The Open Public Health Journal

Content list available at: https://openpublichealthjournal.com

RESEARCH ARTICLE

Exploring Mortality Rates for Major Causes of Death in Korea

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Abstract:

Background:

The trends and patterns of the mortality rates for causes of death are meaningful information. They can provide a basis for national demographic and health care policies by identifying the number, causes, and geographical distribution of deaths.

Objective:

To explore and analyze the characteristics of the mortality rates for major causes of death in Korea.

Methods:

Some common data analysis methods were used to describe the data. We also used some visualization techniques such as heat maps and line plots to present mortality rates by gender, age, and year.

Results:

Our analysis shows the crude mortality rates have continually decreased over the last 25 years from 1983, though they have increased slightly since 2006. In addition, the top eight causes of death accounted for 80% of all Korean deaths in 2015. During the period 2005-2015, the leading cause of death was cancer in male and circulatory diseases in female. The trend for respiratory diseases shows a steep upward trend in males, while a similar trend can be observed for respiratory and nervous system diseases in females.

Conclusion:

The deaths for circulatory, respiratory, nervous system, digestive, and infectious diseases are the highest in the age 80 to 84, while cancer is the leading cause of death for ages 75 to 79. In addition, the mortality rates for circulatory, nervous, and respiratory dis-eases increase rapidly after the age of 80. Therefore, policies on health and welfare for the elderly are getting more and more important.

Keywords: Mortality, Causes of death, Temporal trends, Data visualization, Health policy, Korea.

1. INTRODUCTION

The mortality rate is one of the indicators that reflect the health status of a population [1]. The proportion of the number of deaths in a country to its total population has steadily declined in most regions of the world [2 - 4]. Korea is no exception, experiencing substantial drops of its mortality rates, though there is a slight reversal in the trend since 2010 [5]. Life expectancy at birth in Korea saw a dramatic increase from 52.4 in 1960 to 82.3 years in 2015 [6]. The major reasons for mortality rates reductions are attributed to continuous impro-vements in public health measures [5] and the standard of living along with easy access to various medical services.

However, as Lim *et al.* [7] stated, to speed up the favorable

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trend in the overall mortality, understanding cause-specific mortality rates and their temporal trends seem necessary. The trends and patterns of mortality rates for major causes of death are potentially useful not just for clinicians and researchers seeking to improve health and reduce high risk factors in the medical scene, but also for public health officials because they identify the number, causes, and geographical distribution of deaths, providing a basis for national demographic and health care policies. Examining the changes that occur in the causes of death over a long period of time may even provide some insights regarding how to cope with issues of public health and welfare in developing countries as well as in other countries [8].

The aim of this study is to explore and analyze the characteristics of the mortality rates for major underlying causes of death in Korea. For this purpose, we analyze and visualize Korea's death data. First, we explore the patterns of death by seasons and months, and examine the mortality rate for each cause of death. Second, we analyze frequencies of deaths according to gender and age and investigate the causes that affect most Korean deaths. Lastly, we visualize mortality rates using various graphs including heat map plots, with which we can better explore and understand the relationships between the variables and secular trends, which are inherent in the data. The features and main contributions of this study can, therefore, be summarized as follows: We present the mortality rate patterns for major causes of Korean deaths, which may serve as a reference for the government to establish strategies on the prevention of disease and grasp indirectly the demand of health medicine. Furthermore, we use some visualization techniques including heat maps to investigate the information and associations among the variables. With these visualizations, we can provide a clearer and more accurate understanding of death data.

2. MATERIALS AND METHODS

2.1. Data Sources

Public health data are constructed from different sources *e.g.*, birth and death records, medical records, interview surveys, or through direct physical examinations and laboratory testings. The National Statistics Office (NSO) of South Korea aggregates demographic trends every month. The National Health Insurance Service (NHIS) and the Ministry of Health and Welfare (MOHW) report the statistics on health examination and community health indicators every year, respectively.

In South Korea, the medical certification of death is not mandatory and there may be a problem with the quality of death statistics data for several reasons. Korean death statistics have been perceived as less reliable until the late 1990s [9]. The Korean government, however, has attempted to make various changes to the death registration since 1999. *e.g.*, they have expanded the link to the registered death database to other databases. As the result of these efforts, the quality of the death statistics and the accuracy of identifying the underlying causes have improved [9, 10], and the erroneous misclassification of cause of death has decreased [11]. The underlying cause of death was specifically defined as the disease or injury that

initiated the train of morbid events leading directly to death or the circumstances of the accident or violence that produced the fatal injury [12].

To analyze and visualize mortality rates, we collected relevant data for the period 2005-2015 from the micro data service and 1983-2015 from data service by subjects of the Korean Statistical Information Service (KOSIS, https://www.kosis.kr). As a gateway for Korea's official statistics, KOSIS offers a convenient one stop service to a full range of major domestic and international statistics. The micro data set consists of about 3 million subjects and some indicators/variables including causes of death. The data set obtained from the data service by subjects has information relating to the number of deaths and mortality rates by the causes of death and age groups.

2.2. Statistical Analysis

To explore and analyze the data, common data analysis methods were used. A two sample proportion test was used to compare the proportions of the variables in two groups [13, 14]. Hypothesis testing for a proportion was used to determine if a sampled proportion is significantly different from the other sampled proportion. In addition, exploratory data analysis methods were primarily used to explore the data with more quantitative traditional methods. We also used some visualization techniques such as heat map and line plots to present mortality rates by gender, age and year.

Heat maps are a popular graphical way to summarize data, observe relationships among several statistical variables (the columns in a heat map), and organize the observations from numerous participants (the rows in a heat map) all in one single graph [15]. Heat maps have been made widely popular by Eisen *et al.* [16]. But, as Wilkinson and Friendly [17] pointed out, heat maps and related graphs can be dated back to the 19th century. The underlying idea for heat maps is that the data is split into different intervals that are assigned to a color.

