



## **An Analysis of the Medical Expenses of a Bronchia and Pulmonary Cancer Group by Two- Stage Cluster Method**

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The objective of this study is to discover the influencing factors of groups by gender and age and the expenses related to bronchial and pulmonary cancer for insight into the root of the problem. An aging population has generated huge expenditures in cancer care. This study proposed a two-stage cluster method by using k-means and a Self-Organizing Map (SOM) to conduct a scientific analysis of the health insurance database of cancer prescription and patients in 2016. The findings of this study revealed that bronchial and pulmonary cancers were responsible for the largest medical expenditure; the average cost was \$306,776 for females aged 50 to 54 and \$301,788 for males aged 65 to 69. Meanwhile, the results indicated that incidences of bronchial and pulmonary cancer were concentrated in the ages between 45 and 89 for both males and females, with such incidences representing enormous cancer care expenditure. The implications are summarized in this article.

*Keywords: Two-stage cluster method, tumors, cancers, data mining, self-organization map, k-means*

The occurrence of malignant tumors remains one of the greatest threats to human health and life. With the change in global social patterns, the progress of science and technology, and the change in living habits, the incidence rate of such tumors has risen gradually, leading to the rise in demand for medical treatment resources. The leading causes of death have changed drastically along with the economic boom and advancements in public health in Taiwan since the early 1950s. Malignant neoplasm has been the leading cause of death in Taiwan since 1982 (Chen, You, Lin, Hsu, & Yang, 2002). According to statistics released by the Ministry of Health and Welfare of the Executive Yuan, the major causes of death and the top ten causes of death in Taiwan in 2015 were: (i) malignancy, (ii) heart disease (except hypertensive disease), (iii)

cerebrovascular disease, (iv) diabetes, (v) pneumonia, (vi) accidental injury, (vii) chronic lower respiratory disease, (viii) chronic liver disease and cirrhosis, (ix) hypertensive disease, and (x) nephritis, nephropathy and nephropathy, where the death toll from malignancies was 42,559 (i.e., 183.5 deaths per 100,000 population at a mortality rate of 28.03%) (Chiang, Yang, You, Lai, & Chen, 2013), as shown in Table 1. The top 10 major cancer deaths in the country in 2011 were ranked in the following order: (i) trachea, bronchus and pulmonary cancer, (ii) liver and intrahepatic cholangiocarcinoma, (iii) colon, rectum and anal cancer, (iv) female breast cancer, (v) oral cancer, (vi) gastric cancer, (vii) prostate cancer, (viii) pancreatic cancer, (ix) esophageal cancer, and (x) cervix and some unclear parts of the uterine cancer.

| Rank | Tumors  | Death Toll          | Mortality Per 100,000 Population | Death%             |
|------|---|---------------------|----------------------------------|--------------------|
| 1    | <b><u>Trachea, bronchus, and pulmonary cancer</u></b> | <b><u>8,541</u></b> | <b><u>36.8</u></b>               | <b><u>20.1</u></b> |
| 2    | Liver and intrahepatic cholangiocarcinoma             | 8,022               | 34.6                             | 18.8               |
| 3    | Colon, rectum and anal cancer                         | 4,921               | 21.2                             | 11.6               |
| 4    | Female breast cancer                                  | 1,852               | 16.0                             | 4.4                |
| 5    | Oral Cancer   | 2,463               | 10.6                             | 5.8                |
| 6    | Gastric cancer  | 2,288               | 9.9                              | 5.4                |
| 7    | Prostate (prostate) cancer                            | 1,096               | 9.4                              | 2.6                |
| 8    | Pancreatic cancer                                     | 1,607               | 6.9                              | 3.8                |
| 9    | Esophageal cancer                                     | 1,507               | 6.5                              | 3.5                |
| 10   | Cervix and unclear parts of uterus cancers            | 681                 | 5.9                              | 1.6                |
| 11   | Other   | 9,581               | 41.3                             | 22.5               |

*Table 1. Ten Major Causes of Cancer Death in Taiwan in 2016*

As Table 1 shows, tumors of the trachea, bronchus and pulmonary account for the highest percentage of health care costs in cancer therapy. At present, whether the cost of medical care generated by cancer relates to the age and sex of patients has been lacking. The likely reason for this gap in the literature is the difficulty of collecting large amounts of treatment data and medical information to conduct scientific analysis and estimation, such as data from the National Health Insurance Database (NHID). More than a hundred articles based on the health care costs of individual hospitals have been published in various fields since 1975 (Hay & Mandes, 1984; Vogel, 1984). However, these studies focused on the health care costs of the emergency special illness and service quality (Meyers, Madhwani, Rausch, Candrilli, Krishnarajah, & Yan, 2017; Ruiz, Charpak, Castillo, Bernal, Ríos, Trujillo, & Córdoba, 2017; Seiffert, Schneider, Roessler, Larisch,

& Pfeiffer, 2017). They did not analyze care costs for tumor patients of trachea, bronchus and pulmonary cancers.

