INTEGRATING SIX-SIGMA AND HEALTHCARE QUALITY IMPROVEMENT CIRCLES IN REDUCING THE NEEDLE STICKING

Sen-Ji Chen, Paochien Hospital-Taiwan
Frank F. C. Pan, Tajen University-Taiwan
Hsuen C. H. Chen, Tajen University-Taiwan

ABSTRACT

Six-Sigma (SS) is a managerial philosophy used in detecting the error rate of a particular (set) of activities. This research applies six sigma concepts in dealing with troublesome needle-stick events that occurred in a Taiwan hospital. This research integrates several advanced managerial instruments into one framework, grounded in Continuous Quality Improvement and Total Quality Management. This framework combines Six-Sigma and Health Quality Improvement circle practices. The project suggests preparing a needle-recapping stand and appropriate training on its use. When the stand was implemented in a Taiwan hospital the accident rate decrease significantly.

JEL: I12, I18

INTRODUCTION

Hospitals in Taiwan operate in an extremely challenging and competitive environment. Various hospitals along with other healthcare providers compete for the limited and ever decreasing reimbursements from the National Health Insurance Bureau (NHIB). Remaining profitable and competitive in the market becomes a vital issue for Taiwan hospitals (Schneider, White, & Paul, 1998). Healthcare service is distinctive from other services in the sense that its services are human health related and sensitive. Quality and safety of the service itself as well as the process of providing relevant treatments and supportive services are essential for hospital survival (Kohn, Corrigan, & Donaldson, 1999; Leape, 2002; Robert, 1990).

The advancement of available medical treatments, has resulted in an increasing number of human injections. This has resulted in the nursing staff being exposed to a riskier working environment where needle stick is a major threat (Andrews, Stocking, Krizek, Gottlieb, Krizek, Vargish, & Siegler, 1997). As a major vocational hazard among healthcare professionals, needle sticking has received comprehensive attention. Needle sticks cause infections, which are costly to both healthcare professionals and the hospital. Moreover, they represent a significant corporate risk to the hospital. A government survey reports that 74.8% of hospital employees had experienced various kinds of sticking injuries in their career. By classification, the nurse group has a 98% chance of sticking, followed by physicians at 85.5%, general labor workers at 70.2%, and medical technicians at 64.4% (Institute of Occupation Safety & Health, 2007).

Since many healthcare services require a near-zero tolerance for mistakes or adverse events while simultaneously demanding high service quality and reduced costs, it is essential for hospitals to include six sigma in their improvement approach (Revere and Black, 2004). This research reports a recent application of six-sigma concepts into the activities of healthcare quality improvement circle (HQIC) to reduce the needle-sticking cases among nursing staff. The hospital examined in this research aims to be a reliable provider of efficient, quality, and low cost health services to the hundreds of thousand residents within the service district. Like other rivals, the hospital under consideration has adopted Total Quality Management (TQM) to cope with ever-growing challenges (Modern Healthcare, 1990; Jessee, 2006).

The remainder of the paper is organized as follows. In the following section, we review the literature on service quality, Six-sigma, and Needle Sticks. Next, we discuss the six-sigma and HQIC integrated

approach used by one hospital to reduce needle sticking. A section discussing the results of this approach follows. The paper closes with some concluding comments.

LITERATURE REVIEW

In this section, we address some important constructs that are relevant to this study. We first discuss the literature related to service quality. Next we discuss several quality approaches including continuous quality improvement (CIQ), total quality management (TQM), Deming's cycle and healthcare quality improvement circle (HQIC), and six-sigma.

Needle Sticking

Infection within healthcare facilities, particularly in Taiwan hospitals, has become a major disease control problem. Infections may be transferred through various vehicles. For diseases caused by blood-borne viruses, the common risks for the medical profession are needle stick injuries (Levine and Goody, 1992; Goldman and Lewis, 2003). Although needle free I. V. systems and many other substitutes may provide certain kinds of prevention from infection (Wolfrum, 1994), needles remain the major instrument for many injection associated treatments. Regulatory forces including the 2001 Needlestick Safety and Prevention Act (NPA) and associated agency of Occupational Safety and Health Administration (OSHA) in USA (Ramsay, 2004; Rosenthal, 2006), or the similar in Taiwan as Institute of Occupation Safety & Health (IOSH) dictate some practices regarding the use of needles.