3. RESULTS

3.1. Number of Deaths and Mortality Rate

The crude mortality rates, in deaths per 100,000, have continually decreased over the last 25 years in Korea since 1983, though they have increased slightly since 2006. In contrast, the number of deaths is more or less on an upward trend over the last 30 years [8]. Table **1** summarizes the trends of the number of deaths and crude mortality rates from 1983 to 2015. The crude mortality rate in 2015 was 541.5 per 100,000, which was an increase of 14.2 (2.7%) compared to the rate observed in 2014. The rate in males was 591.0 per 100,000, which was 1.2-fold higher than in female (492.1 per 100,000). The number of deaths in 2015 was the highest since 1983, and the crude mortality rate was the highest since 1992. The total number of deaths in 2015 was 275,895, which was about 0.54% of the population and an increase of 32,012 (13.1%) and 8,203 (3.1%) from 2005 and 2014, respectively. The number of deaths in males was 150,449 with an increase of 3,128 (2.1%) from 2014, while the number of deaths in females was 125,446 with an increase 5,075 (4.2%). Table **2** presents the mortality

Table 1. Number of deaths and crude mortality rates per 100,000 population (1983-2015).

Year	No. of deaths			Crude mortality rate			Gender ratio	Average daily no. of deaths
	Total	Male	Female	Total	Male	Female		
1983	254,563	148,101	106,462	637.8	735.8	538.2	1.37	697
1984	236,445	137,799	98,646	585.2	676.3	492.5	1.37	648
1985	240,418	140,671	99,747	589.2	683.7	493.1	1.39	659
1986	239,256	139,773	99,483	580.5	672.9	486.7	1.38	655
1987	243,504	141,028	102,476	585.0	672.8	496.0	1.36	667
1988	235,779	136,912	98,867	561.0	647.2	473.6	1.37	646
1989	236,818	137,528	99,290	557.9	643.9	470.8	1.37	649
1990	241,616	138,730	102,886	563.6	643.2	483.0	1.33	662
1991	242,270	138,270	104,000	559.6	634.7	483.5	1.31	664
1992	236,162	134,231	101,931	539.8	609.8	469.0	1.30	647
1993	234,257	133,099	101,158	523.5	592.2	454.1	1.30	642
1994	242,439	137,683	104,756	536.3	606.3	465.6	1.30	664
1995	242,838	137,059	105,779	532.1	597.8	465.8	1.28	665
1996	241,149	136,328	104,821	523.5	589.1	457.3	1.29	661
1997	241,943	135,995	105,948	520.6	582.6	458.0	1.27	663
1998	243,193	136,543	106,650	519.2	580.5	457.4	1.27	666
1999	245,364	136,397	108,967	520.2	576.0	464.0	1.24	672
2000	246,163	136,486	109,677	517.9	571.9	463.3	1.23	674
2001	241,521	134,058	107,463	504.5	557.8	450.7	1.24	662
2002	245,317	134,742	110,575	509.7	557.9	461.2	1.21	672
2003	244,506	134,887	109,619	506.1	556.6	455.4	1.22	670
2004	244,217	135,218	108,999	503.7	556.1	451.0	1.23	669
2005	243,883	134,382	109,501	501.0	550.5	451.1	1.22	668
2006	242,266	133,725	108,541	495.6	545.7	445.2	1.23	664
2007	244,874	134,922	109,952	498.4	547.9	448.7	1.22	671
2008	246,113	136,932	109,181	498.2	553.1	443.0	1.25	674
2009	246,942	137,735	109,207	497.3	553.7	440.7	1.26	677
2010	255,405	142,358	113,047	512.0	570.0	454.0	1.26	700
2011	257,396	143,250	114,146	513.6	571.1	456.0	1.25	705
2012	267,221	147,372	119,849	530.8	585.1	476.4	1.23	732
2013	266,257	146,599	119,658	526.6	579.8	473.4	1.22	729
2014	267,692	147,321	120,371	527.3	580.6	474.1	1.22	733
2015	275,895	150,449	125,446	541.5	591.0	492.1	1.20	756

Table 2. Mortality rates per 100,000 population for the major causes of death and age (2015).

Rank	Total		~ 9		10 ~ 19		20 ~ 29		30 ~ 39	
1	Cancer	153.6	Cancer	2.3	Suicide	4.2	Suicide	16.4	Suicide	25.1
2	Circulatory	116.9	Nervous	1.9	Cancer	2.4	Cancer	5.1	Cancer	15.4
3	Respiratory	54.6	Circulatory	1.1	Nervous	1.4	Circulatory	2.3	Circulatory	7.3
4	Suicide	26.5	Respiratory	0.7	Circulatory	0.9	Nervous	1.8	Digestive	3.2
5	Digestive	23.0	Endocrine	0.5	Infectious	0.2	Respiratory	0.5	Infectious	1.2
6	Endocrine	22.9	Infectious	0.4	Endocrine	0.2	Digestive	0.5	Nervous	1.2
7	Nervous	21.1	Digestive	0.2	Digestive	0.2	Infectious	0.5	Endocrine	1.0
8	Infectious	14.3	Suicide	0.0	Respiratory	0.2	Endocrine	0.5	Respiratory	1.0
Rank	**40 ~ 49**		**50 ~ 59**		**60 ~ 69**		**70 ~ 79**		**80 ~**	
1	Cancer	47.7	Cancer	138.2	Cancer	335.1	Cancer	815.2	Circulatory	2273.6
2	Suicide	29.8	Circulatory	52.1	Circulatory	130.2	Circulatory	520.9	Cancer	1475.7
3	Circulatory	23.4	Suicide	34.3	Respiratory	43.1	Respiratory	242.7	Respiratory	1287.8
4	Digestive	15.6	Digestive	30.2	Digestive	39.3	Endocrine	122.7	Nervous	476.6
5	Endocrine	3.7	Endocrine	12.5	Suicide	36.9	Nervous	83.5	Endocrine	363.2
6	Infectious	3.4	Respiratory	10.1	Endocrine	32.4	Digestive	75.5	Infectious	262.3
7	Respiratory	2.8	Infectious	8.2	Nervous	17.2	Suicide	62.5	Digestive	252.0
8	Nervous	2.4	Nervous	5.7	Infectious	16.7	Infectious	61.5	Suicide	83.7

rates for the major causes of death and age in 2015. The rates for suicide and circulatory were the highest for ages of 10 to 39 and over 80, respectively, and the rate for cancer was the highest in all other age groups.

