Causal Relationships of Patient Safety Culture Based on the Chinese Version of Safety Attitudes Questionnaire

Yii-Ching Lee, Pei-Shan Zeng, Chih-Hsuan Huang, Cheng-Feng Wu, Chien-Chang Yang, and Hsin-Hung Wu

Abstract—This study uses the decision-making trial and evaluation laboratory method to identify critical dimensions of the Chinese version of the safety attitudes questionnaire to improve the patient safety culture in Taiwan from experts' viewpoints. Stress recognition, perceptions of management, emotional exhaustion, and work-life balance are causal dimensions, whereas teamwork climate, safety climate, job satisfaction, and working conditions are receiving dimensions. Improving effect-based dimensions might have little impact on effects. In contrast, improving a causal dimension would not only improve the dimension itself but would also result in better performance of other dimension(s) that it directly affects. This work identifies emotional exhaustion as the most critical dimension of the questionnaire, followed by perceptions of management. These two dimensions are main causal dimensions that have significant effects on the other dimensions. Therefore, hospital management needs to address emotional exhaustion and perceptions of management to improve patient safety culture.

Index Terms—patient safety culture, safety attitudes questionnaire, Chinese version of the safety attitudes questionnaire, decision-making trial and evaluation laboratory, causal relationship

I. INTRODUCTION

Patient safety has become an essential topic in healthcare organizations. Several studies have shown that healthcare organizations with better attitudes toward patient safety would result in positive impacts on shorter stays, fewer prescription errors, less ventilator-associated pneumonia, fewer blood-stream and urinary tract infections, and lower mortality [1-3]. That is, patient safety culture plays a critical role for healthcare organizations to relentlessly improve patient safety [4]. To assess the patient safety culture, the safety attitudes questionnaire (SAQ) developed by Sexton et al. [5] with good validity and reliability designed to assess opinions from healthcare organizations' staffs about patient safety issues, medical errors, and even reports has been widely used in practice [6-16].

A better patient safety culture was associated with a lower risk of patient safety issues [17]. In addition, regularly assessing the patient safety culture is critically important to monitor the changes and trends in a particular healthcare organization [16,18]. Moreover, healthcare organization with a more open culture and reflective attitude toward error and patient safety reduce the number of accidents and failures [19]. Therefore, it is important to regularly assess the perceptions of employees' safety attitude in healthcare organizations because a positive patient safety culture would indicate that healthcare organizations place patient safety culture in one of the highest priorities [2,16,17,20].

Analyzing causal relationships among critical dimensions helps the decision maker understand the underlying principles of the relationships and then make accurate predictions of future outcomes [21]. When critical dimensions and their causal relationships are found, enhancements can be taken based on those causal dimensions first to reduce cost and improve effectively, whereas improvements on effect-based dimensions might receive little effects when a great amount of resources have been invested. Decision-making trial and evaluation laboratory (DEMATEL) is one of the most effective methods to establish causal relationships among dimensions by using experts' opinions to identify critical dimensions and then further to construct a digraph to show the entire relationships among them [21-24]. In doing so, the dimension that affects other dimensions most would be the most critical one. Therefore, any improvement can be initiated by starting with this critical dimension.

In healthcare organizations, identifying causal relationships of the safety attitudes questionnaire is practically useful for any decision maker in a particular healthcare organization to improve the patient safety culture continuously [25]. For instance, from cause-effect viewpoints,

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Yii-Ching Lee is with Department of Health Business Administration, Hung Kuang University and Superintendent Office, Ben Tang Cheng Ching Hospital, Taichung City, Taiwan.

Pei-Shan Zeng is with Qisda Corporation, Taoyuan City, Taiwan and was with Department of Business Administration, National Changhua University of Education, Changhua City, Taiwan.

Chih-Hsuan Huang is with School of Business Administration, Hubei University of Economics and Institute for Development of Cross-Strait Small and Medium Enterprise, Hubei University of Economics, Wuhan City, China.