The risk of injury and exposure to bloodborne pathogens from needles and other sharps are mostly found in the Ward area of the hospital due to frequent use of needles for various treatments. The Ward area is a designated room where patients are admitted for close monitoring and easy access to treatment and medications. Other areas such as operating rooms, intensive care units (ICU), physician's offices and emergency rooms are also high-risk areas due to frequent use of injections (Brennan, Localio, Leape, Laird, Peterson, Hiatt, & Barnes, 1990). Needle capping is the primary activity associated with needle stick accidents accounting for 31% to 53% of needle stick injuries respectively. Evidence shows that a heightened awareness and culture of safety is helpful for the reduction of sharps injuries and subsequent exposures to bloodborne pathogens (Swallow, 2006). This implies that a nursing team could be effectively motivated through a well-designed approach toward a safer work environment.

Service Quality

Quality has long been regarded as the main and essential mission of healthcare services. Quality service implies that the hospital assures service is provided through a quality process. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) defines quality as including all products and services delivered by the provider that satisfy the patients' real demands (JCAHO, 1991). Following the framework suggested by Fitzsimmons & Fitzsimmons (1998), quality can be evaluated by assessing five distinctive yet related dimensions. Content of the service is provided in accordance with the procedures of the hospital. Procedure of the treatment refers to the events and activities involved in the interactions between service providers and receivers. Organization structure refers to the physical facilities and service staffing that is consistent with the service offered and declared. Outcomes and associated impacts are the last two dimensions of service quality. The former records the direct outcomes of the treatment on particular patients, and the latter is used to assess the appropriateness, accessibility, usability, and associated impacts to the targeted community. Table 1 shows these five dimensions along with associated description and possible assessing criteria for healthcare services.

CQI and TQM

As requested by JCAHO, hospitals and healthcare facilities shall commit to continuingly improving service quality for the benefit of the patients and service receivers. As a result, Continuous Quality Improvement (CQI) as well as Total Quality Management (TQM) have become two major improvement

approaches for most hospitals in Taiwan. The hospital discussed in this paper follows these approaches. A trend is to incorporate both concepts simultaneously to be effective and efficient in reaching hospital strategic goals. This so-called CQI / TQM approach can be achieved through four associated activities. 1. Building the continuous improvement concept and implement it through process reengineering within the organization, 2. Employing structural and systematic problem-solving models followed by statistical methods to track the progress of improvement, 3. Delegating authority to employees across departments and teams to investigate problems and associated quality-improvements and 4. Balancing organizational focus between external and internal customers (Shortell, 1995).

Table 1: Service Quality And Assessment For Healthcare Service Facility

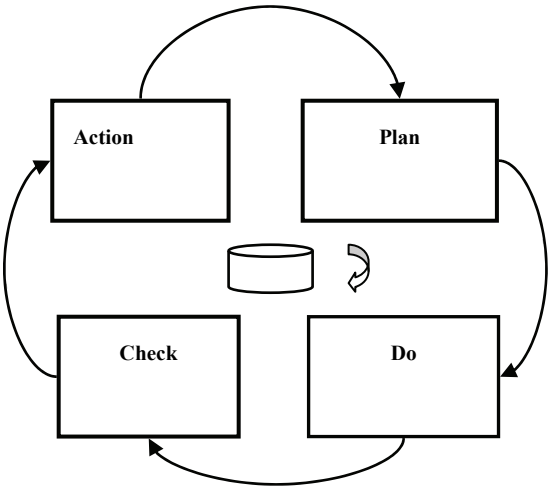
Dimensions	Description	Potential Assessing Criteria
Content	Medical behavior that adheres to national standard	Patient records checking
Procedure	Events involved in the interactions of givers and receivers	Inquire dismissing patients with checking list
Structure	Physical facilities, equipment, professional personnel staffing and qualification	Waiting time, nurses per physician, usage rate of equipment
Outcome	Health status after treatment	Mortality rate, complaints
Impact	Appropriateness, usability, accessibility, and impacts on community	Number of refusals, statistics on patient distribution and distance to the hospital

Deming's Cycle and HQIC

Managerial cycle refers to general managerial activities, involving a Plan-Do-Check-Action (PDCA) recycle process, shown as Figure 1. Applying Deming's concept to quality concern activities, managers plan and set quality standards, produce (do) products that conform to the standard, check the quality of outcomes and associated processes, and modify (action) procedures based on checking results.

Healthcare quality improvement circle (HQIC), as part of the TQM of a hospital, can be effectively conducted using PDCA cycle. Cases from various healthcare facilities provide additional evidence for the usefulness of Deming. By using this logic in HQIC, many rival hospitals have experienced positive outcomes. For example, the National Yuin-Lin Hospital reduced equipment-repair time from 39.8 hours to 20.76 hours using this approach. Lee Hospital in Ta-Jia significantly shortened customer waiting time in pharmacy services. National Taiwan Hospital Medical Center experienced a 43% improvement in its medical inspection department. The Wan-Fang Municipal Hospital sharply shortened radiograph delivery time associated with efficient scheduling as well as resoruce allocation in X-ray department

Figure 1: Deming's Cycle



Six-Sigma

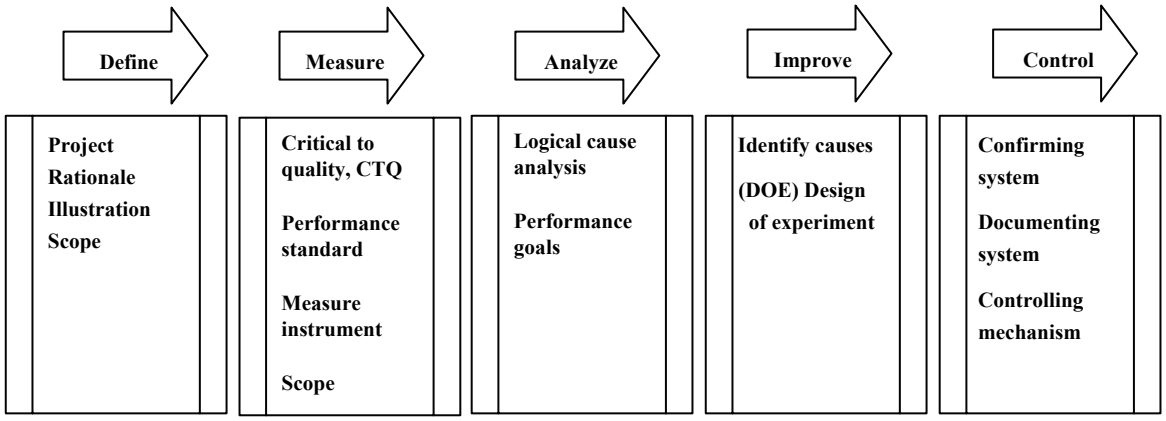
Motorola launched six-sigma in the 1980s as an in-house quality improvement approach. They experienced remarkable results from the approach (Hany & Schroeder, 2004). Six-sigma was adopted and extended in many world-class companies, including General Electric in the 1990s. Six sigma involves several steps to minimize or eliminate waste or errors while attempting to improve customer satisfaction and financial stability (Pande, Newman, and Cavanagh, 2000, and Thompson & Lewis, 2002). Sigma refers to an error rate of particular set of activities. The notion of six-sigma is to produce quality results with a standard that accepts 3.4 errors out of 1 million attributes or products out of specification **(**Voelkel**,** 2004) as shown in Table 2. In today's business environment, the issue is not weather six sigma should be adopted, but rather how to master a business using six-sigma approaches (Thawani, 2004). This is particularly important in most medical industries (Revere and Black, 2004; Jessee, 2006).

Six-sigma can be viewed as an extension of the Failure Mode and Effects Analysis (FMEA) required by JCAHO (Joint Commission on Accreditation of Healthcare Organization) and can be easily integrated into a current quality control system. Many healthcare facilities implemented six-sigma projects, thereby achieving outstanding performance in the form of reduced medical errors, reduced costs, shorter hospital stays, as well as improved financial outcomes (Lazarus & Butler, 2001; Ettinger, 2001; Jones, 2004). Fundamentally, an organization must recognize that six sigma is not a novel tool as many authors suggest but rather an operation strategy or a structural methodology in problem solving (Lanham & Maxson-Cooper, 2003). Applying six-sigma in administrating organizational routines inolves, five distintive yet related steps, each essential for effective adoption as shown in Figure 2.

Table 2: Quality Levels in Each Sigma Standard

Sigma Values	PPM (error/ million)	Improvement
1	691,500	
2	308,537	1.2 times
3	66,807	3.6 times
4	6,210	9.8 times
5	233	25.7 times
6	3.4	67.5 times

Figure 2: Six-Sigma Model



INTERGATING 6σ AND HQIC

Although the six-sigma concept has been demonstrated to be an effective and powerful managerial tool in many cases, a plethora of projects in the healthcare industry have experienced unsatisfactory results. These unsatisfactory results generally occur because of improper data collection for the system. Healthcare quality improvement circle (HQIC) has long been used in the healthcare industry because of its simple and user-friendly characteristics. We propose that techniques used in HQIC are able to provide accurate information for each step of six-sigma in a timely manner, allowing for the effective deployment of a six-sigma system. We illustrate how the HQIC techniques could be integrated into the six-sigma system and help the system work in each individual step of, measurement, analysis, implementation, and control in the following sections. Table 3 shows the steps of six-sigma and corresponding actions where HQIC may help.

Table 3: Six Sigma And Corresponding HQIC Activities

Step	Six Sigma	HQIC
Define	1. Identify and confirm the customer related issues	1. Creating QCC
	2. Define projects' goals and scope	2. Identify problems, finalize project
	3. Identify actionable subjects	
Measure	Gather information regarding current capabilities in possession	3. Analyzing current context
	Distinguishing problem scope	
Analyze	Identify the root causes of problem and associated instrument for problem solving	4. Alternatives generating
Improve	Implement the alternative, modify the business process	5. Optimal alternative decision
		6. Implementing
Control	1. Maintain the production process in the ways of continuous improvement	7. Outcomes approve
	2. Standardized the production process	8. SOP
	3. Integrate all improvements as daily routine	9. Report
		10. Presentation and sharing

Define

The first step in DMAIC is defining the direction, setting the goals, scope, time frame, members, and financial objectives of the project and documenting the project as an official guideline. To identify the key issues involved in the activity flows, a SIPOC (supplier, input, process, output, and customer) chart is established through a project meeting. In the case of the hospital discussed here the objective is "Reducing needle stick events among nursing staff," This step is followed by identifying the problem and opportunities may emerge from this activity.

By employing direct observation and content analysis on each accident report and follow up interview, sharp articles resulted in 51 injuries in the period of January through December of 2004. Nurses represent the major victims of such injuries at 74.5% (38 of 51) of the total reported injuries. Needle sticking happens 1.4 times per hundred nurses per month, which is higher than the national average. We further define the goal as reducing nurses' needle sticking to a level with an increased sigma value.

Causes of needle sticking were categorized by three different criteria. The first classification is by instrument being used. Hypodermic needles represent the major culprit with 81.6 % of cases, followed by I.V. catheter with 10.5% of all cases, and other objects such as surgical instruments, knife needles etc. with 9% of all cases. Next, the injuries were classified by medical action. The results indicate that 34.2% of cases happened in blood extraction procedures, 18.4 % occurred when conducting A-line, IV, CVP etc., 13.2% happened while preparing an injection, and other activities associated with injection accounted for 7.9% of all sticks. Finally, we classify the accidents by activity. We found that 39.47% of total needle sticks happened when recapping the hypodermic needle after injection, 21.0% due to patient motions, loosing needle cap account for 7.9%, and other non-systemic incidents such as

unexpected touch by colleague, account for the remaining 8 %. The data indicate that employees with insufficient experience may assume higher needle stick risk, particularly for those recruited within one year. However, no significant difference is found for the groups with one year and more of experience. Nearly seventy-seven percent of responding nurses reported recapping needle by both hands, of which was popularly recognized an acceptable and safer behavior.

Measure

There are four major works to be performed in this stage. The first and primary work is to design and decide appropriate methods and instruments for the project goals. Associated works included are process capabilities analysis, simulation and system analysis, and incentive programs. In this stage, several charts are designed and produced based on data collected from observations and interviews. Techniques used include cause and effect diagrams, Pareto diagrams, and other QC tools to help identify quality problems. All HQIC teams then agreed on an initial performance standard across every nursing department, as shown in table 4.

Table 4: Needle Stick Rate, Monthly

Year	Events	Number of nurses	Rate（%）	Errors per million	Sigma
2004	38	226	1.4	14,012	3.6972

Analyze

Proactive analysis includes distinctive yet related works of design and analysis. The former shortened the list of alternative to a manageable number (e.g. less than 10), the latter involves finalizing optimal alternative through multiple experiments or surveys. In this stage, we finalize four major causes of needle stick events. Recapping the used hypodermic needle after injection is the first and most frequent cause for needle stick events, ranging from 31% to 53%. The second cause is the lacking of patient cooperation prior to or during injection. Being pricked by needle in other non-medical behaviors such as in preparing dosages is the third major cause. The last major cause is associated with inappropriate positioning of the needle cap.

In this stage, members of each team discuss and identify factors that result in an above average needle-stick rate. A formula is established to compute the rate of needle stick. The current rate is identified as 1.4 times per hundred nurses per month. The project team then set a goal of 0.6 times per month. Thus the goal is a challenging fifty percent improvement.

Improve

Based on the analysis in the previous section, we stepped into the measure stage by selecting and implementing the improvement actions. Consensus emerge regarding five actions to be taken in the project meeting. Criteria employed for action assessment were coordination, accessibility, economics, and implementing capability. The agreed upon actions were on-the-job training focusing on needle stick prevention, establishing a standardized needle and sharp item handling procedure, including the procedures in the on-job training materials, establishing an official nursing guideline, procure a sufficient number of I.V. locks, design and manufacture an effective needle-holder, and finally making the needle holders accessible in every nursing area. The needle holder is a device made of a soft material (plastic and rubber combined). Nurses place the used syringes into the stands. The needles are then removed from the syringe and left within the stand. The used needle stands are then disposed of appropriately as medical waste.

Control

Controlling assures the project is properly implemented to achieve the expected outcomes. Activities included in this stage are all about controlling mechanisms, such as confirming execution capabilities, measurement system analysis, FMEA, flow charts for master projects and sub-units, and coping plans to foster the consistency and continuance.

IMPROVEMENTS

Improvement in needle stick events via the six-sigma project was satisfactory. Needle-sticking injuries declined from 1.4 times to 0.6 times per 100 nurses, or from 3.96 sigma to 4 sigma. These results are shown in Table 5. Thus, the goals of achieving a 0.6 stick ratio were achieved.

Table 5: Needle Stick Events Before And After Improvement

Year	Number of events	Number of nurses	Rate（%）	Errors per million	Sigma
2004	38	226	1.40	14.0118	3.6972
2005	18	249	0.60	6.0241	4.0120

CONCLUSION

Needle-stick is the most important occupational accident among healthcare professionals and employees. Nurses are the biggest group of professionals exposed to this type of accident. On average, nurses are the most frequent victims of needle sticks. Areas that account for such events within the hospital in descending order are wards for internal diseases, external injuries, and surgery rooms. Needle recapping after injection is found to be the riskiest behavior.

This paper examines needle sticking instances within a Taiwan hospital and discusses how advanced management practices can reduce needle sticking incidents. Finally, the paper discusses a device for capping needles that helped the hospital reduce needle sticking dramatically. The project involved six-sigma and other quality management tools and identifies the recapping activities as the major cause of the above-average accident rate of hospital examined here. Grounded on the CQI/TQM framework, this project integrates concepts of six-sigma and HQIC as the project base. Under the needle stick reduction project, HQIC teams of the nursing departments helped gather correct information for the use of DAMIC of six-sigma which avoids defective data and resulting irrelevant actions. This project provided satisfactory outcomes by exceeding the goals set for the project. In addition it acculturated a hospital employee organizational learning mechanism through individual self-motivating and training.

Healthcare service's aim of providing error free services suggests the era of applying six-sigma has arrived. Although huge amount of resources are required to adopt six-sigma systems, adopting six-sigma concepts and techniques into total quality management can be an effective catalyst for organization change.

REFERENCES

Andrews, L. B., Stocking, C., Krizek, T, Gottlieb, L., Krizek, C., Vargish, T., & Siegler, M. (1997) "An Alternative Strategy For Studying Adverse Events In Medical Care," *Lancet*, vol. 349 (3), p. 309-313.

Brennan, T. A., Localio, A. R., Leape, L. L., Laird, N. M., Peterson, L., Hiatt, H. H., & Barnes, B. A. (1990) " Identification Of Adverse Events Occurring During Hospitalization," *Annals of Internal Medicine,* vol. 112, p. 221-226

Deming, W. E. (1986). *Out of The Crisis.* Cambridge: Cambridge University Press.
Fitzsimmons, J. A., & Fitzsimmons, M. J. (1998). *Service Management.* New York: The McGraw-Hill Companies, Inc.

Goldman, Linda, & Lewis, Joan (2003) "Minimising The Risk," Occupational Health, vol. 55 (6), p. 10-12
Harry, M., & Schroeder, R. (2004). *Six Sigma*, 108-15. New York: Rosetta Books
Institute of Occupational Safety and Health (IOSH) (2007). *Survey reports on health status of medical institutes*. Taipei, Taiwan.

J.C.A.H.O. (1991). *Accreditation Manual for Hospitals*. Chicago: J.C.A.H.O.

Jessee, William**. (**2006) "What Patient Safety Looks Like. Six Steps That Mark An Organization That Really Cares About Medical Errors," *Modern Healthcare,* vol. 36 (42) p. 18-18.

Jones, Steve (2004) "Understanding Six Sigma," *Quality*, vol. 43 (3), p. 24-24.

Kohn, L. T., Carrigan, J. M., & Donaldson, M. S. (Eds.). (1999). *To err is human: Building a safer health system.* Washington DC: Institute of Medicine, National Academy Press.

Lanham, B., & Maxson-Cooper, P. (2003) "Is Six-Sigma The Answer For Nursing To Reduce Medical Errors And Enhance Patient Safety?" *NURSING ECONOMICS,* vol. 21 (1), p. 39-41

Leape, L. L. (2002) "Reporting Of Adverse Events," *New England Journal of Medicine*, vol. 347, p. 1633-1638

Revere, Lee, and Black, Ken. (2003) "Integrating Six Sigma with Total Quality Management: A Case Example for Measuring Medication Errors," *Journal of Healthcare Management*, vol. 48 (6), p. 377-391.

Levine, Andrew S., & Goody, Michele M. (1992), "Healthcare Workers and Occupational Exposure to AIDS," *Nursing Management,* vol. 23 (1), p. 59-60.

Modern Healthcare (1990) "Hospital Teams Find Solutions, Savings Through Quality Management," vol. 20 (45), p. 44-44.

Pande, P. S., Newman, R. P., & Cavanagh, R. R. (2000). *The Six Sigma Way*, 3-18. New York: McGraw-Hill.

Ramsay, James (2004) "Needlestick Injuries," *Professional Safety,* vol. 49 (12), p. 20-25

Roberts, K. H. (1990) "Managing High Reliability Organizations," *California Management Review,* vol. 32(4), p. 101-113

Rosenthal, Kelli (2006) "Do Needleless Connectors Increase Bloodstream Infection Risk?" *Nursing Management,* vol. 37 (4), p. 78-80

Schneider, B., White, S. S., & Paul, M. C. (1998) "Liking Service Climate And Customer Perceptions Of Service Quality: Test Of A Causal Model," *Journal of Applied Psychology,* vol. 83, p. 150-163

Shortell, S., Levin, J. & Hughes, E. (1995) "Assessing The Evidence On CQI: Is The Glass Half Empty Or Half Full?" *Hospital & Health Services Administration*, vol. 40 (1), p. 4-24.

Swallow, Anne (2006) "Cutting Down On Sharps Injuries," *Nursing Management, OR Insider*, Nov., p. 6-7

Thawani, Sunil (2004) "Six Sigma - Strategy for Organizational Excellence," *Total Quality Management & Business Excellence*, vol. 15 (5/6), p. 655-664

Thompson, P., and Lewis, M. 2002. "UVa Compliance Department Uses Six Sigma Model to Improve Performance." *Journal of Health Care Compliance*, 4 (5): 19-24.

Voelkel, Joseph G**.** (2004) "What Is 3.4 per Million? *Quality Progress,* vol. 37 (5), p. 63-65.

Wolfrum, Jean (1994) "A Follow-Up Evaluation To A Needle-Free I.V. System," *Nursing Management,* vol. 25 (12), p. 33-35

BIOGRAPHY

Sen-Ji Chen, M. D. Dr. Chen is a physician and currently the director of the Paochien Hospital in Pingtung, Taiwan. He is currently teaching courses associated with healthcare management in several universities including Tajen University on part time basis.

Frank F. C. Pan, PhD. Dr. Pan is an assistant professor of Tajen University in Taiwan. He has published several dozens of papers in various journals and conferences. Dr. Pan is advisor to several hospitals including Paochian. Contact information: Dr. F. C. Pan, Healthcare Administration Department, Tajen University at 20, Wei-Hsin road, Yenpu, Pingtung, Taiwan 907

Hsuen H. C. Chen, M. D. Dr. Chen holds a Master degree of public health from John Hopkins, former directors of Pingtung and Tainan hospital. He is currently an assistant professor and Chair of Healthcare Administration department in Tajen University, Taiwan.
Mailing address (to all authors)

ACKNOWLEDGEMENT

We are deeply grateful to two reviewers' and the editor's valuable comment, of which is very helpful in shaping the organization and the logic of the storyline on earlier version of this paper. However, any errors contained in this paper remain ours.