

Special Article

Open Access

Prediction of Cancer Incidence and Mortality in Korea, 2012

Kyu-Won Jung, MS¹
Sohee Park, PhD¹
Young-Joo Won, PhD¹
Hyun-Joo Kong, MS¹
Joo Young Lee, MD¹
Hong Gwan Seo, MD, PhD²
Jin-Soo Lee, MD, PhD¹

¹The Korea Central Cancer Registry,
 Division of Cancer Registration and
 Surveillance, ²National Cancer Control
 Institute, National Cancer Center,
 Goyang, Korea

Purpose

To estimate the current cancer burden in Korea, cancer incidence and mortality rates were projected for the year 2012.

Materials and Methods

The cancer incidence data from 1999 to 2009 were obtained from the Korea National Cancer Incidence Database, and the cancer mortality data from 1993 to 2010 were obtained from Statistics Korea. Cancer incidence in 2012 was projected by fitting a linear regression model on observed age-specific cancer incidence rates against observed years, then multiplying the projected age-specific rates by the age-specific population. For cancer mortality, a similar procedure was applied, except that a *Joinpoint* regression model was used to determine at which year the linear trend significantly changed.

Results

A total of 234,727 new cancer cases and 73,313 cancer deaths are projected to occur in Korea in 2012. For all sites combined, the crude incidence rates are projected to be 465.6 and 459.7, and the age-standardized incidences to be 345.1 and 300.9 per 100,000 respectively for males and females.

Conclusion

Cancer has become an important public health concern in Korea, and as the Korean population ages, the cancer burden will continue to increase.

Key words

Incidence, Mortality, Neoplasms, Prediction, Korea, 2012

Correspondence: Sohee Park, PhD
 The Korea Central Cancer Registry,
 Division of Cancer Registration and Surveillance,
 National Cancer Center, 323 Ilsan-ro,
 Ilsandong-gu, Goyang 410-769, Korea
 Tel: 82-31-920-2015
 Fax: 82-31-920-2179
 E-mail: shpark@ncc.re.kr
 Received March 2, 2012
 Accepted March 5, 2012

Introduction

Since 1983, as the leading cause of death [1], cancer has become a major public health concern in Korea. Annually, over 190,000 patients are newly diagnosed with cancer in Korea, and one out of four deaths is due to cancer [2,3]. Although the cancer registration system in Korea is very efficient and can provide nationwide cancer statistics within a relatively short time, at least a 2-year lag is still required for accurate data collection and compilation. To plan and apply a cancer control program, it is

important to assess the number of new cases and deaths that are expected to occur during the current year. In this report, we provide the projected cancer incidence and mortality ratio based on the data up to 2009.

Materials and Methods

The Korean Ministry of Health and Welfare initiated a nationwide, hos-

pital-based cancer registry (the Korea Central Cancer Registry [KCCR]) in 1980. The details of the history, objectives, and activities of the KCCR have been documented elsewhere [4]. Incidence data from 1999 to 2009 were obtained from the Korea National Cancer Incidence Database (KNCI DB). Cancer cases were classified according to the International Classification of Diseases for Oncology, 3rd edition [5] and converted according to the International Classification of Diseases, 10th edition (ICD-10) [6].

Mortality data from 1993 to 2010 were obtained from Statistics Korea [1]. The cause of death was coded and classified according to ICD-10.

The cancer sites included in this report are (i) all cancers combined and (ii) the 22 most common cancers: lip, mouth, and pharynx (C00-C14), esophagus (C15), stomach (C16), colon and rectum (C18-C20), liver and intrahepatic bile duct (liver) (C22), gallbladder and other parts of biliary tract (gallbladder) (C23-C24), pancreas (C25), lung and bronchus (lung) (C33-C34), breast (C50), uterine cervix (C53), uterine corpus (C54), ovary (C56), prostate (C61), testis (C62), kidney (C64), bladder (C67), brain and central nervous system (C70-C72), thyroid (C73), Hodgkin lymphoma (C81), non-Hodgkin lymphoma (C82-C85, C96), multiple myeloma (C90), leukemia (C91-C95), and all others.

