CHAPTER 2

REVIEW OF LITERATURE

This chapter presents a summary of the literature review on intensive care units and intermediate care units, the cost of intensive care, length of ICU stay and factors influencing those variables.

Intensive Care Units and Intermediate Care Units

The following description of intensive care units and intermediate care units will help to understand the contextual background of the study.

Organization of Intensive Care Units (ICUs)

ICUs were historically organized to serve specific purposes such as the care of postoperative patients, rhythm monitoring, airway maintenance and mechanical ventilation for patients with reversible neurological diseases (Consensus Conference, 1983). However, during the last two to three decades, ICUs were shifted from relieving suffering to stabilize and support human life (Bone, 1984). The development of ICUs was also associated with the increasing use of technology in the treatment of critically ill patients and the need for specialist staff because of the complexity and intensity of therapy. Notably, the modern definition of an ICU is a place providing necessary care for life support; much of what goes on is due to the fact that there is nursing care and much of the technology is used for the purposes of monitoring and therapy (Clarke, Mackinnon, England, Burr, Fowler, & Fairservice, 2000).

Many people usually view ICU patients as being surrounded by machines, invaded by numerous tubes and close to death (Vaisrub, 1980). Critical care for these patients involves personnel including critical care physicians, critical care nurses, respiratory therapists and auxiliaries. Physical facility would require an area large enough to house a large amount of equipment and unrestricted working space together with pipeline and hand washing facilities (Hayne & Bailey, 1982; chapt 6). Hartshorn, Sole and Lamborn (1997) mentioned that basic administration of laboratories has included blood gases, chemistry and blood counts. Moreover, equipment should include respirators, electrocardiographic (ECG) monitors, drug monitors, defibrillators, infusion pump, oxygen saturation monitors, water manometer, haemodynamic monitors and portable X-ray. According to the last authors, specifically investigative techniques and equipment that have been of tremendous help include ultrasound, computer tomography and magnetic resonance screening. The most important constraint has been financial support provided from the government or private sources (Tejavej, 1993).

The treatments of critically ill patients begin immediately on recognition of the severity of illness, continue as the patients are transferred into the ICU and extend into the recovery phase until the potential for de-compensation is sufficiently low. Critical care physicians are responsible for coordinating and providing integrated care to the patients with acute and chronic complex illness (Lipschik & Kelley, 2001). They should be dedicated to the ICU 24 hours per day. Clarke et al. (2000) suggested that critical care nurses have done the majority of patient assessment, evaluation and care in the ICU. Additionally, the ratio of patient to bedside nurse is typically 1:1 which allows the critical care nurses to spend several hours per patient per shift for collecting information and integrating it into meaningful patient care. The roles of respiratory therapist focus primarily on management of the patient/ventilator system, airway care, delivery of bronchodilators, monitoring of blood gas and the delivery of protocol regulated respiratory care (Brilli et al., 2001). Having a pharmacist available, when patients are evaluated during beside rounds, may reduce the likelihood of preventable adverse drug events because critical care pharmacists will provide recommendations on drug selection, proper dosing to reduce error and costs, as well as complications due to pharmacological agents (Leape et al., 1999). Although there are differences in responsibilities between the above ICU health personnel, the orchestrated performance of them has long been promoted to optimize patient outcomes (Durbin, 2006). According to several authors, the effectiveness of an interdisciplinary team to care for patients in ICU was demonstrated by shorter lengths of stay, decreased number of days on mechanical ventilation and reduced cost of care (Cohen, Bari, Strosberg, Weinberg, Wacksman, Millstein 1991; Dutton, Cooper, Jones, Leone, Kramer, & Scalea, 2003; Henneman, Dracup, Ganz, Molayeme, & Cooper, 2001; Nakajima, Kurata, & Takeda, 2005).