To remedy the gaps in previous studies, this study will propose a model by using two-stage clustering method, the Self-Organizing Map (SOM) and k-means algorithm, and collect the data of the Taiwan Health Care Costs for Cancer Patients to explore the classification groups of bronchial and pulmonary malignancies and medical costs. The research processes and purpose of the study were as follows:

1. Using a two-stage clustering method together with techniques of SOM and k-means algorithm technologies;
2. Conducting a scientific analysis on a large amount of cancer treatment data obtained from health care databases, and using SOM to group the medical expenses of cancer patients; and
3. Applying the k-means algorithm to find the best group in order to discover the relationship between tumor patients' property data and medical costs.

## **LITERATURE REVIEW**

### **-Tumor Definition**

When one of the cells in the human body becomes abnormal due to factors that affect surrounding cells, which then produces sarcoma or local mass, it is called a tumor (Peg, Sansano, Vieites, Bernet, Cano, Córdoba, Sancho, Martín, Vilardell, Cazorla, Espinosa-Bravo, Pérez-García, Cortés, Rubio, & Ramón y Cajal, 2017). Cancer is the most common malignant tumor caused by factors resulting in the generation of abnormal cells that causes disease. In addition to monstrous division, cancer cells invade into the normal tissue around them and even transfer to other parts of the body (Sonoshita & Cagan, 2017). Tumors are divided into benign and malignant categories. The malignant category is a new creature of human body tissues formed by abnormal cells, which is more harmful to health. It is characterized by its abnormal growth and special metabolism. Due to rapid growth and poor differentiation, it can not only damage the structure and function of normal tissues, but also transfer to important organs and systems such as brain, pulmonary, and liver, through the blood or lymphatic circulation. It is life-threatening if not treated in time. However, there

are a small number of cancer patients who have survived for a period of time or even self-disappeared without receiving any treatment (Peg *et al.*, 2017). Tumor classification is the key in determining the prognosis of patients as well as determining the type, length and intensity of treatment (Evans-Knowell, LaRue, & Findlay, 2017; Gross & Hanna, 2017). Criteria for tumor classification are as follows:

1. The anatomical location of primary tumor and metastasis, such as pulmonary, breast, or colon.
2. Tissue type and histological classification.
3. Histological grade of malignant extent.
4. The extent of tumor progression, including the size and metastasis extent.

Cancer staging is based on the extent and severity of the original tumor and the extent of its invasion in the body. For the majority of cancers, the stage of cancer can be roughly divided into four phases: Phase 0: changes before tumor invasion; Phase I: limited location of primary tumor in original organ; Phase II: the size and number of tumors invaded by the primary tumor in the original organ; Phase III: tumors invade and spread to neighboring lymph nodes; Phase IV: tumors invade and spread to distant lymph nodes or tissues (Chen *et al.*, 2002).

#### **-Two Stage Clustering Method**

This study, mainly using two-stage clustering method and combining with techniques of Self-Organizing Map (SOM) and k-means algorithm, examined a large number of cancer patients obtained from health care databases. The research tools used are as follows. Firstly, SOM is an unsupervised learning neural network proposed by Kohonen in 1973, which can extract the characteristics and relevance of the data itself from the input data (Kohonen, Schroeder, Huang, & Maps, 2001). SOM is mainly used in data clustering analysis, in which a large number of data with similar characteristics can be aggregated by SOM analysis (Seno, Kasai, Ikeda, Vaidyanath, Masuda, Mizutani, Murakami, Ishikawa, & Seno, 2016). It is derived from the framework of competitive neural network architecture, of which the neurons will present a meaningful topological structure in the output space in accordance with the characteristics of input data. Since the generated topological structure can represent the classification of different input data characteristics, it is, therefore,

called the Self Organizing Map Network (SOM). Secondly, the k-means algorithm published by J. B. MacQueen in 1967 is a pre-set type of cluster algorithm that tries to find the best cluster organization in accordance with a pre-set number of clusters (Dubey, Gupta, & Jain, 2016; Pena, Lozano, & Larranaga, 1999). The k-means algorithm is a partitioned cluster algorithm that divides information in the data into K groups, while the analysis process adopts the quality center in the cluster as a cluster center in order to produce a new cluster center point (Fahrudin, Syarif, & Barakbah, 2017).