From 2005 to 2015, the gender ratio of the population according to age is reversed starting at age 56. The ratio of male population to female population is 1.06 until age 55, but the ratio of female population to male population is 1.25 after age 55. Fig. (**1**) presents the total number of deaths from 2005 to 2015 by gender and age. The total numbers of deaths of males are higher than those of females in the age groups under 80. The gender ratio of deaths was the highest at 2.9-fold in the

age group of 50, while the gender ratio of the population in the same age group is only 1.005-fold. In the age group over 80, however, the deaths of females are overwhelmingly larger than those of males as the proportion of women is higher *e.g.*, in 2005 and 2015, the ratio of the female population is 2.42 and 2.29 fold higher than the male population. The deaths of females over 80 are 47,022 and 70,836 in 2005 and 2015, which are 1.9 and 1.7-fold larger than 25,079 and 41,802 males, respectively.

Fig. (**2**) presents the number of monthly deaths from 2013 to 2015 using heat maps. In the heat maps, darkish colors represent a high density of deaths, while lightish colors represent a low density of deaths. The heat maps show a seasonal trend that can be associated with cold weather. This observation confirms the results from many previous studies that have investigated the association between temperature and mortality and found a significant association [18, 19].

Recently, there has been a growing body of literature on the temperature mortality relationship among older people in both developed [20 - 24] and developing countries [25 - 28]. Both hot temperatures and temperature variability have been found to impact mortality rates [29]. Cold weather and being cold from living in a home with persistently low temperatures and lack of thermal comfort have been shown to have impacts on physical health and cause death from circulatory and lung diseases that would not have occurred in warmer temperatures and warmer homes [30].

3.2. Exploring the Causes of Death

Statistics Korea has published an annual report on the cause-of-death statistics of the Korean population since 1983. In order to determine the ranking of causes of death, Statistics Korea used the selection list of 103 causes of death for the tabulation of mortality statistics recommended by the World Health Organization to better fit the Korean society. The eight leading causes of death were, in order of mortality rates, cancer, circulatory, respiratory, suicide, digestive, endocrine, nervous system, and infectious disease. The top eight causes of

death accounted for 80% of all Korean deaths in 2015.

Temporal trends in mortality rates for the leading causes of death varied by cause of death and by gender. Fig. (**3**) compares the trends of mortality rates from 2005 to 2015 by causes of death for the rates for males and females. The rates for cancer and circulatory diseases are considerably higher than the rates for other causes. Most causes display slightly changing trends in both males and females except for cancer, respiratory, and nervous system diseases. The leading cause of death each year from 2005 to 2015 was cancer in males and circulatory diseases in females. The trend for respiratory diseases shows a steep upward trend in males, while a similar trend can be observed for respiratory and nervous system diseases in females. In particular, endocrine diseases have a slightly decreasing trend in males, and suicide, as well as endocrine diseases, show a slightly changing trend in females.

Table **3** shows the comparison results of mortality rates by gender in all ages and in the 75 or older group, respectively. In all age groups, the rates for cancer and suicide were significantly different between male and female at the 1% level for the two-tailed test (*p*-value<0.001 and 0.004, respectively). There were no significant statistical differences between the two gender groups for the remaining variables. In the 75 or older group, however, the rates for all causes except for nervous system diseases were significantly higher in males. The *p*-values were 0.008 for digestive diseases and 0.001 or smaller for the remaining six diseases.

Noticeably, about 91% (male: 89%, female: 93%) of all Korean deaths in 2015 occurred after age 50. Fig. (**4**) presents the deaths and mortality rates after age 50 by causes of death. The death toll for cancer is the highest at age 75-79, while the highest death tolls for most other diseases (except for suicide) occur at the age of 80 or older. The death toll for suicide has a tendency to decrease after the age of 50, but death tolls continue to increase until age 80 for most diseases. The mortality rates for circulatory, nervous system and respiratory diseases increase rapidly after the age of 80, while the rate for cancer tends to decrease after the age of 85.
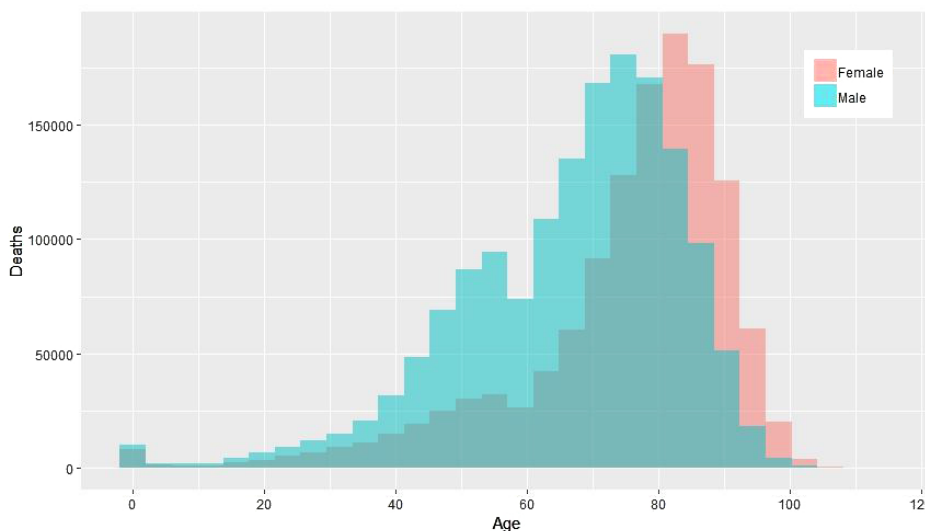

Fig. (1). The total number of deaths by gender and age (2005-2015).