The first ICU in Thailand was established in 1968 at Siriraj hospital (Suwanjutha, 1993). Nowadays, all general and university hospitals throughout the country have their own ICU facility. According to the investigator's survey of 10 general hospitals and Maharaj Nakorn Chiang Mai Hospital, a university hospital in the northern part of Thailand (2006), the results demonstrated that adult ICUs have 6 to 12 beds per unit. Small hospital with less than 500 beds usually have a single medical-surgical ICU while larger hospitals particularly university hospitals tend to have multiple ICUs, most commonly designs as medical, surgical and coronary care. An ICU in a small hospital will typically have physicians, full-time registered nurses (RNs), full-time practical nurses (PNs) and full-time helpers (HPs) but does not have respiratory therapists. Physicians in the ICU have hospital privileges of ICU admission and care for patients themselves, but will often consult other specialists on issue related to ventilator management and complications as they arise.

In Maharaj Nakorn Chiang Mai Hospital, all of ICUs are staffed 24 hours a day. Daily work hours are divided into three shifts: day shift from 8.00 a.m. to 4.00 p.m., evening shift from 4.00 p.m. to 12.00 midnight and night shift from 12.00 midnight to 8.00 a.m. Intensive care is run by an ICU team, consisting of intensivist, residents, medical students, nursing staff and respiratory therapists. The intensivist is a physician who has a certificate of specific qualification in critical care. Their responsibilities include teaching, research and providing medical care for patients who are admitted to this hospital. An intensivist spent 7 hours working each day and takes approximately 30% of 7 working hours (= 2.1 hours per day) for making bedside patient rounds twice a day, supervisory invasive procedures during the day and guiding all ICU staff in patient care (Faculty of Medicine, 2001). Residents refer to physicians who are receiving advanced training in an ICU. Two residents worked during the day shift and they took turn working the two other shifts. The trained physicians as well as residents had privileges of ICU admission. Each resident trainee spent three months in the ICU rotation. The intensivist rotated for every one month.

Physicians use criteria for deciding on patient admission. The criteria are that patients require close observation by physicians and professional nurses, the use of respirators, monitoring of heart function, and special treatments/ procedures such as peritoneal dialysis, plasma exchange, Swang Gang Catheter, and acute renal replacement therapy. Terminally ill cases are not allowed to transfer to any ICUs due to a limitation on ICU beds. If ICU beds are occupied, it is necessary to discharge one patient who is improved enough to intermediate care units or general units. The new patient from general units will then be transferred into ICU (Maharaj Nakorn Chiang Mai Hospital, 2004). Initial medical evaluation is performed by junior resident and medical students. Senior resident supervise the junior resident's performance of invasive procedures during the day and manage the airway when endotracheal intubation would be requested. The ICUs in this hospital lack dedicated full time intensivist coverage for evening and night shifts as well as for the whole period of Saturday and Sunday.

The junior residents and medical students staff the ICUs 24 hours per day and every day of the week.

Nursing staff in the medical and surgical ICUs include RNs, PNs and HPs. There is one year rotating program to orientate new graduates or new employees at the level of RNs and PNs. After completing the orientation, the nursing personnel can choose their permanent work place according to their own needs and available quota of each unit. Annual continuing education for staff nurses is provided at different levels: unit division, department and outside. The examples of such topics have included isolation techniques, cardiopulmonary resuscitation and changes in policies, procedures and security system. The RN to patient ratio was approximate 1:2 during day shift and 1:3 for evening and night shift. This ratio has been maintained irrespective of the day of the week. The ratio of RN to other nursing staff (PN and HP) to patients was 5:2:8 for day shift and 3:2:8 for evening and night shifts. While the head nurse of any ward works only during the day shift of regular office day as the nursing in-charge, other nurses will be rotated among three shifts. Therefore, all nursing personnel, except the head nurses in these wards, are likely to be distributed among three shifts. During evening shift and night shift as well as all of shifts in weekend days, the most senior nurses in those shifts takes the responsibility of the nurse in-charge of the ward.

