

# Disease Patterns and Socioeconomic Status Associated with Utilization of Computed Tomography in Taiwan, 1997–2003

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**Background/Purpose:** The utilization of computed tomography (CT) has rapidly grown year after year. Yet, literature that explores the factors related to CT utilization is limited. We attempted to determine the profiles of populations with high rates of CT usage, and to understand the association of disease patterns and socioeconomic status with CT-involved treatments.

**Methods:** National Health Insurance medical claim data from the cohort of 200,000 samples representing 23 million insured people during 1997–2003 were used for analysis. Multiple logistic regression analysis was performed to identify factors associated with CT usage.

**Results:** Annual growth rate in CT usage during 1997–2003 was 7.35% and average use of CT was 28.69 per 1000 people. The diseases associated with the highest CT usage rates were neoplasm (169 per 1000 people), diseases of the circulatory system (33 per 1000 people), and congenital malformations (20 per 1000 people). Disease patterns with high annual growth rate of CT usage were morbidities originating in the perinatal period (29.85%), mental disorders (15.47%), and other disease patterns without clear symptoms and diagnosis (13.33%). Individuals with lower salary used CT more frequently than those with higher salary. Multiple logistic regression analysis showed that cancer patients had significantly higher likelihood (odds ratio [OR], 7.71) of CT use than those with other diseases. Males (OR, 1.64) and elderly (OR, 1.96–7.05) had higher likelihoods of CT use and those with higher salaries had lower likelihood (OR, 0.50–0.89) of CT use.

**Conclusion:** Neoplasm, diseases of the circulatory system, congenital malformations, and poor socioeconomic status were significantly associated with a higher rate of CT utilization. The distribution of disease patterns varied with gender, age groups, salary levels, and health care region's household income levels. Further study is needed to better understand the nature of the findings. [*J Formos Med Assoc* 2008; 107(2):145–155]

**Key Words:** computed tomography, CT, disease patterns, high-tech equipment, socioeconomic status

In recent years, the growth rate of health care expenditure has been twice that of the gross domestic product in many countries, and the widespread utilization of high-tech medical care is one of the primary underlying reasons.<sup>1–3</sup> Since

the implementation of National Health Insurance (NHI) in 1995, Taiwan has been facing similar health insurance-associated problems as other countries, the most serious of which is that health care expenditure has been soaring.

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Clearly, there are many factors that contribute to the rise in health care expenditure, such as expanded insurance coverage, growth of the elderly population, increased aggressiveness in providing medical care, utilization of high-tech equipment, expensive treatment methods, increased prevalence of chronic diseases, increased income, and economic fluctuations.<sup>4-10</sup> Among them, technologic advance is a key driver of health care spending growth.<sup>11-15</sup> In recent years, the utilization of high-tech equipment has grown year after year. Focusing on the utilization of computed tomography (CT) in hospitals during 1998–2001 as an example, the annual growth rate of CT use in hospital outpatients was 4.47%. Expenses associated with CT use constituted up to 1% of the annual national health care expenditure in each of the 4 years.<sup>16</sup>

With increasingly intense competition in the health care market in recent years, providing high-tech medical equipment and technology has become one of the marketing strategies for many hospitals. It is therefore necessary for hospitals to boost the usage rate of such high-tech medical equipment and technology in order to recover the purchase costs. According to statistics of medical claims provided by the Bureau of NHI (BNHI), the expense of both CT and magnetic resonance imaging (MRI) was approximately NT\$4.4 billion in 1999, and the growth rate was 17.71%, far exceeding that of the total costs of national health care.<sup>17</sup>

