CHAPTER 3

METHODOLOGY

This chapter describes the method for this study. It is divided into the following main sections: design of the study, research setting, population and sample, instrumentations, ethical considerations, data collection and data analysis.

Design of the Study

A descriptive correlational design was implemented to determine length of ICU stay and patient costs including health personnel cost per patient day, nursing personnel cost per patient day and medical care cost per patient day. In addition, the effects of patient characteristics, types of ICU, day and time of patient admission and nurse staffing on nursing personnel cost per patient day, medical care cost per patient day as well as length of ICU stay were evaluated.

Research Setting

This investigation was conducted in both medical and surgical ICUs of a 1,400-bed university hospital in the northern region of Thailand, Maharaj Nakorn Chiang Mai Hospital. This hospital serves as a teaching facility for a medical school, nursing school and other health science students. It provides health services primarily to people in 17 provinces of the northern part of Thailand (Maharaj Nakorn Chiang Mai Hospital, 2004-2005). General ICUs include three medical ICUs and one surgical ICU. There are 4 to 12 beds per unit.

Population and Sample

Records in university hospitals of Thailand are population of the study. A sample of the population is hospital records in a university hospital in a northern part of Thailand, Maharaj Nakorn Chiang Mai hospital, in Chiang Mai. All data used in this study were obtained from four sources: records of critically ill patients, assignment sheets, daily nurse reports and financial reports of the hospital departments. The patient records provided data on demography, severity of illness, length of ICU stay and the volume of services, medical material and equipment used for each critically ill patient. Assignment sheets of ICU personnel and daily nurses' reports provided nurse staffing data. The financial reports consisted of data on annual operating costs and revenues of the hospital.

Sample Size and Sampling Method

Sample size and the sampling method of the study sample were as follows:

1. Patient records. Patient records were selected by purposive sampling with the following criteria: a) the records of patient who was aged 15 years old or older; b) those of patient who was admitted to one of three medical ICUs or a surgical ICU; and c) those of patient who stayed longer than 24 hours in the ICU. *Sample size.* Based on a case to variable ratio as described by Tabanchnick & Fidell (1996), the estimate sample size is approximately 10 to 30 times the number of independent variables for multiple regressions. Thus, the minimum number of sample size with expecting eight independent variables was 80 to 240 patient records. The larger sample size was needed to better analyze all research questions. Therefore, the total number of samples sought for the current study was 242 patient records, divided into 122 records of medical patients and 120 records of surgical patients.

2. Assignment sheets of ICU personnel and daily nurses' reports. These reports were obtained from each ICU which a patient was admitted. The study included all consecutive admissions to the surgical and medical ICUs over a seven month period from November 1, 2005 to May 31, 2006. Therefore, the number of RNs, PNs, HPs and admitted patients at that time were collected prospectively.

3. Financial reports. Financial reports used in the study were obtained from the accounting department and the purchasing department of the hospital. The reports included a budget statement for fiscal year (FY) 2005, a revenue statement for FY 2005 and a database of building and equipment used in the hospital.

Instrumentation

The research instruments of this study were five forms to collect data. The details of each form are as follows.

1. Demographic Data Form

This is a checklist form developed by the investigator. It includes patient age, sex, admission diagnosis, types of ICU, locations prior to ICU admission, level of serum albumin, lymphocyte count, date and time of patient admission, duration of mechanical ventilator, discharge destination, length of ICU stay, date and time of discharge and discharge status. These data were used to describe the sample and serve as the potential factors influencing cost of patient day and length of ICU stay. A copy of the form is shown in Appendix A.

2. Simplified Acute Physiology Score II (SAPS II).

SAPS II was developed by Le Gall et al. (1993) and used as a severity of disease classification system to predict risk of death. It is based on the assumption that the severity of illness can be quantified by the degree of abnormality of physiology variables, patient age, type of admission, and three underlying disease variables. Estimation of physiologic abnormality are obtained from 12 physiologic and laboratory variables (heart rate, systolic blood pressure, temperature, PaO_2, urine output, serum urea level, WBC count, serum potassium level, serum bicarbonate level, bilirubin level, and Glasgow Coma Score). The chronological age component consists of six levels of patient age i.e., less than 40, 40 to 59, 60 to 69, 70 to 74, 75 to 79, and equal or more than 80. The type of admission component is based on three variables referring to the presence of scheduled surgery, unscheduled surgery, or medicine. Three underlying disease variables include acquired immunodeficiency syndrome (AIDS), metastatic cancer, and hematologic malignancies (leukemia or multiple myeloma). Questions were responded by marking a numeric value of each item, which varies from 0 to 3 (for temperature) up to 0 to 26 (for Glasgow coma score). The range of possible SAPS total score is 0 to 163 with the higher score indicating the greater risk of mortality. A copy of the form is provided in Appendix B.