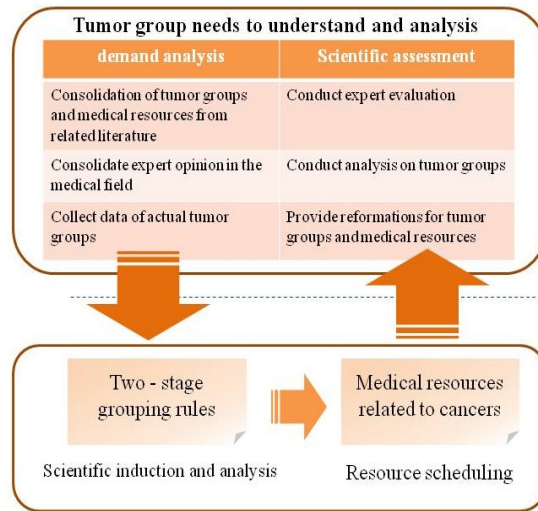
## **METHODOLOGY**

The range of research data was collected from the database of cancer prescribing patients of the National Health Insurance Bureau in 2016, which was explored by two-stage grouping method-SOM and k-means algorithm to study the relationship between the property data of cancer patients and the medical expenses. The research model proposed in this study is shown in Figure 1. First, this study compacted tumor-related literature and collected information relating to cancer patients and medical costs. Second, a data preprocess of cancer prescription patients as well as groups representing the status quo were conducted, including the following factors: age, sex, medical items and medical expenses in the bronchial and pulmonary cancer group. Trachea, bronchus and pulmonary cancer account for the highest expenses. In addition, patients' age and gender held the potential to influence medical expenses. When using Microsoft Excel for the data preprocess, the patient' s cancer prescription should be analyzed in order to screen out the current status of bronchial and pulmonary malignancy, age and sex, medical expenses, and groups.

The parameters of SOM with two phases were set. In doing so, we adopted Liao and Wen (2011)'s suggestion. In phase 1, the neighborhood was set as 2, the initial eta and cycles were set as 0.3 and 20 times. In phase 2, the neighborhood was set as 1 and the initial eta and cycles were set as 0.1 and 150 times. In addition, the parameter of the k-means method was set according to Liao and Wen (2011)'s suggestion, such that the number of clusters was set as 7, the maximum iterations were set as 20, and the similarity calculation used the euclidean distance method.

Finally, a two-stage grouping method was used to examine the relationship between tumor patient property data and medical expenses by means of SOM and k-means algorithm. According to statistics of

patient data of cancer prescriptions from the database of the National Health Insurance Bureau in 2016, as shown in Table 2, this study found that items of bronchial and pulmonary malignancies accounted for the highest amount, NT 10, 295,542 Dollars. Therefore, this study focused on the analysis of bronchial and pulmonary malignancies to explore the correlation between bronchial and pulmonary malignancies as well as the association between age, sex factor and medical costs.



**Figure 1. The Research Model Proposed**

| Cancer prescription category         | Amount       | Percentage |
|--------------------------------------|--------------|------------|
| Bronchial and pulmonary malignancies | \$10,295,542 | 15.2%      |
| Prostate cancer                      | \$9,443,992  | 13.9%      |
| Nasopharyngeal malignancy            | \$8,275,769  | 12.2%      |
| Thyroid malignancy                   | \$8,341,292  | 12.3%      |
| Primary liver malignancy             | \$6,359,193  | 9.4%       |
| Female breast malignancy             | \$7,897,120  | 11.6%      |
| Rectal malignancy                    | \$8,045,775  | 11.9%      |
| Colon malignancy                     | \$4,503,864  | 6.6%       |
| Gastric malignancy                   | \$2,276,146  | 3.4%       |
| Bladder malignancy                   | \$2,384,759  | 3.5%       |
| Total                                | \$67,823,452 | 100.0%     |

**Table 2. Statistics of Cancer Prescription Category**

## RESULTS

Based on the data of cancer prescription patient study data from January to December in 2016 collected from the National Health Insurance Administration database and under the data range of bronchial and pulmonary malignancies, this study used SPSS Clementine 10.0 software for clustering and then conducted analysis by using the two-stage clustering of data exploration. In the first stage, the data correlations were

found to serve as a cluster analysis through SOM network and unsupervised learning features. The k-means algorithm was applied in the second stage to determine the best group.

