

Applying Data Mining Technology on the Using of Traditional Chinese Medicine in Taiwan

Yi-Horng Lai

Department of Health Care Administration
Oriental Institute of Technology
New Taipei City, Taiwan
Email: FL006 [AT] mail.oit.edu.tw

Abstract—This research employed the complete datasets of Traditional Chinese medicine (TCM) outpatient reimbursement claims from 2005 to 2007 to analyze the using of TCM, the characteristics of TCM patients, and the disease categories that were treated by TCM in Taiwan. With the result of this study, female use TCM more frequently than male, is consistent with previous reports from western countries. The reasons for this female predominance were not fully elucidated in previous reports. It was suggested that independent females, or females of good social status, had higher expectations of or belief in TCM in respect of postpartum conditions, menopause and chronic diseases. The age distribution of TCM users peaked in the 20-29 group, followed by the 10-19 group and 31-39 group. Most TCM visits were to private TCM clinics, followed by the private TCM hospitals. According to the results, the most common reasons for TCM visits were Kuru (460), Cough (786.2), Allergic rhinitis cause unspecified (477.9), Lumbago (724.2), Headache (784.0), Myalgia and myositis, unspecified (729.1), Constipation (564.0), Other sleep disturbances (780.59), Sleep disturbances, unspecified (780.50), and Dyspepsia and other specified disorders of function of stomach (536.8). TCM was popular in the Chinese population. More and more subjects used TCM at least once during the 3-year study period. TCM, like western medicine, was commonly used by the Chinese population for problems and diseases of major human organ systems. This study provides information about the use frequencies of TCM and disease categories treated by TCM, which should be useful for health policy makers and for those who consider the integration of Chinese and Western medicine.

Keywords- Traditional Chinese medicine, data mining, disease comorbidity network, Classification and Regression Tree (CART)

I. INTRODUCTION

Traditional Chinese medicine (TCM) was an important topic of complementary and alternative medicine in Western opinion [9]. Current TCM practices can be traced back more than 2000 years. TCM was still commonly used by the Chinese [3]. In Taiwan, not until the 1980s did several researchers start to research issues relevant to TCM, using sampling surveys or studies with small sample sizes [4]. There has been no large-scale investigation of the use of TCM among Chinese people worldwide, now.

Importance in complementary and alternative medicine had increased substantially in western countries during the past decade [1]. Patients and their families seem to have sought their health practitioners' opinions about various complementary and alternative medicine modalities more frequently [2]. Many studies have demonstrated dramatic increases in the use of, and expenditure on, complementary and alternative medicine in the Western opinion [2]. However, most of the prevalent studies of complementary and alternative medicine use were based primarily on questionnaire surveys, telephone interviews or collecting data from insurance claims, and the sample sizes generally were small.

In Taiwan, the National Health Insurance (NHI) was started in 1995 and covers nearly all inhabitants (21,653,555 beneficiaries at the end of 2001) [5]. The use of TCM has been reimbursed by the NHI since 1996. Taiwanese were free to choose Western medicine or TCM, and were allowed to visit either public or private medical facilities. Because all claims data are available to researches in electronic form, it could be conduct a study of TCM use among the Chinese population in Taiwan.

The aim of this study was to conduct a nation-wide survey in order to investigate the using of TCM, the characteristics of TCM users, and the medical conditions for which Taiwanese people most commonly use TCM, by analyzing the NHI claims data from 1997 to 2010. TCM provided by the NHI included Chinese herbal remedies, acupuncture and traumatology manipulative therapy

II. METHODOLOGY

A. Data Sources

The NHI program was initiated in Taiwan since 1995 and covers nearly all inhabitants. In 1999, the Bureau of NHI began to release all claims data in electronic form to the public under the National Health Insurance Research Database (NHIRD) project. The structure of the claim files is described in detail on the NHIRD website and in other publications [4].

It could be obtain the complete TCM claim datasets from the NHIRD in Taiwan. The datasets contained only the visit files, including dates, medical care facilities and specialties,

patients' genders, dates of birth, and the three major diagnoses coded in the International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM) format [6]. To protect privacy, the data on patient identities and institutions had been scrambled cryptographically.

