6%	17.7%
20-24	13.6%	17.7%
25-29	13.6%	17.7%
30-34	13.6%	17.7%
35-39	13.6%	17.7%
40-44	13.6%	17.7%
45-49	13.6%	17.7%
50-54	13.6%	17.7%
55-59	8.0%	10.9%
60-64	8.0%	10.9%
65-69	6.0%	7.2%
70-74	6.0%	7.2%
75-79	5.8%	5.6%
80-84	5.8%	5.6%
85+	5.8%	5.6%

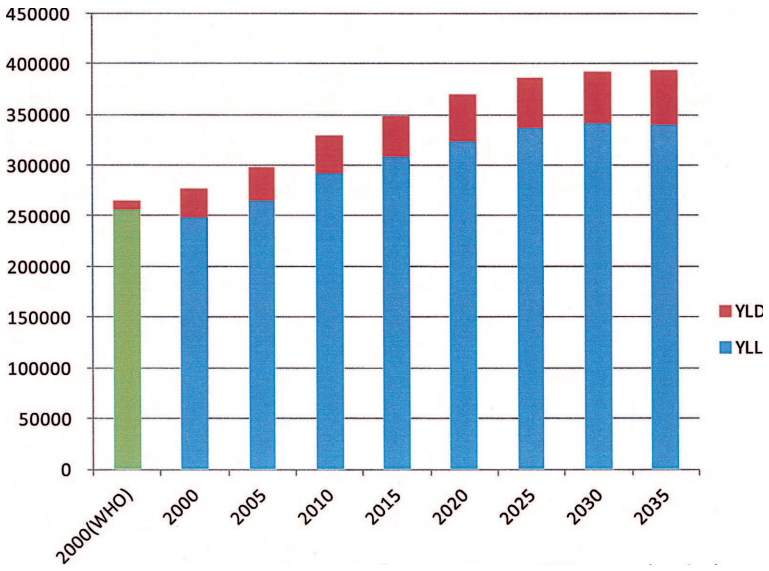
Source: Australian National Burden of Disease Study

Calculation of DALY values

DALY values are the sum of YLL (years of life lost) and YLD. Each was calculated separately, and then the two were added to determine the DALY. We also used the 3% weight for time discounting and age-weighting employed by Murray et al. in their model.

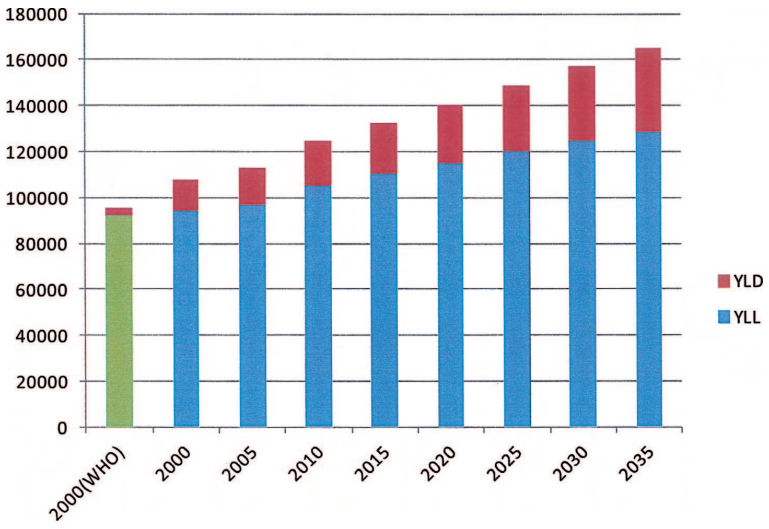
DALY estimates through 2035

To estimate DALY for lung cancer in 5-year increments through 2035, we first ran a Poisson regression analysis on sex and 5-year incremental age class-specific death rates for 1987-2006, and on the number of lung cancer cases for 1987-2002, extrapolated through 2037. We then used the estimates on the death rate, disease prevalence, and population (assuming low birth rate, medium death rate)[12] to calculate DALY values for each year, assuming that disease model, disease duration, and disability weight (DW) remained constant. In the younger age groups (0-19 years), in which relatively few cases were available for analysis, we used the mean of the reference period.