A total of 2,940 cases of bronchial and pulmonary malignancy were collected in this study under the research conditions mentioned in the previous paragraph. A data preprocessing was carried out to avoid inappropriate and erroneous data affecting the results of the survey. Then, a two-dimensional graphic containing the density was produced by SOM network, which was presented in the graphic to understand the differences. The results appeared in seven clusters, which were then served as data basis to analyze factor input by means of k-means algorithm analysis. As shown in Figure 2, it appears in eleven clusters. Then, the detailed medical expenses in each cluster are illustrated in Table 3.

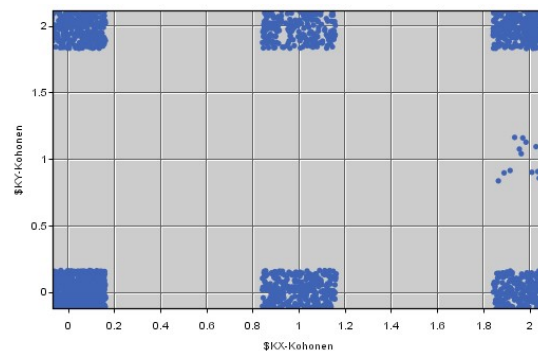


Figure 2. SOM Diagram of Bronchial and Pulmonary Malignancies

On the basis of the data of SOM analysis and the distribution of k-means clusters, the results showed that the ages of bronchial and pulmonary malignancies respectively fall between the intervals of 45 to 89 years of age. In accordance with the age groups defined by the Ministry of Health and Welfare of the Executive Yuan, this study divided the age groups into 0, 1 to 4, 5 to 9, 10 to 14, 15 to 19, 20 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, 70 to 74, 75 to 79, 80 to 84, 85 to 89, and 90 years or older.

According to the average cost of medical care in **cluster 1 of males**, the “Average Total Declared Expense” was up to NT279, 233 Dollars along with NT\$38,117 Dollars of “Average Surgery Expense” between 50 to 54 years old; the “Average Ward Fee” was up to NT109, 177 Dollars between 55 to 59 years

old; the “Average Cost of Pharmacy Services” was up to NT4,708 Dollars between 60 to 64 years old; the “Average Cost of Drugs” was up to NT72,472 Dollars along with the “Average Anesthesia Fee” of NT18,688 Dollars between ages of 65 to 69; the “Average Special Material Cost” was up to NT47,090 Dollars between ages of 75 to 79.

In accordance with the average cost of medical care in **cluster-2 of females**, the highest cost of “Average Total Declared Expense” was up to NT1,093,606 Dollars along with NT\$306,776 Dollars of “Average Cost of Drugs”, NT86,617 of “Average Special Material Cost” and NT290,180 Dollars of “Average Ward Fee” between 50 to 54 years old; the “Average Cost of Pharmacy Services” was up to NT10,055 Dollars between 55 to 59 years old; the “Average Anesthesia Fee” was up to NT\$59,459 Dollars along with NT91,209 Dollars of “Average Surgery Expense” between ages of 60 to 64.

Based on the average cost of medical care in **cluster-3 of females**, the highest cost of “Average Total Declared Expense” was up to NT70,657 Dollars between 85 to 89 years old; the “Average Surgery Expense” was up to NT27,460 Dollars between 70 to 74 years old; the “Average Anesthesia Fee” was up to NT\$11,365 Dollars between ages of 75 to 79; the “Average Cost of Drugs” was up to NT13,595 Dollars between 80 to 84 years old; the “Average Cost of Pharmacy Services” was up to NT3,385 Dollars along with the “Average Ward Fee” was up to NT20,348 Dollars between 85 to 89 years old.

According to the average cost of medical care in **cluster-4 of males**, the maximum cost of “Average Total Declared Expense” was up to NT 707,059 Dollars between aged 65 to 69; the “Average Special Material Cost” was up to NT51,668 Dollars between aged 50 to 54; the “Average Surgery Expense” was up to NT 42,073 Dollars between 60 to 64 years old; the “Average Cost of Pharmacy Services” was up to NT 6,740 Dollars between 65 to 69 years old; the “Average Cost of Drugs” was up to NT 301,788 Dollars between 65 to 69 years old; the “Average Anesthesia Fee” was up to NT 25,799 Dollars between 75 to 79 years old; the “Average Ward Fee” was up to NT 230,394 Dollars between 85 to 89 years old.

