

On Establishing a New Fee Schedule for General Surgical Procedure Using Fuzzy MCDM

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Abstract. In this research a model for establishing a new, rational fee schedule for general surgical procedures in a national health insurance program is developed. A fuzzy multiple criteria decision-making (FMCDM) model is proposed. The relative values of eleven surgical procedures were obtained through an empirical study based on the FMCDM model. Consequently, a new fee schedule obtained from the FMCDM model. This new fee schedule is more convincing than previous schedule and more persuasive to the references for the policy setting.

Keywords: Fee Schedule, National Health Insurance, Fuzzy Multiple Criteria Decision Making

1. INTRODUCTION

Many countries with health insurance programs review payment systems periodically. The main reasons

are to address continually rising health care costs and to ensure an equitable allocation of resources (Hsiao *et al.*, 1988a). From the data of the Organization for Economic Co-operation and Development (OECD) countries, the

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proportion of health care costs as a percentage of Gross Domestic Product (GDP) continues to rise in these years. For example, from 1970 to 2001, health care accounted were 6.9% to 13.9% in the United States' (US) GDP, 5.6% to 10.9% of Switzerland's, and 4.0% to 9.0% of Belgium's. In Taiwan, health care accounted for 3.4% of GDP in 1980 and 5.9% in 2003 (Huber and Orosz, 2003). Another impetus for payment systems reform is the allocation of health care resources, as the payment system can create economic incentives that influence the specialties chosen by medical professionals, their practice behavior, as well as choice of practice locations (Hsiao *et al.*, 1988b).

Taiwan's National Health Insurance (TNHI) program was established on 1995. Following the implementation of TNHI, the ratio of overall payments to surgical specialties was quite low due to many innate restrictions of the fee schedule in the payment systems. In 2001, the ratio of annual surgical expenditures was only 6.18 percent of the total health spending by the Bureau of National Health Insurance (BNHI) (Huang *et al.*, 2004). In contrast to the Medicare system implemented in the United States, the surgical expenditure ratio accounted for 18.3 percent in 1991, and 17.8 percent in 1995 (Folland, 2001).

Although the payment systems of BNHI experienced adjustment many times after its initial implementation, some serious problems from previous programs (such as Labor Insurance and Government Employee Insurance) are still unavoidable. The inherent structure causing irrational fee schedule biases has not changed from past adjustments. Under the current fee schedule, which in essence is "equal remuneration for unequal loading", specializations in areas with low practice risk, light workloads, and less restraint on profits surged among medical students. At the same time, those specializations in areas with long hours on duty, often accompanied by high risk of medical malpractice crisis declined in number dramatically (Sung *et al.*, 1999). Among these latter specialties, general surgery is the least desirable. In order to rectify manpower allocation and balance surgeon volunteers, it is crucial to revise fee schedule, especially for general surgical procedures.

BNHI's fee schedules are established jointly by the insurer and the contracted medical care institutions. However, there are apparent conflicts between these two negotiating parties due to their opposing interests. Because of the lack of objective data and suitable arbitration points, it is very difficult to achieve mutual agreement. Only with support by objective evidence or fair arbitration can the two parties come to mutual satisfaction. Therefore, the core issue is to design a fair method for setting fee schedule that can effectively integrate opinions from different standpoints.

Among numerous methods and techniques docu-

mented in the literature for setting fee schedules, the most frequently adopted approach is experts' opinions. Related techniques include: in-depth interviews (Pope and Mays, 1995), focus group (Powell and Single, 1996), nominal group method (Pope and Mays, 1995), and the Delphi method (Gupta and Clarke, 1996). Regrettably, these research methods, which range from personal interviews to extensive negotiations, reach qualitative conclusions mainly (Patricia, 1996). Such a deficiency brings great difficulties in quantifying and summarizing practical for setting a fee schedule.

To improve previous weaknesses, this research aims to design a fuzzy multiple criteria decision-making (FMCDM) framework to precisely capture experts' opinions. The FMCDM framework includes: the analytical hierarchy process (AHP) (Saaty, 1977; 1980), fuzzy approach (Zadeh, 1965, 1975), and multiple criteria decision-making techniques (Bellman and Zadeh, 1970). FMCDM analysis has been used in different areas as it succeeds in quantifying expert opinion systematically (Bohanec *et al.*, 2000; Tzeng *et al.*, 1992; Tang and Tzeng, 1999). Through application, this research coordinates the opinions of surgeons in the Taiwan Surgical Association to establish a new fee schedule for general surgical procedures.