The SAPS II was developed and validated by using data from 137 adult medical and/or surgical intensive care units in 12 countries in Europe and North America (Le Gall et al., 1993). Logistic regression analysis was used to assist in selecting variables that would constitute SAPS II, and to decide on appropriate grouping and point assignments for each variable. Of the 37 variables collected to build up the SAPS II, only 17 were included in the final SAPS II score. Variables were excluded if they were unrelated to hospital mortality. Goodness of fit tests indicated that the model performed well in developmental sample ($p = 0.88$) and validated well in an independent sample of patients ($p = .104$). The discriminative ability of the model was assessed using the Receiver Operating Characteristic (ROC) curve. Large areas were generally acknowledged to constitute excellent discrimination. Analysis of the ROC curve showed good ability to discriminate correctly between survivors and those that did not survive (*ROC* = 0.88 in the developmental sample and 0.86 in the validation sample, respectively).

Reliability of the SAPS II was tested by an acceptable rate of agreement between the first and second data-collection effort. The intraclass correlation for serum potassium was 0.81. For systolic blood pressure and body temperature, the intraclass correlations were greater than 0.87. For heart rate, serum sodium level, Glasgow coma score, Fio_2, PaO_2, and bilirubin level, the intraclass correlations were greater than 0.90, and they were greater than 0.95 for age, urinary output, serum urea nitrogen level, white blood cell count, and serum bicarbonate level. The kappa value for the presence of hematologic malignancy, metastatic cancer, and acquired immunodeficiency syndrome were greater than 98% agreement and 98.8% for type of admission.

3. Nurse Staffing Data Form

This form was developed by the investigator based on literature review. The form includes the number of RNs, PNs and HPs for each nursing shift, the number of patients for each nursing shift. A copy of the form is provided in Appendix C.

4. Health Personnel Cost Data Form

The form includes two sections (shown in Appendix D). The details of each section are as follows.

4.1 Section 1: ICU personnel's money allowance. This form was developed by the investigator to collect data on the hospital budget allowance for intensivists, residents, RNs, PNs and HPs in ICUs. It consists of salaries, overtime costs and fringe benefits such as professional fees, medical care costs, costs of evening and night shift duties and consulting fees.

4.2 Section 2: Therapeutic Intervention Scoring System-28 (TISS-28). The TISS-28 was developed by Miranda, de Rijk and Schaufeli (1996) and used to measure daily nursing care hours providing by RNs. TISS-28 described a set of nursing activities in relation to therapeutic interventions. It consisted of seven major kinds of nursing activities commonly found in critical care areas. These included *basic activities* (seven items); *cardiovascular support* (seven items); *ventilatory support* (four items); *renal support* (three items); *neurological support* (one item); *metabolic support* (three items); and *specific interventions* (three items). Each item was designed as *yes* or *no* answer. The scores for *yes* varied from one to five and the score for *no* was scaled at zero. Summing the scores yielded the total score ranging from 0 to 79. The association between TISS score and the consumption of nursing care by RNs was studied by Miranda et al. (1996). Using a panel of nurses to list all tasks and activities developed by the nurses of ICUs and then work sampling in the real situation. Results showed that one TISS-28 point equal to 10.6 minutes of each 8 hour nurse's shift.

Miranda et al. (1996) reported the quality of the TISS-28 instrument. The construct validity of the instrument was tested with the principle component factor analysis and revealed that there were seven factors of nursing activities in ICU. The first factor included 11 items (responsible for 14.3% of total variance) and composed of respiratory care and feeding. The second factor (7.5% of variance) composed of items related to cardiovascular system. The third factor (5.9%) composed of items including the basic activities. The association between cardiopulmonary resuscitation and dialytic techniques and forced diuresis (factor four, 4.7%), between intracranial pressure monitoring and specific interventions outside the ICU (factor five, 3.8%), and between single and multiple special interventions in the ICU (factor six, 3.7%) were noteworthy. The reliability of this instrument was not addressed in the study by Miranda et al. (1996). In another study, Moreno & Morais (1996) evaluated performance of TISS-28 in the quantifications of nursing workload in intensive care. The TISS-28 was administered to a sample of 19 intensive care units (ICUs) in Portugal and found that the reliability of TISS-28 was very good, with an intraclass correlation coefficient of 0.93.