In the eight leading causes of death, on the other hand, about 55% of deaths occurred in people aged 75 or older. Exploring the mortality rates, therefore, has a considerable implication in figuring out the influence of each cause of death for those over 75 years of age. Table **4** presents the differences in mortality rates for men and women aged 75 or older. The leading causes of death are cancer, circulatory, and respiratory diseases in males, while circulatory, cancer, and respiratory diseases in females. The rates for males, compared to females, are higher in all causes of death except for nervous system diseases. The absolute difference of the rate for cancer between males and females is the greatest, while the difference is about 33.5 and 12.1 times that for digestive diseases and suicide, respectively. However, the relative difference is the greatest in suicide, which is about 1.6 and 15.5 times that for cancer and circulatory diseases, respectively. The cause that has the greatest difference in mortality rate for men and women aged 75 or older is consequently suicide.
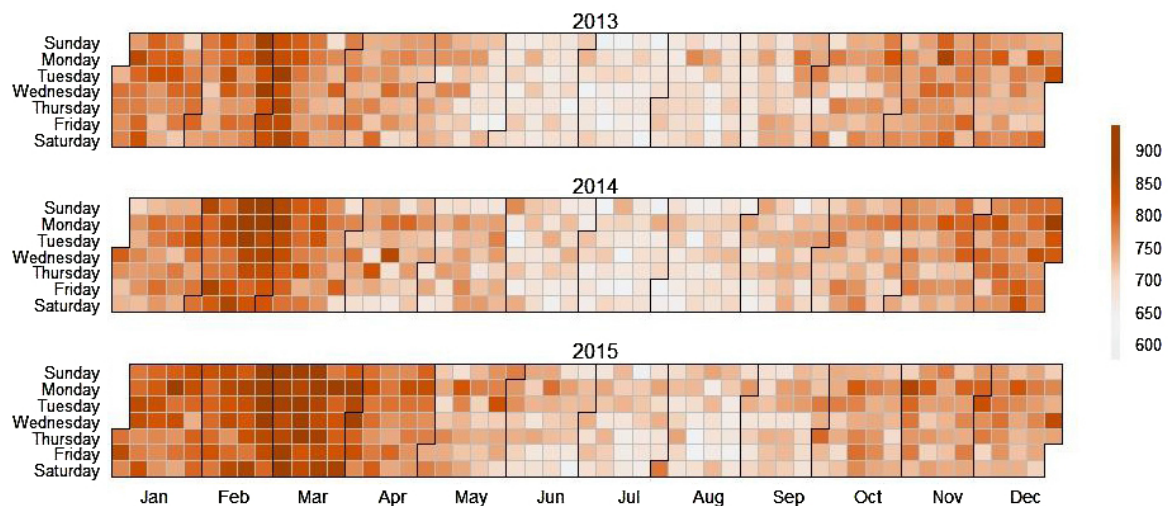

Fig. (2). Heat map of the number of monthly deaths (2013-2015).

Table 3. Comparison of mortality rates per 100,000 population by gender.

	Age(all)			Age (75 or older)		
	Male	**Female**	**p-value**	**Male**	**Female**	**p-value**
Cancer	190.2	117.1	<0.001***	4066.7	1644.2	<0.001***
Circulatory	110.8	123.0	0.464	3287.1	2851.7	<0.001***
Respiratory	60.9	48.2	0.263	2551.9	1199.1	<0.001***
Suicide	37.5	15.5	0.004**	286.5	86.2	<0.001***
Digestive	29.2	16.8	0.093	397.0	324.7	0.008**
Endocrine	22.8	22.9	0.999	598.5	492.9	0.001***
Nervous	17.0	25.2	0.502	593.2	596.1	0.956
Infectious	14.7	13.9	0.999	443.7	302.0	<0.001***

, * statistically significant result at the 5%, 1%, 0.1% level of significance, respectively.

Table 4. Difference of gender for mortality rates per 100,000 population (aged 75 or older).

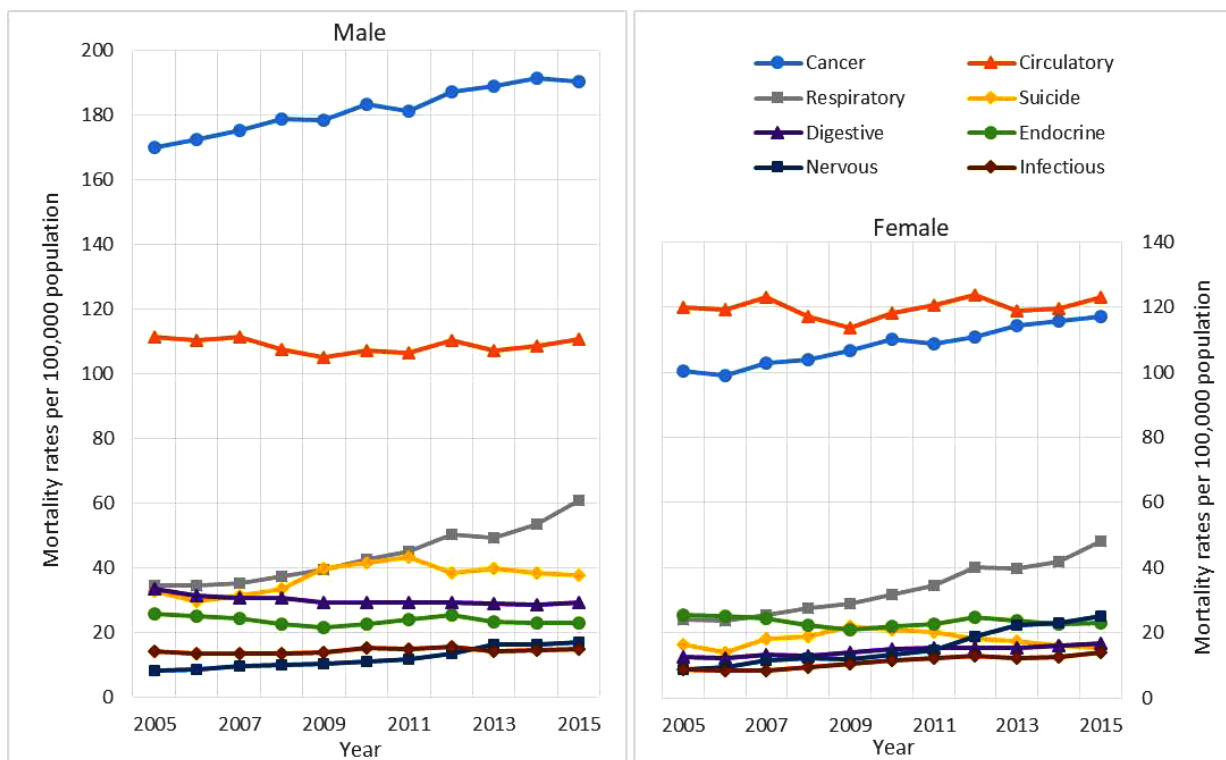|	**Male**	**Female**	**Absolute Difference (Male-Female)**	**Ratio of the difference (Male-Female)/Female**
Cancer	4066.7	1644.2	2422.5	1.47
Circulatory	3287.1	2851.7	435.4	0.15
Respiratory	2551.9	1199.1	1352.8	1.13
Suicide	286.5	86.2	200.3	2.32
Digestive	397.0	324.7	72.3	0.22
Endocrine	598.5	492.9	105.6	0.21
Nervous	593.2	596.1	-2.9	-0.01
Infectious	443.7	302.0	141.7	0.47

Fig. (3). Trends of mortality rates per 100,000 population by causes of death (2005-2015).

