ABSTRACT

Purpose: The authors hypothesized that increases in socioeconomic status (SES) have enabled patients to access medical services more frequently, resulting in the increased detection of small thyroid cancers. This retrospective cohort study was designed to analyze the correlation between thyroid cancer incidence and SES using a 10-year sample cohort database.

Method: Sample cohort database between January 2004 and December 2013 with 1,000,000 cases for each year was enrolled in this study. Thyroid cancer incidence was analyzed by sex and by age. Public health insurance payment was used to reflect SES. The correlation between SES and thyroid cancer incidence was analyzed, and medical checkups done under government programs based on SES were analyzed.

Results: When the results were considered according to SES, the high SES group showed a higher incidence of thyroid cancer than low SES group. Also, participation in government-supported health checkup programs was higher in the high SES group higher in the high SES group compared to low SES group.

Conclusion: SES and incidence of thyroid cancer have positive correlation.

Keywords: Thyroid cancer; Socioeconomic status; Health insurance; Database

INTRODUCTION

According to registered statistics from the US Surveillance, Epidemiology, and End Results Program (SEER) from 1975 to 2011, the incidence rate of thyroid cancer increased threefold over this period. On the other hand, there were no changes in death rates (1-3). This increase in incidence rates is considered to have been due to a growth in diagnoses brought about by greater ease of access to medical services; thus, an increase in health insurance coverage is thought to have led to an more widespread in the diagnosis rates of small thyroid cancers (4-9). Socioeconomic status (SES) is a key determinant regarding the health status of individuals as well as entire populations. In the US, it has been reported that lower SES is associated with higher incidence rates of uterine cervical cancer, gastric cancer, and lung cancer, and also that higher SES is associated with higher incidence rates of breast cancer and melanoma (10). In the case of thyroid cancer, despite some reports indicating higher incidence rates among
those of higher SES, other reports indicate no relations between SES and thyroid cancer incidence rates (11-15). In the case of the Republic of Korea, according to the National Cancer Registration & Statistics Program, the incidence rate of thyroid cancer per 100,000 females for the year 2012 was 120.4, with the incidence rate having increased by approximately 24% every year from 1999 to 2012 (16). In addition, upon comparing the results of GLOBOCAN 2012, an international cancer statistics estimation project in which age-standardized incidence rates have been proposed, it was found that the incidence of thyroid cancer in the Republic of Korea was 4 times higher than in the US and 10 times higher than in Japan and China (17). This steep rise in the incidence of thyroid cancer is difficult to consider a natural phenomenon, and it has been reported that this rise has been caused by overdiagnosis (18).

It is thought that in the Republic of Korea, the enactment of the Medical Insurance Act in 1963 and the completion of national coverage of medical insurance by 1989, which resulted in easier access to medical services compared to other countries, are key factors that have contributed to the overdiagnosis. It is also thought that there are differences in the use of medical services according to socioeconomic status. In light of this, the authors of this study undertook analyses to understand the correlations between SES and incidence rates of thyroid cancer using the National Health Insurance Service sample cohort database, from which big data for research purposes can be acquired.

**MATERIALS AND METHODS**

This study was undertaken using a big data sample cohort database for researchers that were acquired from the National Health Insurance Service with approval of Institutional Review Board of National Health Insurance Service Ilsan Hospital (2016-03-035).

Samples accounting for approximately 2.2% of the 2002 National Health Insurance Recipient Qualifications Database (1,025,340 recipients) were first collected and then used in conjunction with corresponding sample treatment history, medical institution, health exam, and the National Statistical Office of Korea Cause-of-Death databases to undertake retrospective analysis of the data. Samples were collected through a systematic sampling process in which annual total medical expenses for 1,476 strata associated with different combinations of age (18 groups), sex, qualification (3 groups; self-employed members, employed members, and qualifying recipients of medical care), and income bracket (21 groups) were taken into account. Natural reductions (due to death or immigration) of the cohort data due to the passing of time were accounted for by supplementing the data with samples of newborn infants.

Although the cohort data, excluding the year 2002 in which the cohort was formed, was not considered to have sufficiently maintained the representativeness of its sample base for the years after 2002, it was considered possible to address such shortcomings through the characteristics of the representative sample.