5. Medical Care Cost Data Form

The form was developed by the investigator based on an initial literature review and a final discussion with physicians and professional nurses in ICUs. There are three sections in the form (shown in Appendix E). The first section is used to collect information about hospital operating costs, the second section for collecting information about revenue of the hospital and the last section for collecting unit charges and the amount of resources used for incurring individual critically ill patients. The two first sections were used to capture data from financial reports in the accounting and purchasing departments. The last section was used to obtain data from patient records. The details of each section are as follows.

5.1 Section 1: Hospital operating costs. Operating costs refer to costs that are incurred within one year (Zelman, McCue, Millikan, & Glick, 2003). The data collection form includes (a) the hospital budget allowance for hospital personnel i.e., salaries; overtime costs; professional fees; medical care costs; cost of evening and night shift duties and consulting fees, (b) material costs, (c) costs of utilities, (d) expenses for equipment maintenance, (e) rent for computers, (f) rent for medical equipment, (g) expenses for using LAN system management, (h) expenses for outsource services, (i) insurance fees, expense for advertising, (j) expenses for research activities, and (k) expenses for professional promotion.

5.2 Section 2: Hospital revenues. Hospital revenues are defined as earning money from hospital services. Data included in this form consisted of in-patient revenue, out-patient revenue and non-patient revenues such as interest, rent fee, waste incinerating fee, and revenue from the sales of medical services, food, and laundry services.

5.3 Section 3: Medical care of critically ill patients. Data included in this form consists of charges of hospital services and daily usage of radiological investigations; laboratories, equipment used, life support therapies, nutritional products, drugs, medical supplies and fluid infiltration.

Quality of the Research Instruments

The procedures for developing and testing quality of the research instruments include three processes: translation process, validity assessment and reliability assessment. Each step used is described as below.

1. Translation process. Two existing instruments including TISS-28 instrument and SAPS II had to be translated from English to Thai in order to be implemented in the field. Following back translation method developed by Brisline (1970), the instruments were translated into Thai by the investigator and then the instruments were translated back into English by three independent individuals with competency in both Thai and English languages (Appendix N). The items with obvious discrepancies among the three languages were then evaluated and proper semantic adjustments were made. The process was repeated until the investigator and the three translators were in full agreement.

2. Validity assessment. The content validity of the new instrument was evaluated. The Demographic data form, the nurse staffing data form, the data collection for ICU personnel's money allowance and the medical care cost were investigated by a panel of experts. The panel of experts consisted of three professional nurses and two specialists with prior experience in cost accounting (Appendix N). Experts rated each item for its relevancy in representing the topic of interest on a 4-point scale, with 1 indicating not relevant, 2 somewhat relevant, 3 quite relevant and 4 highly relevant. They also provided comments and suggestions about the items and potential alternatives. All questionnaires were also reviewed for face validity, clarity of meaning, the format of the questionnaire and the ready understandability of the panel of experts. The instrument's interrater agreement was calculated; the total questions rated as either one or two and questions rated as three or four were added and then divided by the total number of items. The value of interrater agreement greater than 0.7 is generally considered as acceptable (Davis, 1992). Next, the instrument's content validity index was calculated by dividing the total number of items that were ranked three or four by both raters and then dividing by the total number of items. The Content Validity Index (CVI) is accepted with criteria review of 0.8 for a new instrument (Davis, 1992). In the current study, CVI and the average score of the interrater agreement obtained for all above forms was the same value of 1.0. Since the level of acceptable CVI and interrater agreement should not be less than 0.8 and 0.7, respectively, there was evidence of the content validity of all new collecting data forms.

