Comparative Analysis of Cancer Mortality Rates between Korea and Japan for Radiation-induced Cancer Risk Projection

Seunghee Lee[ab], Juyoul Kim[b], Eun-Hee Kim[a*]
[a] *Dept. of Nuclear Engineering, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Korea (Rep. of)*
[b] *FNC Technology Co., Ltd., 32F, 13, Heungdeok 1-ro, Giheung-gu, Yongin, Korea (Rep. of)*
[*] *Corresponding author: eunhee@snu.ac.kr*

1. Introduction

Fukushima nuclear power plant accident in 2011 has provoked attention of the public to the chance of cancer incidence and its mortality. There are several cancer risk models to use for estimating excess risk and lifetime risk of cancer incidence and its mortality attributed to radiation exposure. National and international organizations such as United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), National Academy of Sciences (NAS), International Commission on Radiological Protection (ICRP), and United States Environmental Protection Agency (US EPA) participated in development of those models and assessment of the validity.

Derivation of the cancer risk models was based mainly on the Life Span Study (LSS) data of Japanese atomic bomb survivors released by the Radiation Effects Research Foundation (RERF). Applying the cancer risk of the bomb survivors from Hiroshima and Nagasaki to any other population has a limitation in that both populations possibly have different baseline cancer rates, genetic characteristics, and life-styles. ICRP 103 mentioned that there is an approximate relationship between excess absolute risk (EAR_{LSS}) and excess relative risk (ERR_{LSS}) for the Japanese as shown in the Equation (1) and the ERR_{LSS} and the EAR_{LSS} are projected to the population of US by the Equations (2) [1]:

$$EAR_{LSS} = ERR_{LSS} \times B_{Japan} \quad (1)$$
$$EAR_{LSS} = ERR_{LSS} \times 12 \times B_{US} \quad (2)$$

where B_{Japan} and B_{US} are the baseline cancer rates for the populations of Japan and US, respectively. Difference of the US population in baseline cancer rate from the Japanese population was roughly corrected by the factor of 12.

The risk projection, a process of converting ERR_{LSS} or EAR_{LSS} to ERR or EAR of another population, can be made in two ways: multiplicative risk projection and additive risk projection. Multiplicative risk projection assumes that ERR is constant, for example ERR = ERR_{LSS}, regardless of the nationality. In additive risk projection, EAR of the population of interest is equal to EAR_{LSS}. The combination of multiplicative and additive risk projection is applied to derive ERR or EAR of the population of interest.

In this study, we investigated the cancer mortality rate in Korea in comparison with that in Japan as a preliminary analysis for applying a proper combination of risk projection methods in developing Korean-specific cancer risk models.

2. Material and Methods

2.1. Data sources

The Korean age-specific cancer mortality rates, defined by ($\frac{Counts\ in\ age\ group}{Population\ in\ age\ group} \times 100{,}000$), from 1983 to 2015 were obtained from Korean Statistical Information Service (KOSIS) and the Japanese datasets from 1950 to 2014 were accessible via National Cancer Center Japan [2,3]. According to the cancer mortality rates in 2014, the major cancerous deaths in Korea and Japan are attributed to stomach cancer (International Classification of Diseases-C16), colon and rectum cancer (ICD-C18~20), liver cancer (ICD-C22), lung and trachea cancer (ICD-C34), and breast cancer for only female (ICD-C50). We analyzed the mortality rates for all cancers (ICD-C00~95) including the major 5 cancers and leukemia (ICD-C91~95).

2.2. Age-standardized Rate

Comparison between the populations of Korea and Japan was made in terms of age-standardized rates (ASRs) of cancer mortality. Age-standardized rate is obtained by adjusting the age structure of a population to a common age distribution structure, so-called a "*standard population*." In this study, we used the world standard population from Segi (1960) [4].