Fig. (**5**) compares the trend in mortality rates depending on age for males and females by causes of death in 2015. The difference in the mortality rate for males and females for cancer dramatically increased after the age of 50. There are similar trends related to gender in the rates for respiratory, endocrine, and digestive diseases. The suicide rate began to vary between males and females after the age of 25, and it increased drastically in the case of male after the age of 70. In particular, the rate for nervous system diseases was slightly higher in males until the age of 70, but higher in females after the age of 70. This is a unique pattern among the leading eight causes of death.

Fig. (**6**) presents the proportions of deaths for eight causes of death in each age group. Under the age of 9, the proportions for cancer and nervous diseases were relatively high. However, suicide deaths were overwhelmingly high from the age of 10 to 39, and the death proportion from cancer was noticeably high from the age of 40 to 79. The proportions from cancer were higher in females up to the age of 69, and they reversed after the age of 70. In addition, there was a substantial difference in the proportion of deaths from cancer between male and female, and it especially showed the biggest difference from the age of 40 to 49. After the age of 70, the diseases with the highest death proportions were cancer, circulatory, and respiratory.

4. DISCUSSION

The annual average number of births in South Korea was about 457,000, while the annual average number of deaths was about 256,000 from 2005 to 2015. The number of births was over 1 million in the early 1970s, but it decreased to about 438,000 in 2015. This has led to the lowest population growth since the publication of demographic statistics. The number of deaths has continued to grow slightly from about 259,000 in 1970 to 276,000 in 2015 while the number of births has reduced and the proportion of the aging population has increased. The proportion of deaths for the eight leading causes of death increased from 74% in 2005 to 80% in 2015.

The highest mortality rate among the eight leading causes of death was cancer, and the lowest was nervous system diseases in 2005. The mortality rate for nervous system diseases, however, increased steeply in 2015, with its former place replaced by infectious diseases. The most remarkable changes from 2005 in mortality rates were the increase in nervous system diseases and the decrease in endocrine diseases, such that the rate of nervous system diseases increased by 148% and the rate of endocrine diseases decreased by 10% in 2015, compared to 2005. Nervous system diseases include meningitis, Alzheimer, and other diseases associated with the nervous system. Endocrine diseases consist of diabetes, malnutrition, endocrine, and other diseases related to nutrition and and metabolism. In terms of the mortality rates by gender, the highest was cancer for males and circulatory diseases for females in both 2005 and 2015. The lowest was nervous and infectious diseases for males and females, respectively, in 2005, but it changed to infectious diseases for males in 2015.
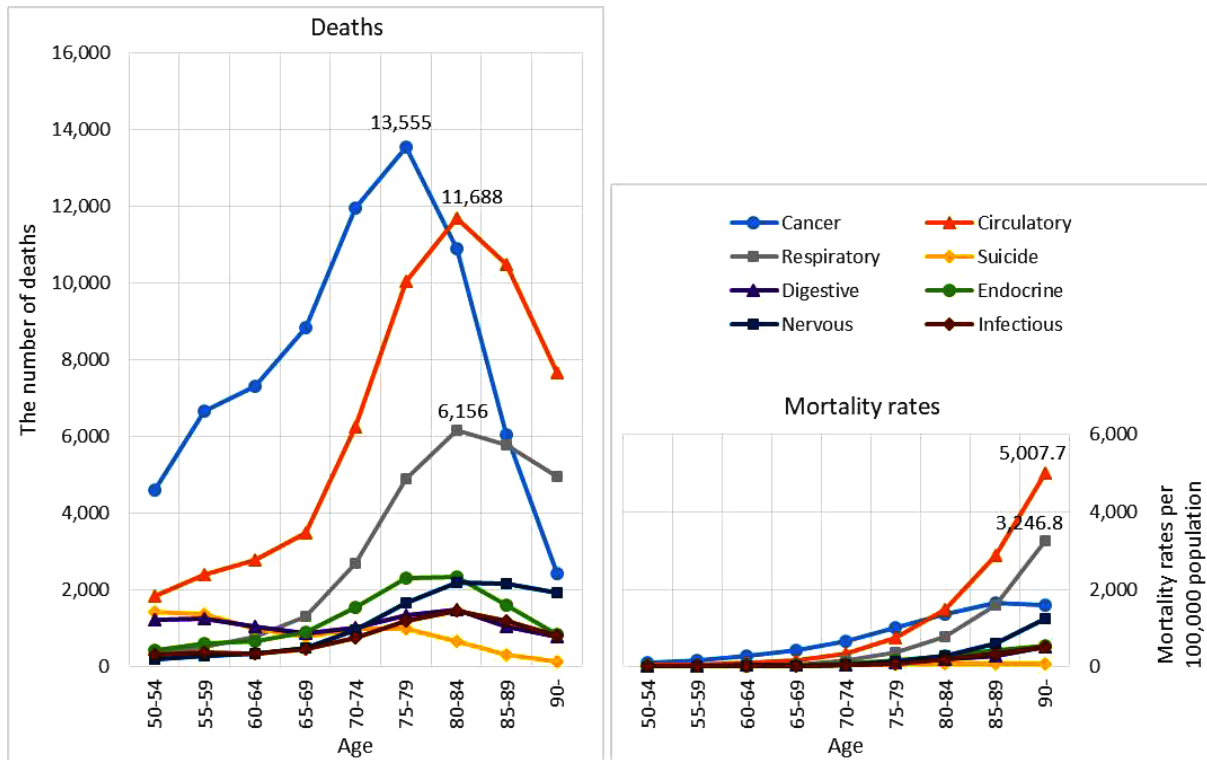
Fig. (4). The number of deaths and mortality rates per 100,000 population depending on age (2015).
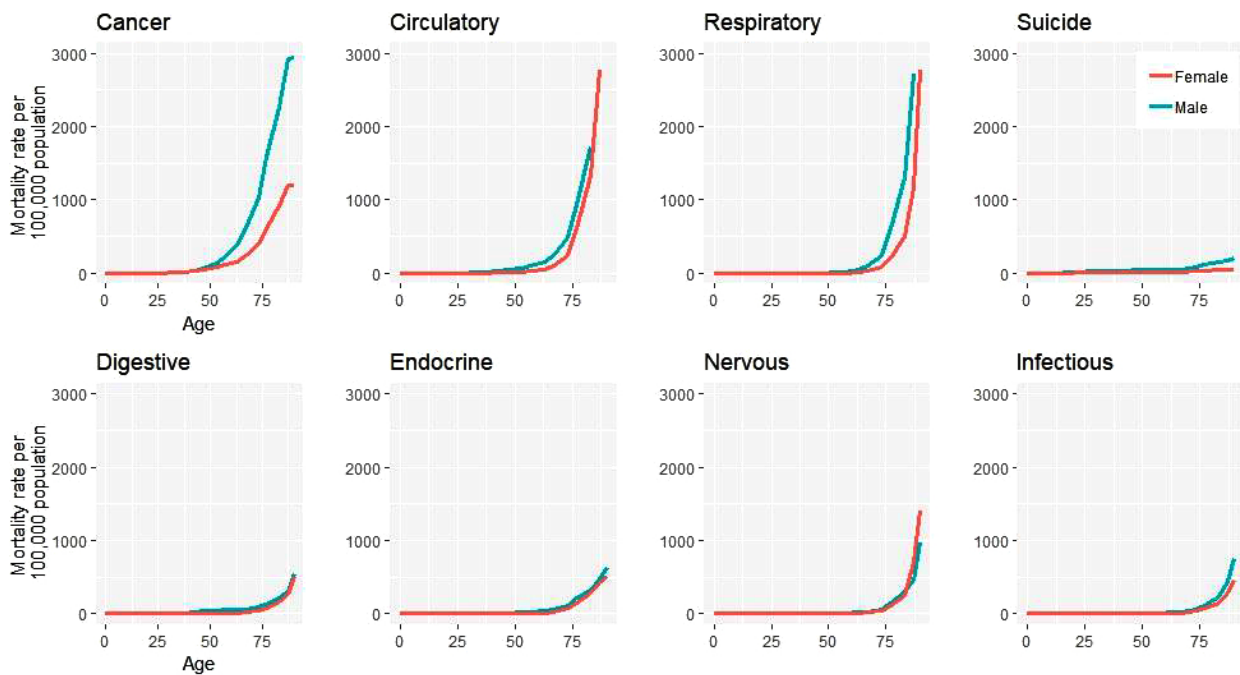

