DEVELOPMENT OF BENCHMARK ANALYSIS BY DEPARTMENTS USING ELECTRONIC MEDICAL DATE

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1. INTRODUCTION

In terms of the services they provide, it is necessary for medical facilities to achieve stability and to improve the quality of those services and their own effectiveness in management. Various benchmark analyses have been undertaken to determine the strengths and weaknesses of hospitals using comparative indices related to the quality of medical services and hospital management in similar hospital groups [1–4]. In comparisons among various facilities, many studies have investigated the size of sickbeds and responsible organization for establishment among similar hospital groups. However, because the disease range and patient composition differ among hospitals, differences in the size of sickbeds and responsible organization for establishment don’t provide wholly satisfactory measures.

Within hospitals, daily medical practice is conducted under the management unit of each department, and decisions are made as appropriate by those units. In many hospitals, the departments operate such that the duties of department physicians do not overlap. However, even when departments carry the same name, the range of conditions they treat and their patient composition differ among different hospitals according to the needs of medical services and specialties of physicians (Fig. 1). Thus, simple comparative analyses among departments that bear the same name do not necessarily reflect the actual situation in those hospitals. A comparative analysis among departments is not therefore a straightforward matter. To develop feasible measures to improve the quality of medical services, benchmark analysis demands a uniform disease range and patient structure.

With regard to evaluating group composition, analyses using similarity indices have been conducted in the area of community ecology, [4–7] in which the similarity of groups α and β is expressed quantitatively using a similarity index. We applied this method of evaluating group composition to assess similarities in patients’ conditions recorded in the departments of different medical institutions as the basis for our analysis; we attempted to identify medical departments with a similar patient composition.

Appropriate management at the level of each department unit is needed to improve the quality of services and the effectiveness in administration of medical facilities. However, a comparative analysis among departments is not straightforward because of their heterogeneity in patient composition and medical functions.

We conducted a similarity evaluation of patient images of the hospital department using the similarity index. We attempted to identify medical departments with a similar patient composition. The C1 values ranged from 0.826 to 0.97 in the H001 and H002 departments of internal medicine, the H005 and H006 departments of respiratory diseases, and the H009 and H010 departments of respiratory internal medicine. This indicates that the patient profiles were similar among those six departments. The C2 value in the H004 department of respiratory diseases and the H008 department of surgery was 0.081, which shows that the departments were the most dissimilar. The C3 values in the H004 department of respiratory diseases and the other nine departments were in the range of 0.081 to 0.321, which indicates that this department had different patient profiles to those of other hospital departments.

In this study, we developed benchmark analyses, which can be used in the management of hospital departments where the range of disease and patient composition are similar. We believe that using comparative analyses among groups whose similarity is confirmed by similarity indices offers an effective means of analysing the current situation regarding medical services and evaluating the quality of such services.

Keywords: similarity index • C1 • department • Medical information • DPC date

2. PURPOSE

To develop a benchmark analysis of department units using similarity indices, in which the range of diseases and patient composition were uniform.

3. METHODS

3.1 National Hospital Organization data collection base

National Hospital Organization created a medical information analysis databank (Table 1). This serves as database to collect diagnostic procedure combination (DPC) data and receipt data, which are anonymized since October 2010, from 144 facilities in Japan, and to analyze them.

3.2 Analysis data

3.2.1 DPC data

The DPC data were divided into 18 major diagnostic categories based on the International Classification of Diseases, 10th Revision. For basic diseases belonging to those 18 categories, a 14-digit diagnostic category code (14-digit DPC) was assigned according to severity, age, presence or absence of surgery or treatment, and presence or absence of sub-ordinate injuries or diseases. The coding focuses...
on the patients’ clinical similarity and sources of medical services (Fig. 2) [8,9]. This coding is used in the DPC system, which is a comprehensive evaluation system in Japan for fees for medical services in cases of acute hospitalization. Among about 8,700 hospitals in the country, approximately 1,600 hospitals participate in this system or are preparing to do so. In the National Hospital Organization, 53 hospitals use the DPC system or intend to do so.

3.2.2 Receipt data
Medical fee receipts contain details of medical expenses, which are charged by medical facilities to such organizations as local authorities or health insurance associations. The receipt contains personal information, such as the following: the patient’s name, sex, and birth date; the patient’s health insurance details; the name of the medical facility involved; the medical department; the type of disease; and details of the medical treatments given over a 1-month period of medical services. The latter details include those relating to all kinds of treatment, medication, injections, surgery, examinations, imaging diagnosis, and rehabilitation. The fee receipt covers a period of 1 month for each insured patient at the medical facility. Recently, these data have become increasingly computerized. We analysed the receipt data as medical records from 91 hospitals other than those using the DPC system. With those 91 hospitals, the 14-digit DPC was assigned according to the receipt data, taking into account such details as the type of disease, prescribed drugs, injections, treatment, surgery, and examination over a period of 1 month of medical services.