High-tech equipment was introduced into Taiwan somewhat later than in many other developed countries, but the availability of such equipment has increased at a staggering rate. It has been shown through statistics provided by the Department of Health (DOH) that the number of CT units approved increased from 175 to 495 between 1992 and 2003, wherein the annual growth rate was 9.91%. In 2003, the number of CT units per million population was 21.9 in Taiwan, ranking third among the members of the Organization for Economic Cooperation and Development (OECD).<sup>18</sup> Prior research in the utilization of high-tech equipment focused mainly on health care

expenditure, without extensive and long-term investigations into the relevant factors that affect the use of CT.<sup>11,14,19</sup> The relevant factors that influence CT utilization remain unknown. In general, there is a positive relationship between the availability of technology and health care expenditure. People without health insurance coverage or who need a high deductible payment would have lower financial ability to use diagnostic imaging due to its high cost. In publicly funded medical delivery systems, the utilization of medical care services should be equitable, irrespective of socioeconomic status (SES). A previous study indicated that the relative rate of diagnostic imaging utilization was higher for people with higher income.<sup>20</sup> However, literature that explores the association between SES, disease patterns and CT utilization is limited. Previous studies did not specifically address patient characteristics and disease types with high CT usage. Is the relationship between SES and CT utilization under the Taiwan NHI different from that determined in previous studies?

This study aimed to explore the features of segments of the population with high CT usage and the associated disease patterns over a multi-year period, and to attempt to understand the association of SES with CT utilization under a comprehensive and universal national health insurance program.

## Methods

### *Study population*

To understand health care utilization by the 23 million insured in Taiwan, the BNHI used the Registry for Beneficiaries (RFB) to create a cohort of the sample population, sampling 200,000 participants from the entire insured population by carefully designed random sampling to form the RFB Sampling File (RFBSF), in which all individual health care-related data (i.e. outpatient clinic visits, emergency department visits, hospitalizations) were collected. The RFBSF is a representative sample of the entire NHI-insured population

and forms a continuous profile of health care information, and is published by the BNHI. The purpose of the RFBSF is to provide current information about health care for NHI beneficiaries. There were no significant differences in the mean or distributions of age, gender, medical care expenses, and geography between the RFBSF samples and the entire 23 million NHI-insured population. Those insured who used CT in the RFBSF samples between 1997 and 2003 served as the subjects of research in the present study.

### **Data sources**

The data collected in the present study are secondary data; data regarding individual CT utilization were derived from NHI medical claims data. Patient profiles were derived from the RFBSF in 2003, and included gender, age, location of residence, and monthly premium-based salary. The monthly premium of each insured person is based on 1 month's salary and classified into eight different levels (from NT\$15,840 to NT\$87,600). It means that individuals with higher monthly salaries would pay a higher monthly insurance premium, but based on a calculation with the salary capped at NT\$87,600 before 2004. Spouses and minor children are provided coverage by the insured and are referred to as the insured dependants. The DOH divided the national geography according to medical care accessibility into 17 health care regions (HCRs). HCRs are the residential areas in which the health care needs of residents can be conveniently met, and each HCR consists of approximately 20 townships in Taiwan. In the present study, the 17 HCRs were further divided into high- and low-income HCRs according to the average household income in Taiwan in 1997.<sup>18</sup> According to the ICD-9-CM, diseases were classified into 18 disease patterns. We used these 18 types of disease patterns to examine the diseases associated with CT utilization.

### **Statistical methods**

The current study included descriptive and multiple logistic regression analyses. Descriptive analysis was employed to understand the frequency of

CT usage as it pertained to every variable under scrutiny and the annual growth rate, and to compare the distribution of disease patterns among patients with different features and income who used CT. Trend analysis was also employed to examine variations in CT usage per 1000 people during the period between 1997 and 2003. If a person had multiple CT uses within a year, this study counted the multiple uses based on the type of disease patterns for CT use rate per 1000 people.

In order to understand the influence of disease patterns and income on CT utilization when personal features were designated as the controlled factor, this study used the data of the RFBSF in 2003. Multiple logistic regression analysis was used to analyze the factors that influenced CT utilization, in which the presence of CT use was the dependent variable, and gender, age, monthly premium-based salary, type of disease, and living area's (i.e. HCR's) average household income were the independent variables.

