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# A DEMATEL method in identifying key success factors of hospital service quality

Jiunn-I Shieh [a,*], Hsin-Hung Wu [b], Kuan-Kai Huang [c,d]

[a] Department of Information Science and Applications, Asia University, Taiwan
[b] Department of Business Administration, National Changhua University of Education, Taiwan
[c] Department of Computer Science and Information Engineering, Asia University, Taiwan
[d] Department of Administration, Show Chwan Memorial Hospital, Changhua City, Taiwan

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ABSTRACT

Since National Health Insurance program formally went into effect in March 1995 in Taiwan, the residents enjoy high quality but relatively cheaper medical care compared with the most developed countries. To manage a hospital successfully, the important goals are to attract and then retain as many patients as possible by meeting potential demands of various kinds of the patients. This study first conducted the survey based on SERVQUAL model to identify seven major criteria from patients' or their families' viewpoints at Show Chwan Memorial Hospital in Changhua City, Taiwan. When the key criteria were found, the second survey developed for applying decision-making trial and evaluation laboratory (DEMATEL) method was issued to the hospital management by evaluating the importance of criteria and constructing the causal relations among the criteria. The results show that trusted medical staff with professional competence of health care is the most important criterion and mutually affects service personnel with good communication skills, service personnel with immediate problem-solving abilities, detailed description of the patient's condition by the medical doctor, and medical staff with professional abilities. Therefore, trainings on communication skills and problem-solving abilities would result in positive interaction for patients to trust medical staff. When the trusted medical staff provides professional competence of health care to patients, satisfaction would be increased.



## 1. Introduction

Before March 1995, there were 13 independent public medical insurance systems featuring distinct premiums and benefits to different segments of the society. This public medical insurance network only covered 60% of the population but the remaining 40%, mostly senior citizens, children, and unemployed workers, were uninsured (source: http://www.nhi.gov.tw/english/webdata.asp?menu=11&menu_id=290&webdata_id=2964). In order to provide health care to all citizens in Taiwan, the National Health Insurance program executed by Bureau of National Health Insurance was launched by the government, which is a mandatory, single-payer social health insurance system based on the principle that each person should have equal access to health care services by providing universal coverage, health care of acceptable quality, comprehensive benefits, and convenient access to treatment with low premiums and health care expenditures. Under such program, citizens are able to freely choose health care providers and medical institutions. The satisfaction rating by the citizens has been very consistent by more than 70%. More importantly, the National Health Insurance program was highly recognized and praised by international media, such as Dissent, US political magazine, in the winter 2008 edition with the title of "Health care in Taiwan: why cannot the United States learn some lessons?" and Nobel Laureate and New York Times columnist Paul Krugman, who praised Taiwan's health care system that had expanded coverage without a major increase in health expenditures in a November 7, 2005 column called "Pride, prejudice, insurance" (source: http://www.nhi.gov.tw/english/webdata.asp?menu=11&menu_id=290&webdata_id=2972).

Though citizens can enjoy high quality but cheaper health care, some problems have been identified. Because of low reimbursement, high-priced and high-quality medicines and medical equipment are out of health care market to possibly lower medical quality. In addition, medical staff, particularly nurses, faces high pressure, long working hours but low wages which might have negative impact on the patients' rights. The implementation of the referral system is not successful because citizens tend to attend medical centers for any type of treatments instead of regional hospitals, district hospitals, and clinics. As a result, a number of small and medium sized hospitals and clinics have closed down because there is no economies of scale or integrated into large hospitals. Moreover, there is a lack of new blood in high-risk and burden specialists, such as internal medicine, surgery, obstetrics and

* Corresponding author. Address: Department of Information Science and Applications, Asia University, No. 500, Lioufeng Rd. Wufeng, Taichung County, Taiwan 41354. Tel.: +886 4 23323456x1832; fax: +886 4 23316699.
*E-mail address:* jishieh@yahoo.com.tw (Jiunn-I Shieh).

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gynecology, and pediatrics, because there are no obvious reactions to these specialists by the insurance program. Finally, Bureau of National Health Insurance intends to introduce diagnosis-related groups (DRGs) system to classify hospital cases into groups expected to have similar hospital resource use in some diseases. In doing so, the Bureau of National Health Insurance can determine how much to pay the hospital since patients within each category are similar clinically and expected to use the same level of hospital resources. Under DRGs system, medical centers might be impacted most with lesser reimbursement. Thus, the medical quality might be influenced negatively.