Based on the average cost of medical care in **cluster-5 of females**, the maximum cost of “Average Total Declared Expense” was NT101,754 Dollars between 60 to 64 years old; the “Average Cost of Pharmacy Services” was up to NT2,640 Dollars along with NT76,480 Dollars of the “Average Cost of Drugs”, NT36,262 of the “Average Special Material Cost”, NT23,779 Dollars of the “Average Anesthesia Fee”,



NT38,337 Dollars of the “Average Surgery Expense” and NT124,140 Dollars of the “Average Ward Fee” between 65 to 69 years old.

Based on the average cost of medical care in **cluster-6 of males**, the maximum cost of the “Average Total Declared Expense” was up to NT61,068 Dollars between the 65 to 69 years old; the “Average Surgery Expense” was up to NT29,902 Dollars between 55 to 59 years old; the “Average Anesthesia Fee” was up to NT11,382 Dollars between 60 to 64 years old; the “Average Ward Fee” was up to NT18,312 Dollars along with NT2,545 Dollars of the “Average Special Material Cost”, and NT1,098 Dollars of the Average Cost of Pharmacy Services between 65 to 69 years old; the “Average Cost of Drugs” was up to NT7,918 Dollars between 70 to 74 years old.

Based on the average cost of medical care in **cluster-7 of males**, the maximum cost of the “Average Total Declared Expense” was up to NT395,265 Dollars along with NT32,948 Dollars of the “Average Cost of Drugs”, NT45,808 Dollars of the “Average Special Material Cost”, NT59,459 Dollars of the “Average Anesthesia Fee”, NT91,209 Dollars of the “Average Surgery Expense” and NT87,420 Dollars of the “Average Ward Fee” between 65 to 69 and 85 to 89 years old; the “Average Cost of Pharmacy Services” was up to NT2,075 Dollars between 70 to 74 years old (see Appendix-I).

To summarize the cluster results above, **cluster 1** revealed that male patients between 55 to 59 years old represented the highest cost in ‘Ward Fee’ for medical expenses related to bronchia and pulmonary Cancer. The **cluster 2** analysis revealed that the highest cost appeared on ‘Drugs’ in bronchial and lung cancer in female patients aged 50 to 54 years. The **cluster 3** results indicated that female patients between 70 to 74 years old expend the highest cost in ‘Surgery’. The **cluster 4** results indicated that male patients consumed the highest cost in ‘Drugs’ between 65 to 69 years old. The **cluster 5** results indicated that the highest cost is from ‘Ward Fee’ for female patients between 65 to 69 years old. The **cluster 6** results revealed that the most cost was consumed in ‘Surgery’ for male patients aged 55 to 59. The **cluster 7** results revealed that male patients aged 65 to 69 consumed the most cost in ‘surgery’. Finally, the study found that the most medical expenses of bronchial and pulmonary malignancies were also concentrated in the middle and high age groups: male patients aged 55 to 59 and 65 to 69, and female patients aged 50 to 54, 65 to 69 and 70 to 74. Meanwhile, elderly patients incur medical expenses in drugs, ward and surgery. This means that these

medical items were required often, resulting in medical expenses being consumed due to the number of elderly people suffering from malignant tumors, which will increase following the proportion of the future increase in the elderly population.

### CONCLUSION AND RECOMMENDATIONS

In Taiwan, the higher incidences of tracheal, bronchial and lung malignant cancers might be caused by factors related to diet, lifestyle, cigarette smoking, and air pollution, among others. Given that the higher the age, the higher the relative incidence, it is recommended that individuals receive regular examinations for early detection and early treatment. Based on the cancer prescription patient study data collecting from the National Health Insurance Administration database from January to December 2016 under the data range of bronchial and pulmonary malignancies and by means of data exploration techniques of SOM and k-means, this study aimed to explore the patient group analysis.

Patients with cancer prescription were included in the study, which was conducted through data exploration of SOM to determine the clusters of patients after data pretreatment. The results could help us to understand where patients will fall in terms of age group, gender, and medical expenses. Malignant tumor is a common disease that threatens human life. With the wide range of malignant tumors as well as the different parts of the body that are affected, the number of patients will also be various. Finally, this research used k-means algorithm in data exploration to identify the significant relationship between both age group and sex of patients and both bronchial and pulmonary malignancies, and medical expenses. The analysis of cancer prescription and gender, age group and medical costs could be clearer from the results of this study. However, because the definition of the severity of the disease is different, the analysis of medical costs also varies. In the future, if combined with the database of National Health Insurance Administration and cancer registration file, it is recommended that a further investigation be conducted to understand the degree of differentiation of malignant tumors, the severity of each site of the body, and related medical resources.