Cheng-Feng Wu with School of Business Administration, Hubei University of Economics; Institute for Development of Cross-Strait Small and Medium Enterprise, Hubei University of Economics; and Research Center of Hubei Logistics Development, Hubei University of Economics, Wuhan City, China.

Chien-Chang Yang is with Human Resource Management, Far Eastern Memorial Hospital and Department of Healthcare Administration, Oriental Institute of Technology, New Taipei City, Taiwan.

Hsin-Hung Wu is with Department of Business Administration, National Changhua University of Education, Changhua City, Taiwan and Department of M-Commerce and Multimedia Applications, Asia University, Taichung City, Taiwan (e-mail: hhwu@cc.ncue.edu.tw).

enhancing effect-based dimension(s) would receive little improvement, while strengthening the causal dimension(s) would have direct and great impacts on effect-based dimension(s) [25,26]. Thus, understanding the contextual relationships among dimensions in the SAQ enables the decision maker to take improvement actions more effectively from causal viewpoints. In the past, few studies have been found to study the causal relationships among dimensions of the safety attitudes questionnaire. For instance, Lee et al. [25] analyzed six dimensions of the SAQ, and Lee et al. [26] depicted the causal relationships among nine dimensions based on the Chinese version of the SAQ in Taiwan. However, the current Chinese version of the SAQ has been changed from nine dimensions to eight dimensions since 2014 [27,28]. There is a need to identify causal relationships among eight dimensions of the Chinese version of the SAQ in order to improve the patient safety culture in healthcare organizations in Taiwan.

II. Literature Review

A. Safety Attitudes Questionnaire

The safety attitudes questionnaire developed by Sexton et al. [5] has six dimensions, including teamwork climate, safety climate, perceptions of management, job satisfaction, working conditions, and stress recognition. Teamwork climate is defined as the perceived quality of collaboration between personnel. Safety climate is the perceptions of a strong and proactive organizational commitment to safety. Perceptions of management is referred to the approval of managerial action. Job satisfaction is the positivity about the work experience. Working conditions is defined as the perceived quality of the work environment and logistical support. Finally, stress recognition is the acknowledgement of how performance is influenced by stressors [5,14,15].

The Taiwan Joint Commission on Hospital Accreditation developed the Chinese version of the SAQ based on the six dimensions of the SAQ by the forward and backward translation to check the quality of the translation and the pilot-testing and discussion by an expert panel for intelligibility and applicability of the items [13,18]. Later, three hospital-level aspects of safety culture borrowed from the Agency for Healthcare Research and Quality including hospital management support for patient safety, teamwork across hospital units, and hospital handoffs and transitions were integrated into the questionnaire to become nine dimensions [18,25].

The latest version beginning in 2014 retained the six dimensions of the original SAQ, removed three dimensions from the Agency for Healthcare Research and Quality, and incorporated two new dimensions, i.e., emotional exhaustion and work-life balance (burnout), to eventually become eight dimensions [28,29]. Emotional exhaustion is to assess the degree of fatigue toward the work from staffs' perceptions, while work-life balance is to evaluate the work-life balance for each staff each week in terms of frequency [13,29].

Two previous studies have been found to examine the causal relationships among dimensions based on the SAQ and the Chinese version of the SAQ, respectively. Lee et al. [25] summarized that teamwork climate, job satisfaction, perceptions of management, and working conditions are net causes, and safety climate and stress recognition are net effects based on the six dimensions of the SAQ. From an overall evaluation, stress recognition is solely influenced by teamwork climate which is the only causal dimension to have direct influences on both stress recognition and safety climate positively. To sum up, teamwork climate is the most essential dimension for the hospital management to improve the patient safety culture. Lee et al. [26] evaluated the contextual relationships of nine dimensions from the Chinese version of the SAQ. Cause-based dimensions are teamwork climate, job satisfaction, working conditions, hospital management support for patient safety, and teamwork across hospital units, whereas effect-based dimensions include safety climate, stress recognition, perceptions of management, and hospital handoffs and transitions. In addition, stress recognition is neutral, which is not affected by any dimension. In summary, teamwork climate and hospital management support for patient safety are the two essential dimensions that the hospital management needs to pay much attention in order to improve the patient safety culture because these two dimensions have direct impacts on six dimensions except for stress recognition. In contrast, the current Chinese version of the SAQ has eight dimensions, and there is a need to further examine the causal relationships among them when the hospital management is intended to enhance the patient safety culture in healthcare organizations in Taiwan.