Nowadays, the citizens are more aware of high-quality medical care than ever. They pay much attention to medical treatment safety, instructions from physicians, and the overall service quality performed by the hospital. To manage a hospital successfully, the important goals are to attract and then retain as many patients as possible. In order to meet potential demands of the various kinds of the patients, each medical organization focuses on not only purchasing advanced medical equipment but also developing and implementing marketing strategies. As a result, the hardware equipment might not be the only factor to attract the patients. In contrast, patients' satisfaction to the overall medical care quality becomes the more important indicator. Under such circumstances, the hospital needs to understand the patients' needs regularly and then provide the needed medical care services to retain the patients.

The case illustrated in this study is Show Chwan Memorial Hospital in Changhua City, Taiwan. Show Chwan Memorial Hospital and Changhua Christian Hospital are the two major hospitals in Changhua City. Show Chwan Memorial Hospital is classified as a regional hospital, while Changhua Christian Hospital is one of the 14 medical centers in Taiwan. Taichung City, an adjacent city of Changhua City that can be reached within an hour, has two medical centers, i.e., Taichung Veterans General Hospital and China Medical University Hospital, and five regional hospitals. Moreover, the patients in Changhua area can reach more than seven medical centers in Taipei City, including National Taiwan University Hospital and Mackay Hospital, within 2 h by Taiwan High Speed Rail. That is, patients have a wide variety of selections for medical services with high quality but relatively low medical cost. In fact, the medical services in Taiwan are very competitive. Therefore, there is a need to evaluate medical service provided by Show Chwan Memorial Hospital from patients' viewpoints for continuously improvement.

In the past, SERVQUAL model proposed by Parasuraman et al. [22] has been widely applied in health care hospitals or institutions to evaluate service quality [1,2,5,13,25,29]. Therefore, the questionnaire with 22 criteria was designed based on the SERVQUAL model and consultation of management team of Show Chwan Memorial Hospital in order to evaluate the importance of criteria from patients' viewpoints at Show Chwan Memorial Hospital.

The survey was taken among 218 patients or their families at Show Chwan Memorial Hospital from July 28, 2008 to August 8, 2008 by asking the importance of each criterion with a Likert-type five-point scale, where 1 and 5 represent very unimportant and very important, respectively. The number of valid questionnaire is 206. The demographic information of these 206 respondents is summarized in Table 1. The cronbach's $\alpha$ is 0.9417, which represents the internal consistency reliability is excellent [7]. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy provides an index (between 0 and 1) of the proportion of variance among the variables that might be common variance (i.e., that might be indicative of underlying or latent common factors). A high KMO indicates the existence of a statistically acceptable factor solution representing relations between the parameters. In our study, the Kaiser–Meyer–Olkin (KMO) value was found to be 0.9036, which is far better than the suggested 0.6 value [11]. The criteria as well as the importance of the criteria are summarized in Table 2.

It is worth noting that the importance values of 22 criteria fall in the range of 4.0628 and 4.4976. If the patients could possibly have various medical hospitals to choose from, the medical services provided by Show Chwan Memorial Hospital would be compared with other regional hospitals or even medical centers by higher standards. Therefore, it is reasonable to have all of the criteria to be extremely important from patients' point of view. When the importance of criteria was identified, it is unrealistic to improve all of the criteria simultaneously with limited resources. In order to improve the criteria more effectively, seven major criteria were

**Table 1**
The demographic information of the respondents.

| Demographic information | | Frequency | Percentage (%) |
|---|---|---|---|
| Gender | Male | 82 | 39.8 |
| | Female | 124 | 60.2 |
| Age group | 15-20 | 41 | 19.9 |
| | 21-40 | 97 | 47.1 |
| | 41-65 | 55 | 26.7 |
| | 65 and above | 13 | 6.3 |
| Education level | High school below | 31 | 15.1 |
| | High school | 60 | 29.1 |
| | Technological school | 46 | 22.3 |
| | University | 65 | 31.6 |
| | Graduate | 4 | 1.9 |
| Occupation | Service industry | 48 | 23.3 |
| | Physical labor | 20 | 9.7 |
| | Agricultural industry | 3 | 1.5 |
| | Business industry | 24 | 11.7 |
| | Government employee | 11 | 5.3 |
| | Other | 100 | 48.5 |
| Location | Changhua city | 56 | 27.2 |
| | Changhua county | 111 | 53.9 |
| | Taichung city and Taichung county | 24 | 11.7 |
| | Nantou city and Nantou county | 7 | 3.3 |
| | Other | 8 | 3.9 |