Fig. (5). The mortality rates per 100,000 population for male and female by causes of death (2015).
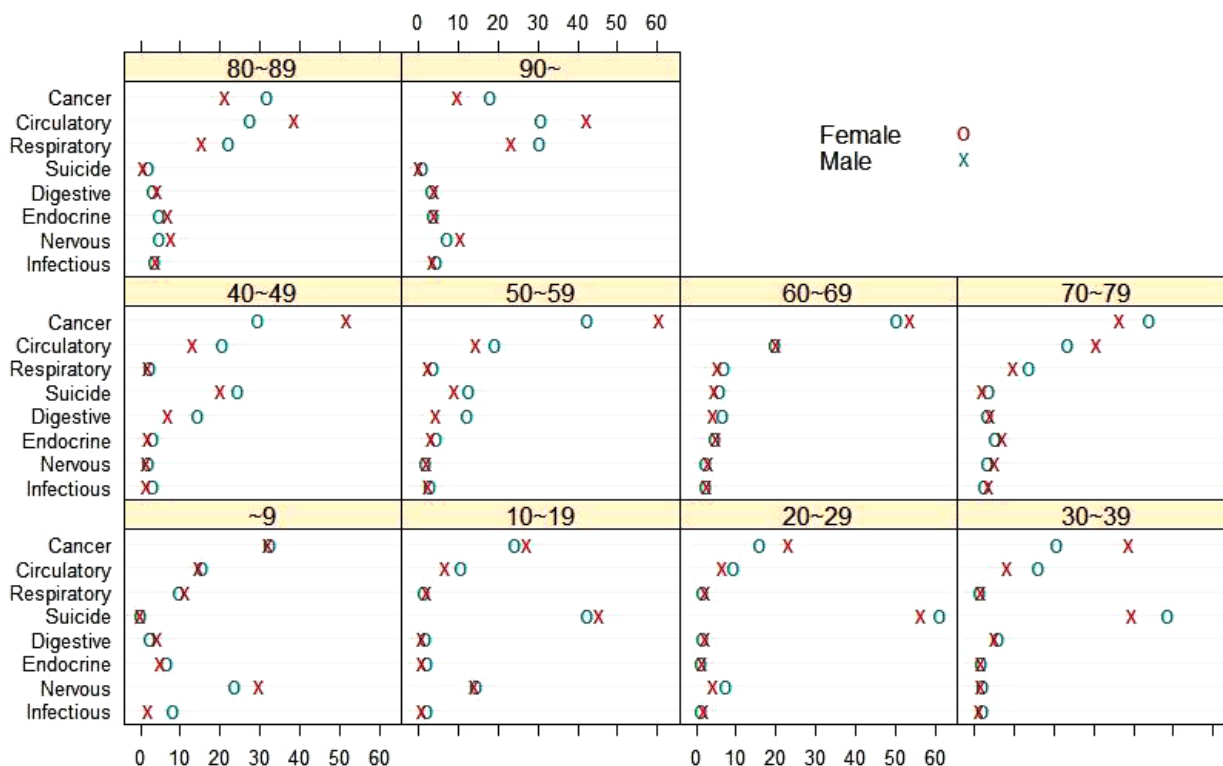
Fig. (6). The proportions of deaths for eight leading causes of death in each age group (2015).