## **Results**

### **Descriptive statistical results**

Between 1997 and 2003, the frequency of CT use per 1000 people significantly increased from 22.72 to 34.30 ( $p < 0.05$ ), with a mean of 28.69, and an annual growth rate of 7.1% (Table 1). During the 7-year span, average CT usage among males (32.2‰) was higher than in females (25.0‰); however, the 7-year growth rate of female usage (51.2%) was similar to that of males (51.1%). The frequency of CT usage increased with age. Specifically, average usage among those  $\geq 61$  years of age was 108.7 per 1000 people, but the annual growth rate for those  $\geq 41$  years of age was small ( $< 3\%$ ). The trend of annual increase was statistically significant in those aged  $\leq 20$  and those between 21 and 40 ( $p < 0.05$ ).

With respect to monthly premium-based salary (Table 1), the insured who had the highest level of CT usage (42.85) per 1000 were those who earned  $\leq$  NT\$15,840, which is the lowest

**Table 1.** Frequency of CT utilization per 1000 people, 1997–2003\*

	1997	1998	1999	2000	2001	2002	2003	7-yr average	Annual growth rate% <sup>†</sup>	Trend analysis <i>p</i>
Frequency of use per 1000	22.72	26.72	29.36	27.02	28.12	32.56	34.30	28.69	7.11	0.005
Gender										
Female	20.03	22.42	24.76	23.61	25.11	28.90	30.30	25.02	7.14	<0.001
Male	25.29	30.82	33.75	30.27	31.00	36.06	38.22	32.20	7.12	0.017
Age (yr)										
≤20	5.30	6.47	7.34	6.19	6.72	7.51	7.77	6.76	6.59	0.033
21–40	10.45	11.92	13.08	12.21	12.09	13.70	15.00	12.64	6.22	0.013
41–60	33.36	36.59	39.20	33.58	35.35	38.73	39.49	36.61	2.85	0.194
≥60	95.66	110.87	116.12	106.04	102.98	116.02	113.48	108.74	2.89	0.238
Premium-based salary (NT\$)										
Insured dependants <sup>‡</sup>										
≤15,840	21.00	23.92	25.56	22.49	22.83	26.03	27.36	24.17	4.51	0.076
15,841–22,800	34.13	41.19	44.97	40.18	41.32	45.90	52.25	42.85	7.36	0.023
22,801–28,800	24.59	30.22	33.03	33.08	34.30	41.27	42.34	34.12	9.48	<0.001
28,801–36,300	16.29	16.65	17.73	18.93	19.53	21.09	24.53	19.25	7.06	<0.001
36,301–45,800	14.42	13.26	21.05	14.77	15.35	20.00	20.24	17.01	5.81	0.159
45,801–57,800	15.50	18.14	19.93	16.98	22.25	24.57	24.37	20.25	7.83	0.006
57,801–72,800	9.68	14.31	17.89	15.78	16.20	18.31	21.54	16.24	14.26	0.010
≥72,801	16.87	19.02	21.78	17.18	19.02	26.07	24.51	20.64	6.42	0.059
≥72,801	8.70	6.52	17.39	14.49	29.71	21.01	28.18	18.00	21.65	0.013
Average household income										
High-income HCRs	16.50	19.67	21.48	18.42	19.33	22.59	22.56	20.08	5.35	0.054
Low-income HCRs	31.14	36.42	39.97	38.57	39.89	46.05	48.98	40.15	7.84	0.001
CT scan field										
Head	15.90	8.72	8.01	4.11	3.05	2.64	3.01	6.49	−24.22	0.007
Part of body	984.10	991.28	991.99	995.89	996.95	997.36	996.99	993.51	0.22	0.007

\*Frequency of CT use/1000 (sampled population in RFBSF each year); <sup>†</sup>annual growth rate =  $(\sqrt[7]{2003\text{data}/1997\text{data}} - 1) \times 100$ ; <sup>‡</sup>insured dependants are spouses and children of the insured. HCR = health care regions.

level. Individuals with higher 7-year growth rate were those who earned a premium-based salary  $\geq$  NT\$72,801 (224.1%) or NT\$45,801–57,800 (122.5%). The average rate of CT usage per 1000 people was 40.15 in low-income HCRs, which was two times higher than that (20.08) in high-income HCRs. In addition, patients who had head CT scans decreased year by year, with an annual growth rate of −24.2% (Table 1).