3. Reliability assessment. Since four research instruments, including the demographic data form, the SAPS II instrument, the TISS-28 instrument and the collecting data form for medical care of critically ill patients, are dependent on accurate abstraction of data from the patient records, inter-rater agreement is carefully monitored. Each research assistant who participated in data collection was trained by the investigator and had to achieve a 100% agreement on each measure before independent data were collected. In addition, the guideline for collecting data in this study (see Appendix F) was kept so that reliability could be maintained. Interrater reliability was checked on a random selection of

25 patient records. The investigator reviewed 15 of 25 patient records and then the same records were reviewed by two RAs. The percentages of agreement between the investigator and the two RAs were tested. For the demographic data form, the SAPS II instrument and the TISS-28 instrument, the percentages of agreement were equal to 100. For the collecting data form for medical care of critically ill patients, the percentages of agreement between the investigator and the two RAs were 93 and 96. Discrepancies in judgments were managed by consensus. Differences in scoring were analyzed and resolved through the construction of additional coding rules. The test for interrater reliability of the last form was repeated by reviewing the other ten of 25 patient records. The percentages of agreement between the investigator and the two RAs were achieved to 100.

For remaining collecting data forms, the investigator reviewed assignment sheets of ICU personnel, daily nurse's reports and financial reports recorded in September, 2004. The reliability of these instruments was assessed by using one-week test-retest reliability. The calculated reliability coefficient of each instrument was the same value of 1.0. Since the reliability coefficient around 0.7 is considered an acceptable value for the instruments (Ferketich, 1990), there was evidence of the reliability of all new collecting data forms.

Ethical Considerations

The research proposal was submitted for reviewing and approving from the Research Ethic Committee (REC) of the Faculty of Nursing, Chiang Mai University and a selected university hospital. Additionally, permission from the Dean of the Faculty of Medicine, Chiang Mai University, the Director of the Maharaj Nakorn Chiang Mai Hospital, the Head of Surgical Department, the Head of Medical Department and the Head of Nursing Department was obtained. Prior to entry into the study, the investigator visited medical and surgical ICUs, the accounting department and the purchasing department of the hospital. Head of Accounting Department, Head of Purchasing Department and Head Nurses were informed about the purpose, procedure of this study and the protection of patient's confidentiality. After that, the above people were asked to sign a written consent (see Appendix G). In order to ensure the confidentiality of the data, all data were kept confidential by replacing the name on records with an assigned code number. The linkage between code number and subject on code sheet was known only by the researcher. The code sheets were stored in a separate locked cabinet apart from the collected data in order to protection of patient's confidentiality. Any reference and description which would make the subject easily identifiable was excluded from any final reports, any publications and the presented paper.

Data Collection

Research Assistant Preparation

Two registered nurses with prior ICU experience were assigned to be research assistants (RAs) and were formally trained by the investigator. The information regarding the objectives of this study, inclusion criteria of the patient records and the information of collecting data forms were provided and discussed. During the training sessions, questions and concerns from the RAs were clarified. Interrater agreement was monitored before independent data were collected. Two RAs and the investigator reviewed the same 25 patient records. The percentage of agreement between the investigator and the two RAs was 100.

Data Collection Procedures

1. *Obtaining the permission.* The investigator submitted the letter asking for permission to the Dean of Faculty of Medicine, Chiang Mai University. Once permission was obtained, an approval letter (Appendix H) was sent to the Head Nurses of medical and surgical ICUs, the Head of Accounting Departments and the Head of Purchasing Department in Maharaj Nakorn Chiang Mai Hospital.

2. *Obtaining informed consent.* The investigator contacted the Head Nurses of medical and surgical ICUs, the Accounting Departments as well as the Purchasing Department by telephone and visited them to invite them to take part in this study. After a brief introduction, the researcher clearly explained the objectives and procedures of the study and asked for permission to collect data. Once permission was obtained, they were asked to sign an informed consent form.

3. *Data extraction.* The following procedures were taken to obtain data for the study.

3.1) ward rounds were made every day in all ICUs to assess patient eligibility. Data extraction was then done prospectively by two RAs. Patient records were reviewed at least every other day until the patients were discharged from the ICU. Assessment of individual patient information was performed during the first 24 hours after admission and on the date of discharge. The information included patient age, types of ICUs, admission diagnosis, locations prior to ICU admission, level of serum albumin, lymphocyte count, duration of mechanical ventilator, discharge destination, length of ICU stay, date and time of discharge and discharge status. During the first ICU day and subsequent 24 hours in the ICU, the RAs recorded the extent of physiological abnormality using SAPS II.