2. BUILDING A FMCDM MODEL

In a simple environment or using a single measurement index, the traditional minimum cost, maximum profit or the cost efficiency methods can be employed to conduct alternative evaluation. However, in an increasingly complex and diversified decision making environment, there is much correlated information that needs to be analyzed and traditional analysis is not suitable for problem solving (Bohanec *et al.*, 2000; Tzeng *et al.*, 1992; Tang and Tzeng, 1999). Therefore, this research uses the MCDM to evaluate different relative values of surgical procedures in the new fee schedule.

Since evaluators may have different perceptions on different objectives and criteria, in terms of their importance and the possible adverse consequence, the evaluation is conducted in an uncertain and fuzzy environment. This fuzzy evaluation design allows evaluators to express their opinions in fuzzy expression manners. Based on the above reasons, the FMCDM is selected to conduct this evaluation.

We examined the fee schedule for general surgical procedures in the draft announced by the BNHI authority on March, 21, 2003, and designed a study to obtain a new fee schedule. The study was conducted in three steps: first, to classify all existing general surgical procedures of general surgery into groups through questionnaire survey of experts' opinions; second, to con-

Table 1. The classified groups of surgical procedures and the representative procedure in general surgery

Groups	Items	Representative procedure
1. Breast procedures	10	Unilateral modified radical mastectomy (P1)
2. Thyroid procedures	11	Unilateral subtotal thyroidectomy (P2)
3. Splenic and lymphatic procedures	10	Splenectomy (P3)
4. Minor procedures	13	Excision of subcutaneous tumor - 5 to 10 cm (P4)
5. Complex procedures	5	Pancreatico-duodenectomy, Whipple type, with reconstruction (P5)
6. Gastric procedures	35	Gastrectomy, subtotal or hemigastrectomy without vagotomy (P6)
7. Procedures of the gastro-intestinal tract	43	Appendectomy (P7)
8. Hepatic procedures	16	Total left lobectomy (P8)
9. Procedures of biliary tree	15	Traditional cholecystectomy (P9)
10. Pancreatic procedures	13	Distal partial pancreatectomy (P10)
11. Procedures of abdominal cavity and wall	15	Repair of inguinal hernia -without bowel resection (P11)

struct the main FMCDM framework; and finally, to perform an empirical study of the FMCDM model and obtain a new fee schedule.

2.1 Questionnaire survey of experts' opinions

In establishing a fee schedule, the opinions of experts with special expertise are a valuable and often important source of qualitative data analysis. Nine senior general surgeons from the Taiwan Surgical Association were requested to express their opinions about classifying existing surgical procedures promulgated by the BNHI into groups. As a result, all 186 surgical procedures were classified into 11 groups according to the similarity of characteristics of the organ systems, operation sites, and the difficulty of techniques of each procedure. Finally, one procedure was chosen from each group as a representative procedure. The content of classified groups is shown in Table 1.

2.2 Constructing the main FMCDM framework

In considering the proportion of different surgical procedures, surgeons of different sub-specialties diverge greatly in converting practice costs, risks, workload and specialty training costs into fee schedule (Ellis and McGuire, 1993, Marc *et al.*, 2002). In order to integrate these hetero-perceptions, we adopted a fuzzy multiple criteria decision-making (FMCDM) model, which was introduced by Bellman and Zadeh in 1970. The FMCDM model for establishing the new fee schedule for general surgical procedures, as illustrated in Figure 1, contains four evaluation aspects, sixteen criteria, and eleven representative procedures. The resource-based relative value scale (RBRVS) used in U.S. Medicare is the blueprint for the evaluation aspects and criteria (Harris-Shapiro, 1998;

Grimaldi, 2002).

The evaluation process includes two steps:

2.2.1 Evaluating the weights for the hierarchy relevance system using AHP

The AHP weighting is determined by the evaluators who conduct pairwise comparisons, so as to reveal the comparative importance of two criteria. If there are evaluation aspects /criteria, then the decision-makers have to conduct pairwise comparison. Moreover, the relative importance derived from these pairwise comparisons allows a certain degree of inconsistency within a domain. Saaty used the principle eigenvector of the pair-wise comparison matrix derived from the scaling ration to find the comparative weight among the criteria of the hierarchy system (Saaty, 1977; 1980).