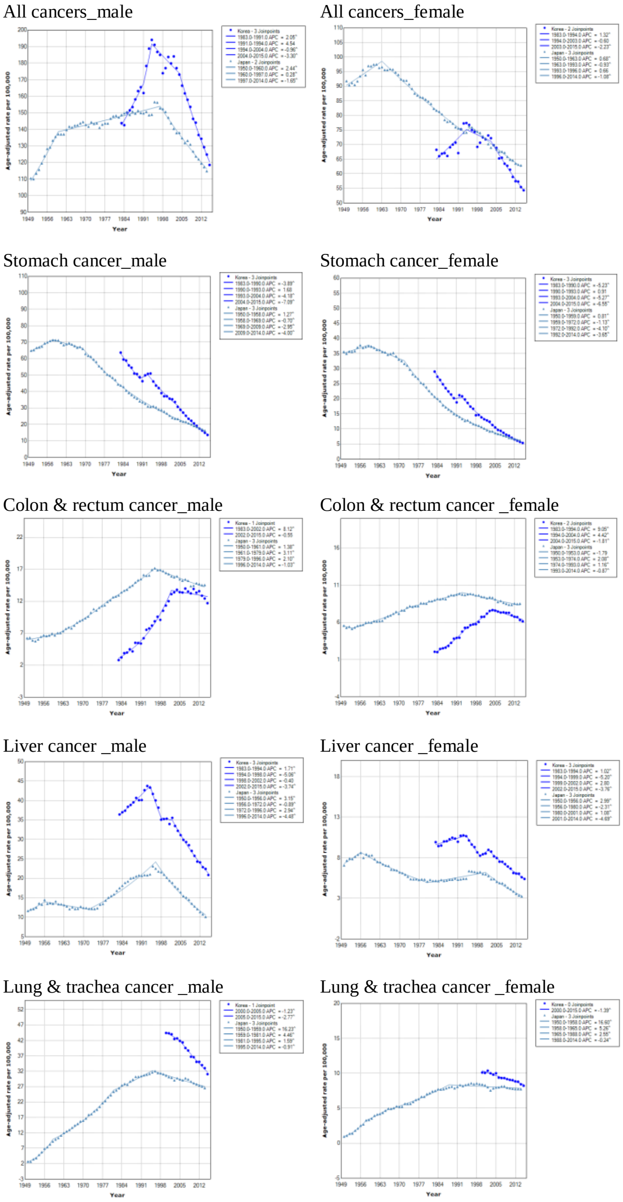
2.3. Joinpoint Regression Analysis

We analyzed the ASRs of cancer mortality in Korea and Japan using a joinpoint regression analysis software (Version 4.5.0.1, National Cancer Institute, USA) with maximum 3 joinpoints. In joinpioint regression analysis, several straight lines were fit to the ASRs on a logarithmic scale and the slope of each line was expressed as Annual Percentage Change (APC). APC informs the long-term trend of ASRs of cancer mortality and the degree of increase or decrease per year [5].

3. Results

3.1. ASR Trend

Fig. 1 shows the sex-specific ASRs of major cancer mortalities: all cancers, stomach cancer, colon and rectum cancer, liver cancer, lung and trachea cancer, leukemia and breast cancer. During the recent years, the cancer mortality rates have been decreasing except female breast cancer. Although the comparison of the ASRs between Korea and Japan during the earlier years was not possible due to lack of data, the trend of ASRs decreasing in recent years was consistent in Korea and Japan. Overall, the cancer mortality rates decreased faster in Korea than in Japan. The absolute values of APCs during the last period in Korea were greater than those in Japan with all the cancers except liver cancer for male and female and colon and rectum cancer for male.