**Table 2**
The importance of 22 criteria.

| Criterion | Importance |
|---|---|
| 1. Warm and comfortable environment in the hospital | 4.1594 |
| 2. Tidy appearance of service personnel | 4.1353 |
| 3. Well-equipped medical equipment | 4.4638 |
| 4. Clear marked signs in the hospital | 4.2367 |
| 5. Exact outpatient locations guided by service personnel | 4.2899 |
| 6. Service personnel with good communication skills | 4.3430 |
| 7. Trusted medical staff with professional competence of health care | 4.4300 |
| 8. Patient meals services | 4.0628 |
| 9. Service personnel with immediate problem-solving abilities | 4.3575 |
| 10. Outpatient drug-picking services | 4.1159 |
| 11. Ease of use of the hospital reservation system | 4.2319 |
| 12. Outpatient waiting time for medical treatment | 4.1498 |
| 13. Operating procedures of the emergency room | 4.3092 |
| 14. Processes of hospitalized services | 4.1353 |
| 15. Detailed description of the patient's condition by the medical doctor | 4.4928 |
| 16. Medical staff with professional abilities | 4.4976 |
| 17. Pharmacist's advices on taking medicine | 4.4976 |
| 18. Medicine preservation advices by pharmacists | 4.2899 |
| 19. Feeling a sense of security when medical services are provided | 4.3140 |
| 20. Concern for individual needs by medical staff | 4.2077 |
| 21. Caring attitude of medical staff | 4.2850 |
| 22. Cordial attitude of service personnel | 4.2802 |

determined to be in higher priority after the discussions with the management team of Show Chwan Memorial Hospital, including (3) well-equipped medical equipment, (6) service personnel with good communication skills, (7) trusted medical staff with professional competence of health care, (9) service personnel with immediate problem-solving abilities, (15) detailed description of the patient's condition by the medical doctor, (16) medical staff with professional abilities, and (17) pharmacist's advices on taking medicine. It is worth to explain that service personnel with good communication skills are required since the patients have different ages, education levels, and different medical needs by different dialects. In addition, item 7 tends to focus on the interaction between patients and medical staff, while item 16 focuses on the license or professional training.

When the key criteria were found, the second questionnaire developed for applying decision-making trial and evaluation laboratory (DEMATEL) method was issued to the management of Show Chwan Memorial Hospital to first prioritize the importance of these criteria and then construct the causal relations among the criteria. In doing so, the key success factors for improving the overall medical care service quality can be identified and the improvement can be made by observing the causal relationships of these key success factors.

This paper is organized as follows: Section 2 briefly reviews medical care service quality and DEMATEL method. A case study of applying DEMATEL method to evaluate the criteria used for Show Chwan Memorial Hospital is conducted and described in Section 3. Finally, conclusions are drawn in Section 4.

## 2. Literature review of medical care service quality and DEMATEL

Service quality has been defined by several ways. Bitner and Hubbert [4] defined service quality as "the consumer's overall impression of the relative inferiority/superiority of the organization and its services." On the other hand, a more traditional definition of service quality is the comparison of consumer expectations with actual service performance [3,8,21]. Service quality has long been studied by researchers in the field of business management. However, it also can be applied in medical care service quality. Research using SERVQUAL model in health care setting has focused on patients' satisfaction and perceptions of quality [1,2,5,9,17–19,28]. The result shows that the higher patients' appraisal on medical care service quality, the higher satisfaction a hospital receives. As a result, the more patients go back to hospital for heal.

Perceived quality is related to recent customers' consumption or assessment of experience, so perceived quality would directly influence customers' satisfaction [6]. Positive perceived quality will improve the value and satisfaction at the same time [20]. According to the classification of service industries, the hospital is a service industry that needs to contact people directly, communicate with people frequently, and provide customized and professional services. Therefore, customers' demand oriented services are needed to promote high customer satisfaction [16].

Decision-making trial and evaluation laboratory method was originally developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976 to study and resolve the complicated and intertwined problem group [24,27]. DEMATEL method could improve understanding of the specific problematique, the cluster of intertwined problems, and contribute to identification of workable solutions by a hierarchical structure [10,23,24]. Unlike the traditional techniques such as analytic hierarchy process with the assumption that elements are independent, this method, one of the structural modeling techniques, can identify the interdependence among the elements of a system through a causal diagram [12,24,26]. The causal diagram uses digraphs rather than directionless graphs to portray the basic concept of contextual relationships and the strengths of influence among the elements [27].