Population data were obtained from the resident registration population reported by Statistics Korea. The mid-year population on July 1 of the respective year was applied when computing the incidence and deaths.

Due to the time required for data collection and analysis, incidence and mortality data are available is usually 2-3 years behind the current year. As such, we projected the expected number of new cancer cases and deaths in Korea in the current year to provide an estimate of the current cancer burden.

Linear regression models [7] were used to assess the time trend and the projection of rates. Based on the observed cancer incidence data, a linear regression model was fitted to the age-specific rates by 5-year age group against observed years. From the projected age-specific rates in 2012, the estimated number of cancer cases was calculated by multiplying the rates by 2012's projected age-specific population size. For thyroid and prostate cancer, which showed significant curvilinear trends, we used a square root

transformation when fitting a linear regression model and converted the predicted values back to the original scale.

To estimate the number of cancer deaths in 2012, we first ran a *Joinpoint* regression model on the data for 1993-2010 to detect the year of significant changes in the trend of cancer mortality by sex and cancer site. A *Joinpoint* regression describes changes in data trends by connecting several different line segments on a log scale at "joinpoints." This analysis was performed using the Joinpoint software (version 3.3, <http://srab.cancer.gov/joinpoint>) from the Surveillance Research Program of the National Cancer Institute in the USA [8]. After identifying the year of significant trend changes using Joinpoint regression analysis, a simple linear regression model was fitted to the last line segment to estimate age-specific cancer mortality rates in 2012. Similar to the method used for the projection of cancer incidence, the number of new deaths was then projected by multiplying the age-specific cancer mortality rates by 2012's projected age-specific population.

We summarized the results using the crude rates (CRs) and age-standardized rates (ASRs) of cancer incidence and mortality. The ASRs were standardized using the World Health Organization (WHO) world standard population [9].

Results

1. Incidence

Table 1 presents the estimated number of new cancer cases and deaths during 2012 in Korea by sex and cancer site. It is projected that 234,727 cases of cancer incidence will occur in 2012.

Table 2 presents the estimated CRs and ASRs of cancer incidence in 2012 by sex and cancer site. The CRs of all sites combined in males and females respectively in 2012 are projected to be 465.6 and 459.7 per 100,000, and the ASRs of all sites combined are projected to be 345.1 and