3.2.3 Data used for analysis
We used department code and 14-digit DPC for our analysis.

3.3 Analytical method
3.3.1 Subjects and methods
In departments treating patients with respiratory disease among 10 randomly selected hospitals with general wards among institutions of the National Hospital Organization, we calculated the following: the number of patients, the number of categories of 14-digit DPC, and similarity indices. Next, using a multidimensional scaling method, we spatially arranged similarity indices, and we examined similarities and comparative conditions among the departments of the 10 hospitals.

3.3.2 Calculation of similarity indices
Various studies [4–7] have examined similarity indices. In this investigation, we calculated the similarity degree using the Cα index [10], which is advantageous in that it is not affected by group factors (the number of patients being treated at a particular department). The Cα index approaches 1 as the patient profiles are increasingly similar; it approaches
ind = np.argsort(w)
x1 = ind[-1]
x2 = ind[-2]

(e) Visualization using multiplication of characteristic value by standard deviation

s=P.std(axis=0)
w1=s[x1]
w2=s[x2]

4. RESULTS

Figure 3 and Tables 2 show the number of patients, the number of categories of 14-digit DPC, and Cl indexes in the hospital departments analysed. Among those, departments in which the Cl index was high included the following: H006, department of respiratory diseases, and H010, department of respiratory internal medicine (Cl=0.970); H005, department of respiratory diseases, and H006, department of respiratory diseases (Cl=0.954); and H005, department of respiratory diseases, and H010, department of respiratory internal medicine (Cl=0.954). Departments with a low Cl index value included the following: H004, department of respiratory diseases, and H010, department of respiratory internal medicine (Cl=0.141); H002, department of internal medicine, and N004, department of respiratory diseases (Cl=0.119); and N004, department of respiratory diseases, and N008, department of surgery (Cl=0.081).

In individual departments, the Cl index value in the department of internal medicine was 0.919 in H001 and H002. In the department of respiratory diseases, the Cl index value was as follows: 0.954 in H005 and H006; 0.399 in H004 and H005; 0.162 in H003 and H004; and 0.145 in H004 and H006. In the department of respiratory internal medicine, the Cl index value was 0.928 in H009 and H010. There were cases in which the Cl index value was high or low within the same department. However, the H003 department of respiratory diseases and H008 department of surgery showed a high Cl index value of 0.784 even though they offered different medical services.

Figure 4 and Table 3 show the results of plotting with MDS. The Cl index values ranged from 0.826 to 0.97 in the H001 and H002 departments of internal medicine, the H005 and H006 departments of respiratory diseases, and the H009 and H010 departments of respiratory internal medicine. This indicates that the patient profiles were similar among those six departments. The Cl index value in the H004 department of respiratory diseases and the H008 department of surgery was 0.081, which shows that the departments were the most dissimilar. The Cl index values in the H004 department of respiratory diseases and the other nine departments were in the range of 0.081 to 0.321, which indicates that this department had different patient profiles to those of other hospital departments.

5. DISCUSSION

In this study, similarities among patients with respiratory diseases at randomly selected hospital departments were quantitatively examined using similarity indices. The 14-digit DPC used in this study contain details of the medical procedures undertaken for patients, such as

Table 2 - Number of patients and number of categories of 14-digit DPC in groups

<table>
<thead>
<tr>
<th>Hospital name dummy</th>
<th>Name of department</th>
<th>Number of patients</th>
<th>Number of categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>H001</td>
<td>Internal medicine</td>
<td>2256</td>
<td>111</td>
</tr>
<tr>
<td>H002</td>
<td>Internal medicine</td>
<td>1372</td>
<td>87</td>
</tr>
<tr>
<td>H003</td>
<td>Respiratory diseases</td>
<td>1112</td>
<td>97</td>
</tr>
<tr>
<td>H004</td>
<td>Respiratory diseases</td>
<td>1158</td>
<td>98</td>
</tr>
<tr>
<td>H005</td>
<td>Respiratory diseases</td>
<td>1007</td>
<td>93</td>
</tr>
<tr>
<td>H006</td>
<td>Respiratory diseases</td>
<td>954</td>
<td>118</td>
</tr>
<tr>
<td>H007</td>
<td>Allergies</td>
<td>891</td>
<td>127</td>
</tr>
<tr>
<td>H008</td>
<td>Surgery</td>
<td>531</td>
<td>119</td>
</tr>
<tr>
<td>H009</td>
<td>Respiratory internal medicine</td>
<td>1025</td>
<td>79</td>
</tr>
<tr>
<td>H100</td>
<td>Respiratory internal medicine</td>
<td>904</td>
<td>90</td>
</tr>
</tbody>
</table>

0 as they are increasingly different. That is, when the Cl index is almost 1, the patient profiles in the departments under consideration are very alike.