The number of samples by year of the sample cohort database was as shown in Table 1. Although the number of individuals fluctuated by year, the total number of samples was maintained at levels accounting for approximately 2% of the total population. 11-year thyroid cancer patients from January 1, 2002 to December 31, 2013 are those patients that have insurance coverage histories in which their main illness codes begin with C73 according to their claims documents. All claims were considered, regardless of in-patient or out-patient status, or insurance qualifications.
The number of claimed cases of thyroid cancer by year and the number of overlapping patients within each given year were as shown in Table 2. Over the 11 years, the number of claimed cases of thyroid cancer and the number of patients were found to have risen. For new thyroid cancer patients, the patients were sorted by their initial date of treatment; the date at which claims associated with the illness codes concerned were first made was considered to be the initial date of diagnosis (Table 3).

Monthly contributions made according to the health insurance duty system were considered indirect parameters of evaluating SES, and were classified into 10 levels to study the correlations between each level and their associated incidence rates of thyroid cancer (Tables 4 and 5). In addition, general health exams, cancer screenings, and turning-point-of-life health exams

### Table 1. Number of samples of the sample cohort database by year

| Year | Total   | Male     | Female   | Nationally registered populationa |
|------|---------|----------|----------|----------------------------------|
| 2002 | 1,025,340 | 513,258  | 512,082  | 48,229,948                       |
| 2003 | 1,077,468 | 509,212  | 508,256  | 48,386,823                       |
| 2004 | 1,016,580 | 508,223  | 508,357  | 48,583,805                       |
| 2005 | 1,016,820 | 508,377  | 508,503  | 48,782,274                       |
| 2006 | 1,002,005 | 500,808  | 501,197  | 48,991,779                       |
| 2007 | 1,020,743 | 510,009  | 510,734  | 49,268,928                       |
| 2008 | 1,000,785 | 501,019  | 499,766  | 49,540,367                       |
| 2009 | 998,527   | 499,689  | 498,838  | 49,773,145                       |
| 2010 | 1,002,031 | 501,338  | 500,693  | 50,015,666                       |
| 2011 | 1,006,481 | 503,428  | 503,053  | 50,734,284                       |
| 2012 | 1,011,123 | 505,614  | 505,509  | 50,948,272                       |
| 2013 | 1,014,730 | 507,289  | 507,441  | 51,141,463                       |

*aNationally registered population: Ministry of the Interior and Safety, nationally registered population status.

### Table 2. Number of patients and claimed cases of thyroid cancer per year

| Year | Number of claimed cases | Number of patients |
|------|-------------------------|-------------------|
| 2002 | 2,236                   | 597               |
| 2003 | 2,917                   | 751               |
| 2004 | 3,784                   | 867               |
| 2005 | 5,117                   | 1,068             |
| 2006 | 6,465                   | 1,323             |
| 2007 | 8,828                   | 1,752             |
| 2008 | 10,956                  | 2,213             |
| 2009 | 14,030                  | 2,859             |
| 2010 | 16,403                  | 3,466             |
| 2011 | 21,238                  | 4,252             |
| 2012 | 27,799                  | 5,001             |
| 2013 | 30,174                  | 5,713             |

### Table 3. Estimated number of new thyroid cancer patients

| Year | Total number of samples (A) | Number of new thyroid cancer patients (B) | =B/A 100,000 | Cancer registration statistics crude ratesa |
|------|-----------------------------|------------------------------------------|--------------|-------------------------------------------|
| 2004 | 1,016,580                   | 287                                      | 28.2         | 21.4                                      |
| 2005 | 1,016,820                   | 319                                      | 31.4         | 26.2                                      |
| 2006 | 1,002,005                   | 374                                      | 37.3         | 33.0                                      |
| 2007 | 1,020,743                   | 497                                      | 48.7         | 43.2                                      |
| 2008 | 1,000,785                   | 588                                      | 58.8         | 55.2                                      |
| 2009 | 998,527                     | 771                                      | 77.2         | 65.2                                      |
| 2010 | 1,002,031                   | 751                                      | 74.9         | 73.5                                      |
| 2011 | 1,006,481                   | 904                                      | 89.8         | 82.0                                      |
| 2012 | 1,011,123                   | 971                                      | 96.0         | 87.4                                      |
| 2013 | 1,014,730                   | 907                                      | 89.4         | -                                         |

*aCancer registration statistics crude rate: excerpts from the National Cancer Registration Program Yearly Report (2012, Cancer Registration Statistics), Crude Rate = (Number of New Cancer Patients/Mid-Year Population)×100,000.
provided for free by the government were studied to indirectly analyze access to medical services. To account for the possibility of error regarding the initial diagnosis date of thyroid cancer patients during the earlier years, new thyroid patients for the years 2002 and 2003 were excluded.