B. DEMATEL Method

Decision-making trial and evaluation laboratory originally developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976 was intended to study and solve the complicated and intertwined problems by improving the understanding through hierarchical structures [22,30,31]. Unlike the traditional techniques, such as analytic hierarchy process, that require the elements to be independent, DEMATEL method does not require this basic assumption [23]. Specifically, DEMATEL method uses the structural modeling technique to identify the interdependence among the factors/dimensions in a system through a causal diagram based on digraphs rather than the directionless graphs [32]. Moreover, DEMATEL method uses arithmetic means to aggregate opinions from a group of people [33]. The number of experts adopted by DEMATEL method might range from 7 to 21 depending upon the availability of experts [23,24,30,34-36].

DEMATEL method has been widely applied in a wide variety of areas including healthcare management areas. For example, Nasiripour et al. [37] applied DEMATEL method to find the most important factor on the performance of pre-hospital emergency system in Iran. Shieh et al. [34] used DEMATEL method to identify trusted medical staff with professional competence of health care which is the most important criterion that can ultimately result in better patient satisfaction in Taiwan. Mamikhani et al. [38] applied DEMATEL method to find critical factors that affect the compensation for services provided by emergency department nurses. Further, Sener and Dursun [39] combined fuzzy theory and DEMATEL method for supplier selections in a healthcare industry. Moreover, Shieh et al. [32] used a

modified DEMATEL method to establish a framework to examine the medical service quality by a case study. Therefore, DEMATEL method is very useful and practical in evaluating causal relationships in healthcare industries.

The computational procedures of DEMATEL method can be depicted by the following four major steps [21,23,24,33,35].

Step 1: Calculate the average matrix. The direct influence between any two factors can be assessed by an integer score of 0, 1, 2, and 3 representing the respective "no influence", "low influence", "medium influence", and "high influence" for each respondent. The notation, 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 indicating no influence. An *n*×*n* non-negative matrix is established as $X^k = \left[x_{ij}^k\right]$ for each respondent, where *k* is the number of respondents with $1 \le k \le H$, and *n* is the number of elements in the system. If there are *H* respondents (i.e., X^1, X^2, X^3, …, and X^H), the average matrix $A = \left[a_{ij}\right]$ can be constructed to aggregate all opinions from *H* respondents by the following equation:

$$a_{ij} = \frac{1}{H}\sum_{k=1}^{H} x_{ij}^k \qquad (1)$$

Step 2: Compute the normalized initial direct-relation matrix *D* by $D = A \times S$, where $S = \dfrac{1}{\max\limits_{1\le i\le n}\sum\limits_{j=1}^{n} a_{ij}}$. Each element in matrix *D* falls between zero and one.

Step 3: Calculate the total relation matrix *T* by $T = D(I-D)^{-1}$, where *I* is the identity matrix. Let *r* and *c* be *n*×1 and 1×*n* vectors that represent the respective sum of rows and sum of columns of the total relation matrix *T*. Denote 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. In addition, c_j is defined as the sum of *j*-th column in matrix *T* by considering both direct and indirect effects by factor *j* from the other factors. If *j* = *i*, the sum ($r_i + c_j$) is the total effects given and received by factor *i*. That is, ($r_i + c_j$) represents the degree of importance for factor *i* in the entire system. On the other hand, the difference ($r_i - c_j$) is the net effect that factor *i* contributes to the system. Moreover, if ($r_i - c_j$) is positive, factor *i* is a net cause. If ($r_i - c_j$) is negative, factor *i* is a net receiver or result.