Suppose we wish to compare a set of n aspects /criteria in pairs according to their relative importance (weights). Denote the aspects /criteria by c_1, c_2, \dots, c_n and their weights by w_1, w_2, \dots, w_n . If $\mathbf{W} = (w_1, w_2, \dots, w_n)^t$ is given, the pairwise comparison may be represented by a matrix \mathbf{A} of the following formula:

$$(\mathbf{A} - \lambda_{\max} \mathbf{I}) \mathbf{W} = 0 \quad (1)$$

Equation (1) denotes that \mathbf{A} is a matrix of pairwise comparison values derived from intuitive judgment (perception) for ranking order.

In order to find the principle eigenvector, we must find the eigenvector w_i with respective λ_{\max} which satisfies $\mathbf{A}\mathbf{W} = \lambda_{\max} \mathbf{W}$. The comparative importance derived from the pairwise comparisons allows a certain degree of inconsistency within a domain. Saaty used the principle eigenvector of the pairwise comparison matrix contrived by scaling ration to find the comparative weight among the criteria (Saaty, 1977; 1980).

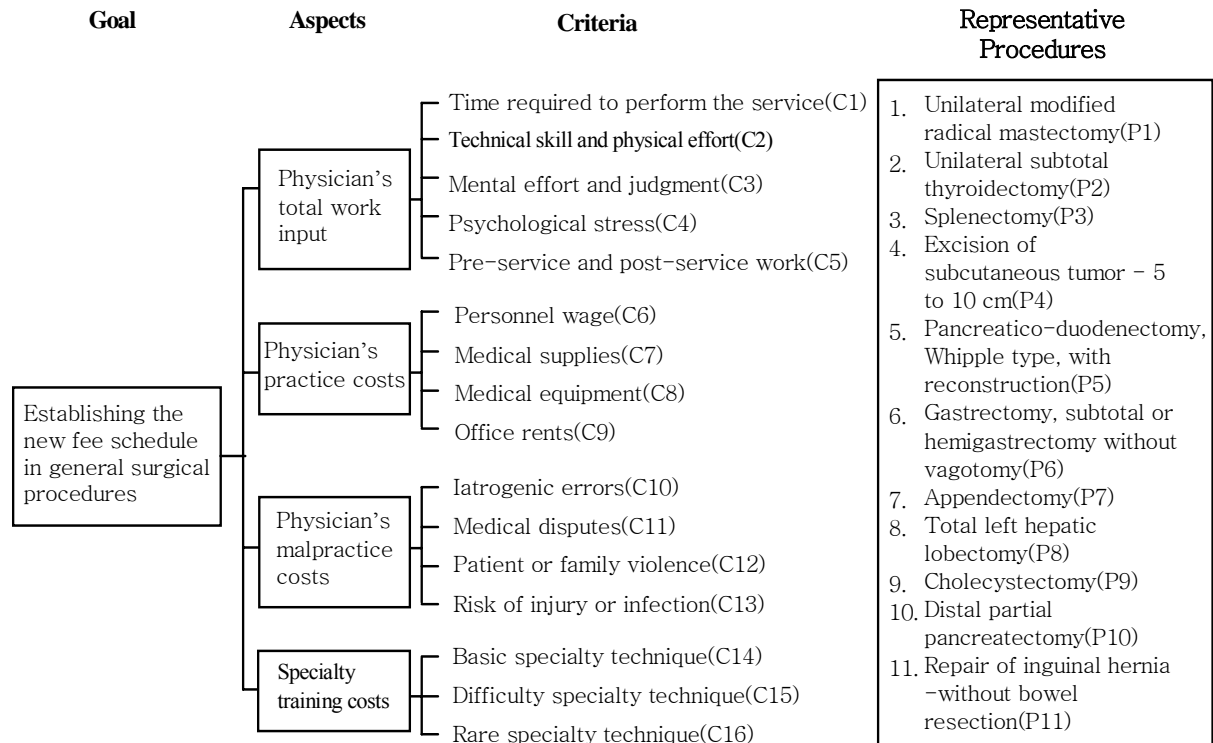


Figure 1. The fuzzy multiple criteria decision making framework for establishing the new fee schedule in general surgical procedures