The procedure of DEMATEL method is summarized as follows based on Tzeng et al. [24] and Wu [27]:

Step 1: Compute the average matrix. Each respondent was asked to evaluate the direct influence between any two factors by an integer score ranging from 0, 1, 2, and 3, representing "no influence", "low influence", "medium influence", and "high influence", respectively. The notation of $x_{ij}$ indicates the degree to which the respondent believes factor $i$ affects factor $j$. For $i = j$, the diagonal elements are set to zero. For each respondent, an $n \times n$ non-negative matrix can be established as $X^k = \left[x_{ij}^k\right]$, where $k$ is the number of respondents with $1 \leqslant k \leqslant H$, and $n$ is the number of factors. Thus, $X^1$, $X^2$, $X^3$, ..., $X^H$ are the matrices from $H$ respondents. To incorporate all opinions from $H$ respondents, the average matrix $A = [a_{ij}]$ can be constructed as follows:

$$a_{ij} = \frac{1}{H}\sum_{k=1}^{H} x_{ij}^k. \tag{1}$$

Step 2: Calculate the normalized initial direct-relation matrix. Normalize initial direct-relation matrix $D$ by $D = A \times S$, where $S = \frac{1}{\max_{1\leqslant i\leqslant n}\sum_{j=1}^{n} a_{ij}}$. Each element in matrix $D$ falls between zero and one.

Step 3: Calculate the total relation matrix. The total relation matrix $T$ is defined as $T = D(I - D)^{-1}$, where $I$ is the identity matrix. Define $r$ and $c$ be $n \times 1$ and $1 \times n$ vectors representing the sum of rows and sum of columns of the total relation matrix $T$, respectively. Suppose $r_i$ be the sum of $i$th row in matrix $T$, then $r_i$ summarizes both direct and indirect effects given by factor $i$ to the other factors. If $c_j$ denotes the sum of $j$th column in matrix $T$, then $c_j$ shows both direct and indirect effects by factor $j$ from the other factors. When $j = i$, the sum $(r_i + c_j)$ shows the total effects given and received by factor $i$. That is, $(r_i + c_j)$ indicates the degree of importance that factor $i$ plays in the entire system. On the contrary, the difference $(r_i - c_j)$ depicts the net effect that factor $i$ contributes to the system. Specifically, if $(r_i - c_j)$ is positive, factor $i$ is a net cause, while factor $i$ is a net receiver or result if $(r_i - c_j)$ is negative [14,15].

Step 4: Set up a threshold value to obtain the digraph. Since matrix $T$ provides information on how one factor affects another, it is necessary for a decision maker to set up a threshold value to filter out some negligible effects. In doing so, only the effects greater than the threshold value would be chosen and shown in digraph. In this study, the threshold value is set up by computing the average of the elements in matrix $T$. The digraph can be acquired by mapping the dataset of $(r + c, r - c)$.

## 3. A case of Show Chwan Memorial Hospital

During the first survey, seven major criteria were identified including (A) well-equipped medical equipment, (B) service personnel with good communication skills, (C) trusted medical staff with professional competence of health care, (D) service personnel with immediate problem-solving abilities, (E) detailed description of the patient's condition by the medical doctor, (F) medical staff

with professional abilities, and (G) pharmacist's advices on taking medicine. The second questionnaire was developed based on these seven criteria to 21 managerial personnel of Show Chwan Memorial Hospital, including Director of Nutrition Department, Director of Management Department, Director of Pharmacy Department, Director of Nursing Department, Deputy Director of Surgical Department, Head Nurse of Health Education Department, and Head Nurse of Outpatient Nursing Station. Nineteen valid questionnaires have been received, representing a 90.5% return rate. Therefore, the computation of using DEMATEL method is based upon these 19 experts' opinions.

To follow the procedure of DEMATEL method, first construct 19 $7 \times 7$ non-negative matrices, including

$$X^1 = \begin{bmatrix} 0 & 1 & 2 & 2 & 3 & 2 & 1 \\ 2 & 0 & 2 & 2 & 2 & 2 & 1 \\ 2 & 2 & 0 & 2 & 3 & 3 & 2 \\ 1 & 1 & 2 & 0 & 2 & 2 & 1 \\ 3 & 2 & 3 & 2 & 0 & 3 & 1 \\ 3 & 2 & 3 & 2 & 3 & 0 & 1 \\ 1 & 2 & 2 & 1 & 2 & 2 & 0 \end{bmatrix}, \quad X^2 = \begin{bmatrix} 0 & 0 & 2 & 1 & 0 & 2 & 0 \\ 2 & 0 & 1 & 2 & 1 & 1 & 1 \\ 1 & 0 & 0 & 1 & 1 & 3 & 1 \\ 1 & 3 & 1 & 0 & 1 & 1 & 1 \\ 1 & 0 & 2 & 0 & 0 & 2 & 1 \\ 2 & 0 & 2 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 1 & 0 \end{bmatrix},$$