These visit files represented all the TCM outpatient activities within the NHI from 2005 to 2007. Insurance benefits were available for TCM that included Chinese herbal remedies, acupuncture and traumatology manipulative therapy, especially for joint dislocation. In Taiwan, TCM is reimbursed by NHI only in ambulatory clinics, not for inpatient care. In addition, only licensed TCM physicians qualify for reimbursement from the NHI.

B. Study Design

Although the concept of disease entities in TCM was quite different from that in Western medicine, TCM physicians are requested to follow the standard diagnoses according to the ICD-9-CM coding system when claiming reimbursement. Common diagnostic groups for TCM visits were categorized according to the reclassification of primary ICD-9-CM codes for use in the National Ambulatory Medical Care Survey and National Hospital Ambulatory Medical Care Survey data in the United States.

To calculate patients' ages in relation to the 3-year use frequency of TCM from 2005 to 2007, December 31, 2007 was taken as the index of subtrahend. The denominator was the number of people who were insured during this 3-year period.

In order to compare the average numbers of visits between TCM and Western (allopathic) medicine, it could be obtained the total number of ambulatory visits to Western medicine from the website of Department of Health, Taiwan. In addition, we obtained the sampling claim datasets for ambulatory care visits at Western medicine clinics in order to compare the top ten disease categories between TCM and Western medicine visits. The sampling was random and visit-based but was separated monthly to eliminate possible seasonal variations. According to the NHIRD, these sampled files were representative of all utilization within the NHI in Taiwan.

C. Methodology

Decision tree learning was a method commonly used in data mining. The goal was to create a model that predicts the value of a target variable based on several input variables. Each interior node corresponds to one of the input variables; there were edges to children for each of the possible values of that input variable. Each leaf represents a value of the target variable given the values of the input variables represented by the path from the root to the leaf.

A decision tree was a simple representation for classifying examples. Decision tree learning was one of the most successful techniques for supervised classification learning. For this section, assume that all of the features have finite discrete domains, and there was a single target feature called the classification. Each element of the domain of the classification is called a class. A decision tree or a classification tree was a

tree in which each internal node was labeled with an input feature. The arcs coming from a node labeled with a feature are labeled with each of the possible values of the feature. Each leaf of the tree was labeled with a class or a probability distribution over the classes.

A tree can be learned by splitting the source set into subsets based on an attribute value test. This process was repeated on each derived subset in a recursive manner called recursive partitioning. The recursion was completed when the subset at a node has all the same value of the target variable, or when splitting no longer adds value to the predictions.

In data mining, decision trees could be described also as the combination of mathematical and computational techniques to aid the description, categorization and generalization of a given set of data.

Data comes in records of the form:

$$(x, Y) = (x_1, x_2, x_3, \dots, x_k, Y)$$

The dependent variable, Y, is the target variable that we are trying to understand, classify or generalize. The vector x is composed of the input variables, x₁, x₂, x₃ etc., that are used for that task.

The term Classification And Regression Tree (CART) analysis was an umbrella term used to refer to both of the above procedures, first introduced by Breiman, Friedman, Olshen, Stone, [10] Trees used for regression and trees used for classification have some similarities, but also some differences, such as the procedure used to determine where to split.

Used by the CART algorithm, Gini impurity is a measure of how often a randomly chosen element from the set would be incorrectly labeled if it was randomly labeled according to the distribution of labels in the subset. Gini impurity can be computed by summing the probability of each item being chosen times the probability of a mistake in categorizing that item. It reaches its minimum (zero) when all cases in the node fall into a single target category.