RAs recorded treatment information for each patient. For each day of stay, *a daily record of nursing care hours* was produced which selected either *yes* or *no* on each item of TISS-28 instrument. A daily TISS-28 point was computed by scoring each selected item and summing all items into a total score. Additionally, *a daily medical care record* was produced which documented the number of services that patients had received, together with the charges of those services in the collection form. The daily medical care records for each patient were aggregated into a summary of services. The daily care and summary of service records support both audit and analysis which make economic evaluation of intensive care feasible for the first time.

3.2) the investigator reviewed financial reports in the accounting department. The revenue statement for FY 2005 (from October, 2004 to September, 2005) provided data on hospital revenues. In addition, budget statement for FY 2005 was reviewed to derive information on hospital budget allowance for hospital personnel (including ICU staff), material costs and costs of utilities.

Data on depreciation costs of buildings and equipment were not available from the accounting department; consequently, the cost was estimated based on a straight-line method. This method assumes that services from building and equipment use are divided equally over the useful life for them. Thus the formula for measuring annual depreciation costs of buildings and equipment is the purchasing price of them divided by their expected useful life (Zelman et al., 2003). In this study the entire contents of buildings and equipment were obtained from the purchasing department. The databases were programmed in Microsoft Excel and kept in Apricot PI computers of the department. After getting permission from the head of the purchasing department, the details of buildings and equipment e.g., the number of them, purchasing prices and years' life were extracted from that program. However, overall items of buildings and equipment were not used according to the assumption of straight line method that limits depreciation analysis to only any building and equipment with year life less than its expected working life. The working life of a piece of buildings and equipment varies considerably, depending on these types of them. In this study the information of expected working life of equipment and building were obtained from a published paper of the Thai Government Procurement in 2000. Consequently, there were only 2,576 items that were included in the depreciation analysis. These included two items of buildings; 1,405 items of non-medical equipment; 969 items of medical equipment; 15 items of vehicle equipment and 185 items of computers. The purchasing cost for each item was aggregated into total purchasing costs of buildings, non-medical equipment, medical equipment, vehicle equipment and computers. All data were then analyzed by the investigator to determine depreciation costs of buildings and equipment for FY2005. For a better understanding about how data were analyzed, Appendix I provides a description of the depreciation cost analysis.

Two summary sheets were designed by the investigator to explain overall operating costs and revenues of the hospital. First, a summary statement of ICU personnel's money allowance for FY2005 displayed money allowance to each type of personnel in ICU. Data in this statement were necessary to further estimate health personnel cost per patient day and nursing personnel cost per patient day. Second, a summary statement of overall hospital operating cost and revenues for FY2005 described annual costs and revenues of the hospital. Data in this statement were used to compute medical care cost per patient day. To assure that both statements are accurate, the statements were double checked by the head of the accounting department of this hospital. A copy of these summary statements is shown in Appendices J and K.

3.3) to assess nurse staffing in each 8-hour shift, RAs reviewed assignment sheets of ICU personnel to capture the total number of RNs, PNs and HPs in each 8-hour shift. The investigator also reviewed daily nurse reports to obtain the total number of patients in each 8-hour shift.

Data Analysis

Data were coded and entered into the statistical package for analysis. Descriptive statistics were used to check and clean the data. The statistics used in this study include as follows:

1. Assessment of the Distribution of Demographic Data of the Study Sample

Frequency, percentage, mean and standard deviation of each demographic variable were conducted to assess the distribution of these variables among the study sample.

2. Assessment of Health Personnel Cost Per Patient Day

Health personnel cost per patient day was defined as a monetary value attached to care hours delivered to an individual patient for one day. A method for assigning health personnel costs according to care hours was used due to the reason that this method allowed greater sensitivity in reflecting caring time demand by individual patients. There are three steps to compute the health personnel cost per patient day of the study.

Step1: Calculation of ICU personnel's hourly money allowance. ICU personnel's budget allowance is defined as the sum of salaries, overtime costs and fringe benefits that is paid to the hospital employee for working in ICUs. Hourly money allowance was calculated by the gross combined average annual budget allowance for ICU personnel in FY 2005 and dividing this total by the total number of working hours per day within FY 2005.