As shown in Table 2, the top three diseases with the highest rate of CT usage were neoplasm, circulatory diseases, and congenital malformations, in which every 1000 neoplasm patients used

CT an average of 169.14 times annually, and the annual growth rate was 6.54%. Considering the annual growth rate of CT use, the top three diseases with the highest annual growth rates were morbidities originating in the perinatal period (29.9%), mental disorders (15.5%), and disease patterns without clear symptoms and diagnosis (13.3%). This study further examined CT utilization between 1997 and 2003 by trend analysis and found that the rate of CT utilization per 1000 people showed a significant increasing trend for mental disorders, disease patterns without clear diagnosis, skin and epidermal diseases, neoplasm,

**Table 2.** CT utilization per 1000 people for different disease patterns, 1997–2003\*

	1997	1998	1999	2000	2001	2002	2003	7-yr average	Annual growth rate% <sup>†</sup>	Trend analysis <i>p</i>
Morbidities originating in perinatal period	3.31	5.59	1.80	6.32	8.77	46.15	15.87	12.54	29.85	0.133
Mental disorders	7.97	8.51	11.49	11.95	13.11	18.03	18.90	12.85	15.47	<0.001
Disease patterns without clear symptoms, conditions, and diagnosis	6.17	6.73	8.88	7.81	9.68	11.47	13.08	9.12	13.33	<0.001
Skin and epidermal diseases	0.44	0.43	0.54	0.43	0.48	0.76	0.77	0.55	9.70	0.029
Digestive system diseases	4.04	4.34	3.99	3.73	4.13	5.04	6.35	4.52	7.84	0.068
Neoplasm	133.84	153.68	167.02	178.06	171.54	184.20	195.68	169.14	6.54	0.001
Trauma and poisoning	14.92	16.53	15.30	14.04	14.92	21.53	20.46	16.81	5.41	0.091
Combined conditions of pregnancy, parturition and puerperium	0.26	0.26	0.52	0.00	1.22	0.31	0.33	0.41	4.08	0.662
Respiratory system diseases	2.19	2.16	1.81	1.89	1.82	2.43	2.77	2.15	4.00	0.256
Urinary and reproductive system diseases	3.13	2.92	2.98	3.11	3.03	3.51	3.96	3.23	4.00	0.044
Nervous system and sensory organ diseases	5.07	5.89	5.66	6.04	5.15	6.27	6.00	5.73	2.84	0.246
Blood and hematogenic organ diseases	8.26	9.61	10.17	9.62	10.80	7.16	9.30	9.27	2.00	0.877
Infectious and parasitic diseases	10.12	10.74	13.81	9.06	9.78	11.18	11.34	10.86	1.92	0.956
Bone, muscle and connective tissue diseases	9.26	10.54	11.06	9.60	9.89	10.16	9.51	10.00	0.45	0.760
Endocrine, nutrition and metabolic diseases	7.09	7.34	9.29	6.43	7.10	7.56	7.21	7.43	0.29	0.797
Circulatory system diseases	32.41	33.94	35.29	32.91	30.11	34.11	32.53	33.04	0.06	0.652
Congenital malformations	18.83	19.19	27.70	17.56	18.30	26.72	16.06	20.62	-2.62	0.924
Other factors affecting health	2.72	3.00	1.73	1.55	0.90	1.73	1.84	1.92	-6.31	0.114

\*Frequency of CT use/1000 (number of people with the disease); <sup>†</sup>annual growth rate =  $(\sqrt[5]{2003\text{data}/1997\text{data}} - 1) \times 100$ .

and diseases of the urinary and reproductive systems ( $p < 0.05$ ).