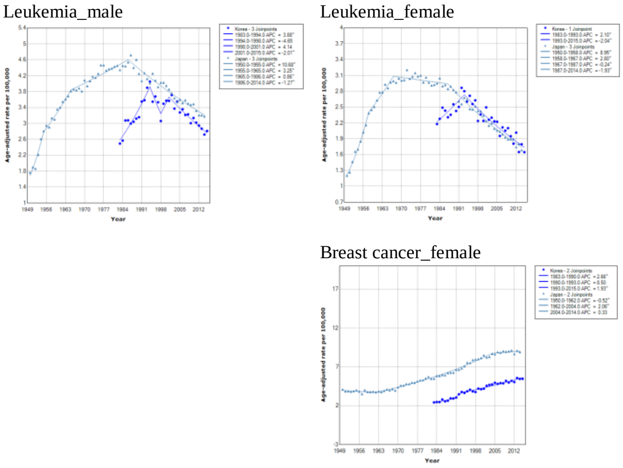
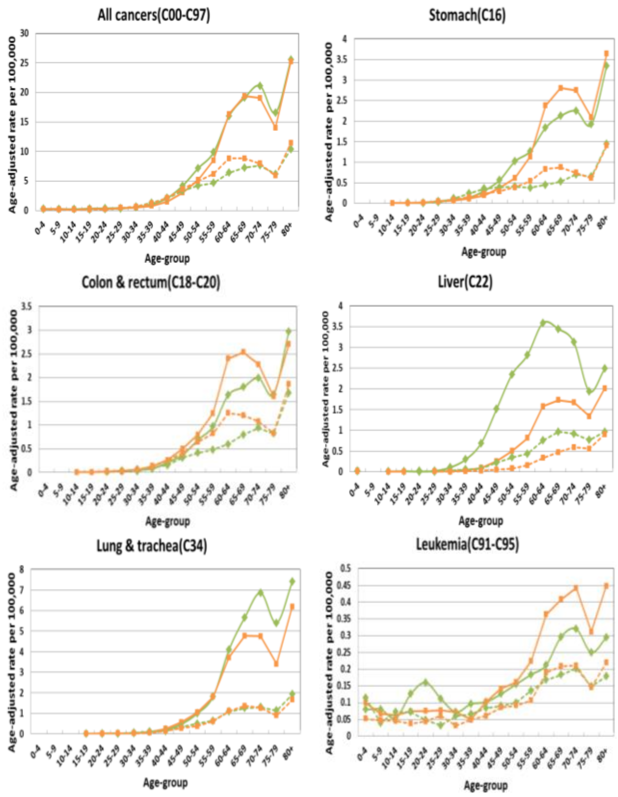


Fig. 1. Age-standardized mortality rates of Korea (blue circle) from 1983 to 2015 and Japan (sky-blue triangle) from 1950 to 2014: male (left) and female (right).

3.2. Age-specific Cancer Mortality Ratio

Fig. 2 presents the age-specific cancer mortality rates adjusted by the age distribution of standard populations of Korea and Japan in 2014. The whole population was categorized into 17 age groups. There were little differences between Korea and Japan and also between male and female in age groups younger than 30s and even the greatest difference between Korea and Japan was less than 2 per 100,000. Greater difference was attributed to the male data than female data.



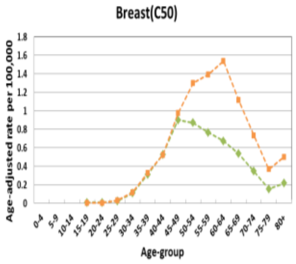


Fig. 2. Age-specific cancer mortality rates of Korea (green) and Japan (orange) in 2014: male (solid lines) and female (dashed lines).

The age-specific cancer mortality ratio was defined as Equation (3) and the maximum and minimum values are listed in Table 1.

$$\text{Ratio} = \frac{Age\text{−}specific\ Korean\ mortality\ rate}{Age\text{−}specific\ Japanese\ mortality\ rate} \quad (3)$$

Koreans show higher mortality rates in liver and lung & trachea cancers, but lower mortality rates in stomach, colon & rectum, and breast cancers, and leukemia as compared to Japanese. The cancer mortality of male Koreans was higher by approximately 7.39 times at most than that of male Japanese whereas the female Korean mortality was higher by approximately 4.48 times at most than that of female Japanese.

Table I: Maximum and minimum age-specific cancer mortality ratios of Korea and Japan in 2014.

Cancer site	Male		Female	
	Min	Max	Min	Max
All cancers	0.90	1.48	0.72	1.69
Stomach cancer	0.44	1.67	0.54	1.60
Colon & rectum cancer	0.38	1.12	0.43	1.58
Liver cancer	0.35	7.39	0.79	4.48
Lung & trachea cancer	0.78	3.03	0.45	2.39
Leukemia	0.58	2.12	0.53	2.19
Breast cancer	-	-	0.42	2.91

4. Summary

In this study, we made comparisons of major cancer mortality rates in Korea with those in Japan as a preceding work for risk projection from Japanese to Korean population. The latest trends of cancer mortality rates were similar between Korea and Japan: decreasing in all cancers except breast cancer for female. Furthermore, we investigated the discrepancies in cancer mortality baseline rates between Korea and Japan. These data will be employed to develop a Korean-specific radiation-induced cancer risk model.

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