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| Cluster   | Gender | Age   | Medical Items                     | Cost             |
|-----------|--------|-------|-----------------------------------|------------------|
| cluster-1 | male   | 50~54 | Average Total Declares Expense    | \$279,233        |
|           |        |       | Average Surgery Expense           | \$38,117         |
|           |        | 55~59 | <b>Average Ward Fee</b>           | <b>\$109,177</b> |
|           |        | 60~64 | Average Cost of Pharmacy Services | \$4,708          |
|           |        |       | Average Cost of Drugs             | \$72,472         |
|           |        | 65~69 | Average Anesthesia Fee            | \$18,688         |
|           |        | 75~79 | Average Special Material Cost     | \$47,090         |
| cluster-2 | female | 50~54 | Average Total Declared Expense    | \$1,093,606      |
|           |        |       | <b>Average Cost of Drugs</b>      | <b>\$306,776</b> |
|           |        |       | Average Special Material Cost     | \$86,617         |
|           |        |       | Average Ward Fee                  | \$290,180        |
|           |        | 55~59 | Average Cost of Pharmacy Services | \$10,055         |
|           |        | 60~64 | Average Anesthesia Fee            | \$59,459         |
|           |        |       | Average Surgery Expense           | \$91,209         |
| cluster-3 | female | 85~89 | Average Total Declared Expense    | \$70,657         |
|           |        | 70~74 | <b>Average Surgery Expense</b>    | <b>\$27,460</b>  |
|           |        | 75~79 | Average Anesthesia Fee            | \$11,365         |
|           |        | 80~84 | Average Cost of Drugs             | \$13,595         |
|           |        | 85~89 | Average Cost of Pharmacy Services | \$3,385          |
|           |        |       | Average Ward Fee                  | \$20,348         |
| cluster-4 | male   | 65~69 | Average Total Declared Expense    | \$707,059        |
|           |        | 50~54 | Average Special Material Cost     | \$51,668         |
|           |        | 60~64 | Average Surgery Expense           | \$42,073         |
|           |        | 65~69 | Average Cost of Pharmacy Services | \$6,740          |
|           |        |       | <b>Average Cost of Drugs</b>      | <b>\$301,788</b> |
|           |        | 75~79 | Average Anesthesia Fee            | \$25,799         |
|           |        | 85~89 | Average Ward Fee                  | \$230,394        |
| cluster-5 | female | 60~64 | Average Total Declared Expense    | \$101,754        |
|           |        | 65~69 | Average Cost of Pharmacy Services | \$2,640          |
|           |        |       | Average Cost of Drugs             | \$76,480         |
|           |        |       | Average Special Material Cost     | \$36,262         |
|           |        |       | Average Anesthesia Fee            | \$23,779         |
|           |        |       | Average Surgery Expense           | \$38,337         |
|           |        |       | <b>Average Ward Fee</b>           | <b>\$124,140</b> |
| cluster-6 | male   | 65~69 | Average Total Declared Expense    | \$61,068         |
|           |        | 55~59 | <b>Average Surgery Expense</b>    | <b>\$29,902</b>  |
|           |        | 60~64 | Average Anesthesia Fee            | \$11,382         |
|           |        |       | Average Ward Fee                  | \$18,312         |
|           |        |       | Average Special Material Cost     | \$2,545          |
|           |        |       | Average Cost of Pharmacy Services | \$1,098          |
|           |        | 70~74 | Average Cost of Drugs             | \$7,918          |
| cluster-7 | male   | 65~69 | Average Total Declared Expense    | \$395,265        |
|           |        |       | Average Cost of Drugs             | \$32,948         |
|           |        |       | Average Special Material Cost     | \$45,808         |
|           |        |       | Average Anesthesia Fee            | \$59,459         |
|           |        |       | <b>Average Surgery Expense</b>    | <b>\$91,209</b>  |
|           |        |       | Average Ward Fee                  | \$87,420         |
|           |        | 70~74 | Average Cost of Pharmacy Services | \$2,075          |

Table 3. Medical Expenses of Bronchia and Pulmonary Cancer Group by K-Means Cluster