To compute Gini impurity for a set of items, suppose i takes on values in {1, 2, ..., m}, and let f_i be the fraction of items labeled with value i in the set.

$$I_G(f) = \sum_{i=1}^m f_i(1 - f_i) = \sum_{i=1}^m (f_i - f_i^2) = \sum_{i=1}^m f_i - \sum_{i=1}^m f_i^2 = 1 - \sum_{i=1}^m f_i^2$$

In CART,[10] variance reduction was often employed in cases where the target variable was continuous (regression tree), meaning that use of many other metrics would first require discretization before being applied. The variance reduction of a node N was defined as the total reduction of the variance of the target variable x due to the split at this node:

$$I_V(N) = \frac{1}{|S|} \sum_{i \in S} \sum_{j \in S} \frac{1}{2} (x_i - x_j)^2 - \left(\frac{1}{|S_t|} \sum_{i \in S_t} \sum_{j \in S_t} \frac{1}{2} (x_i - x_j)^2 + \frac{1}{|S_f|} \sum_{i \in S_f} \sum_{j \in S_f} \frac{1}{2} (x_i - x_j)^2 \right)$$

where S, S_t, and S_f are the set of presplit sample indices, set of sample indices for which the split test is true, and set of sample indices for which the split test is false, respectively.

D. Software for Data Mining

IBM SPSS Modeler 14.1 and PAJEK 4.0.1 were the main software used for data linkage and processing. Descriptive data, including frequencies, percentage and means, are presented.

III. RESULTS

Among the 1089885 valid beneficiaries of the NHI program at the end of 2007, 16153 had used TCM during the year, with a total of 1547708 visits. The annual number and percentage of TCM users steadily increased from 2005 to 2007 (as Table 1). The age distribution of the TCM users peaked in the 20-29, followed by the 10-19 and 30-39 (as Table 2), while the age distribution for visit counts showed a peak in the 40-49 followed by the 30-39 and 20-29.

A. Classification and Regression Tree (CART)

Base on the age group and sex, the result of Cart decision tree was as Figure 1. Predictor importance of age group was .53 and sex was .47 (as Figure 2).

Most of the TCM visits identified in the study were performed in private TCM clinics (11586971), followed by private TCM hospitals (126277), public TCM hospitals (45665) and public TCM clinics (403). Visits to private TCM hospitals decreased yearly, while visits to private TCM clinics, public TCM hospitals and others increased (as Table 3).

TABLE 1 PATIENT USE AND VISIT COUNTS OF TRADITIONAL CHINESE MEDICINE (TCM) WITHIN NATIONAL HEALTH INSURANCE (NHI) FROM 2005 TO 2007 IN TAIWAN

Year	Valid beneficiaries within NHI	Total No	Subjects using TCM		New patient	Total visits
			Female	Male		
2005	370211	113832	65860	47972	113832	588079
2006	362007	110715	64426	46289	43650	571634
2007	357667	113244	66145	47099	31121	599603
Total	1089885	337791	196431	141360	188603	1759316

TABLE 2 AGE-SPECIFIC USAGE FREQUENCY OF TRADITIONAL CHINESE MEDICINE (TCM) DURING THE 3-YEAR PERIOD FROM 2005 TO 2007 IN TAIWAN

Age (years)	Number of total population	Number of subjects using TCM	(%)	Number of TCM visits
≤9	43977	13607	30.94	108557
10–19	54409	26006	47.80	174824
20–29	64656	34869	53.93	258758
30–39	64046	33418	52.18	322126
40–49	62566	32775	52.38	354501
50–59	46130	24135	52.32	264651
60–69	26232	12871	49.07	144838
70–79	19375	8348	43.09	100455
≥80	8318	2574	30.94	30606

TABLE 3 SERVICE VOLUME OF TRADITIONAL CHINESE MEDICINE (TCM) BY FACILITY TYPE FROM 2005 TO 2007 IN TAIWAN

Year	Public TCM hospital	Private TCM hospital	Public TCM clinics	Private TCM clinics	Total
2005	15202	44002	145	528730	588079
2006	14802	41113	157	515562	571634
2007	15661	41162	101	542679	599603
Total	45665	126277	403	1586971	1759316