The difference in the disease patterns of CT users based on characteristics was also investigated (Table 3). It was found that the disease patterns with the highest CT use rates in males were neoplasm (269.3‰), circulatory system diseases (40.7‰) and trauma and poisoning (19.2‰), and for females were neoplasm (122.9‰), circulatory system diseases (26.1‰) and congenital malformations (23.1‰). By examining the correlations between HCRs with different incomes

and distribution of disease patterns, it was found that the highest CT utilization was for cancer (148 per 1000 in high-income HCRs, 186 per 1000 in low-income HCRs), and the second highest was for circulatory system diseases (31 per 1000 in high-income HCRs, 35 per 1000 in low-income HCRs). The third highest was for congenital malformations for high-income HCRs and trauma and poisoning for low-income HCRs.

The distribution of disease patterns varied with age group (Table 3). The most frequent disease patterns in CT usage per 1000 people for those

**Table 3.** Average frequency of CT utilization per 1000 patients for different types of diseases, 1997–2003

Classification	Gender		Regional income				Age (yr)				Premium-based salary (NT\$)		
	Female	Male	High income	Low income	≤20	21–40	41–60	≥61	Insured dependant	≤15,840	15,840–36,300	≥36,301	
Neoplasm	122.90	269.30	147.88	186.61	40.07	56.85	164.33	391.41	172.57	252.12	157.06	114.41	
Morbidities originating in perinatal period	21.66	0.00	8.61	14.53	13.38	4.93	0.00	0.00	2.86	33.04	10.20	91.84	
Congenital malformations	23.10	17.67	22.28	19.38	12.97	24.20	40.11	33.13	16.26	34.49	25.47	24.70	
Circulatory system diseases	26.10	40.71	30.86	34.58	11.13	10.13	18.69	51.49	41.70	43.02	27.72	13.01	
Trauma and poisoning	12.64	19.22	14.18	19.40	12.91	13.21	15.76	30.05	14.27	27.02	15.62	10.06	
Bone, muscle and connective tissue diseases	9.17	10.95	10.55	9.64	3.70	7.15	9.91	16.19	9.35	13.74	9.80	7.46	
Disease patterns without clear symptoms, conditions and diagnosis	7.23	11.87	9.79	8.70	3.67	5.48	9.84	21.90	8.31	14.05	8.93	7.18	
Infectious and parasitic diseases	8.34	13.72	9.77	11.75	1.94	4.17	13.33	43.41	8.94	20.83	11.56	5.36	
Mental disorders	10.83	15.53	12.08	13.42	4.98	6.54	7.98	30.07	15.28	18.51	10.45	4.90	
Nervous system and sensory organ diseases	5.06	6.58	5.22	6.12	2.19	4.66	6.56	12.79	4.78	9.90	5.97	4.55	
Endocrine, nutrition and metabolic diseases	7.66	7.21	5.99	8.52	6.02	3.89	4.86	12.42	9.54	8.30	6.83	3.49	
Digestive system diseases	3.41	5.77	3.75	5.17	0.33	2.23	6.57	17.13	2.98	8.26	5.42	3.36	
Respiratory system diseases	1.52	2.85	2.05	2.23	0.55	1.41	2.92	7.86	1.53	4.40	2.29	2.04	
Urinary and reproductive system diseases	2.44	7.38	2.86	3.52	1.04	0.99	3.28	13.84	4.37	4.71	2.59	2.00	
Blood and hematogenic organ diseases	7.72	13.85	7.76	10.34	5.43	5.26	7.11	21.02	10.66	17.09	7.62	1.83	
Other factors affecting health	1.20	4.39	1.95	1.93	1.40	0.79	3.06	3.38	1.91	3.78	1.85	1.58	
Combined conditions of pregnancy, parturition and puerperium	0.34	5.83	0.37	0.45	0.00	0.33	2.12	8.91	0.55	1.20	0.23	0.64	
Skin and epidermal diseases	0.38	0.78	0.52	0.57	0.19	0.27	0.80	1.71	0.51	1.28	0.46	0.23	

≤20 years of age over the 7 years were neoplasm (40.0‰) and morbidities originating in the perinatal period (13.4‰), while the most frequent disease patterns among people aged 21–40 and 41–60 years were neoplasm (56.9‰ and 164.3‰) and congenital malformations (24.2‰ and 40.1‰), and those for people aged ≥61 years were neoplasm (391.4‰) and circulatory system diseases (51.5‰).