$$X^3 = \begin{bmatrix} 0 & 1 & 2 & 1 & 1 & 1 & 2 \\ 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 & 2 & 2 & 2 \\ 2 & 2 & 1 & 0 & 1 & 1 & 1 \\ 1 & 1 & 2 & 1 & 0 & 2 & 1 \\ 2 & 1 & 2 & 2 & 2 & 0 & 1 \\ 0 & 1 & 1 & 1 & 2 & 2 & 0 \end{bmatrix}, \quad X^4 = \begin{bmatrix} 0 & 2 & 2 & 2 & 2 & 2 & 2 \\ 2 & 0 & 2 & 2 & 2 & 2 & 2 \\ 2 & 1 & 0 & 2 & 2 & 2 & 2 \\ 2 & 2 & 2 & 0 & 2 & 2 & 2 \\ 2 & 2 & 2 & 2 & 0 & 2 & 2 \\ 2 & 1 & 2 & 1 & 2 & 0 & 2 \\ 1 & 1 & 2 & 1 & 2 & 2 & 0 \end{bmatrix},$$

$$X^5 = \begin{bmatrix} 0 & 2 & 2 & 3 & 3 & 2 & 0 \\ 2 & 0 & 3 & 3 & 3 & 3 & 3 \\ 3 & 3 & 0 & 3 & 3 & 3 & 2 \\ 2 & 3 & 3 & 0 & 2 & 3 & 2 \\ 2 & 3 & 2 & 3 & 0 & 3 & 1 \\ 2 & 3 & 3 & 3 & 3 & 0 & 3 \\ 1 & 3 & 2 & 3 & 1 & 2 & 0 \end{bmatrix}, \quad X^6 = \begin{bmatrix} 0 & 2 & 3 & 2 & 3 & 2 & 2 \\ 2 & 0 & 2 & 2 & 3 & 2 & 2 \\ 2 & 2 & 0 & 2 & 3 & 2 & 2 \\ 0 & 2 & 2 & 0 & 3 & 2 & 2 \\ 0 & 1 & 2 & 1 & 0 & 1 & 1 \\ 0 & 1 & 2 & 2 & 2 & 0 & 2 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 \end{bmatrix},$$

$$X^7 = \begin{bmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 3 & 2 & 2 & 2 & 2 \\ 1 & 2 & 0 & 2 & 3 & 3 & 2 \\ 1 & 2 & 3 & 0 & 3 & 3 & 1 \\ 2 & 2 & 2 & 2 & 0 & 2 & 2 \\ 1 & 2 & 2 & 2 & 2 & 0 & 2 \\ 1 & 2 & 2 & 2 & 2 & 2 & 0 \end{bmatrix}, \quad X^8 = \begin{bmatrix} 0 & 1 & 3 & 3 & 2 & 3 & 2 \\ 2 & 0 & 3 & 3 & 3 & 2 & 3 \\ 3 & 3 & 0 & 3 & 3 & 3 & 3 \\ 2 & 3 & 3 & 0 & 3 & 3 & 2 \\ 1 & 3 & 3 & 2 & 0 & 3 & 2 \\ 2 & 3 & 3 & 3 & 3 & 0 & 2 \\ 1 & 3 & 3 & 2 & 2 & 3 & 0 \end{bmatrix},$$

$$X^9 = \begin{bmatrix} 0 & 2 & 3 & 2 & 3 & 3 & 3 \\ 3 & 0 & 3 & 3 & 3 & 3 & 3 \\ 2 & 2 & 0 & 2 & 3 & 3 & 3 \\ 3 & 3 & 3 & 0 & 3 & 3 & 3 \\ 3 & 3 & 3 & 3 & 0 & 3 & 3 \\ 3 & 3 & 3 & 3 & 3 & 0 & 3 \\ 3 & 3 & 3 & 3 & 3 & 3 & 0 \end{bmatrix}, \quad X^{10} = \begin{bmatrix} 0 & 1 & 1 & 2 & 2 & 2 & 1 \\ 3 & 0 & 2 & 2 & 3 & 2 & 1 \\ 3 & 2 & 0 & 2 & 2 & 2 & 1 \\ 3 & 2 & 2 & 0 & 2 & 2 & 1 \\ 3 & 2 & 2 & 2 & 0 & 2 & 1 \\ 3 & 2 & 2 & 2 & 2 & 0 & 1 \\ 3 & 2 & 2 & 2 & 2 & 1 & 0 \end{bmatrix},$$