Step 4: Set up a threshold value to obtain the digraph by filtering out some negligible effects by showing the effects greater than the threshold value in digraph. The threshold value can be established by computing the average of the elements in Matrix *T*. The digraph can be acquired by mapping the dataset of (*r*+*c*, *r*–*c*).

III. Research Method

The questionnaire was developed using these eight dimensions of the Chinese version of the SAQ. Thirteen questionnaires have been issued from April 2016 to June 2016, but only eleven questionnaires were valid, representing an 84.6% effective response rate. The demographic information about these eleven experts is provided in Table I, and these experts are from three medical centers, four regional hospitals, and two universities. The computations and analyses in DEMATEL method are based upon the opinions of these eleven experts.

TABLE I
Demographic Information of Eleven Experts

Demographic Variable	Frequency	Percentage
Gender		
Male	5	45.5
Female	6	54.5
Age		
21-30 years old	1	9.1
31-40 years old	2	18.2
41-50 years old	7	63.6
51-60 years old	1	9.1
Education		
College/University	5	45.5
Master's Degree	4	36.4
Doctoral Degree	2	18.2
Working Experience		
5 to 10 years	2	18.2
11-20 years	7	63.6
21 years and above	2	18.2
Areas of Expertise (multiple choice)		
Patient Safety	6	
Medical Quality	5	
Human Resources Management	3	
Working Experience in the Areas of Expertise		
Less than 1 year	1	9.1
1 to 2 years	0	0
3 to 4 years	1	9.1
5 to 10 years	4	36.4
11-20 years	4	36.4
21 years and above	1	9.1

IV. Results

Eleven 8×8 matrices should be established to record eleven experts' opinions on these eight dimensions. In Step 1, the average matrix *A* based on Equation (1) becomes

$$A = \begin{bmatrix} 0 & 2.8182 & 2.7273 & 1.9091 & 2.5455 & 2.6364 & 2.0000 & 1.3636 \\ 2.4545 & 0 & 2.4545 & 1.9091 & 2.2727 & 2.3636 & 1.7273 & 1.5455 \\ 2.8182 & 2.1818 & 0 & 2.0000 & 2.1818 & 2.6364 & 2.3636 & 2.3636 \\ 1.9091 & 2.0000 & 2.3636 & 0 & 2.1818 & 2.3636 & 2.2727 & 2.1818 \\ 2.8182 & 2.2727 & 2.7273 & 1.7273 & 0 & 2.4545 & 2.0909 & 1.9091 \\ 2.4545 & 2.2727 & 2.8182 & 2.0909 & 2.1818 & 0 & 2.1818 & 2.2727 \\ 2.1818 & 2.0000 & 2.3636 & 2.2727 & 2.3636 & 2.1818 & 0 & 2.2727 \\ 2.0000 & 1.7273 & 2.2727 & 1.9091 & 1.9091 & 2.1818 & 2.0909 & 0 \end{bmatrix}.$$

Step 2 is to construct the normalized initial direct-relation matrix *D*, where $D = A \times \dfrac{1}{\max\limits_{1\le i\le 8}\sum\limits_{j=1}^{8} a_{ij}} =$

$$\begin{bmatrix} 0 & 0.1703 & 0.1648 & 0.1154 & 0.1538 & 0.1593 & 0.1209 & 0.0824 \\ 0.1484 & 0 & 0.1484 & 0.1154 & 0.1374 & 0.1429 & 0.1044 & 0.0934 \\ 0.1703 & 0.1319 & 0 & 0.1209 & 0.1319 & 0.1593 & 0.1429 & 0.1429 \\ 0.1154 & 0.1209 & 0.1429 & 0 & 0.1319 & 0.1429 & 0.1374 & 0.1319 \\ 0.1703 & 0.1374 & 0.1648 & 0.1044 & 0 & 0.1484 & 0.1264 & 0.1154 \\ 0.1484 & 0.1374 & 0.1703 & 0.1264 & 0.1319 & 0 & 0.1319 & 0.1374 \\ 0.1319 & 0.1209 & 0.1429 & 0.1374 & 0.1429 & 0.1319 & 0 & 0.1374 \\ 0.1209 & 0.1044 & 0.1374 & 0.1154 & 0.1154 & 0.1319 & 0.1264 & 0 \end{bmatrix}.$$