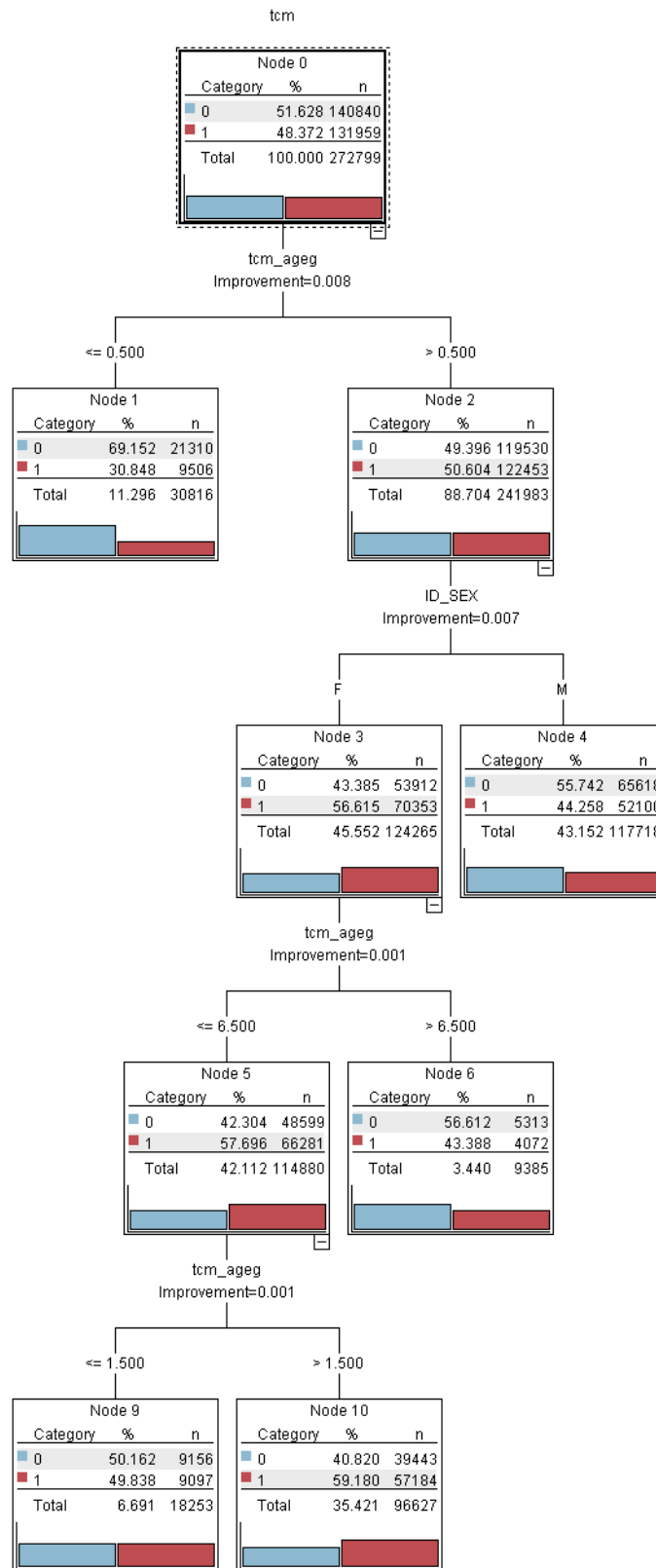


Figure 1. The result of CART

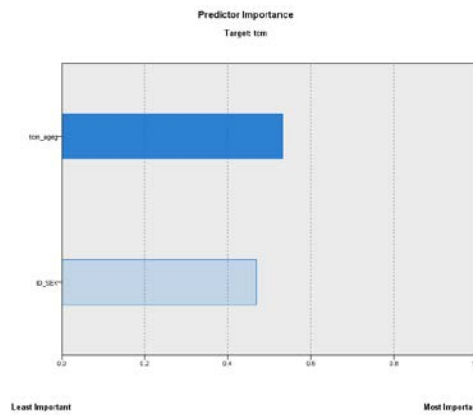


Figure 2. Predictor importance

Among the 1947696 TCM visits, each of them had one, two, or three clinical diagnoses according to the ICD-9-CM coding system. The top ten diseases for TCM visits were Kuru (7.64%), Cough (5.04%), Allergic rhinitis cause unspecified (3.50%), Lumbago (3.07%), Headache 2.99%), Myalgia and

myositis, unspecified (2.52%), Constipation (2.43%), Other sleep disturbances (2.02%), Sleep disturbances, unspecified (1.82%), and Dyspepsia and other specified disorders of function of stomach (1.80%) (as Table 4).