In this study information about working hours is determined from Maharaj Nakorn Chiang Mai hospital's personnel policy (Faculty of Medicine, 2001). The number of hours staff work each shift is 8 hours and the average number of yearly working days is 365 days. Thus, a total of 8 working hours X 365 working days per year equals 2,920 hours per day. The summary of ICU personnel's money allowance for FY 2005 was displayed in Appendix J. Stratified by type of ICU personnel, a total annual budget allowance for RNs was 241,205.6 baht, for PNs was 190,756.0 baht, for HPs was 106,862.9 baht, for intensivists was 525,774.3 baht and for residents was 150,664.4 baht. The total working hours for one year in FY 2005 was 2,920 hours (8 hours per day X 365 days). Therefore, hourly money allowance for RNs was 82.6 baht (241,205.6 ÷ 2,920 hours), for PNs was 65.3 baht (190,756.0 ÷ 2,920 hours), for HPs was 36.6 baht (106,862.9 ÷ 2,920 hours), for intensivists was 180.1 baht (525,774.3 ÷ 2,920) and for residents was 51.6 baht (150,664.4 ÷ 2,920 hours).

Step 2: Calculation of care hours consumed by an individual critically ill patient. Personnel who provided intensive care consisted of RNs, PNs, HPs, intensivists and residents. Hours of care to be provided by RNs were measured by using the TISS-28 instrument. Each patient was rated on independent element of intensive care in the TISS-28 instrument; each element was scored; scores were summarized; and required hours of care by RNs were determined by multiplying the sum of the scores by 10.6 minutes.

Hour of care by other nursing staff (PNs and HPs) to be provided to each patient was calculated from a ratio of other nursing staff to patient which extends to assume that total nursing care hours by PNs and HPs would be equally distributed between individual patients. According to this hospital policy, a PN or a HP spends 7 hours for each 8-hour shift to provide nursing care. The total hours of care provided to all patients in each shift was estimated by totaling the number of PNs and HPs and then multiplying this total with 7 hours. For instance, assume there are 4 PNs and 1 HP providing intensive care for 8 patients in a day shift so that the total care hours provided to all patient is 35 hours ([4+1] X 7 hours). Based on the assumption that each patient requires equal nursing care hours from PNs and HPs, hours of care for each patient in this day shift are 4.3 hours (35 hours ÷ 8 patients).

A total number of hours of care by medical staff (intensivists or residents) was also found by using a ratio of medical staff to patient. An intensivist spent approximately 30 percent of 7 working hours (2.1 hours) to make bedside all patient rounds twice a day during the day shift, supervisory invasive procedures and guiding all ICU staff in patient care during the day shift. Thus, daily hours of intensivist care for each patient were estimated by dividing 2.1 hours by the number of patients in any day shift. In terms of residents, a resident spends a whole day in an ICU to perform a wide range of clinical duties for all critically ill patients. Removing break times (1 hour for each 8-hour shift), a resident spends 21 hours per day (7 hours per shift X 3 shifts) providing care. Daily hours of resident care for each patient were estimated by dividing 21 hours by the number of patients in any ICU day. For instance, assume there are 8, 7 and 7 patients in day, evening and night shifts respectively. Thus, the total hours of intensivist care for each patient in this day is 0.3 hour (2.1 hours ÷ 8 patients) while the total hour of resident care for each patients in this day is 1.0 hour (21 hours ÷ 22 patients).

Step 3: Calculation of health personnel cost per patient day. Health personnel cost per patient day was computed by multiplying the ICU personnel hourly money allowance (from step 1) with the average nursing care hours delivered to an individual patient for one day (step 2). For instance, assume Mr.A consumes hours of intensive care for one day by RNs, PNs, an intensivist and a resident of 20, 15, 1 and 10 respectively. Also assume that hourly money allowance is 82.6, 65.3, 180.1 and 51.6 baht for care by the RNs, the PNs, the intensivist and the resident respectively. This figure yields nursing personnel cost per day for Mr A of 3,327.6 baht ([20 hours X 82.6 baht] + [15 hours X 65.3 baht] + [1 hour X 180.1 baht] + [10 hour X 51.6 baht]). Descriptive analysis was used to describe health personnel costs per patient day of the study sample. Theses included frequency, percentage, mean, standard deviation and median of health personnel cost per patient day.

3. Assessment of Medical Care Costs per Patient Day

Medical care cost per patient day refers to a monetary value attached to a group of medical care which is provided to an individual patient for one day. There are two steps to calculate medical care cost per patient day in the study.