Finally, the distribution of disease patterns for CT use among different premium-based salaries were compared (Table 3). It was found that the disease patterns of CT usage per 1000 people for insured dependants and individuals with premium-based salary ≤NT\$15,840 or NT\$15,841–36,300 were generally the same, in which the disease patterns with the highest CT use were neoplasm, circulatory system diseases and congenital malformations. The most frequent disease patterns on average among people with premium-based salary ≥NT\$36,301 were neoplasm, morbidities originating in the perinatal period, and congenital malformations.

#### *Multiple logistic regression results*

Multiple logistic regression analysis was used to understand the factors that affect CT utilization (Table 4). If other variables were controlled for, the likelihood of using CT by males was higher than by females, with an odds ratio (OR) of 1.64 (95% confidence interval [CI], 1.53–1.76). The older a person was, the greater the likelihood that he or she used CT. Compared to those aged ≤20 years, the ORs of CT use were 1.96, 3.30 and 7.05 for those aged 21–40, 41–60 and ≥61 years, respectively. With regard to income, all other premium-based salary groups had a lower likelihood (OR, 0.50–0.89) of using CT than the group with the lowest premium-based salary of ≤NT\$15,840 ( $p < 0.05$ ).

With regard to disease patterns, when people had neoplasm, congenital malformations, infectious and parasitic diseases, disease patterns without clear symptoms and diagnosis, trauma and poisoning, endocrine, nutrition and metabolic diseases, blood and hematogenic organ diseases,

mental disorders, nervous and sensory organ diseases, circulatory system diseases, or digestive system diseases, they had a greater likelihood of using CT. However, those with respiratory system diseases, combined conditions of pregnancy, parturition and puerperium, or skin and epidermal diseases had a lower likelihood of using CT. The disease patterns that were associated with most frequent CT use were neoplasm (OR, 7.71; 95% CI, 7.13–8.34), congenital malformations (OR, 3.13; 95% CI, 2.40–4.08), mental disorders (OR, 1.97; 95% CI, 1.80–2.16), circulatory system diseases (OR, 1.95; 95% CI, 1.81–2.09), and other disease patterns without clear symptoms and diagnosis (OR, 1.94; 95% CI, 1.82–2.08). Finally, since the observation period was yearly, we also used the dataset to perform logistic regression for the years 1997 to 2002, and the results were similar to those for 2003.

## **Discussion**

The BNHI of Taiwan implemented a medical instruction notification system, which requested notification from hospitals within 24 hours of performing a medical service using high-tech instruments such as CT or MRI. The implementation of the notification system resulted in a reduction in CT usage in 2000, but CT usage returned to previous levels between 2001 and 2003. Trend analysis showed that the average rate of CT use rose significantly each year between 1997 and 2003, indicating that strict scrutiny before and after a procedure was a diminishing effect on CT utilization control. Interestingly, the number of head CT scans significantly decreased each year, and the annual growth rate was –24.2%, which may be attributed to the policy of mandatory wearing of helmets while riding motorcycles that took effect in June 1997, and the corresponding large reduction in head trauma cases.<sup>21</sup>

This study showed that the rate of CT use by males was significantly higher than that of females between 1997 and 2003, but the annual growth rate was very similar for both females and