Note: "2000 (WHO)" indicates the values estimated using the "structural model" by the World Health Organization

Figure 2. Estimated DALY of lung cancer in 2000-2035 (Males)



Note: "2000 (WHO)" indicates the values estimated using the "structural model" by the World Health Organization

Figure 3. Estimated DALY of lung cancer in 2000-2035 (Females)

Results

Lung cancer DALY values for Japan in 2000 were 270,182 for males and 104,849 for females. For both sexes, YLL was 90%, and the majority was due to death-related loss. Gradual increases that leveled off around 2035 were observed for the 5-year incremental DALY estimates among males, while DALY estimates among females increased at a constant rate through 2035. Proportion of DALY comprising the YLD showed gradual increases in both sexes, but the absolute proportion and rate of increase were higher in females (9.97% and 12.63% in males and females, respectively, in 2000, and 13.70% and 21.84%, respectively, in 2035) (Figures 2, 3).

Discussion

Many studies have predicted future disease burden for various diseases.[14-17] However, all of these did so by simply extrapolating past data on death rates and morbidity. The previously mentioned GBD research employed a structural model, established death rate-related explanatory variables such as income and smoking rate, and incorporated estimated changes in these explanatory variables for their estimates on changes in death rate. Mathers et al.[18] built upon this particular methodology but added new data so that DALY estimates could be made through 2030. Their regression model employed GDP (per capita) and human capital to estimate sex-, age group-, and disease-specific death rates as explanatory variables. They also added smoking rate as an explanatory variable to predict death rates due to cancer, circulatory diseases, and respiratory diseases. With regard to their explanatory variables aside from the smoking rate (GDP per capita and human capital), the authors state, "These are distal determining factors, but actually explain a fair amount of the variability in death rate ($R^2 > 0.25$)." In addition, although "tracheal, bronchial, and lung cancer" was the ninth highest illness-related cause of death worldwide in 2002, it is estimated to be the sixth highest in 2030. In contrast, the illness-specific disease burden (by DALY) in 2030 is estimated to be highest for HIV/AIDS, depression, ischemic heart disease, traffic accidents, perinatal illnesses, and cerebrovascular diseases (in that order), and did not include "tracheal, bronchial, or lung cancer" among the top 15.

The disease-specific future medical cost estimate research conducted by Vos et al.[6] in Australia used an epidemiologic model as we did, and estimated death rates, disease prevalence, and morbidity. With regard to cancer, Vos et al.[6] assumed that all changes in the death rate were due to changes in morbidity, and assumed no change in the lethality rate as a result of improved medical care. As a result, their estimates predict an increase in lung cancer cases from 2003 to 2033 from 8,734 to 13,333, but age-adjusted morbidity decreases by half in males, while that for females stays constant, reflecting effects of population growth.

Our results showed that lung cancer DALY for males increased gradually and leveled off by 2035, while that for females showed a gradual but constant increase through 2035. We surmise that this is due to changes in smoking rates. The proportion of DALY comprising YLD and the rate of increase was also much higher than that observed for males. The main reasons for this may include a higher level of aging, as well as the longer disease duration following treatment for those who are treated. Our results also showed that the higher proportion of DALY comprising YLD compared the previous estimates using the structural model by the WHO. The reason for this can also be explained by the longer disease duration of lung cancer in Japan.

Regardless of the type of model (structural or epidemiological), any dramatic improvement in medical technology, or changes in risk factors such as smoking or obesity, will significantly affect the estimate outcomes. For example, if population and morbidity do not change, improvements in medical diagnostic and treatment technologies would lead to a lower lethality rate, which would in turn decrease the YLL, thereby increasing the YLD. In addition, a decrease in risk factors would lead to lower morbidity, and therefore an overall lower DALY.

The present study used lung cancer as a model system to calculate future disease burden estimates according to DALY values. These were based not only on death rates but on disability as well. As we utilized a simplified and epidemiological model, the results contain many uncertainties, and future studies should run sensitivity analyses on several scenarios that employ variation in estimated morbidity and case-fatality rates as well as collecting those values by conducting more descriptive epidemiologic studies. Determination of disease burden estimates for other diseases will also allow for comparisons across various illnesses, which will likely be useful for healthcare policymakers.

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