In Step 3, matrix T can be computed by $T = D(I-D)^{-1}$ and becomes

$$T = \begin{bmatrix} 2.1848 & 2.1700 & 2.4409 & 1.9412 & 2.1897 & 2.3337 & 2.0551 & 1.9257 \\ 2.1596 & 1.8813 & 2.2663 & 1.8116 & 2.0321 & 2.1665 & 1.9053 & 1.8038 \\ 2.3857 & 2.1924 & 2.3586 & 1.9939 & 2.2262 & 2.3904 & 2.1234 & 2.0214 \\ 2.1900 & 2.0404 & 2.3215 & 1.7570 & 2.0811 & 2.2232 & 1.9828 & 1.8845 \\ 2.3285 & 2.1431 & 2.4389 & 1.9313 & 2.0547 & 2.3237 & 2.0582 & 1.9499 \\ 2.3378 & 2.1668 & 2.4708 & 1.9715 & 2.1960 & 2.2211 & 2.0869 & 1.9909 \\ 2.2460 & 2.0808 & 2.3671 & 1.9140 & 2.1305 & 2.2584 & 1.9005 & 1.9248 \\ 2.0520 & 1.8960 & 2.1676 & 1.7408 & 1.9344 & 2.0718 & 1.8474 & 1.6473 \end{bmatrix}.$$

The degree of importance and net effect for each dimension are depicted in Table II, where the importance of these eight dimensions in terms of (r+c) values is as follows: job satisfaction > working conditions > teamwork climate > perceptions of management > emotional exhaustion > safety climate > stress recognition > work-life balance. That is, job satisfaction is the most important dimension, while work-life balance is the least important dimension. For net effects, stress recognition, perceptions of management, emotional exhaustion, and work-life balance are net causes due to positive (r-c) values. On the contrary, teamwork climate, safety climate, job satisfaction, and working conditions are net receivers based on negative (r-c) values. Finally, Step 4 is to set up a threshold value by averaging all the elements' values in matrix T, which is 2.0983. The digraph of eight dimensions is shown in Figure 1, and the interaction effects between a pair of dimensions are provided in Table III.

TABLE II
THE DIRECT AND INDIRECT EFFECTS OF EIGHT DIMENSIONS

Dimension	r + c	r – c
Teamwork Climate	35.1255	-0.6433
Safety Climate	32.5973	-0.5443
Job Satisfaction	36.5237	-1.1397
Stress Recognition	31.5418	1.4192
Perceptions of Management	34.0730	0.3836
Working Conditions	35.4306	-0.5470
Emotional Exhaustion	32.7817	0.8625
Work-Life Balance	30.5056	0.2090

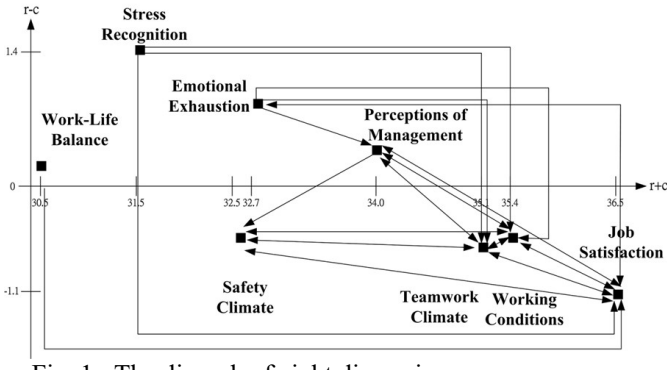

Fig. 1. The digraph of eight dimensions

TABLE III
INTERACTION EFFECTS BETWEEN DIMENSIONS

Dimension	Affected Dimension(s)
Teamwork Climate	Safety Climate Job Satisfaction Perceptions of Management Working Conditions
Safety Climate	Teamwork Climate Job Satisfaction Working Conditions
Job Satisfaction	Teamwork Climate Safety Climate Perceptions of Management Working Conditions Emotional Exhaustion
Stress Recognition	Teamwork Climate Job Satisfaction Working Conditions
Perceptions of Management	Teamwork Climate Safety Climate Job Satisfaction Working Conditions
Working Conditions	Teamwork Climate Safety Climate Job Satisfaction Perceptions of Management
Emotional Exhaustion	Teamwork Climate Job Satisfaction Perceptions of Management Working Conditions
Work-Life Balance	Job Satisfaction