2.2.2 Obtain the performance value

The evaluators choose a score for each surgical procedure based on their subjective judgment. By doing this, we can use the methods of fuzzy theory to estimate the payment level of each procedure in a fuzzy environment. Since Zadeh introduced fuzzy set theory (Zadeh, 1965), and Bellman and Zadeh (1970) described the decision-making method in fuzzy environments, an increasing number of studies have dealt with uncertain fuzzy problems by applying fuzzy set theory. The application of fuzzy theory to get the performance values can be described as follows (Bellman and Zadeh, 1970):

(i) fuzzy numbers:

According to the definition made by Dubis and Prade (1978), the fuzzy number \tilde{A} is a fuzzy set, and its membership function is $\mu_{\tilde{A}}(x) : R \rightarrow [0,1]$, where x represents the policy tools. It is common to use triangular fuzzy numbers (TFNs) $\mu_{\tilde{A}}(x) = (L, M, U)$, for fuzzy operations, as shown in equation (2) and Figure 2.

$$\mu_{\tilde{A}}(x) = \begin{cases} (x-L)/(M-L) & \text{if } L \leq x \leq M \\ (U-x)/(U-M) & \text{if } M \leq x \leq U \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

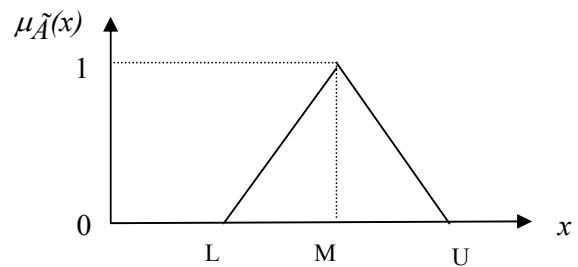


Figure 2. The membership function of the triangular fuzzy number

According to the nature of triangular fuzzy numbers and the extension principle put forward by Zadeh (1965), the algebraic calculation of the triangular fuzzy number can be displayed as follows:

- Addition of a fuzzy number \oplus

$$(L_1, M_1, U_1) \oplus (L_2, M_2, U_2) = (L_1+L_2, M_1+M_2, U_1+U_2) \quad (3)$$

-Multiplication of a fuzzy number \odot

$$(L_1, M_1, U_1) \odot (L_2, M_2, U_2) = (L_1L_2, M_1M_2, U_1U_2) \quad (4)$$

-Any real number k : \odot

$$\mu_{\tilde{A}}(x) = k \odot (L, M, U) = (kL, kM, kU) \quad (5)$$

-Subtraction of a fuzzy number \ominus

$$(L_1, M_1, U_1) \ominus (L_2, M_2, U_2) = (L_1 - L_2, M_1 - M_2, U_1 - U_2) \quad (6)$$

-Division of a fuzzy number \odot

$$(L_1, M_1, U_1) \odot (L_2, M_2, U_2) = (L_1/L_2, M_1/M_2, U_1/U_2) \quad (7)$$

(ii) Linguistic Variable:

A linguistic variable is a variable whose values are words or sentences in a natural or artificial language. For example, the expression “maximize technical skill and physical effort” and “mental effort and judgment” represents a linguistic variable in the context in these problems. Linguistic variables may take on effect-values such as “very high”, “high”, “fair”, “low”, and “very low”. The use of linguistic variables is rather widespread at present and the linguistic effect values of general surgical procedures found in this study are primarily used to assess the linguistic ratings given by the evaluators. Furthermore, linguistic variables are used as a way to measure the achievement of the performance value for each aspect/criterion (Zadeh, 1975).

(iii) Fuzzy multiple criteria decision-making:

Bellman and Zadeh (1970) were the first to probe into the decision-making problem under a fuzzy environment, and they heralded the initiation of FMCDM. This study uses this method to evaluate various surgical procedures and ranks each procedure according to its score. The following will be the method and procedures of the FMCDM theory. One is management of evaluation criteria. Under the measurement of linguistic variables to demonstrate the criteria performance by expressions such as “very high”, “high”, “fair”, “low” and “very low”, the evaluators were asked to conduct their judgments and each linguistic variable can be indicated by a triangular fuzzy number (TFN) within the scale range of 0-100. Also, the evaluators can subjectively assume their personal range of the linguistic variable.