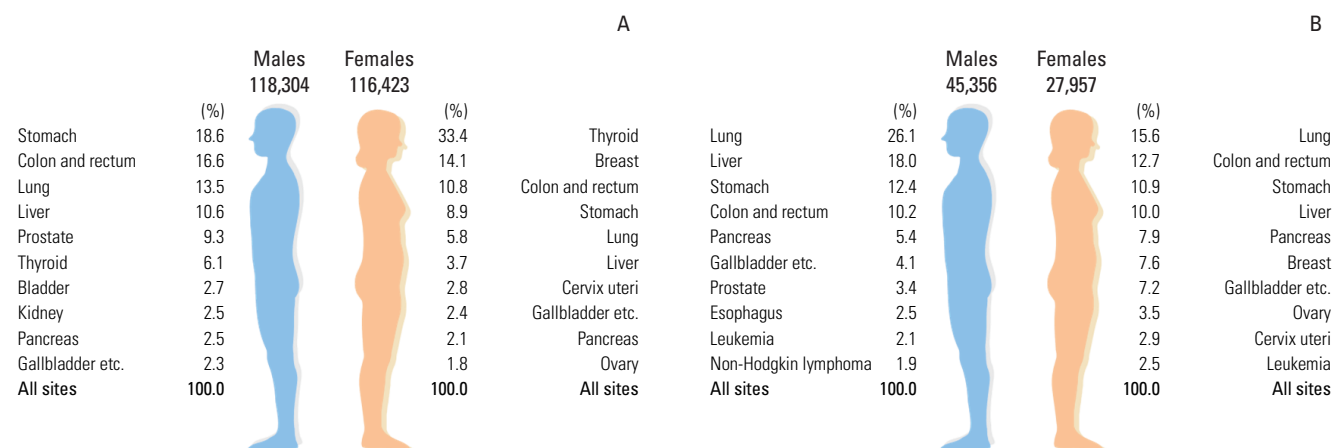
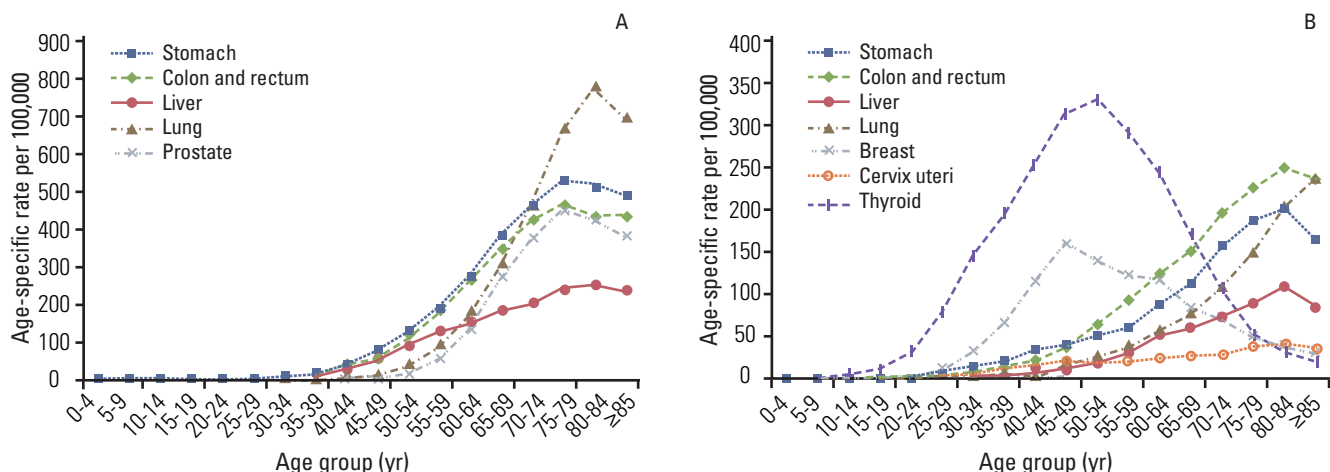


Fig. 1. The 10 leading types of estimated new cancer cases and deaths by gender in 2012. (A) Estimated new cases. (B) Estimated deaths.

Table 1. Estimated new cancer cases and deaths by gender during 2012 in Korea

Sites	Estimated new cases			Estimated deaths		
	Both genders	Male	Female	Both genders	Male	Female
All sites	234,727	118,304	116,423	73,313	45,356	27,957
Lip, oral cavity, and pharynx	2,801	2,102	699	1,024	754	270
Esophagus	2,262	2,075	187	1,223	1,139	84
Stomach	32,455	22,054	10,401	8,685	5,630	3,055
Colon and rectum	32,215	19,669	12,546	8,195	4,648	3,547
Liver	16,910	12,585	4,325	10,973	8,186	2,787
Gallbladder ^{a)}	5,481	2,697	2,784	3,884	1,879	2,005
Pancreas	5,396	2,911	2,485	4,663	2,445	2,218
Larynx	1,077	1,036	41	226	210	16
Lung	22,737	15,991	6,746	16,168	11,819	4,349
Breast	16,436	63	16,373	2,146	16	2,130
Cervix uteri	3,292	-	3,292	819	-	19
Corpus uteri	2,085	-	2,085	259	-	259
Ovary	2,124	-	2,124	987	-	987
Prostate	11,016	11,016	-	1,540	1,540	-
Testis	215	215	-	18	18	-
Kidney	4,310	2,949	1,361	846	558	288
Bladder	3,969	3,185	784	1,026	737	289
Brain and CNS	1,837	975	862	1,061	575	486
Thyroid	46,021	7,158	38,863	360	100	260
Hodgkin lymphoma	253	160	93	41	26	15
Non-Hodgkin lymphoma	4,506	2,502	2,004	1,493	865	628
Multiple myeloma	1,236	648	588	841	424	417
Leukemia	2,885	1,609	1,276	1,676	964	712
Other and ill defined	13,208	6,704	6,504	5,159	2,823	2,336