**Table 4.** Multiple logistic regression analysis of CT utilization\*

	OR	95% CI	
Gender			
Female (reference)			
Male	1.642 <sup>‡</sup>	1.534	1.757
Age (yr)			
≤ 20 (reference)			
21–40	1.958 <sup>‡</sup>	1.687	2.272
41–60	3.297 <sup>‡</sup>	2.849	3.816
≥ 61	7.047 <sup>‡</sup>	6.124	8.108
Average household income			
High-income HCRs (reference)			
Low-income HCRs	1.027	0.964	1.094
Premium-based salary (NT\$)			
≤ 15,840 (reference)			
Insured dependant	0.891 <sup>§</sup>	0.809	0.981
15,840–22,800	0.789 <sup>§</sup>	0.720	0.864
22,801–28,800	0.649 <sup>‡</sup>	0.540	0.779
28,801–36,300	0.564 <sup>‡</sup>	0.464	0.685
36,301–45,800	0.631 <sup>‡</sup>	0.531	0.749
45,801–57,800	0.547 <sup>‡</sup>	0.425	0.705
57,801–72,800	0.503 <sup>‡</sup>	0.380	0.664
≥ 72,801	0.668 <sup>‡</sup>	0.488	0.914
Classification <sup>†</sup>			
Neoplasm	7.710 <sup>‡</sup>	7.132	8.335
Congenital malformations	3.127 <sup>‡</sup>	2.400	4.075
Mental disorders	1.972 <sup>‡</sup>	1.802	2.159
Circulatory system diseases	1.948 <sup>‡</sup>	1.813	2.092
Disease patterns without clear symptoms, conditions and diagnosis	1.944 <sup>‡</sup>	1.820	2.075
Trauma and poisoning	1.766 <sup>‡</sup>	1.657	1.882
Infectious and parasitic diseases	1.662 <sup>‡</sup>	1.551	1.781
Blood and hematogenic organ diseases	1.591 <sup>‡</sup>	1.310	1.933
Endocrine, nutrition and metabolic diseases	1.351 <sup>‡</sup>	1.249	1.462
Nervous system and sensory organ diseases	1.136 <sup>‡</sup>	1.065	1.211
Digestive system diseases	1.074 <sup>‡</sup>	1.005	1.147
Respiratory system diseases	0.831 <sup>‡</sup>	0.778	0.889
Combined conditions of pregnancy, parturition and puerperium	0.708 <sup>§</sup>	0.510	0.981
Skin and epidermal diseases	0.875 <sup>‡</sup>	0.817	0.937
Urinary and reproductive system diseases	1.029	0.952	1.112
Bone, muscle and connective tissue diseases	0.989	0.925	1.058
Morbidities originating in the perinatal period	2.508	0.962	6.538

\*The dependent variable is whether CT was used or not ( $N = 4846$  for CT use and  $N = 158,191$  for no CT use; CT usage is used as event); <sup>†</sup>each disease type is divided into two groups: with and without the disease (people without the disease comprised the reference group); <sup>‡</sup> $p < 0.01$ ; <sup>§</sup> $p < 0.05$ . OR = odds ratio; CI = confidence interval; HCR = health care regions.

males. The results are consistent with those of a previous study that showed greater CT utilization by men than by women (sex ratio M/F, 1.17).<sup>22</sup> Another population-based study showed a positive

correlation between the proportion of females in the population and the increase in CT usage for the years 1998 to 2001,<sup>23</sup> which resulted from the growth rate being higher for females (11%)



than for males (0.6%), although the rate of CT use by males was higher than that by females between 1998 and 2001. It was shown by further analysis that although the most frequent disease patterns leading to CT use by both males and females were neoplasm and circulatory system diseases, the use rate due to congenital malformations and trauma and poisoning ranked the third for females and males respectively and varied greatly between males and females. Almost all CT use rates of diseases were higher for males than for females except for two diseases: *congenital malformations* and *endocrine, nutrition and metabolic disease* (morbidity originating in the perinatal period only for females).