Let E_{ij}^k indicate the fuzzy performance value of evaluator k toward procedure i under aspect /criterion j , and let the performance of the aspect /criterion be indicated by the set S , then,

$$E_{ij}^k = (LE_{ij}^k, ME_{ij}^k, UE_{ij}^k), j \in S \quad (8)$$

Since the perception of each evaluator varies according to the evaluator’s experience and knowledge, and the definitions of the linguistic variables vary as well, the study uses the notion of average value so as to integrate the fuzzy judgment value of m evaluators, that is,

$$E_{ij} = (1/m) \odot (E_{ij}^1 \oplus E_{ij}^2 \dots \oplus E_{ij}^k) \quad (9)$$

The sign \odot indicates fuzzy multiplication, the

sign \oplus denotes fuzzy addition, E_{ij} is the average fuzzy number of the judgment of the decision-maker, and it can be displayed by a triangular fuzzy number as follows:

$$E_{ij} = (LE_{ij}, ME_{ij}, UE_{ij}) \quad (10)$$

The proceeding end-point values can be solved by the method introduced by Buckley (1985).

$$\begin{aligned} LE_{ij} &= (1/m) \odot \left(\sum_{k=1}^m LE_{ij}^k \right), ME_{ij} \\ &= (1/m) \odot \left(\sum_{k=1}^m ME_{ij}^k \right), UE_{ij} \\ &= (1/m) \odot \left(\sum_{k=1}^m UE_{ij}^k \right) \end{aligned}$$

(iv) Fuzzy synthetic decision:

The weights of each aspect /criterion of general surgical procedures as well as fuzzy performance values has to be integrated by the calculation of fuzzy numbers so as to be located at the fuzzy performance value of the integral evaluation, which is of the procedures of fuzzy synthetic decision. According to the weight w_i derived by AHP, the weight vector can be obtained while the fuzzy performance matrix E of each of the alternatives can also be obtained from the fuzzy performance value of each alternative under n criteria, that is,

$$W = (w_1, \dots, w_j, \dots, w_n)^t \quad (11)$$

$$E = (E_{ij}) \quad (12)$$

$$R = E \Leftrightarrow W \quad (13)$$

and the sign “ \Leftrightarrow ” indicates the operation of the fuzzy numbers, including addition and multiplication. Since the operation of fuzzy multiplication is rather complex, it is usually denoted by the approximate multiplied result of the fuzzy multiplication and the approximate fuzzy number R , of the synthetic decision of each procedure. The expression then becomes,

$$R_i = (LR_i, MR_i, UR_i), \forall i \quad (14)$$

where

$$LR_i = \sum_{k=1}^m LE_{ij} \odot w_j \quad (15)$$

$$MR_i = \sum_{k=1}^m ME_{ij} \odot w_i \quad (16)$$

$$UR_i = \sum_{k=1}^m UE_{ij} \odot w_i \quad (17)$$

(v) Ranking the procedures (fuzzy number):

The result of fuzzy synthetic decision of each procedure is a fuzzy number. Therefore, it is necessary that the non-fuzzy ranking method for fuzzy numbers be employed during the comparison of the strategies. In

other words, the procedure of defuzzification is to locate the best non-fuzzy performance value (BNP). Methods of such defuzzified fuzzy ranking generally include mean of maximal (MOM), center of area (COA), and α -cut, three kinds of method (Zhou and Govind, 1991). To utilize the COA method to find out the BNP is a simple and practical method and there is no need to bring in the preference of any evaluators. For those reasons, the COA method is used in this study. The BNP value of the fuzzy number R_i can be found by the following equation:

$$BNP_i = [(UR_i - LR_i) + (MR_i - LR_i)] / 3 + LR_i, \forall I \quad (18)$$

According to the value of the derived BNP, the evaluation of each general surgical procedure can then proceed.

2.3 Empirical study of FMCDM model

A temporary Board meeting of the Taiwan Surgical Association was held on May 31, 2003. Thirty surgeons participated in answering our FMCDM questionnaire. Based on the FMCDM framework, every expert could express his subjective preference in pairs of comparisons among the hierarchy system. These subjective and qualitative judgments were then transformed through mathematical programming into objective and quantitative results.