CNS, central nervous system. ^{a)}Includes gallbladder and other/unspecified parts of the biliary tract.

**Fig. 2.** Projected age-specific incidences of major cancers during 2012 in Korea. (A) Male. (B) Female.

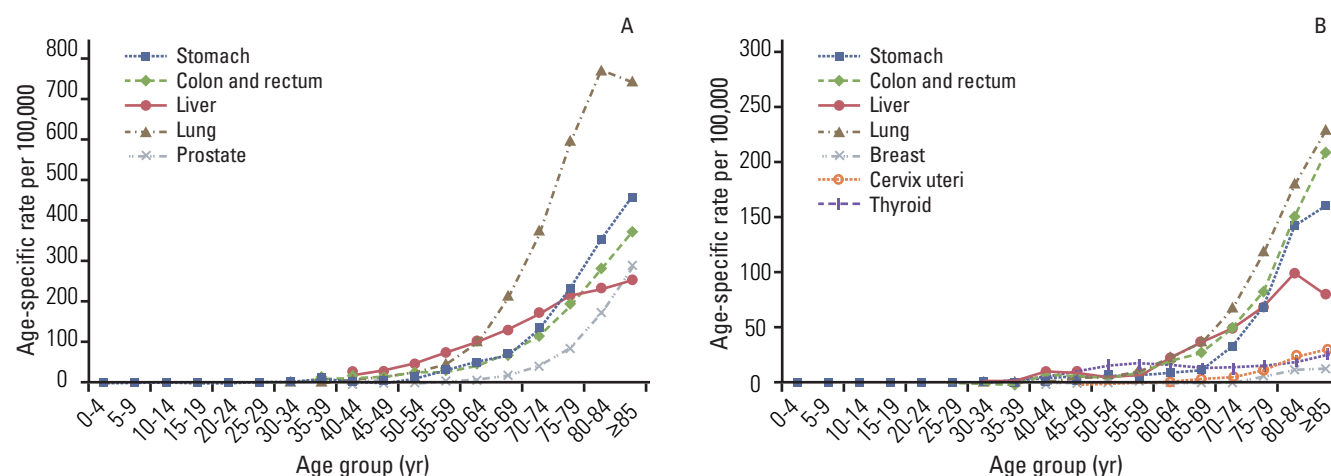
300.9 per 100,000. In males, the five leading primary sites of cancer are expected to be the stomach (CR, 86.8; ASR, 63.2), colon and rectum (CR, 77.4; ASR, 56.7), lung (CR, 62.9; ASR, 46.6), liver (CR, 49.5; ASR, 35.6), and prostate (CR, 43.4; ASR, 32.5), accounting for 68.7% of all newly

diagnosed cancers in 2012. In females, the most common cancer sites are expected to be thyroid (CR, 153.4; ASR, 109.4), breast (CR, 64.6; ASR, 44.1), colon and rectum (CR, 49.5; ASR, 29.5), stomach (CR, 41.1; ASR, 24.7), lung (CR, 26.6; ASR, 14.7), and liver (CR, 17.1; ASR, 10.0), ac-