The age-standardized mortality rate of Korea was the 13th lowest among 34 Organization for Economic Co-operation and Development (OECD) countries in 2012 [31]. The rate for cancer was 24.2 per 100,000 lower than the OECD average of 207.5 per 100,000, and it was ranked 29th. The rate is at a quite low level compared to Hungary with 293.3 and Slovenia with 257.3 per 100,000. On the contrary, suicide (1st), gastric cancer (3rd), diabetes (5th), and cerebrovascular disease (10th) rates were considerably higher. In 2012, the mortality rate for suicide in Korea was 29.1 per 100,000, which was 17.0 per 100,000 more than the OECD average of 12.1 per 100,000. The suicide rate was the highest among OECD countries, followed by Hungary with 22.0 per 100,000. The rate for gastric cancer in Korea has been much lower than in the past, but it was still the third-largest in the OECD countries. Chile with 27.9 per 100,000 had the highest risk of gastric cancer among OECD countries, followed by Japan with 25.4 per 100,000. The rate for cerebrovascular diseases in Korea was 8.4 per 100,000 higher than the OECD average of 68.1 per 100,000. The country with the highest mortality rate for cerebrovascular diseases was Slovakia with 136.7 per100,000, followed by Hungary with 122.3 per 100,000. With the advances of preventive medicine and medical insurance systems, diseases that require advanced medical technologies have shown reduced rates. However, the rates for some causes such as suicide and diabetes show an increasing tendency, thus requiring some appropriate countermeasures.

It should be noted that Korea is experiencing a rapidly aging population. Older people aged 65 and over were only 4.5% in 1992, but increased to 8.8% in 2005, and accounted for 13.2% of the population in 2015 [32]. This is a substantially larger percentage than the 8.5% worldwide in 2015 [33]. In addition, the life expectancy at birth in 2015 is 82.3 years which gives Korea a world life expectancy ranking of 11 [34, 35]. Therefore, policies on health and welfare for the elderly are very important issues.

This study has some limitations. As mentioned above, the quality of the death statistics and the accuracy of identifying the causes have improved over time in Korea. Nevertheless, the data sources used in this study may be subject to potential misclassification of causes of death in official death certificates. Second, the study explored and analyzed the characteristics of mortality for only eight major causes of death, but not all causes such as the full WHO table for causes of death. The results, therefore, should only be interpreted for the causes analyzed in this article.

CONCLUSION

In this study, we analyzed and visualized the characteristics of the mortality rates for major causes of death in Korea. The age-standardized mortality rate in Korea has steadily declined since the 1980s. The crude mortality rate, however, has changed from a decreasing to an increasing trend starting from 2010. In the case of nervous system and resp-iratory diseases, there is a large increase in 2015 compared to 2010. The rates for cancer and circulatory diseases, among the eight leading causes of death, are significantly higher than the other diseases from 2005 to 2015. The administrative agencies

related to health and welfare should establish relevant prevent-
ive policies/strategies in order to reduce the mortality rates.
Korea is rapidly aging as the population growth rate decreases.
We explored the mortality rate focusing on data from the
elderly in this study. The deaths for circulatory, respiratory,
nervous system, digestive, and infectious diseases are the
highest in the age 80 to 84 group, while cancer is the leading
cause of death for ages 75 to 79. In addition, the mortality rates
for circulatory, nervous, and respiratory diseases increase
rapidly after the age of 80. Therefore, policies on health and
welfare for the elderly are getting more and more important.

ETHICS APPROVAL AND CONSENT TO PART-ICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No Animals/Humans are used for studies that are bases of
this research.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or
otherwise.