Before answering the questionnaire, we fully explained the purpose and background of this research to every participant, as well as the steps and sources of the FMCDM model. In addition, all other information was provided, such as the Medicare’s RBRVS schedule, the current payment scheme, the proposal draft by the BNHI authority, and the official declaration of surgical procedures from previous years.

3. RESULTS

100% (30/30) of the surveys were returned by respondents, and 87% (26/30) of those returned were valid. The invalid surveys were those that could not pass the AHP consistency verification tests or weren’t completely answered.

3.1 Evaluating the criteria weights

See Table 2 for the analysis of relative weightings in valid survey responses. In the first-tier evaluation aspects, the rankings of factors among the 26 surgery respondents were: (1) physician’s total work input (0.425); (2) physician’s practice costs (0.227); (3) specialty training costs (0.250); and (4) physician’s malpractice costs (0.098). In the second-tier valuation crite-

Table 2. The relative weightings in 26 valid survey responses in GS

Aspects and Criteria	First-tier weighting	Second-tier weighting
Physician’s total work input	0.425	
Time required to perform the service (C1)		0.075
Technical skill and physical effort (C2)		0.092
Mental effort and judgment (C3)		0.098
Psychological stress(C4)		0.087
Pre-service and post-service work (C5)		0.073
Physician’s practice costs	0.227	
Personnel wage (C6)		0.090
Medical supplies (C7)		0.034
Medical equipment (C8)		0.052
Office rents (C9)		0.051
Physician’s malpractice costs	0.098	
Iatrogenic errors (C10)		0.024
Medical disputes (C11)		0.031
Patient or family violence (C12)		0.020
Risk of injury or infection (C13)		0.023
Specialty training costs	0.250	
Basic specialty techniques (C14)		0.058
Complex specialty techniques (C15)		0.093
Rare specialty techniques (C16)		0.099

ria, of the 16 factors, the top five ranked as follows: (1) rare specialty technique (0.099); (2) mental effort and judgment (0.098); (3) difficulty specialty technique (0.093); (4) technical skill and physical effort (0.092); and (5) personnel wage (0.090).

3.2 Estimating the performance matrix

The relative weighting of a total of 16 criteria can also be interpreted as a vector and ranked as follow: $\vec{W} = (0.075, 0.092, 0.098, 0.087, 0.073, 0.090, 0.034, 0.052, 0.051, 0.024, 0.031, 0.020, 0.023, 0.058, 0.093, 0.099)$. The subjective value on the 11 representative procedures of the respondent i can be expressed as another vector $U_{\text{respondent } i}$ ($i = 1 \sim 26$). \vec{W} is then multiplied with $U_{\text{respondent } i}$, and a synthetic value matrix on the new fee schedule is obtained as the equation:

$$\begin{aligned} \text{New fee schedule} &= \vec{W} \times U_{\text{respondent } i} \\ &= \begin{matrix} & \text{procedure1} & \text{procedure2} & \cdots & \text{procedure11} \\ \text{Criterion1} & u_{i,1}^1 & u_{i,1}^2 & \cdots & u_{i,1}^{11} \\ \text{Criterion2} & u_{i,2}^1 & u_{i,2}^2 & \cdots & u_{i,2}^{11} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \text{Criterion16} & u_{i,16}^1 & u_{i,16}^2 & \cdots & u_{i,16}^{11} \end{matrix} \\ &= [u_{i1}, u_{i2}, u_{i3}, \dots, u_{i11}] \end{aligned} \tag{19}$$

Where u_{ij} represents the new fee schedule of re-

spondent i regarding procedure 1; u_{i2} represents the new fee schedule of respondent i regarding procedure 2; ... and u_{i11} represents the new fee schedule of respondent i regarding procedure 11. The results composed by their average of 26 experts are shown in Table 3.