Table 2. Estimated crude and age-standardized cancer incidences by gender during 2012 in Korea

	Crude incidence rates/100,000			Age-standardized incidence rates/100,000 ^{a)}		
	Both genders	Male	Female	Both genders	Male	Female
All sites	462.7	465.6	459.7	312.5	345.1	300.9
Lip, oral cavity, and pharynx	5.5	8.3	2.8	3.8	6.0	1.9
Esophagus	4.5	8.2	0.7	2.9	6.1	0.4
Stomach	64.0	86.8	41.1	42.1	63.2	24.7
Colon and rectum	63.5	77.4	49.5	41.9	56.7	29.5
Liver	33.3	49.5	17.1	22.0	35.6	10.0
Gallbladder ^{b)}	10.8	10.6	11.0	6.7	7.9	5.7
Pancreas	10.6	11.5	9.8	6.7	8.4	5.3
Larynx	2.1	4.1	0.2	1.4	3.0	0.1
Lung	44.8	62.9	26.6	28.2	46.6	14.7
Breast	32.4	0.2	64.6	22.2	0.2	44.1
Cervix uteri	6.5	-	13.0	4.4	-	8.5
Corpus uteri	4.1	-	8.2	2.8	-	5.5
Ovary	4.2	-	8.4	3.0	-	5.8
Prostate	21.7	43.4	-	14.1	32.5	-
Testis	0.4	0.8	-	0.4	0.8	-
Kidney	8.5	11.6	5.4	5.9	8.5	3.5
Bladder	7.8	12.5	3.1	4.9	9.2	1.6
Brain and CNS	3.6	3.8	3.4	3.1	3.4	2.7
Thyroid	90.7	28.2	153.4	64.5	20.1	109.4
Hodgkin lymphoma	0.5	0.6	0.4	0.4	0.5	0.3
Non-Hodgkin lymphoma	8.9	9.8	7.9	6.4	7.7	5.4
Multiple myeloma	2.4	2.6	2.3	1.6	1.9	1.4
Leukemia	5.7	6.3	5.0	5.1	6.0	4.4
Other and ill defined	26.0	26.4	25.7	18.1	20.7	15.9

CNS, central nervous system. ^{a)}Age adjusted to the World Health Organization world standard population, ^{b)}Includes gallbladder and other/unspecified parts of biliary tract.

**Fig. 3.** Projected age-specific mortality rates of major cancers during 2012 in Korea. (A) Male. (B) Female.

counting for 76.7% of all newly diagnosed cancers (Fig. 1). Thyroid cancer alone is projected to account for 33.4% (38,863 cases) of incident cases in females in 2012.

Table 3 presents the most common cancer sites expected in 2012 by sex and age group. Leukemia and thyroid cancer are projected to be the most common forms of cancer in both sexes for the 0-14 and 15-34 age

Table 3. Estimated cancer incidence by age group and sex during 2012 in Korea

Rank	Age group (yr)			
	0-14	15-34	35-64	≥ 65
Male				
1	Leukemia (4.9)	Thyroid (12.2)	Stomach (98.2)	Lung (479.0)
2	Brain and CNS (2.4)	Leukemia (3.2)	Colon and rectum (86.6)	Stomach (449.8)
3	Non-Hodgkin lymphoma (1.8)	Non-Hodgkin lymphoma (2.9)	Liver (65.9)	Colon and rectum (404.0)
4	Kidney (0.5)	Colon and rectum (2.8)	Thyroid (47.9)	Prostate (350.5)
5	Testis (0.4)	Stomach (2.5)	Lung (41.3)	Liver (207.2)
Female				
1	Leukemia (4.0)	Thyroid (68.5)	Thyroid (272.4)	Colon and rectum (198.8)
2	Brain and CNS (2.0)	Breast (11.2)	Breast (119.4)	Stomach (154.9)
3	Non-Hodgkin lymphoma (1.0)	Cervix uteri (4.9)	Colon and rectum (49.9)	Lung (129.8)
4	Ovary (0.7)	Stomach (4.3)	Stomach (43.1)	Thyroid (96.5)
5	Kidney (0.5)	Colon and rectum (2.7)	Lung (20.6)	Liver (76.7)