TABLE 4 THE TOP 10 MAJOR DISEASE CATEGORIES FOR TRADITIONAL CHINESE MEDICINE VISITS FROM 2005 TO 2007 IN TAIWAN

Disease	ICD-9-CM code	Number of visits	(%)
Kuru	460	1167572	5.80
Cough	786.2	759727	3.78
Lumbago	724.2	519769	2.58
Headache	784.0	447936	2.23
Myalgia and myositis, unspecified	729.1	432323	2.15
Allergic rhinitis cause unspecified	477.9	398124	1.98
Constipation	564.0	347317	1.73
Dyspepsia and other specified disorders of function of stomach	536.8	256241	1.27
Flatulence, eructation, and gas pain	787.3	237215	1.18
Other sleep disturbances	780.59	220872	1.10
Others		16042767	76.20
Total		20115535	100.00

Furthermore, it could be analyzed the percentage distribution of major disease categories for TCM visits by age (as Table 5). The results show that Kuru (460), Allergic rhinitis cause unspecified (477.9), Dyspepsia and other specified disorders of function of stomach (536.8), Myalgia and myositis, unspecified (729.1), and Other sleep disturbances (780.59) were higher in the 31-39 groups. The results show that Constipation (564.0) was higher in the 21-29 groups. The results show that Lumbago (724.2), Headache (784), and Flatulence, eructation, and gas pain (787.3) were higher in the 41-49 groups. The results show that Cough (786.2) was higher in the 41-49 groups.

It could be found no significant differences between males and females in the percentage distributions of the commonest disease categories for TCM visits (Table 6). However, female

subjects visited TCM for Kuru (460), Dyspepsia and other specified disorders of function of stomach (536.8), Constipation (564.0), Lumbago (724.2), Myalgia and myositis, unspecified (729.1), Other sleep disturbances (780.59), Headache (784), Cough (786.2), and Flatulence, eructation, and gas pain (787.3) more frequently than males.

It also be compared the percentage distribution of major disease categories for TCM visits among different locations and the results revealed that Kuru (460), Cough (786.2), Lumbago (724.2), Headache (784.0), Myalgia and myositis, unspecified (729.1), Allergic rhinitis cause unspecified (477.9), Constipation (564.0), Dyspepsia and other specified disorders of function of stomach (536.8), Flatulence, eructation, and gas pain (787.3), and Other sleep disturbances (780.59) were more commonly seen in clinics than in hospitals (Table 7).

B. Disease Comorbidity Network

In these years, the biomedical informatics is the research fields of information engineering. The application of networks to integrate different genetic, proteomic, and metabolic datasets has been proposed as a viable path toward elucidating the origins of specific diseases. This study applied the 2005-2007 medical records of hospitalization of National Health Insurance Research Database to construct Taiwanese disease network. This study estimated the prevalence of all diseases stratified

and calculated cases and phi-correlation coefficient as comorbidity in the using of Traditional Chinese Medicine as equation (1). The disease network of the using of Traditional Chinese Medicine was constructed with nodes representing diseases and links representing comorbidity as Figure 3.

$$\phi_{ij} = \frac{n_{ij} - n_i n_j}{\sqrt{n_i n_j (n - n_i)(n - n_j)}} \quad (1)$$

TABLE 5 PERCENTAGE DISTRIBUTION OF DISEASES CATEGORIES FOR TRADITIONAL CHINESE MEDICINE VISITS BY DIFFERENT AGE GROUPS, 2005–2007, IN TAIWAN