Team nursing is a selected method to provide nursing care for the ICU patients. The concept of team nursing is one in which there is a team leader who is a RN and several team members who may be RNs, PNs or HPs. In this university, there are two teams in one unit. A team leader is responsibility for the coordination of care of four to six patients. The team leader delegates certain aspects of the patient's care to specific team members, including RNs, PNs and HPs. Two RNs and one PN might be assigned the total care of four patients while the team leader is responsible for coordinating other order transcription, holding a team conference, making round with physicians, and supervising and assisting the care being given.

RNs, as integral members of the team nursing, provide comprehensive care for the patients. According to a short preliminary study by the investigators in 2005, the work performed by the RNs included (a) data gathering such as sampling for laboratory biochemistry tests; logging of hourly records; measurement of blood loss and urine output, (b) therapeutic maneuvers such as administration of clear fluids; blood volume expanders and drugs, (c) respiratory care such as endotracheal and gastric aspiration; adjustment of mechanical ventilation; removal of ventilatory support, (d) adjustment to monitoring equipments such as infusion pumps; oxygen saturation, (e) housekeeping in the bed area such as cleaning equipment; movement equipment; change of urine collection vessel; change linen, (f) learning activities such as reading patient notes; attention to patients or monitors, (g) surgical maneuvers such as removal of drains; placement of intravascular cannulae or ECG plates, and (h) miscellaneous nursing care such as removal of drains; placement of intravascular cannulae or ECG plates; wound dressing; change of posture; bed bathing.

The results of the preliminary study also demonstrated that PNs have been trained to serve as assistants to RNs. They could be utilized to assist in bathing, turning of patients, tube care, tube suction and housekeeping in bed area. In addition, HPs have been a vital part of the critical care team. They would take an important role in maintaining a clean environment in the ICU. Their works involved checking delivered supplies, keeping up with equipment and moving patients in or out of the ICU and managing all of the non-clinical aspects of the unit.

Organization of Intermediate Care Units

Intermediate care units are multipurpose progressive care units or single-organ subspecialty floors such as cardiac telemetry, neurological monitoring areas or chronic respiratory care units (Popovich, 1991). These units make available an added measure of monitoring and intensity of services that exceeds what is available in the general wards. This is also reassuring to concern that the patient who is not sick enough to be in the ICU is adequately taken care of. Hayne and Bailey (1982, chapt 6) presented that the design of these units should include the following characteristics. First, they should have fewer beds than the general wards, yet more beds than ICUs. Second, the patient rooms should be large enough to accommodate ECG monitors, ventilators and occasional arterial pressure monitoring. Lastly, wall services outlets need not be as numerous as those in an ICU, but these units may need to include more vacuum outlets than the general wards. One nurse could be used for every three patients, instead of one nurse for every one or two patients as in the typical intensive care unit. This may be due to the fact that the patient's acuity of illness is less than the critically ill patients (Hayne & Bailey, 1982, chapt 13).

An intermediate care unit can reduce cost, demand for ICU beds and does not impact on patient outcome or increase length of stay (Rudy, Daly, Douglas, Montenegro, Song, & Dyer, 1995; Zimmerman, Wagner, Knaus, Williams, Kalakowski, & Draper, 1995). In this era of cost containment, the concept of intermediate care unit promotes greater flexibility in patient triage, increases accessibility to limited intensive care resources and provides a cost effective alternative to ICU admission. A study conducted by Henneman et al. (2001) indicated that 40% of medical ICU and 30% of surgical ICU patients were admitted strictly for monitoring purposes and did not receive any active intervention. An additional study in Thailand has confirmed that 48% of ICU patients were admitted for monitoring and did not receive ICU-specific interventions (Buri, Tantiphan, Hathirat, & Srikasipun, 1987). These patients filled the expensive ICU beds and consumed the precious resources, often to the exclusion of other patients who could have been in greater need of the critical care resources (Daly, Rudy, Thompson, & Happ, 1991). If intermediate care units were available, more cost effective medical care could be provided without compromising the quality of care (Junker, Zimmerman, Alzola, Draper, & Wagner, 2002).