All analyses were performed using the SAS v9.4 software package (SAS Institute, Cary, NC, USA).

RESULTS

1. Incidence rates of thyroid cancer by year
Incidence rates of thyroid cancer were analyzed using a 10-year sample cohort database which accounted for the years from 2004 to 2013. During the years of 2004 and 2005, a 0.03% increase was observed, whereas during the period from 2006 to 2009 an increase of up to 0.08% was observed. In 2010, the increase dipped slightly, to 0.07%, but then rose again to 0.10% in 2012 and 0.09% in 2013 (Table 4).

2. Correlation between Thyroid Cancer Incidence and Socioeconomic Status

Table 4. Income bracket classification

| Income bracket | Occupation (won) | Region (won) | Other |
|----------------|-----------------|--------------|-------|
| Bracket 1      | 23,980 or less  | 9,760 or less | 10% or less |
| Bracket 2      | 23,980–28,590   | 91,760–16,080 | 11% or more and 30% or less |
| Bracket 3      | 28,590–34,640   | 16,080–23,270 | 21% or more and 30% or less |
| Bracket 4      | 34,640–41,730   | 23,270–34,980 | 31% or more and 40% or less |
| Bracket 5      | 41,730–50,740   | 34,980–49,670 | 41% or more and 50% or less |
| Bracket 6      | 50,740–62,290   | 49,670–68,250 | 51% or more and 60% or less |
| Bracket 7      | 62,290–77,730   | 68,250–90,750 | 61% or more and 70% or less |
| Bracket 8      | 77,730–99,870   | 90,750–121,360 | 71% or more and 80% or less |
| Bracket 9      | 99,870–136,290  | 121,360–163,850 | 81% or more and 90% or less |
| Bracket 10     | 136,290–1,753,300 | 163,850–1,718,200 | 91% or more and 100% or less |

Table 5. Incidence rates of thyroid cancer by income bracket

| Number of examinations | 2002–2003 | 2004–2005 | 2006–2007 | 2008–2009 | 2010–2011 | 2012–2013 | Total |
|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-------|
| Income bracket         | (column percent, %) | Year of examination |          |          |          |          |       |
| 0                      | 107       | 762       | 1,631     | 3,279     | 4,233     | 6,936     | 30,713 |
| 1                      | 14,873    | 15,946    | 18,380    | 22,177    | 23,647    | 23,909    | 61,105 |
| 2                      | 13,738    | 15,278    | 17,785    | 22,332    | 23,863    | 24,364    | 62,783 |
| 3                      | 15,208    | 17,052    | 19,895    | 24,705    | 26,962    | 27,801    | 73,410 |
| 4                      | 17,161    | 19,356    | 22,740    | 28,542    | 30,910    | 32,194    | 84,346 |
| 5                      | 17,700    | 20,762    | 25,241    | 31,731    | 34,819    | 36,259    | 95,283 |
| 6                      | 19,567    | 23,405    | 28,489    | 35,664    | 39,372    | 40,954    | 105,911|
| 7                      | 20,501    | 25,026    | 31,107    | 38,349    | 42,384    | 44,112    | 115,664|
| 8                      | 22,488    | 27,411    | 33,707    | 41,719    | 46,437    | 48,147    | 126,485|
| 9                      | 24,620    | 30,220    | 37,394    | 45,015    | 49,748    | 51,489    | 133,863|
| 10                     | 23,509    | 29,227    | 36,486    | 45,177    | 50,006    | 51,517    | 135,777|
| Total                  | 189,472   | 224,445   | 272,855   | 338,690   | 372,381   | 387,682   | 1,025,340|

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2. Incidence rates of thyroid cancer by sex

The incidence rates of thyroid cancer per year according to sex were analyzed using a 10-year sample cohort database for the years from 2004 to 2013.

In 2004, the largest sex gap in the incidence of thyroid cancer was shown, with a male:female ratio of 1:7.2. The ratio then gradually declined, to 1:6.3 in 2005, 1:6.2 in 2006, 1:6 in 2007, and 1:5.5 in 2008. Thereafter, the ratio was 1:5.3 in 2009, 1:4.6 in 2010, 1:4.1 in 2011 and 1:4.3 in 2012. By 2013 the ratio reached 1:3.6, notably smaller than the ratio of the first year studied (Table 7).

3. Incidence rates of thyroid cancer by age

Between 2004 and 2010, the incidence rates of those in their 40s were found to be the highest, whereas the incidence rates for those in their 50s were found to be highest from 2011 and thereafter. After those in their 40s and 50s, those in their 30s presented the next highest incidence rates (Table 8).