This study demonstrated that the frequency of CT utilization increased with age. Nevertheless, it is noteworthy that those aged  $\leq 20$  years exhibited the highest annual growth rate of CT usage per 1000 people. According to the statistics of the DOH of Taiwan, accident-related trauma and suicide ranked first and third, respectively, as causes of death in teenagers aged 15–24 years, and accident-related trauma also ranked first for those aged 1–14 years.<sup>24</sup> CT is the most commonly used examination following accidents, so common reasons for using CT by those under 20 years of age are trauma and poisoning. This implies that more effort is required to reduce childhood accidents.

With other variables controlled for, the current study showed that the likelihood of CT usage was not significantly relevant to whether a person was in a high- or low-income HCR, though there was a higher growth rate in the low-income HCRs. Because the cost of CT (without copayment) is paid by national health insurance, personal income is irrelevant to the financial burden of CT usage. The statistics of the DOH showed that the number of CT units increased by 189 between 1997 and 2003, with 123 units attributed to low-income HCRs.<sup>25</sup> Therefore, the high growth in low-income HCRs may be attributed to increasing accessibility. However, after other variables were controlled for, it was found that premium-based salary was negatively correlated to CT usage. Further analysis of disease patterns found that

individuals with lower premium-based salaries have higher rate of CT usage for all disease patterns, especially for neoplasm, circulatory system diseases, trauma and poisoning, infectious and parasitic diseases, mental diseases, and blood and hematogenic organ diseases. This implies that individuals with lower income were more likely to use CT due to health problems. The proportion of the population with a premium-based salary  $\leq$  NT\$15,840 is approximately 3–5% of the insured population; the government needs to pay more attention to the health status of this group. However, the results of this study were inconsistent with that of a Canadian study that focused on an urban region and which indicated that higher diagnostic imaging utilization rates were associated with higher SES for all levels of diagnostic imaging sophistication, including CT and MRI.<sup>20</sup> Since both Canada and Taiwan have universal and comprehensive health insurance coverage, the cost of CT should not be a financial barrier to low-income people for accessing CT. The problem might be the difference in health status and disease patterns between higher-income and lower-income groups in both countries.

The most common disease patterns leading to CT use per 1000 people were neoplasm, circulatory system diseases, and trauma and poisoning. It is known from past studies that MRI can partially replace CT<sup>26–28</sup> and is particularly well-suited for the diagnosis of injuries involving muscles and bones.<sup>29</sup> The results herein showed that bone, muscle and connective tissue diseases contributed very little to the growth in CT usage, hence the extent to which MRI can replace CT is worthy of further research.

It is intriguing that the average annual growth rate of CT utilization in disease patterns without clear symptoms, conditions and diagnosis was very high. Because physicians place an emphasis on evidence-based medicine and strive to make medical plans and provide medical services to patients using currently available medical evidence, physicians might prefer to use CT examination.<sup>30</sup> In order to improve the quality of health care, and because of the surging number of medical

malpractice cases, physicians may prefer to use high-tech equipment to reach an accurate diagnosis so as to avoid unnecessary disputes. Whether or not that has led to a squandering of medical resources needs further investigation. The annual growth rate of CT usage for mental disorders was very high (15.5%). The number of people who sought medical treatment for mental disorders in Taiwan was 1,591,667 in 1998 and 2,019,805 in 2004, with an annual growth rate of 4.1%.<sup>24</sup> CT has become a common examination tool for mental disorders, and the growth in the number of patients with mental disorders is one of the reasons that CT usage has increased.

In summary, from the 7 years of observation data, under Taiwan's comprehensive and universal national health insurance, SES was found to have a strong correlation with CT-involved medical treatments. Disease patterns needing CT-involved treatments were similar among different personal characteristics but the use rates were quite different. Low SES and neoplasm, diseases of the circulatory system and congenital malformations had significantly higher rates of CT utilization. Finally, there are some limitations to this study. Since the data source of the study was obtained from the RFB published by the BNHI, the real income of insured dependants is unknown, and the difference between premium-based salary and an individual's real income was not ascertained in this study. The possibility exists that real income was somewhat underestimated. In addition, since severity or morbidity level was one of the medical need factors that was not included in our analysis, it could be included in future study.

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