The Cl index is calculated using the following equation:

\[ C_\lambda = \frac{2}{\lambda_\alpha + \lambda_\beta} \sum_{i=1}^{\infty} n_\alpha n_\beta \]

\[ \lambda_\alpha = \frac{\sum_{i=1}^{\infty} n_\alpha(n_\alpha - 1)}{N_\alpha(N_\alpha - 1)} \quad \lambda_\beta = \frac{\sum_{i=1}^{\infty} n_\beta(n_\beta - 1)}{N_\beta(N_\beta - 1)} \]

Spatial arrangement of similarity indices with multidimensional scaling

Cl values obtained using the above calculation method were arranged visually by means of multidimensional scaling (MDS), in which similar departments were placed closer together and different departments were inserted at greater distance. For MDS, the calculation was made using numpy-1.7.0b2-win32-superpack-python2.6 with the following procedures and spatial arrangement:

(a) Distance square matrix

\[ S = D \times D \]

(b) Centering matrix

\[ \text{one} = \text{np.eye}(N) - \text{np.ones}(N,N)/N \]

(c) Young-Householder transformation

\[ P = 1.0/2 \times \text{one} \times S \times \text{one} \]

(d) Spectral resolution

\[ w,v = \text{np.linalg.eig}(P) \]

Table 3 - Spatial arrangement by MDS with coordinates

<table>
<thead>
<tr>
<th>Hospital</th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>H001</td>
<td>0.000304</td>
<td>0.000064</td>
</tr>
<tr>
<td>H002</td>
<td>0.000382</td>
<td>0.000046</td>
</tr>
<tr>
<td>H003</td>
<td>0.000139</td>
<td>-0.000558</td>
</tr>
<tr>
<td>H004</td>
<td>-0.000809</td>
<td>-0.000129</td>
</tr>
<tr>
<td>H005</td>
<td>0.000215</td>
<td>0.000200</td>
</tr>
<tr>
<td>H006</td>
<td>0.000306</td>
<td>0.000346</td>
</tr>
<tr>
<td>H007</td>
<td>-0.000329</td>
<td>0.000440</td>
</tr>
<tr>
<td>H008</td>
<td>0.000364</td>
<td>-0.000480</td>
</tr>
<tr>
<td>H009</td>
<td>0.000287</td>
<td>0.000108</td>
</tr>
<tr>
<td>H010</td>
<td>0.000339</td>
<td>0.000226</td>
</tr>
</tbody>
</table>

Spatial arrangement of similarity indices with multidimensional scaling

Cl values obtained using the above calculation method were arranged visually by means of multidimensional scaling (MDS), in which similar departments were placed closer together and different departments were inserted at greater distance. For MDS, the calculation was made using numpy-1.7.0b2-win32-superpack-python2.6 with the following procedures and spatial arrangement:

(a) Distance square matrix

\[ S = D \times D \]

(b) Centering matrix

\[ \text{one} = \text{np.eye}(N) - \text{np.ones}(N,N)/N \]

(c) Young-Householder transformation

\[ P = 1.0/2 \times \text{one} \times S \times \text{one} \]

(d) Spectral resolution

\[ w,v = \text{np.linalg.eig}(P) \]
surgery and other forms of treatment, in addition to details of the patients’ conditions. High similarity indices among departments reflect similarities in terms of medical practice carried out for patients in addition to the disease range and the patient structure of departments.

This study determined that the range of medical conditions and patient composition differed among some departments that bore the same name, and they were similar among departments that had different names. Thus, the similarity indices quantitatively revealed that even when their departments have the same names, the patient composition may differ greatly among some hospitals. As is evident in the spatial arrangement by MDS among the departments of the 10 hospitals, the patient composition for H003, H004, H007, and H008 differed from that of the other hospitals. If these four hospitals are excluded from the analysis of department units, the six remaining hospitals present a similar patient composition, and they allow a comparative analysis of the current situation regarding medical services.

When evaluating the quality of medical services in each department, determining the similarity indices among the various subject areas permits an analysis of the current situation regarding medical services. The analysis covers such areas as the number of days of hospitalization, mortality, and blood transfusions, and the information provided allows an evaluation of the department in terms of quality of services, such as medical techniques.

The various departments are important units with respect to hospital management. Departments can conduct medical activities based on plan-do-check-action cycles, in which the current situation regarding medical services can be understood, and necessary measures may be implemented, evaluated, and improved upon as appropriate. Thus, it is evident that analysing the various departments is a necessary step towards improving the medical standard of the whole hospital, and it is essential to improve the accuracy of such analysis.

6. CONCLUSION

In this study, we developed benchmark analyses, which can be used in the management of hospital departments where the range of disease and patient composition are similar. We found that even when departments had the same name, the patient compositions varied. We believe that using comparative analyses among groups whose similarity is confirmed by similarity indices offers an effective means of analysing the current situation regarding medical services and evaluating the quality of such services with, for example, medical techniques. In assessing medical services, we believe it is necessary to analyse by department and that increasing the accuracy of such analyses will contribute to improving the quality of services of the hospital as a whole.

References: