

A New Approach to Identify High Burnout Medical Staffs by Kernel K-Means Cluster Analysis in a Regional Teaching Hospital in Taiwan

Yii-Ching Lee, PhD^{1,2,3}, Shian-Chang Huang, PhD⁴, Chih-Hsuan Huang, PhD⁵, and Hsin-Hung Wu, PhD⁴

Abstract

This study uses kernel k-means cluster analysis to identify medical staffs with high burnout. The data collected in October to November 2014 are from the emotional exhaustion dimension of the Chinese version of Safety Attitudes Questionnaire in a regional teaching hospital in Taiwan. The number of effective questionnaires including the entire staffs such as physicians, nurses, technicians, pharmacists, medical administrators, and respiratory therapists is 680. The results show that 8 clusters are generated by kernel k-means method. Employees in clusters 1, 4, and 5 are relatively in good conditions, whereas employees in clusters 2, 3, 6, 7, and 8 need to be closely monitored from time to time because they have relatively higher degree of burnout. When employees with higher degree of burnout are identified, the hospital management can take actions to improve the resilience, reduce the potential medical errors, and, eventually, enhance the patient safety. This study also suggests that the hospital management needs to keep track of medical staffs' fatigue conditions and provide timely assistance for burnout recovery through employee assistance programs, mindfulness-based stress reduction programs, positivity currency buildup, and forming appreciative inquiry groups.

Keywords

kernel k-means cluster analysis, Maslach Burnout Inventory, emotional exhaustion, Safety Attitudes Questionnaire, burnout, resilience, patient safety

Introduction

Shanafelt¹ stated that burnout, defined as losing enthusiasm for work, treating people as if they were objects, and having sense that the work is no longer meaningful, is a pervasive problem for physicians. Physicians' overwork, stress, and fatigue are contributing factors to medical errors. That is, medical errors are highly related to physicians' degree of burnout and mental quality of life.² Cimiotti et al³ described that nurse burnout is highly linked to job satisfaction and patient safety. An increase in nurses' workload would result in higher infections. Bria et al⁴ further concluded that burnout is a response to the prolonged exposure to occupational stress that influences the individuals, organizations, and health care service recipient negatively. Most importantly, the patients might suffer serious medical errors from burnout medical staffs.

Because medical staffs with burnout would result in poor patient safety, it is essentially important for hospital management to observe and understand the attitudes from medical staffs toward burnout.⁵ Maslach Burnout Inventory–Human

Services Survey (MBI-HSS) with 3 dimensions along with 22 questions has been widely used in practice to assess the degree of burnout for medical staffs.⁶ These 3 dimensions are emotional exhaustion with 9 questions, depersonalization with 8 questions, and low personal accomplishment with 5 questions.^{1,7}

¹Cheng Ching General Hospital–Chung Kang Branch, Taichung City, Taiwan

²Chung Shan Medical University, Taichung City, Taiwan

³Hung Kuang University, Taichung City, Taiwan

⁴National Changhua University of Education, Changhua City, Taiwan

⁵Hubei University of Economics, Wuhan City, China

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Corresponding Author:

Hsin-Hung Wu, Department of Business Administration, National Changhua University of Education, No. 2 Shida Road, Changhua City 500, Taiwan.

Email: hhwu@cc.ncue.edu.tw



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Table 1. Nine Questions of Emotional Exhaustion Dimension From the Chinese Version of SAQ.

Dimension	Question
Emotional exhaustion	Q1. I feel like I'm at the end of my rope.
	Q2. I feel burned out from my work.
	Q3. I feel frustrated by my job.
	Q4. I feel I'm working too hard on my job.
	Q5. I feel emotionally drained from my work.
	Q6. I feel used up at the end of the workday.
	Q7. I feel fatigued when I get up in the morning and have to face another day on the job.
	Q8. Working with people all day is really a strain for me.
	Q9. Working with people directly puts too much stress on me.

Note. SAQ = Safety Attitudes Questionnaire.

Lee et al⁷ used a Chinese version of MBI-HSS to assess nurses' burnout in Taiwan. Loera et al⁶ uses MBI-HSS to evaluate Italian nurses' burnout. Furthermore, Lee et al⁵ pointed out that the Chinese version of Safety Attitudes Questionnaire (SAQ) originally developed by Sexton et al⁸ has incorporated 9 questions from the emotional exhaustion dimension of MBI-HSS to form a new Chinese version of SAQ since 2014.^{5,8} These 9 questions are provided in Table 1. The purpose of this modified Chinese SAQ is to assess the patient safety culture as well as the degree of burnout (emotional exhaustion) from all of the staffs' perceptions for each health care organization in Taiwan on a yearly basis.

Assessing the patient safety culture in a particular health care organization is critically important. Through the Chinese SAQ survey from staffs' perceptions, staffing deficits of the patient safety culture can be identified such that the hospital management can improve health care quality and patient safety.⁹ Wagner et al¹⁰ also pointed out that health care organizations with a more positive culture and reflective attitude toward errors and patient safety would result in reducing the number of accidents and failures. That is, a positive patient safety culture implies that the health care organization places patient safety in one of the highest priorities.⁹

By considering the needs of health care organizations in assessing the patient safety culture in Taiwan from medical staffs' viewpoints, the Taiwan Joint Commission on Hospital Accreditation adopted emotional exhaustion dimension from MBI-HSS to evaluate the degree of burnout with 9 questions.⁵ That is, emotional exhaustion dimension might be the better dimension to characterize and assess the degree of burnout for medical staffs in health care organizations in Taiwan. When medical staffs are in high degree of burnout from occupational stress, the patients might suffer medical errors from burnout medical staffs. Therefore, regularly assessing the patient safety culture through the Chinese SAQ survey to evaluate employees' degree of burnout is essentially important. Moreover, when employees in health care organizations have higher degree of burnout, the hospital management needs to take actions to keep track of medical staffs' fatigue conditions and then provide timely assistance for burnout recovery to enhance patient safety.

Lee et al⁵ used 9 questions of emotional exhaustion dimension from the Chinese version of SAQ and found that medical staffs with different demographic variables perceive burnout differently by analysis of variance. On the contrary, cluster analysis which is one of the data mining techniques can be applied to divide the entire medical staffs into an appropriate number of groups based on their similarities.¹¹ In marketing applications, the values of different customer groups after cluster analysis can be calculated and evaluated to provide the management useful decisional information for resources allocation.¹¹⁻¹⁵ The purpose of this study is to identify medical staffs with high burnout by cluster analysis such that the hospital management can take actions to improve the resilience, further reduce the potential medical errors, and, eventually, enhance the patient safety.

Methods

The data collected in October to November 2014 are from the emotional exhaustion dimension of the Chinese version of SAQ survey results conducted by a regional teaching hospital in central Taiwan. By removing incomplete questionnaires, the number of effective questionnaires including the entire staffs such as physicians, nurses, technicians, pharmacists, medical administrators, and respiratory therapists is 680. The demographic variables included in the Chinese version of SAQ survey are gender, age, supervisor/manager, respondents reporting events in the past 12 months, job position, job status, experience in organization, experience in position, education, and direct patient contact.

Each question in emotional exhaustion dimension uses a 5-point Likert scale that ranges from *strongly agree* to *strongly disagree* with the respective values of 5 to 1. In addition, all questions in emotional exhaustion dimension are reversed questions such that each respondent's answer is adjusted. That is, a higher (lower) value for each question represents a lower (higher) degree of fatigue or burnout. On the contrary, each demographic variable uses a numerical value from 2 to 7 to represent the selections of that particular variable.

Table 2. The Number of Clusters Analyzed by Variance Ratio Criterion.

Number of Clusters	6	7	8	9	10
Variance ratio value	2.9618	3.8064	4.6218	4.1755	2.9301

Kernel k-means method by R language with package “Kernlab” along with the kernel function of the radial basis (Gaussian kernel) is chosen to perform cluster analysis. Kernel k-means method, which is a more generalized k-means method for cluster analysis, is very suitable for both linear and nonlinear separable inputs because the type of the data is usually unknown.^{16,17} Similar to k-means method, kernel k-means method cannot determine the number of clusters itself. In this case study, we employ variance ratio criterion introduced by Calinski and Harabasz to determine the number of clusters.^{18,19} Table 2 summarizes the values of variance ratio criterion, where a higher value indicates the better cluster quality. In this study, the number of clusters is set to 8 with the highest value based on variance ratio criterion.

Results

Nine questions from emotional exhaustion dimension and 10 demographic variables are the input variables. In addition, the number of the clusters by kernel k-means method is set to 8. Six hundred eighty employees are classified into 8 groups, where Table 3 summarizes the average values of 9 questions from emotional exhaustion dimension for each cluster and the grand average values of 9 questions from the entire employees. The notations denoted by Q1 to Q9 represent 9 questions of emotional exhaustion dimension, and an asterisk sign indicates that the average value of a particular question from a cluster is greater than the grand average.

From the numerical values of 9 questions depicted in Table 3, Q1, Q3, Q8, and Q9 are above the average value of 3 based on a 5-point Likert scale, showing that employees feel less in emotional exhaustion. In contrast, Q2, Q4, Q5, Q6, and Q7 are below the average value of 3, indicating that employees are in relatively high emotional exhaustion. Specifically, Q6 has the lowest value among 9 questions showing that employees agree that they feel used up at the end of the workday followed by Q4 which has the second lowest value, stating that employees also agree that they are working too hard on their jobs. On the contrary, Q9 has the highest value among 9 questions. That is, employees agree that working with people directly does not put too much stress on themselves. In addition, Q8 has the second highest score which shows that working with people all day is not really a strain for employees.

In contrast to the numerical values of 9 questions from emotional exhaustion, the performance for each cluster can be assessed by these 9 questions in terms of asterisks. Specifically, all of the average values in cluster 4 are greater

than the grand average values, indicating that employees in this cluster are in low degree of fatigue or burnout. Employees in cluster 1 are also in lower degree of fatigue or burnout except for Q9 (Working with people directly puts too much stress on me) that has a slightly lower average value than the grand average value. Moreover, employees in cluster 5 are in lower degree of fatigue or burnout except for Q3 (I feel frustrated by my job) and Q9 that both questions have slightly lower average values than the grand average values.

Clusters 2, 3, 6, and 7 having all of the average values less than the grand average values show that these employees are in high degree of burnout or fatigue. In addition, cluster 8 has 8 out of 9 questions having the average values smaller than the grand average values except for Q4 (I feel I’m working too hard on my job) which has a larger average value than the grand average value. From the viewpoints of the hospital management, employees in clusters 1, 4, and 5 are relatively in good conditions, whereas employees in clusters 2, 3, 6, 7, and 8 need to be closely monitored from time to time because they have relatively higher degree of fatigue or burnout.

In general, employees in 8 clusters can be further categorized into 2 types of groups, that is, lower degree of fatigue (clusters 1, 4, and 5) with the sample size of 396 and higher degree of fatigue (clusters 2, 3, 6, 7, and 8) with the sample size of 284. The hospital management needs to pay much attention to those who are in higher degree of fatigue. The frequencies of these 2 groups in demographic variables are quite similar. Table 4 provides the more specific information for each cluster in terms of demographic variables. The majority of employees are characterized as follows: female, 21 to 50 years old, not in charge of supervisors/managers, reporting less than 6 events in the past 12 months, nurses, full-time, with the experience of 5 to 20 years in organization, with the experience of 5 to 20 years in position, college/university degree, and very often to direct patient contact. From the cluster analysis results, the hospital management might not be able to identify those employees who are in higher degree of burnout. However, with the link of further demographic variables such as the department a particular employee works along with the individual demographic variables, employees who are in higher degree of burnout can be found.

This study suggests that the hospital management needs to keep track of medical staffs’ fatigue conditions and then provide timely assistance. The recommendations are as follows. First, unit heads can use team resource management (TRM) on a daily basis for improvement. The coverage of TRM includes leadership, situation monitoring, mutual support, and communication. That is, unit heads can group all of the members before the work every day and then use an I’M SAFE (Illness, Medication/Menstruation, Stress/Sleep, Alcohol/Drugs, Fatigue, and Emotion/Eating and Elimination) checklist to know whether each employee is in a good condition physically or psychologically. If not, adjust the employees’ daily work to ensure members and patient safety.

Table 3. Average Values of 9 Questions From Emotional Exhaustion.

	Nine questions from emotional exhaustion								
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Grand average (sample size)	3.125	2.869	3.109	2.693	2.863	2.537	2.899	3.372	3.468
Cluster 1 (158)	3.234*	3.057*	3.133*	2.848*	3.013*	2.690*	3.082*	3.405*	3.430
Cluster 2 (61)	2.016	1.623	2.082	1.852	1.590	1.410	1.705	2.361	2.557
Cluster 3 (72)	2.653	2.153	2.611	1.944	2.167	1.903	2.194	2.958	3.208
Cluster 4 (106)	4.179*	4.208*	4.349*	3.575*	4.226*	3.670*	4.217*	4.547*	4.575*
Cluster 5 (132)	3.189*	2.902*	3.106	2.742*	2.909*	2.629*	2.939*	3.379*	3.462
Cluster 6 (26)	2.923	2.385	3.000	2.577	2.462	2.038	2.385	3.308	3.346
Cluster 7 (48)	2.604	2.250	2.500	2.313	2.187	1.938	2.250	2.667	2.854
Cluster 8 (77)	3.052	2.792	3.052	2.714*	2.818	2.532	2.818	3.325	3.416

Note. The asterisk sign indicates that the average value of a particular question is greater than the grand average.

Table 4. Demographic Information of 8 Clusters.

Demographic information	Frequency in each cluster							
	1	2	3	4	5	6	7	8
Gender								
Male	35	9	13	21	15	4	2	17
Female	123	52	59	85	117	22	46	60
Age, y								
Less than 20	0	0	0	3	1	0	3	2
21-30	23	26	9	30	54	4	25	39
31-40	81	22	31	41	49	17	15	20
41-50	48	12	27	25	24	4	4	11
51-60	6	1	5	6	4	1	1	5
61 and above	0	0	0	1	0	0	0	0
Supervisor/manager								
Yes	18	6	13	16	11	2	6	8
No	140	55	59	90	121	24	42	69
Respondents reporting events in the past 12 months								
0 event	86	29	35	63	79	14	29	27
1-5 events	64	30	32	30	49	12	18	43
6-10 events	8	1	4	9	4	0	1	5
11-15 events	0	1	0	2	0	0	0	2
16 events and above	0	0	1	2	0	0	0	0
Job position								
Physician	10	3	3	14	7	2	1	9
Nurse	73	49	32	52	93	15	29	39
Technician	22	1	15	11	9	1	9	0
Pharmacist	0	3	0	8	6	0	1	21
Medical administrator	52	4	22	14	15	7	8	5
Respiratory therapist	1	1	0	7	2	1	0	3
Job status								
Full-time	139	57	71	93	123	24	36	69
Part-time	10	4	0	8	5	2	4	7
Agency	2	0	0	3	0	0	3	0
Contract	7	0	1	2	4	0	5	1

(continued)

Table 4. (continued)

Demographic information	Frequency in each cluster							
	1	2	3	4	5	6	7	8
Experience in organization								
Less than 6 mo	1	5	0	17	8	0	13	9
6-11 mo	7	1	0	7	4	0	3	4
1-2 y	16	9	5	17	27	0	14	17
3-4 y	13	9	3	14	27	6	7	12
5-10 y	38	18	11	12	32	8	2	14
11-20 y	80	18	49	34	32	11	9	19
21 y and more	3	1	4	5	2	1	0	2
Experience in position								
Less than 6 mo	5	6	1	18	10	0	20	14
6-11 mo	8	1	0	10	4	0	2	4
1-2 y	17	9	5	17	30	0	14	18
3-4 y	19	9	3	14	29	6	5	14
5-10 y	40	22	15	15	30	9	3	11
11-20 y	69	13	46	28	28	11	4	16
21 y and more	0	1	2	4	1	0	0	0
Education								
Junior high school and below	0	0	0	1	0	0	0	0
Senior high school	8	1	1	3	1	0	1	3
College/university	134	56	60	92	127	25	46	68
Graduate school	16	4	11	10	4	1	1	6
Direct patient contact								
No	10	1	10	8	6	2	4	3
Rare	21	6	8	8	11	1	10	16
Very often	127	54	54	90	115	23	34	58

Second, labor safety and health management committee should be established, and the members should include superintendent or vice superintendent, labor safety and

health management personnel, human resources management personnel (including directors), medical and nursing unit supervisors, and occupational medicine specialists. The committee should establish fatigue management plan, investigate the staff's level of fatigue, and then provide prevention and elimination programs for recovery. The specific contents are depicted below. The labor safety and health management or human resource management personnel can set up a high secrecy instant notification system. The hospital can provide each staff a "self-fatigue prevention" booklet issued by Institute of Labor, Occupational Safety and Health, Ministry of Labor, Executive Yuan in Taiwan since 2007. If an employee is found to have the symptoms listed in the booklet, the committee should provide timely intervention for necessary assistance to avoid further fatigue phenomenon. In addition, the committee should regularly conduct hospital-wide fatigue surveys by using the fatigue scales with both reliability and validity such as MBI-HSS or Copenhagen Burnout Inventory. The committee can develop and then implement fatigue prevention, recovery, and elimination for each medical staff based on survey results. Moreover, the fatigue surveys and analyses should be conducted annually such that the fatigue management plan and the employee assistance programs (EAPs) can be performed to relentlessly reduce the staffs' levels of fatigue.

Discussion

This study has 4 major recommendations for burnout recovery. First, the hospital (human resource management department) should establish EAPs to set up a long-term service system plan to prevent and resolve the possible causes from either the organization or individuals that might lead to the decrease of employee productivity. In doing so, employees can work in good conditions physically and psychologically to reduce medical accidents that might strengthen the hospital competitiveness and establish a good relationship between the hospital management and the staff. EAP covers 3 individual levels, that is, job including the work adaptation, adjustment of organizational change, work-life balance, career (retirement) planning, and so forth; life including legal advice (such as legal issues containing the public service, car accidents, debt, inheritance, marriage, conflict, etc) and financial advisory (such as tax treatment, debt management, insurance planning, etc), and health including mental health (such as stress adaptation, anger management, workplace interpersonal communication, the major crisis response and management during the various stages of the career, etc) and health care (such as providing the health care measures and health care resources information in civil societies).

Second, the hospital can provide mindfulness-based stress reduction (MBSR) programs to its staff. MBSR, created by Dr Jon Kabat-Zinn in 1979 at the University of Massachusetts Medical School, combines western medicine/psychology and traditional eastern meditation to assist participants in the

mindfulness view of dealing with stress, pain, and illness. In the past 3 decades, MBSR has been proven to be an effective group training courses.²⁰⁻²²

Third, cultivate and help employees to build up their "positivity currency." Resilience cannot be printed just the way countries print money. In contrast, when individuals focus on positive attitudes toward interactions, life events, and memories and express his or her gratitude, then the "positivity currency" can be printed and stored as assets. In addition, maintaining a positive outlook and expressing gratitude regularly are the real values for employees to build resilience. Kopans²³ pointed out that creating "positivity currency" can decrease anxiety, reduce illness symptoms, improve the quality of sleep, and, ultimately, lead to greater personal resilience. By being more positive ourselves, we encourage others to do the same. This in turn creates a positive feedback loop that our own resilience is increased and strengthened by the actions of others.

Fourth, set up "appreciative inquiry" groups. Appreciative inquiry is a model that can be used to cultivate employees in self-determined changes. Cooperrider and Whitney²⁴ stated that appreciative inquiry is the coevolutionary search for the best in people, their organizations, and the relevant world around them. By attempting to praise the employees who have been achieved over the past, the reasons behind the results to the past successful experience can be found and be the beginning to encourage medical staffs enthusiastically to enhance resilience and positive psychology, which will become the driving force for the organizational development. That is, appreciative inquiry seeks to enlarge the traits of the past behaviors to achieve the organizational progress and enhance the cohesion of purpose. Therefore, this study suggests that the hospital can form appreciative inquiry groups to focus on those employees with high burnout to improve their resilience.

Authors' Note

The clinical trial approval certificate (ethic statement) was approved by Cheng Ching General Hospital in Taichung City, Taiwan, with protocol number of HP150029.

Declaration of Conflicting Interests

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