Step 1: Calculation of average charge of medical care for each patient. Charges of medical care refer to money that a patient pays for medical care during ICU stay. The medical care for each patient included radiological investigation, laboratories, equipment used, life supporting therapies, nutrition, blood products, pharmacy, medical supply usage and intravenous (IV) fluid. Calculation of each medical care charge was performed by using the following equations.

Charge of radiological investigations for each patient = ***The number of usage of radiological investigation X the prices set by the hospital.***

Charge of laboratories for each patient = ***The number of laboratory usage X the prices set by the hospital.***

Charge of equipment used for each patient = ***The duration of usage of equipment X the prices set by the hospital.***

Charge of life supporting therapies for each patient = ***The number of usage of therapies X the prices set by the hospital.***

Charge of nutrition for each patient = *The number of usage of nutrition products X the prices set by the hospital.*

Charge of blood product for each patient = *The number of usage of blood products X the prices set by the hospital.*

Charge of pharmacy, medical supplies and IV fluid for each patient = *The number of usage of pharmacy, medical supplies and IV fluid X the prices set by the hospital.*

At this point each medical care charge for each individual patient was known. With the following equations, the investigator was able to measure a total charge of medical care and average charge of medical care per day for each patient:

Total charge of medical care for each patient = *The summation of the charge of radiological investigation, laboratories, equipment used, life supporting therapies, nutrition, blood products and the charge of pharmacy and medical supply usage.*

$$\text{Average charge of medical care per day for each patient} = \frac{\text{Total charge of medical care}}{\text{Length of ICU stay}}$$

Step 2: Converting the average charge of medical care to medical care cost per day. Charges are defined as the price set by the hospital. Hospital charges will exceed actual costs because of the need for replacement of equipment and facilities overtime and because some payers do not pay full charges (they take a discount). Since charges cannot be interchangeable with costs, the charges must be converted to reflect true costs.

In this study the cost to charge ratio (CCR) was used as a specific method to convert charges to costs. While questions of accuracy always arise, the CCR method is generally acceptable and is as close to "true" costs as possible at this setting. The CCR begins with charges and assumes that costs are a certain percentage of this amount (Zelman et al., 2003). For example, assume Mr. A is charged for 8,000 baht for medical care. If the ratio of cost to charges is 1.5, cost of the care for Mr. A is 12,000 baht (8,000 baht X 1.5). In general, the ratio of cost to charge is usually determined by a hospital norm value or using the formula provided by OSHPD (1998). Since, no studies illustrated a norm value of cost to charge ratio for hospitals in Thailand, the following formula provided by OSHPD was used in the calculation of a ratio of cost to charge for this study.

$$\textit{The ratio of cost to charge} = \frac{\textit{Total Hospital Operating Cost}}{\textit{Total of hospital Revenue}}$$

In this study the total hospital operating cost from October, 2004 to September, 2005 was 2,164,280,551.2 baht and the total hospital revenue in the same period was 2,008,959,044.8 baht (see in Appendix K.). Substituting these values into the formula, cost to charge ratio of this study was 1.077 (2,164,280,551.2 ÷ 2,008,959,044.8). The investigator was thus able to measure medical care cost per day for each patient by multiplying the total charge of that patient with 1.077. Descriptive analysis was used to describe medical care costs per patient day of the study sample. These included frequency, percentage, mean, standard deviation and median of medical care cost per patient day.

4. Assessment of Nursing Personnel Costs per Patient Day

Nursing personnel cost per patient day is defined as a monetary value attached to care hours by RNs and other nursing staff delivered to an individual patient for one day. Nursing care hours was used for assigning nursing personnel costs. As mentioned previously, hourly money allowances for a RN, a PN and a HP were 82.6, 65.3, 36.6 baht respectively. Daily hours of care by RNs were measured by using a research instrument namely therapeutic intervention scoring system-28 while those by other nursing personnel were determined by using a ratio of other nursing staff to patient. Therefore, nursing personnel cost per patient day was computed by multiplying the average daily hours of care by RNs by 82.6, average daily hours of care by PNs by 65.3 and average daily hours of care by HPs by 36.6. Summing all of these yielded nursing personnel cost per patient day. Descriptive analysis was used to describe nursing personnel cost per patient day of the study sample. Descriptive statistics included frequency, percentage, mean, standard deviation and median of nursing personnel cost per patient day.