CNS, central nervous system.

groups. Gastric cancer is predicted to be the most common cancer in males 35-64 years of age, whereas lung cancer is predicted to be more frequent for males ≥ 65 years of age. Thyroid cancer is predicted to be the most common cancer for females 35-64 years of age, whereas colorectal cancer is predicted to be the most common cancer for females ≥ 65 years of age. Fig. 2 shows the age-specific incidence rates of the selected cancers for men and women in 2012. The projection indicates that the incidence of gastric, lung, liver, and colorectal cancers will increase gradually with age. In women, the age-specific incidence rates of breast and thyroid cancer will increase with age until the 5th and 6th decades of life, and then level off.

2. Mortality

It is estimated that 73,313 cancer deaths will occur in Korea during 2012 (Table 1). The CRs of all sites combined in 2012 respectively for males and females are projected to be 178.5 and 110.4 per 100,000, and the ASRs of all sites combined are expected to be 135.8 and 59.0 per 100,000 (Table 4).

In 2012, the five leading cancer sites causing mortality in males are predicted to be lung (CR, 46.5; ASR, 34.4), liver (CR, 32.2; ASR, 23.5), stomach (CR, 22.2; ASR, 16.4), colon and rectum (CR, 18.3; ASR, 13.7), and pancreas (CR, 9.6; ASR, 7.1). During the same time period, in fe-

males, lung cancer (CR, 17.2; ASR, 8.7) is projected to be the leading cancer site causing mortality, followed by cancers of the colon and rectum (CR, 14.0; ASR, 7.1), stomach (CR, 12.1; ASR, 6.1), liver (CR, 11.0; ASR, 6.0), and pancreas (CR, 8.8; ASR, 4.5).

Fig. 3 shows the age-specific predicted mortality rates of the selected cancers for males and females in 2012. When examined by age, Korean males > 60 years of age are expected to have the highest mortality rates from liver cancer, followed by lung cancer. In contrast, Korean females > 55 years of age are expected to have the highest mortality rates from breast cancer, followed by lung cancer.

Conclusion

This report provides the estimated nationwide cancer incidence and mortality in Korea for the current year. A total of 234,727 new cancer cases and 73,313 cancer deaths are expected in Korea during 2012. In Korean males, gastric, colorectal, lung, liver, and prostate cancers are estimated to have the highest rates of incidence, while lung, liver, gastric, colorectal, and pancreatic cancers are estimated to be the most common causes of cancer-related deaths. In Korean females, thyroid, breast, colorectal, gastric, and lung cancer are estimated to have the highest rates of

Table 4. Estimated crude and age-standardized cancer mortality rates by gender during 2012 in Korea