3.3 Establishing the new fee schedule

Table 3 summarized the synthetic value matrix composed by the average of 26 experts. Line (A) in Table 3 is the accumulated points for each procedure, the relative point as shown in line (B) ranging from 0.385 (excision of subcutaneous tumor (P4)) to 1.483 (Whipple’s operation (P5)). To date, we have conducted a relative value of new fee schedule by the FMCDM model. Compared to current BNHI fee schedule, according to our results, the ratio of the highest procedure compared to the lowest is 3.8 (1.483/ 0.385), while the ratio is 13.0 (37449/ 2890) in BNHI’s system. The decision range for these two standards is likewise different. Based on this fact, we standardized the relative values obtained from the FMCDM model to overcome its limitation. After standardization, the FMCDM model decision range can be increased 10 times based on the index ratio. The computations are shown below:

$$RV_{(s)} = 10^{RV-1} \tag{20}$$

where RV is the relative value, and the footnote (s) means standardization.

Table 3. Summary of the synthetic value matrix composed by the average of 26 experts

Criteria \ Procedures	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
C1	5.368	4.088	4.776	1.638	8.455	6.195	3.220	6.503	3.903	5.670	3.383
C2	4.896	4.608	4.816	1.692	7.343	5.024	3.251	6.010	3.891	5.121	2.731
C3	6.487	5.829	6.023	2.127	8.465	6.098	3.454	7.801	5.151	7.161	3.562
C4	3.887	3.998	4.390	1.854	6.408	4.542	2.558	5.484	3.586	4.419	2.179
C5	2.459	2.845	3.185	0.954	4.388	3.508	2.317	3.760	2.301	3.594	1.891
C6	6.726	6.341	6.770	1.813	9.856	7.720	3.876	8.154	5.153	7.445	3.398
C7	1.998	1.807	1.919	0.794	2.922	2.322	1.348	2.451	2.013	2.198	1.294
C8	2.504	1.755	2.052	0.695	4.307	2.830	1.215	3.110	1.719	2.587	1.312
C9	1.585	1.070	1.417	0.469	2.724	1.927	0.844	2.019	1.270	1.812	0.892
C10	0.931	1.085	0.892	0.517	1.471	1.385	1.125	1.309	1.228	1.124	0.846
C11	1.086	1.182	0.979	0.634	1.448	1.428	1.267	1.278	1.407	1.011	0.964
C12	0.902	0.931	0.861	0.632	0.897	0.926	0.857	0.877	0.897	0.843	0.791
C13	0.712	0.667	0.766	0.421	0.957	0.890	0.649	0.941	0.837	0.775	0.603
C14	3.263	3.073	3.064	0.860	3.844	2.929	1.773	3.475	2.597	3.426	1.749
C15	2.612	2.269	2.298	1.909	3.767	2.818	1.978	3.424	2.195	2.500	1.998
C16	3.063	2.909	3.668	1.673	4.635	3.656	2.051	4.234	2.797	4.114	2.016
Total (A)	48.481	44.458	47.877	18.681	71.887	54.198	31.782	60.830	40.946	53.799	29.610
Relative value (B)	1.000	0.917	0.988	0.385	1.483	1.118	0.656	1.255	0.845	1.110	0.611
Standardized relative value (C)	1.000	0.826	0.972	0.243	3.039	1.312	0.452	1.798	0.699	1.287	0.408

Table 4. The results of the relative value of 11 surgical procedures in two different schedules, respectively by draft of the BHI, and our result conducted by FMCDM model

Procedures	Draft of the BNHI		The FMCDM model	
	Value	Original Data	Value	Original Data
Unilateral modified radical mastectomy (P1)	1.000	(16810)	1.000	(16810)
Unilateral subtotal thyroidectomy (P2)	0.618	(10389)	0.826	(13885)
Splenectomy (P3)	0.897	(15079)	0.972	(16339)
Excision of subcutaneous tumor - 5 to 10 cm (P4)	0.157	(2639)	0.243	(4085)
Pancreatico-duodenectomy, Whipple type, with reconstruction (P5)	2.228	(37453)	3.039	(51086)
Gastrectomy, subtotal or hemigastrectomy without vagotomy (P6)	1.616	(27165)	1.312	(22055)
Appendectomy (P7)	0.610	(10254)	0.452	(7598)
Total left lobectomy (P8)	1.799	(30241)	1.798	(30224)
Cholecystectomy (P9)	0.955	(16054)	0.699	(11750)
Distal partial pancreatectomy (P10)	1.060	(17819)	1.287	(21634)
Repair of inguinal hernia -without bowel resection (P11)	0.720	(12103)	0.408	(6858)

BNHI: Bureau of National Health Insurance.