4. Incidence rates of thyroid cancer by income bracket

The incidence rates of thyroid cancer per year according to income bracket were analyzed using a 10-year sample cohort database for the years from 2004 to 2013.

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**Table 6. Yearly incidence rates of thyroid cancer**

| Year of new diagnostics | Number of new thyroid cancer patients | Total No. of samples (%) |
|-------------------------|--------------------------------------|--------------------------|
| 2004                    | 287                                  | 1,016,580 (0.03)         |
| 2005                    | 319                                  | 1,016,820 (0.03)         |
| 2006                    | 374                                  | 1,002,005 (0.04)         |
| 2007                    | 497                                  | 1,020,743 (0.05)         |
| 2008                    | 588                                  | 1,000,785 (0.06)         |
| 2009                    | 771                                  | 998,527 (0.08)           |
| 2010                    | 751                                  | 1,002,031 (0.07)         |
| 2011                    | 904                                  | 1,006,481 (0.09)         |
| 2012                    | 971                                  | 1,011,123 (0.10)         |
| 2013                    | 907                                  | 1,014,730 (0.09)         |

**Table 7. Incidence rates of thyroid cancer by sex**

| Year | Sex   | Number of cases |
|------|-------|-----------------|
| 2004 | Male  | 35              |
|      | Female| 252             |
| 2005 | Male  | 44              |
|      | Female| 275             |
| 2006 | Male  | 52              |
|      | Female| 322             |
| 2007 | Male  | 71              |
|      | Female| 426             |
| 2008 | Male  | 90              |
|      | Female| 498             |
| 2009 | Male  | 121             |
|      | Female| 650             |
| 2010 | Male  | 134             |
|      | Female| 677             |
| 2011 | Male  | 176             |
|      | Female| 728             |
| 2012 | Male  | 183             |
|      | Female| 788             |
| 2013 | Male  | 194             |
|      | Female| 713             |
Thyroid cancer incidence rates were found to be higher in higher income bracket groups, and for all years, the highest incidence rates were associated with the highest income bracket, which was the 10th income bracket.

### 5. Number of health exams by income bracket

Based on the premise that some people often receive health exams once every year while some receive them once every 2 years, figures were extracted according to the even number years. Higher rates of receiving health exams were found among those in higher income brackets (Table 9).

### DISCUSSION

Thyroid cancer is reported to occur approximately 3 times more in females than in males (19,20). In the current study, the largest gender gap occurred in 2004 at a male: female ratio of 1: 7.2. After this time point, the gap gradually decreased (Table 7) to around 1:3.6 by 2013.

Of the thyroid cancers, the highest prevalence of papillary cancer was found in those in their thirties and forties, while the highest prevalence of follicular cancer was found in those in their fifties. However, according to recent reports, the age at which follicular thyroid cancer occurs is becoming increasingly younger, with approximately half of all cases typically being discovered before the age of 40 while the progression of the illness is still at its initial stages. In this study, all thyroid cancers were analyzed without further classification of papillary and follicular cancers. Between the years 2004 and 2010, incidence rates among those in their forties were found to be the highest, whereas from 2011 onward the incidence rates among those in their fifties were found to be highest. After those in their 40s and 50s, those in their 30s presented the next highest incidence rates. Looking at rates of thyroid cancer incidence

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**Table 8. Incidence rates of thyroid cancer by age**

| Ages (yr) | Year of examination |
|-----------|---------------------|
|           | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| 0–19      | 1    | 2    | 2    | 3    | 1    | 5    | 6    | 1    | 6    | 2    |
| 20–29     | 21   | 20   | 20   | 28   | 21   | 45   | 32   | 38   | 48   | 49   |
| 31–39     | 57   | 55   | 72   | 93   | 99   | 146  | 133  | 168  | 186  | 150  |
| 40–49     | 90   | 110  | 118  | 154  | 197  | 220  | 213  | 261  | 254  | 274  |
| 50–59     | 55   | 74   | 103  | 126  | 164  | 208  | 219  | 268  | 298  | 263  |
| 60–69     | 38   | 41   | 46   | 76   | 81   | 99   | 99   | 117  | 134  | 101  |
| 70–79     | 23   | 14   | 10   | 15   | 20   | 42   | 42   | 40   | 42   | 60   |
| 80–99     | 2    | 3    | 3    | 2    | 5    | 6    | 7    | 11   | 3    | 8    |