5. Assessment of Length of ICU Stay

Length of ICU stay was calculated by subtracting day of discharge from day of patient admission. Day of patient admission is defined as admitting date, month and year to an ICU while day of discharge is discharge date, month and year from an ICU. The mean, standard deviation, median and percentile of length of ICU were used to assess length of ICU stay of the study sample.

6. Assessment of the Relationship between Patient Characteristics, Types of ICU, Day and Time of Patient Admission, Nurse Staffing, Nursing Personnel Cost per Day, Medical Care Cost per Day and Length of Stay in Adult ICUs

Multiple regression analysis was used to construct three regression models. One is the model for predicting nursing personnel cost per patient day in the ICU, another model is for predicting medical care cost per patient day and the last model is for predicting ICU length of stay. These models were developed using the known values of each dependent variable (DV) that included nursing personnel cost per patient day, medical care cost per patient day and length of ICU stay, and independent variables (IVs) that included patient age, severity of illness at admission, the levels of serum albumin, lymphocyte counts, day and time of patient admission, types of ICU, the average ratio of RN to patient and the average ratio of RN to other nursing staff. The *p-value* was set as 0.05 and the square multiple correlation (R^2) as defined as the magnitude of the relationship between a dependent variable and several independent variables was reported.

Before performing regression analysis, any discrete independent variable was converted into a set of dichotomous variables by dummy variable coding with 1s and 0s. IVs that were converted to dummy variables are shown in Table 1. Additionally, two continuous variables (the levels of serum albumin and lymphocyte counts) were converted to discrete variables, using the normal level of each variable as threshold. Patients with serum albumin of less than 3.2 gram per lit were grouped in the abnormal level of serum albumin whereas individual with equal or more than 3.2 gram per lit were classified as the normal level of serum albumin. For the lymphocyte count, the threshold for being categorized into abnormal lymphocyte count patients was set at less than 2,000 cells per cubic meter, while individuals with equal or more than 2,000 cells per cubic meter were classified as the normal lymphocyte count. Next, two modified discrete variables were converted to dummy variables. These variables were also shown in Table 1.

Table 1

Dummy variables used in the multiple regression analysis of the study

Dummy variables	Code in SPSS program	Description
Levels of serum albumin	0	Patients with levels of albumin ≥3.2 gm/lit
	1	Patients with levels of albumin < 3.2 gm/lit
Lymphocyte counts	0	Patients with levels of albumin ≥2,000 cells/mm^3
	1	Patients with levels of albumin < 2,000 cells/mm^3
Day of patient admission	0	Week days
	1	Weekend days
Time of patient admission	0	Office hours
	1	Non-office hours
Types of ICU	0	Surgical ICU
	1	Medical ICU

Stepwise multiple regression analysis was used in this study for the reason that there was no theoretical basis for considering that any particular independent variable was causally prior to another. Thus, stepwise regression is perhaps best suited because decisions about which variable should enter regression equation were based on statistical, rather than theoretical or logical criteria (Tabanchnick & Fidell, 1996).

Normality and homoscadasticity of the dependent variable distribution are the assumptions for multiple regression analysis. Residual scatter plot was used to check for the violation of the assumptions for multiple regression. If the assumptions are met, the residuals will be nearly rectangularly distributed with a concentration of scores along the center (Polit, 1996; Tabanchnick & Fidell , 1996). A second test for the normality of the distribution of residuals is a normal probability plot of residuals in which their expected normal values are plotted against their actual normal values. If the expected normal values of residuals corresponds to actual normal values (i.e. if the distribution of residuals is normal), the points will fall along a straight line running from the bottom left to the upper right corners of the graph (Polit, 1996; Tabanchnick & Fidell, 1996).

Another important consideration was the assessment of multicollinearity, i.e., the presence of a high intercorrelation between independent variables. Multicollinearity should be avoided for the reason that the results of a regression analysis, when multicollinearity is present, tend to be unstable. This may be because the inclusion of highly intercorrelated independent variables increases the variance accounted for in the dependent variable and suppress some independent variables that are irrelevant to the dependent variable. Multicollinearity was assessed by means of the Variance Inflation Factors (*VIF*) (Polit, 1996). A *VIF* greater than 10 will be considered suggestive of moderate to severe multicollinearity.