FMCDM: fuzzy multiple criteria decision making.

Figures in parentheses show the original data of BNHI and data derived by the FMCDM model.

The new relative value with standardization is listed in line (C) of table 3. The suggested relative value to each representative procedure is set to be (1.000, 0.826, 0.972, 0.243, 3.039, 1.312, 0.452, 1.798, 0.699, 1.287, and 0.408). After the transformation, the contrastive ratio in our result is 12.5 (3.039/0.243) and much closer to that of the BNHI.

In Table 4, we compared our results with the proposed drafts by the BNHI and the expert opinions of the Taiwan Surgical Association. The high correlation implies that there is no divergence among these two schedules.

4. DISCUSSION AND CONCLUSION

This study consolidated AHP, fuzzy theory and multiple criteria decision-making techniques to form the FMCDM model. In the model, the synthetic value matrix for 11 representative procedures was derived using strict mathematical calculations. The source data combined with relative weightings from the AHP results and experts' opinions of each surgical procedure. Thus, the final data are both qualitative and quantitative.

The RBRVS system has been implemented in the US for more than one decade. Grimaldi's review of the results concluded that physician workloads accounted for 50% of Medicare payments, while practice costs accounted for 46%, and malpractice insurance accounted for 4% (Grimaldi, 2002). Compared with the AHP results, surgeons in Taiwan list physician workloads (42.5 %) as the major consideration in their decision-making, not far from results

in the US. However, the following items are quite different: training costs of sub-specialties (25 %); practice cost (22.7 %); and malpractice cost (9.8 %).

Table 4 lists the relative values of the 11 surgical procedures in two different fee schedule structures. These are the draft of BNHI and the results conducted by the FMCDM model respectively, it can be seen that there are few differences in the data among the two schedules. The BNHI draft presents views of the new fee schedule that the members of Surgical Association will not necessarily agree to. However, the relative values derived from the FMCDM model are combinations of rational hierarchy processing and strict mathematic computation. When used in the negotiation of a new fee schedule, the results are very convincing and more persuasive; hence, the possibility of acceptance by both parties is greater.

In the past, expert opinions from various groups were usually gathered to determine fee schedule for each surgical procedure. If expert opinions were not in consensus then there was no way to come to a conclusion and it would pose a great obstacle toward rationally adjusting a fee schedule. The FMCDM model developed in this study and verified by results show precise principles, easy operation, and effective gathering of the opinions of surgical experts. The complicated determination of relative values for fee schedule for surgical procedures can be shown by using a simplified hierarchy structure. After expert evaluation and mathematical calculations, each influencing factor can be concretely shown as a ranked value and thus, new fee schedule values can be obtained.

The biggest difference between the FMCDM model and traditional methods is that our model has more precise calculations and the results are both qualitative and quantitative. It can tackle problems that formerly quantitative data and research methods could not solve easily. Examples of these problems are differences in expert opinions, difficulty in coming to a consensus, analytical results that are qualitative data, tests and conclusions not easily verified, and experts' bias sampling that would severely skew reference points (Hoddinott and Pill, 1997, Chapple and Rogers, 1998, Malterud, 2001). The new method effectively consolidates expert opinions, is suitable for integrating opinions from different groups, and can solve the complex problem of many evaluating factors. The values derived from the FMCDM model are convincing and can serve as an important reference for setting or revising the fee schedule.

In conclusion, this study suggests a new fee schedule based on a synthetic value matrix through hierarchy reasoning and mathematical programming from the FMCDM model. In contrast to traditional methods, our research outperforms at synthesizing both quantitative and qualitative analysis and hence overcoming the defects of previous studies. The result is more convincing than previous structures and more persuasive as a reference for policy setting. Furthermore, research in compliance with this method of determining a fee schedule can be expected in the future. Beyond the procedures of general surgery proposed in this study, we suggest further research in cross-boards, cross-specialties, and overall fee schedules of BNHI.

ACKNOWLEDGEMENTS

This study is deeply indebted to the cooperation provided by the board of the Taiwan Surgical Association, and the Bureau of National Health Insurance, Department of Health, Executive Yuan, Taiwan for providing research funding (BNHI Project, Doc. No.: DOH91-NH-1040 and DOH93-NH-1002).

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