ICD-9 code	-9	10-19	21-29	31-39	41-49	51-59	61-69	71-79	81-
460	193320	166582	143657	205835	200918	133688	72758	39916	10898
477.9	80908	103387	58983	61171	46592	27236	11287	6877	1683
536.8	26740	30649	34037	44368	48451	35054	19328	13451	4163
564.0	12724	29343	84159	75965	60121	36529	18902	19572	10002
724.2	691	18757	67774	100036	117341	94235	61086	45404	14445
729.1	3429	28784	74436	87342	97608	71732	37533	24699	6760
780.59	838	6015	25678	46318	58175	46989	21410	12197	3255
784.0	4817	25059	58350	100644	114895	75407	39065	23275	6424
786.2	147625	87669	68232	117612	121975	96617	64008	43594	12395
787.3	15291	20444	32332	46986	52082	35162	19299	11999	3620
Total	486383	516689	647638	886277	918158	652649	364676	240984	73645

TABLE 6 NUMBER OF VISITS AND PERCENTAGE DISTRIBUTION OF DISEASES CATEGORIES FOR TRADITIONAL CHINESE MEDICINE VISITS BY GENDER, 2005-2007, IN TAIWAN

ICD-9 code	Female	Male	Unknown
460	708005	459015	552
477.9	197331	200762	31
536.8	144991	111148	102
564.0	279487	67620	210
724.2	276822	242519	428
729.1	261110	170754	459
780.59	143968	76892	15
784.0	327772	119795	369
786.2	427163	332304	260
787.3	144251	92861	103
Total	2910900	1873670	2529

TABLE 7 PERCENTAGE DISTRIBUTIONS OF DISEASES CATEGORIES FOR TRADITIONAL CHINESE MEDICINE VISITS BY LOCATION, 2005-2007, IN TAIWAN

ICD-9 code	Public TCM hospital	Private TCM hospital	Public TCM clinics	Private TCM clinics	Others
460	7414	44936	198	1115024	0
477.9	26562	54629	101	316831	1
536.8	10543	15252	154	230292	0
564.0	12073	24147	208	310885	4
724.2	14104	44462	232	460971	0
729.1	16111	56215	195	359802	0
780.59	2911	4155	31	213778	0
784.0	5731	19889	165	422149	2
786.2	11174	31897	347	716309	0
787.3	5072	8832	56	223255	0
Total	111695	304414	1687	4369296	7

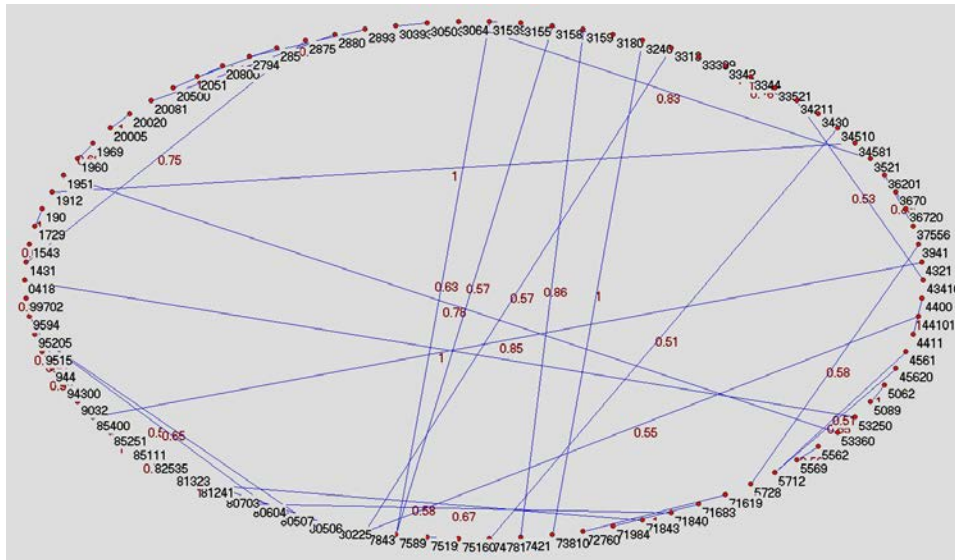


Figure 3. The disease comorbidity network of the using of traditional Chinese medicine (Phi-correlation>.5)

IV. DISCUSSION AND CONCLUSION

After all, this study is the first extensive survey of TCM use in Chinese society. Only with the help of a computerized insurance reimbursement database could such a large-scale TCM utilization study feasibly be analyzed. Previous studies from western countries on the frequency and characteristics of TCM use have mainly consisted of surveys of clinic attendees, telephone interviews, written surveys, household interviews, and hospital and private clinic surveys; and the sample sizes have been limited. In addition, the use of TCM in western countries is usually not covered by insurance [7]. Thus, the survey results might be affected by the socio-economic status of the subjects [8]. Fortunately, TCM is reimbursed by NHI in Taiwan, so the study would seem to be less biased.