$$X^{11} = \begin{bmatrix} 0 & 2 & 1 & 3 & 3 & 3 & 1 \\ 2 & 0 & 1 & 3 & 3 & 3 & 1 \\ 2 & 2 & 0 & 2 & 2 & 2 & 2 \\ 2 & 3 & 1 & 0 & 2 & 2 & 2 \\ 3 & 3 & 1 & 2 & 0 & 2 & 2 \\ 2 & 2 & 1 & 2 & 2 & 0 & 2 \\ 1 & 2 & 2 & 2 & 1 & 2 & 0 \end{bmatrix}, \quad X^{12} = \begin{bmatrix} 0 & 1 & 2 & 0 & 1 & 1 & 0 \\ 1 & 0 & 2 & 3 & 3 & 2 & 1 \\ 2 & 1 & 0 & 2 & 2 & 3 & 1 \\ 0 & 1 & 1 & 0 & 2 & 2 & 1 \\ 1 & 2 & 2 & 2 & 0 & 2 & 1 \\ 2 & 2 & 2 & 2 & 2 & 0 & 2 \\ 0 & 1 & 1 & 1 & 0 & 1 & 0 \end{bmatrix},$$

$$X^{13} = \begin{bmatrix} 0 & 2 & 3 & 2 & 3 & 3 & 2 \\ 2 & 0 & 2 & 2 & 3 & 3 & 2 \\ 3 & 3 & 0 & 2 & 3 & 3 & 2 \\ 2 & 3 & 2 & 0 & 3 & 3 & 2 \\ 3 & 3 & 3 & 2 & 0 & 3 & 2 \\ 2 & 3 & 2 & 2 & 3 & 0 & 2 \\ 2 & 3 & 3 & 3 & 3 & 3 & 0 \end{bmatrix}, \quad X^{14} = \begin{bmatrix} 0 & 1 & 1 & 1 & 2 & 1 & 0 \\ 1 & 0 & 1 & 2 & 1 & 1 & 1 \\ 2 & 2 & 0 & 1 & 2 & 2 & 2 \\ 0 & 2 & 2 & 0 & 2 & 2 & 1 \\ 3 & 2 & 2 & 2 & 0 & 2 & 2 \\ 3 & 2 & 2 & 2 & 3 & 0 & 2 \\ 1 & 1 & 1 & 1 & 2 & 1 & 0 \end{bmatrix},$$

$$X^{15} = \begin{bmatrix} 0 & 2 & 2 & 2 & 2 & 2 & 2 \\ 0 & 0 & 2 & 2 & 2 & 2 & 1 \\ 1 & 2 & 0 & 2 & 2 & 2 & 2 \\ 1 & 2 & 2 & 0 & 2 & 2 & 2 \\ 1 & 1 & 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}, \quad X^{16} = \begin{bmatrix} 0 & 2 & 2 & 1 & 3 & 2 & 1 \\ 1 & 0 & 2 & 2 & 3 & 3 & 1 \\ 2 & 2 & 0 & 3 & 3 & 2 & 1 \\ 1 & 2 & 3 & 0 & 3 & 3 & 1 \\ 1 & 2 & 3 & 1 & 0 & 3 & 1 \\ 3 & 2 & 3 & 2 & 3 & 0 & 1 \\ 1 & 2 & 1 & 1 & 1 & 0 & 0 \end{bmatrix},$$

$$X^{17} = \begin{bmatrix} 0 & 3 & 3 & 3 & 3 & 3 & 3 \\ 2 & 0 & 2 & 3 & 3 & 2 & 2 \\ 1 & 2 & 0 & 2 & 2 & 2 & 2 \\ 1 & 2 & 2 & 0 & 2 & 2 & 2 \\ 2 & 2 & 2 & 2 & 0 & 2 & 2 \\ 2 & 2 & 2 & 2 & 2 & 0 & 2 \\ 2 & 2 & 2 & 2 & 2 & 2 & 0 \end{bmatrix}, \quad X^{18} = \begin{bmatrix} 0 & 2 & 3 & 3 & 3 & 1 & 2 \\ 0 & 0 & 3 & 3 & 3 & 2 & 1 \\ 2 & 3 & 0 & 3 & 3 & 3 & 3 \\ 1 & 2 & 2 & 0 & 2 & 2 & 2 \\ 1 & 2 & 2 & 1 & 0 & 1 & 0 \\ 2 & 2 & 1 & 1 & 0 & 0 & 1 \\ 1 & 2 & 3 & 2 & 0 & 2 & 0 \end{bmatrix},$$

and

$$X^{19} = \begin{bmatrix} 0 & 1 & 2 & 2 & 3 & 2 & 1 \\ 2 & 0 & 2 & 2 & 2 & 2 & 1 \\ 2 & 2 & 0 & 2 & 3 & 3 & 2 \\ 1 & 1 & 2 & 0 & 2 & 2 & 1 \\ 3 & 2 & 3 & 2 & 0 & 3 & 1 \\ 3 & 2 & 3 & 2 & 3 & 0 & 1 \\ 1 & 2 & 2 & 1 & 2 & 2 & 0 \end{bmatrix}.$$