Teamwork climate, safety climate, job satisfaction, and working conditions are mutually affected. For instance, teamwork climate directly influences working conditions, and, at the same time, working conditions affects teamwork climate. On the other hand, emotional exhaustion affects teamwork climate, job satisfaction, perceptions of management, and working conditions but is influenced by job satisfaction solely. Moreover, stress recognition has influences on teamwork climate, job satisfaction, and working conditions but is not affected by any dimension. Work-life balance solely impacts job satisfaction but is not influenced by any dimension. It is worth to note that job satisfaction has the highest degree of importance but is a net receiving dimension, which will be affected by the other seven dimensions. That is, enhancing job satisfaction itself will not have the substantial improvements because any dimension with poor performance would result in poor job satisfaction based on a causal relationship.

From Figure 1 and Table III, based on the overall causal relationships, emotional exhaustion is the most critical dimension followed by perceptions of management because both of them are causal dimensions in terms of (r–c) values. In addition, perceptions of management has direct impacts on four dimensions, i.e., teamwork climate, safety climate, job satisfaction, and working conditions. Moreover, emotional exhaustion has direct influences on four dimensions including teamwork climate, job satisfaction, perceptions of management, and working conditions. Therefore, any improvement on emotional exhaustion would result in a positive improvement on perceptions of management.

Emotional exhaustion, perceptions of management, stress recognition, and work-life balance are causal dimensions.

Based upon our study, the results might indicate that medical professions have been gradually shifted the importance from the group performance to individual performance or perceptions. These findings are somewhat different to the previous studies showing that teamwork climate is the most critical dimension to promote the patient safety culture [25,26]. It is quite reasonable when more and more medical professions have been reported as suspected sudden death cases due to fatigue, particularly physicians and nurses in Taiwan. These medical professions might pay much attention to themselves first in order to provide a better healthcare quality to patients. More importantly, fatigue or emotional exhaustion might become more important than ever since medical professions with high emotional exhaustion or a high level of fatigue might lead to an increase in the risk of death for patients. Therefore, the hospital management needs to understand the "paradigm shift" from the group performance to the individual performance or perception in order to improve the patient safety culture in Taiwan.

V. Conclusions

Improving patient safety culture plays a critical role to relentlessly enhance patient safety in healthcare organizations. Analyzing causal relationships among dimensions helps the decision maker to classify dimensions into cause-based and effect-based dimensions. Improvements on effect-based dimensions might receive little effects when a great amount of efforts have been invested. On the contrary, enhancements can be taken based on those causal dimensions in order to receive higher paybacks in reality. This study uses DEMATEL method to identify four causal dimensions including stress recognition, perceptions of management, emotional exhaustion, and work-life balance and four receiving dimensions consisting of teamwork climate, safety climate, job satisfaction, and working conditions. Specifically, job satisfaction has the highest degree of importance but is a receiving dimension and will be affected by the other seven dimensions based on a causal relationship. That is, poor performance from one or more dimensions would deteriorate job satisfaction. In contrast, emotional exhaustion is the most critical dimension among eight dimensions followed by perceptions of management. These two dimensions are both causal dimensions and have significant influences on four dimensions apiece. Moreover, emotional exhaustion has a direct influence on perceptions of management. Our study shows that medical professions might gradually shift the importance from the group performance to individual performance or perceptions. Therefore, the hospital management needs to pay much attention to the changes that emotional exhaustion and perceptions of management are more critical to improve the patient safety culture for healthcare organizations in Taiwan rather than teamwork climate.

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