REFERENCES

[1]   Piotrowski W, Polakowska M, Koziarek J, Broda G. Sudden
       cardiovascular death rate and ischaemic heart disease death rate
       changes during the 5-year period of 2003-2008. Kardiol Pol 2012;
       70(12): 1225-34.
       [PMID: 23264239]
[2]   WHO. Global health observatory (GHO) data. Mortality and Global
       Health Estimates. Available from: http:// wwwwhoint/ gho /
       mortality_burden_disease/ en/ 2012.
[3]   Wise J. Cancer death rate falls steadily in England over past decade.
       BMJ 2014; 349: g7069.
       [http://dx.doi.org/10.1136/bmj.g7069] [PMID: 25416305]
[4]   Siegel R, Ma J, Zou Z, Jemal A. Cancer statistics, 2014. CA Cancer J
       Clin 2014; 64(1): 9-29.
       [http://dx.doi.org/10.3322/caac.21208] [PMID: 24399786]
[5]   Park KA. Recent trends and patterns of mortality in Korea. Dev Soc
       1998; 27(2): 67-81.
       [PMID: 12295269]
[6]   Yang S, Khang YH, Harper S, Davey Smith G, Leon DA, Lynch J.
       Understanding the rapid increase in life expectancy in South Korea.
       Am J Public Health 2010; 100(5): 896-903.
       [http://dx.doi.org/10.2105/AJPH.2009.160341] [PMID: 20299661]
[7]   Lim D, Ha M, Song I. Trends in the leading causes of death in Korea,
       1983-2012. J Korean Med Sci 2014; 29(12): 1597-603.
       [http://dx.doi.org/10.3346/jkms.2014.29.12.1597] [PMID: 25469057]
[8]   Shin HY, Lee JY, Song J, et al. Cause-of-death statistics in the
       Republic of Korea, 2014. J Korean Med Assoc 2016; 59(3): 221-32.
       [http://dx.doi.org/10.5124/jkma.2016.59.3.221]
[9]   Hendin H, Phillips MR, Vijayakumar L, et al. World Health
       Organization. Suicide and suicide prevention in Asia. Available from:
       https://wwwwhoint/mental_health/resources/suicide_prevention_asiap
       df 2008.
[10]   Statistics Korea. A report on the current condition of supplementation
       of deaths statistics in South Korea 2008.
[11]   Chan CH, Caine ED, Chang SS, Lee WJ, Cha ES, Yip PSF. The
       impact of improving suicide death classification in South Korea: a
       comparison with Japan and Hong Kong. PLoS One 2015; 10(5):
       e0125730.
       [http://dx.doi.org/10.1371/journal.pone.0125730] [PMID: 25992879]
[12]   WHO. International statistical classification of diseases and related
       health problems. Available from: http:// appswhoint/ iris/ bitstream/
       handle/ 10665/ 42980/ 9241546530 _ eng pdf ? sequence=1 & is
       Allowed = y 2004.
[13]   Wilson EB. Probable inference, the law of succession, and statistical
       inference. J Am Stat Assoc 1927; 22: 209-12.
       [http://dx.doi.org/10.1080/01621459.1927.10502953]
[14]   Newcombe RG. Interval estimation for the difference between
       independent proportions: comparison of eleven methods. Stat Med
       1998; 17(8): 873-90.
       [http://dx.doi.org/10.1002/(SICI)1097-0258(19980430)17:8<873::AID
       -SIM779>3.0.CO;2-I] [PMID: 9595617]
[15]   Moyer-Packenham PS, Tucker SI, Westenskow A, Symanzik J.
       Examining patterns in second graders' use of virtual manipulative
       mathematics apps through heat map analysis. International Journal of
       Educational Studies in Mathematics 2015; 2(2): 1-16.
       [http://dx.doi.org/10.17278/ijesim.2015.02.001]
[16]   Eisen MB, Spellman PT, Brown PO, Botstein D. Cluster analysis and
       display of genome-wide expression patterns. Proc Natl Acad Sci USA
       1998; 95(25): 14863-8.
       [http://dx.doi.org/10.1073/pnas.95.25.14863] [PMID: 9843981]
[17]   Wilkinson L, Friendly M. The history of the cluster heat map. Am Stat
       2009; 63(2): 179-84.
       [http://dx.doi.org/10.1198/tas.2009.0033]
[18]   Xuan TT, Egondi T, Ngoan T, Toan TT, Huong T. Seasonality in
       mortality and its relationship to temperature among the older
       population in Hanoi, Vietnam. Glob Health Action 2014; 7: 23115.
       [http://dx.doi.org/10.3402/gha.v7.23115] [PMID: 25511883]
[19]   Carder M, McNamee R, Beverland I, et al. The lagged effect of cold
       temperature and wind chill on cardiorespiratory mortality in Scotland.
       Occup Environ Med 2005; 62(10): 702-10.
       [http://dx.doi.org/10.1136/oem.2004.016394] [PMID: 16169916]
[20]   Basu R, Malig B. High ambient temperature and mortality in
       California: exploring the roles of age, disease, and mortality
       displacement. Environ Res 2011; 111(8): 1286-92.
       [http://dx.doi.org/10.1016/j.envres.2011.09.006] [PMID: 21981982]
[21]   Revich B, Shaposhnikov D. Excess mortality during heat waves and
       cold spells in Moscow, Russia. Occup Environ Med 2008; 65(10):
       691-6.
       [http://dx.doi.org/10.1136/oem.2007.033944] [PMID: 18417550]
[22]   Rocklöv J, Ebi K, Forsberg B. Mortality related to temperature and
       persistent extreme temperatures: a study of cause-specific and age-
       stratified mortality. Occup Environ Med 2011; 68(7): 531-6.
       [http://dx.doi.org/10.1136/oem.2010.058818] [PMID: 20962034]
[23]   Rocklöv J, Forsberg B. The effect of high ambient temperature on the
       elderly population in three regions of Sweden. Int J Environ Res
       Public Health 2010; 7(6): 2607-19.
       [http://dx.doi.org/10.3390/ijerph7062607] [PMID: 20644691]
[24]   Ricardo A, Paula S, Elisabete F, João V. Seasonal mortality patterns
       and regional contrasts in Portugal. Bulletin of Geography 2016; 32:
       7-18.
[25]   Egondi T, Kyobutungi C, Kovats S, Muindi K, Ettarh R, Rocklöv J.
       Time-series analysis of weather and mortality patterns in Nairobi's
       informal settlements. Glob Health Action 2012; 5: 23-32.
       [http://dx.doi.org/10.3402/gha.v5i0.19065] [PMID: 23195509]
[26]   Rofi A, Doocy S, Robinson C. Tsunami mortality and displacement in
       Aceh province, Indonesia. Disasters 2006; 30(3): 340-50.
       [http://dx.doi.org/10.1111/j.0361-3666.2005.00324.x] [PMID: 169114
       32]
[27]   Xu W, Thach TQ, Chau YK, et al. Thermal stress associated mortality
       risk and effect modification by sex and obesity in an elderly cohort of
       Chinese in Hong Kong. Environ Pollut 2013; 178: 288-93.
       [http://dx.doi.org/10.1016/j.envpol.2013.03.020] [PMID: 23587859]
[28]   Gouveia N, Hajat S, Armstrong B. Socioeconomic differentials in the
       temperature-mortality relationship in São Paulo, Brazil. Int J
       Epidemiol 2003; 32(3): 390-7.
       [http://dx.doi.org/10.1093/ije/dyg077] [PMID: 12777425]
[29]   Cheng J, Xu Z, Bambrick H, Su H, Tong S, Hu W. Impacts of heat,
       cold, and temperature variability on mortality in Australia, 2000-2009.
       Sci Total Environ 2019; 651(Pt 2): 2558-65.
       [http://dx.doi.org/10.1016/j.scitotenv.2018.10.186] [PMID: 30340191]
[30]   Ieman B, Behrooz T. Excess seasonal mortality. Available from:
       https://wwwlbbdgovuk/wp-content/uploads/2017/01/77-Excess-Season
       al-Mortality-2016pdf 2016.

[31]   Jang YS, Ham SU. The comparison of the mortality rates for OECD countries by causes of deaths. Issue and Focus of Health and Welfare 2014; 257: 1-8.

[32]   Jeon B, Kwon S. Health and long-term care systems for older people in the Republic of Korea: Policy challenges and lessons. Health Systems & Reform 2017; 3(3): 214-23.
[http://dx.doi.org/10.1080/23288604.2017.1345052]

[33]   He W, Goodkind D, Kowal P. An aging world: 2015, U.S. Census

Bureau. Available from: https:// wwwcensusgov/ content/ dam/ Census/ library/ publications/ 2016/ demo/ p95-16-1pdf 2016.

[34]   WHO. World health statistics 2016: Monitoring health for the WHO. Available from: http:// wwwwhoint/ gho/ publications/ world_health_statistics/ 2016/ Annex_B/ en/ 2016.

[35]   Oh YM. Life expectancy of 90.8 years: Political implications and responses. Weekly Issue of Korea Health Promotion Institute 2017; 15: 1-8.