The average matrix $A$ can be constructed based on Eq. (1):

$$A = \begin{bmatrix} 0.0000 & 1.5789 & 2.0526 & 1.7895 & 2.2632 & 2.0000 & 1.3158 \\ 1.5263 & 0.0000 & 2.0526 & 2.3684 & 2.3684 & 2.0526 & 1.6316 \\ 1.9474 & 1.9474 & 0.0000 & 2.0526 & 2.4211 & 2.5263 & 1.9474 \\ 1.3684 & 2.2632 & 2.1053 & 0.0000 & 2.2105 & 2.2632 & 1.5789 \\ 1.8421 & 2.0000 & 2.2105 & 1.7895 & 0.0000 & 2.2105 & 1.4737 \\ 2.0526 & 1.8421 & 2.1579 & 1.8421 & 2.2105 & 0.0000 & 1.6842 \\ 1.0526 & 1.7368 & 1.8421 & 1.6316 & 1.5263 & 1.7368 & 0.0000 \end{bmatrix}.$$

Step 2 is to calculate the normalized initial direct-relation matrix $D$, depicted below:

$$D = A \times \frac{1}{\max\limits_{1\leqslant i\leqslant 7}\sum\limits_{j=1}^{7} a_{ij}} = \begin{bmatrix} 0.0000 & 0.1230 & 0.1598 & 0.1393 & 0.1762 & 0.1557 & 0.1025 \\ 0.1189 & 0.0000 & 0.1598 & 0.1844 & 0.1844 & 0.1598 & 0.1270 \\ 0.1516 & 0.1516 & 0.0000 & 0.1598 & 0.1885 & 0.1967 & 0.1516 \\ 0.1066 & 0.1762 & 0.1639 & 0.0000 & 0.1721 & 0.1762 & 0.1230 \\ 0.1434 & 0.1557 & 0.1721 & 0.1393 & 0.0000 & 0.1721 & 0.1148 \\ 0.1598 & 0.1434 & 0.1680 & 0.1434 & 0.1721 & 0.0000 & 0.1311 \\ 0.0820 & 0.1352 & 0.1434 & 0.1270 & 0.1189 & 0.1352 & 0.0000 \end{bmatrix}.$$

In Step 3, calculate matrix $T$ by the following formula:

$$T = D(I-D)^{-1} = \begin{bmatrix} 0.9927 & 1.2297 & 1.3460 & 1.2484 & 1.4098 & 1.3778 & 1.0605 \\ 1.1747 & 1.2081 & 1.4398 & 1.3705 & 1.5132 & 1.4773 & 1.1551 \\ 1.2602 & 1.4063 & 1.3750 & 1.4194 & 1.5918 & 1.5790 & 1.2322 \\ 1.1513 & 1.3414 & 1.4250 & 1.1983 & 1.4858 & 1.4711 & 1.1382 \\ 1.1593 & 1.3015 & 1.4057 & 1.2966 & 1.3128 & 1.4420 & 1.1112 \\ 1.1878 & 1.3108 & 1.4227 & 1.3178 & 1.4801 & 1.3155 & 1.1395 \\ 0.9477 & 1.1035 & 1.1863 & 1.1029 & 1.2124 & 1.2107 & 0.8507 \end{bmatrix}.$$

Table 3 depicts the direct and indirect effects of seven criteria. Finally, the threshold value used in Step 4 is to compute the average of the elements in matrix $T$, which is 1.2836. The digraph of these seven criteria is depicted in Fig. 1.

Based on Table 3, the importance of the seven criteria can be prioritized as $C > F > E > B > D > A > G$ based on $(r + c)$ values, where trusted medical staff with professional competence of health care is the most important criterion with the value of 19.4643, while pharmacist's advices on taking medicine is the least important criterion with the value of 15.3015. In contrast to the importance, ($A$) well-equipped medical equipment, ($B$) service personnel with good communication skills, ($C$) trusted medical staff with professional competence of health care, and ($D$) service personnel with immediate problem-solving abilities are net causes, whereas ($E$) detailed description of the patient's condition by the medical doctor, ($F$) medical staff with professional abilities, and ($G$) pharmacist's advices on taking medicine are net receivers based on $(r - c)$ values. Specifically, Fig. 1 shows that criterion A (well-equipped medical equipment) is not affected by the others but affects C (trusted medical staff with professional competence of health care), $E$ (detailed description of the patient's condition by the medical doctor), and $F$ (medical staff with professional abilities). Generally, any pair of criteria $B$, $C$, $D$, $E$, and $F$ is mutually influenced by each other. Finally, criterion $G$ (pharmacist's advices on taking medicine) is more independent compared with the other criteria.