The use of TCM in western countries has increased dramatically in recent years [9]. It goes without saying that TCM had been commonly used in Asian countries, especially in the Chinese population, for centuries [4]. Owing to the different definitions of complementary and alternative medicine, the types of complementary and alternative medicine surveyed, survey methodologies and types of complementary

and alternative medicine reimbursed by insurance, it was difficult to compare the use frequency of TCM among countries [11]. According to the results, there was a steady increase in the annual number of TCM users in Taiwan between 1997 and 2010; this does not include folk medicine, which is not reimbursable by insurance. Chinese people believe that Western medicine may react faster to the target but also causes more adverse side effects, while TCM reacts slowly but is subtle and safe [8,9,10]. Furthermore, the insurance coverage for TCM visits might also play a significant role [8].

It was interesting to know how health care was used when both Western medicine (WM) and TCM were available in Taiwan. Table 8 compares the use frequencies of outpatient visits between TCM and WM. The results show that people visited WM clinics more commonly than TCM clinics for their illnesses. Notably, the average number of outpatient visits per person per year in both TCM and WM decreased on 2006. WM still decreased on 2007, but TCM increase on 2007.

TABLE 8 COMPARISON OF THE AVERAGE NUMBER OF OUTPATIENT VISITS PER PERSON PER YEAR BETWEEN TRADITIONAL CHINESE MEDICINE (TCM) AND WESTERN MEDICINE (WM) FROM 2005 TO 2007 IN TAIWAN

Year	Valid beneficiaries	Total TCM visits	change from previous year (%)	Total WM visits	change from previous year (%)
1997	11524103	10445935	-	-1078168	
1998	12390066	11237075	7.57	1152991	6.94
1999	12983433	11786995	4.89	1196438	3.77
2000	12876760	11708286	-.67	1168474	-2.34
2001	12932622	11741824	0.29	1190798	1.91
2002	13235493	12014254	2.32	1221239	2.56
2003	13301940	11964572	-.41	1337368	9.51
2004	14805381	13313138	11.27	1492243	11.58

2005	15037163	13570002	1.93	1467161	-1.68
2006	14275405	12848000	-5.32	1427405	-2.71
2007	14324995	12829753	-.14	1495242	4.75
2008	14214089	12666665	-1.27	1547424	3.49
2009	14668653	13028641	2.86	1640012	5.98
2010	14598864	13035699	.05	1563165	-4.69

With the result of this study, female use TCM more frequently than male, is consistent with previous reports from western countries. The reasons for this female predominance were not fully elucidated in previous reports. It was suggested that independent females, or females of good social status, had higher expectations of or belief in TCM in respect of postpartum conditions, menopause and chronic diseases.

The age distribution of TCM users peaked in the 20-29 group, followed by the 10-19 group and 31-39 group. Most TCM visits were to private TCM clinics, followed by the private TCM hospitals.

According to the results, the most common reasons for TCM visits were Kuru (460), Cough (786.2), Allergic rhinitis cause unspecified (477.9), Lumbago (724.2), Headache (784.0), Myalgia and myositis, unspecified (729.1), Constipation (564.0), Other sleep disturbances (780.59), Sleep disturbances, unspecified (780.50), and Dyspepsia and other specified disorders of function of stomach (536.8).

TCM was popular in the Chinese population. More and more subjects used TCM at least once during the 3-year study period. TCM, like western medicine, was commonly used by the Chinese population for problems and diseases of major human organ systems. This study provides information about the use frequencies of TCM and disease categories treated by TCM, which should be useful for health policy makers and for those who consider the integration of Chinese and Western medicine.

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