Sites	Crude incidence rates/100,000			Age-standardized incidence rates/100,000 ^{a)}		
	Both genders	Male	Female	Both genders	Male	Female
All sites	144.5	178.5	110.4	89.7	132.8	59.0
Lip, oral cavity, and pharynx	2.0	3.0	1.1	1.3	2.1	0.6
Esophagus	2.4	4.5	0.3	1.5	3.3	0.1
Stomach	17.1	22.2	12.1	10.4	16.4	6.1
Colon and rectum	16.2	18.3	14.0	9.8	13.7	7.1
Liver	21.6	32.2	11.0	14.0	23.5	6.0
Gallbladder ^{b)}	7.7	7.4	7.9	4.5	5.5	3.8
Pancreas	9.2	9.6	8.8	5.7	7.1	4.5
Larynx	0.4	0.8	0.1	0.3	0.6	0.0
Lung	31.9	46.5	17.2	19.3	34.4	8.7
Breast	4.2	0.1	8.4	2.8	0.0	5.4
Cervix uteri	1.6	-	3.2	1.0	-	1.8
Corpus uteri	0.5	-	1.0	0.3	-	0.6
Ovary	1.9	-	3.9	1.2	-	2.3
Prostate	3.0	6.1	-	1.7	4.7	-
Testis	0.0	0.1	-	0.0	0.1	-
Kidney	1.7	2.2	1.1	1.0	1.6	0.6
Bladder	2.0	2.9	1.1	1.1	2.2	0.5
Brain and CNS	2.1	2.3	1.9	1.5	1.8	1.3
Thyroid	0.7	0.4	1.0	0.4	0.3	0.5
Hodgkin lymphoma	0.1	0.1	0.1	0.1	0.1	0.0
Non-Hodgkin lymphoma	2.9	3.4	2.5	1.9	2.6	1.3
Multiple myeloma	1.7	1.7	1.6	1.0	1.2	0.9
Leukemia	3.3	3.8	2.8	2.4	3.0	1.9
Other and ill defined	10.2	11.1	9.2	6.4	8.4	5.0

CNS, central nervous system. ^{a)}Age adjusted to the World Health Organization world standard population, ^{b)}Includes gallbladder and other/un-specified parts of biliary tract.

incidence, while lung, colorectal, stomach, liver, and pancreas cancers are estimated to be the most common causes of cancer-related deaths.

Cancer has become an important public health concern in Korea, and as the population continues to age, the cancer burden will continue to increase. The estimated cancer statistics of the current year given in this report represent an important resource to plan and evaluate cancer-control programs. The estimates in this report, however, are projected numbers based on statistical models and may vary from year to year; hence, these estimates should be used with caution.

Conflicts of Interest

Conflict of interest relevant to this article was not reported.

Acknowledgments

This work was supported by a research grant from the National Cancer Center (No. 1010160) and National Health Promotion Program grants (Nos. 1160390 and 1160400) from the Ministry of Health and Welfare, Republic of Korea.

References

1. Statistics Korea, 2012 [Internet]. Daejeon: Statistics Korea; 2012 [cited 2012 Jan 14]. Available from: <http://kostat.go.kr>.
2. Ministry of Health and Welfare. 2009 annual report of cancer statistics in Korea. Seoul: Ministry of Health and Welfare; 2011.
3. Won YJ, Sung J, Jung KW, Kong HJ, Park S, Shin HR, et al. Nationwide cancer incidence in Korea, 2003-2005. *Cancer Res Treat*. 2009;41:122-31.

4. Shin HR, Won YJ, Jung KW, Kong HJ, Yim SH, Lee JK, et al. Nationwide cancer incidence in Korea, 1999–2001: first result using the national cancer incidence database. *Cancer Res Treat*. 2005;37:325–31.
5. Fritz A, Percy C, Jack A, Shanmugaratnam K, Sobin L, Parkin DM, et al. International classification of diseases for oncology. 3rd ed. Geneva: World Health Organization; 2000.
6. World Health Organization. Manual of the international statistical classification of diseases, injuries, and causes of death. 10th rev. Geneva: World Health Organization; 1992.
7. Boyle P, Parkin DM. Statistical methods for registries. In: Jensen OM, Parkin DM, MacLennan R, Muir CS, Skeet RG, editors. *Cancer registration: principles and methods*. IARC Scientific Publication No. 95. Lyon: IARC; 1991. p. 126–58.
8. National Cancer Institute. Joinpoint Regression Program, version 3.3 [Internet]. Bethesda, MD: National Cancer Institute; 2012 [cited 2012 Jan 6]. Available from: <http://srab.cancer.gov/joinpoint/>.
9. Segi M. Cancer Mortality for selected sites in 24 countries (1950–1957). Sendai: Tohoku University School of Medicine; 1960.