**Table 3**
The sum of influences given and received among these seven criteria on dimensions.

| Dimensions | $r + c$ | $r - c$ |
|---|---|---|
| A (well-equipped medical equipment) | 16.5386 | 0.7913 |
| B (service personnel with good communication skills) | 18.2399 | 0.4373 |
| C (trusted medical staff with professional competence of health care) | 19.4643 | 0.2635 |
| D (service personnel with immediate problem-solving abilities) | 18.1651 | 0.2573 |
| E (detailed description of the patient's condition by the medical doctor) | 19.0350 | −0.9767 |
| F (medical staff with professional abilities) | 19.0475 | −0.6994 |
| G (pharmacist's advices on taking medicine) | 15.3015 | −0.0733 |

In summary, Show Chwan Memorial Hospital should pay much attention to four causes ($A$, $B$, $C$, and $D$) rather than receivers ($E$, $F$, and $G$). Well-equipped medical equipment ($A$) is a key criterion since it is not only a cause but also not affected by the other criterion. The improvement of well-equipped medical equipment would result in better trusted medical staff with professional competence of health care ($C$), detailed description of the patient's condition by the medical doctor ($E$), and medical staff with professional abilities ($F$). However, the importance of well-equipped medical equipment ranks only sixth. In contrast, trusted medical staff with professional competence of health care is the most important criterion and mutually affects service personnel with good communication skills ($B$), service personnel with immediate problem-solving abilities ($D$), detailed description of the patient's condition by the medical doctor, and medical staff with professional abilities. This indicates that the interaction between medical staff and patients are far more important. The better interaction, the better satisfaction the patients feel. Though well-equipped medical equipment has the influence on interaction improvement, it is not a necessity to enhance trusted medical staff with profes-

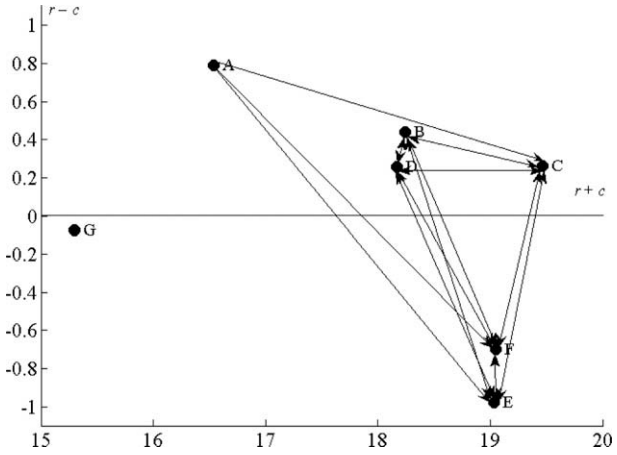


**Fig. 1.** The digraph of showing causal relations among these seven criteria.

sional competence of health care. On the contrary, service personnel with good communication skills and service personnel with immediate problem-solving abilities might have greater impact than well-equipped medical equipment to strengthen patients' images on trusted medical staff because of $(r + c)$ values. Therefore, trainings on communication skills and problem-solving abilities would result in positive interaction for patients to trust medical staff. When the trusted medical staff provides professional competence of health care to patients, satisfaction would be increased.

## 4. Conclusions

This study first conducted the survey based on SERVQUAL model to identify seven major criteria among 22 criteria from the patients' or their families' viewpoints. When the key criteria were found, the second survey developed for applying DEMATEL method was issued to the management of Show Chwan Memorial Hospital. Unlike the traditional multiple criteria decision-making techniques which typically assume the criteria are mutually independent; DEMATEL method does not require this assumption but further helps the decision makers in identifying the casual relationships among criteria. That is, by applying DEMATEL method, the importance of seven criteria can be determined and the causal relations among the criteria can be constructed. The results show that trusted medical staff with professional competence of health care is the most essential criterion. Though well-equipped medical equipment has the influence on trusted medical staff with professional competence of health care, there are five criteria which have the influence on trusted medical staff with professional competence of health care but the contribution of well-equipped medical equipment is the smallest. Thus, well-equipped medical equipment is not a necessity. In contrast, service personnel with good communication skills and service personnel with immediate problem-solving abilities are the two more essential criteria to strengthen trusted medical staff with professional competence of health care from hospital management' viewpoints.

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