**Table 9. Calculated number of examinations by income bracket**

| Income bracket | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|----------------|------|------|------|------|------|------|------|------|------|------|
| Bracket 0      | 2    | 5    | 1    | 5    | 15   | 19   | 3    | 60   | 18   | 20   |
| Bracket 1      | 18   | 12   | 16   | 30   | 30   | 51   | 41   | 54   | 54   | 61   |
| Bracket 2      | 9    | 17   | 20   | 24   | 27   | 34   | 40   | 54   | 61   | 50   |
| Bracket 3      | 18   | 25   | 17   | 31   | 30   | 50   | 46   | 52   | 48   | 51   |
| Bracket 4      | 22   | 11   | 24   | 30   | 28   | 57   | 45   | 64   | 59   | 65   |
| Bracket 5      | 18   | 24   | 29   | 38   | 47   | 58   | 62   | 60   | 72   | 66   |
| Bracket 6      | 31   | 30   | 33   | 46   | 57   | 57   | 62   | 76   | 75   | 94   |
| Bracket 7      | 35   | 33   | 33   | 40   | 66   | 59   | 64   | 85   | 103  | 81   |
| Bracket 8      | 30   | 37   | 46   | 62   | 60   | 104  | 116  | 102  | 125  | 86   |
| Bracket 9      | 47   | 46   | 67   | 82   | 96   | 119  | 115  | 140  | 163  | 145  |
| Bracket 10     | 57   | 79   | 88   | 109  | 132  | 163  | 157  | 157  | 193  | 188  |

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per 100,000 members of the population reported by the Korea Central Cancer Registry for
the year 2011, males between the ages of 45 and 49 presented the highest incidence rates
among their sex at 24.5 cases, whereas females between the ages of 50 and 54 presented the
highest incidence rates among their sex at 84.8 cases. These statistics present a similar result
to that found in this study (Table 8).

The correlations between socioeconomic status and thyroid cancer have been discussed
in many overseas reports (21-23). Due to the high cost of insurance in the US, despite the
relatively smaller number of health insurance holders, those with insurance are typically
reported to have higher incidence rates of thyroid cancer due to their ease of access to
medical services compared to those without insurance. Due to difficulties in accessing
medical services, those without insurance typically only visit hospitals upon the onset of
symptoms, leading to late diagnoses and higher incidence rates of progressive thyroid
cancers (24,25). In Canada, due to its universal health care system, socioeconomic factors
and thyroid cancer incidence rates are reported to have no correlation (11). In Switzerland,
however, which has a similar universal health care system, differences in death rates
according to socioeconomic factors have been reported (26).

In the Republic of Korea, the Medical Insurance Act was first enacted in 1963 and a system
requiring the compulsory application of health insurance was first implemented in July
1977. The system was expanded to include public servants and private school employees in
1979, rural agriculture and fisheries workers in 1988, and self-employed workers within cities
in 1989. By requiring self-employed workers within cities who were not salaried laborers
to be covered by health insurance, the Republic of Korea established a health care system
covering all of its citizens.

This study classified income into 10 brackets using data related to collected insurance
contributions, and further analyses were undertaken based on an assumption that inclusion
in the higher brackets entailed higher income (Table 4). Through the analysis of the 10-year
sample cohort data taken from 2004 to 2013, it was found that thyroid cancer incidence rates
were higher as the income brackets became higher (Table 5). In addition, the rate of receiving
health exams provided free of charge by the government was analyzed according to income
bracket. In consideration of the fact that such exams are typically received every 2 years, the
analysis was carried out in 2-year intervals. The rate of receiving health exams was also found
to be higher for those in higher income brackets. Considering that health exams paid for out-
of-pocket by individuals could not be included in this study, the rate of receiving health exams
was not considered to be completely accurate. An attempt was made through this study to
analyze correlations between socioeconomic factors and thyroid cancer incidence rates. In
order to carry out an accurate analysis of socioeconomic factors, the residential areas, level
of education, income, status of health insurance subscriptions of each subject needs to be
collected. As such, this study is considered limited, in that the data regarding income used in
this study was derived indirectly by tracking only health insurance contributions (27-30).

This study indicated an increase in thyroid cancer incidence rates and rates of receiving
health exams among individuals with a higher SES. Despite this being considered to be
related to a greater access to medical services among those with higher SES, which in turn
gives them a greater chance at early diagnosis of thyroid cancer, there still are several other
factors that may affect the incidence rates of thyroid cancer that should be studied, which can
be an area for further investigation (31).
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