According to the investigator's survey of 10 general hospitals and Maharaj Nakorn Chiang Mai Hospital, a university hospital in the northern part of Thailand (2006), the results demonstrated that only the university hospital has had two intermediate care units for medical patients. There were 12 beds per unit. The RN to patient ratio was approximate 1:3 during day shift and 1:4 for evening and night shift. This ratio has been maintained irrespective of the day of the week. The ratio of RN to other nursing staff (PN and HP) to patients was 5:2:12 for day shift and 3:2:12 for evening and night shifts. Physicians use criteria for deciding on patient admission. The criteria are that patients have to require only monitoring and intensive nursing care, but not ICU-specific interventions such as peritoneal dialysis, plasma exchange, Swang Gang Catheter, and acute renal replacement therapy.

Cost of Intensive Care

Cost is the monetary value of resources used to produce something including a specific health service or a set of services (Clewer & Perkin, 1998; Finkler & Kovner, 1993; Jacobs et al., 2000). The cost of any care service is the product of its unit cost and the number of service units which are provided. Thus, if the resources labor, machine costs, supplies and overhead which go into a complete blood count (CBC) cost 40 baht and a patient requires six units of CBC, then the cost of laboratory for the patient is 240 baht. In order to develop the cost of a patient episode, one must sum up costs of all services which are provided in the episode.

Cost- Finding Methods

Health care organizations consume a variety of resources in providing their services. Labor, supplies and equipment are needed to provide care to each patient. The challenge face by researchers is both accumulate cost information relating to all resources used and to find an efficient and economical way to accurately associate with each patient the costs incurred to treat that patient. There are several ways to calculate cost of intensive care.

The simplest cost finding method is to simply dividing the total dollar spent over period of time by the number of patients treated over that period (Finkler & Kovner, 2000). The result is the same average cost per patient for all patients. One of the advantages of this method is that it can be used by several studies on cost of illness partly because detailed resource utilization data were not available. On the other hand, it is widely criticized for inadequately representing the variability in resources consumed for different types of patients. Therefore, this method holds little promise, if the purpose of cost finding is to attribute the true cost of care to each patient.

Some studies used an average bed day cost that is derived from the hospital ledger (Bams & Miranda, 1985; Chaix, Durand-Zaleski, Alberti, & Brun-Buisson, 1999; Loes, Smith-Erichsen, & Lind, 1987). An average cost per bed day is calculated by dividing the sum of all relevant costs by the number of patient days. Costs per patient can be found by multiplying the cost per bed day with length of ICU stay per patient. This method can be used where variation in resource use between patients is reasonably small. However, this method cannot be used to differentiate resources used between patients. An additional problem with this method is that this method relies on an assumption that resources used for care to each patient are constant during the entire stay in a hospital unit. Actually, a normal hospital stay will have a high initial cost and then cost per day will decline as the stay proceeds. The same situation holds for ICU patients. During the first hours after admission, critically ill patients may require extensive resources, as the patients are intubated and connected to various monitoring devices. However, after these initial activities, the resource use does not follow a uniform pattern, as some patients quickly become stabilized while others require more resources (Rapoport, Teres, Zhao, & Lemeshow, 2003). Thus, a constant cost per day is an inappropriate assumption to make.

Some studies used a cost to charge ratio to estimate cost of care (Ahmad, Fergus, & Stothard, 1988; Dasta, Mclaughlin, Mody & Piech, 2005; Munoz, Josephson & Tenenbaum, 1989). Charges are defined as the price set by a hospital, the purchaser may not pay this full price. Hospital charges will exceed current expense because of the need for replacement of equipment and facilities over and above these expenses and because some payers do not pay full charges or they take a discount. The charges are converted to costs by using a constant ratio of cost to charge, which is estimated by dividing total hospital operation expenditure with hospital revenue (Office of Statewide Health Planning and Development [OSHPD], 1998). The main concern with using this method is that a single cost to charge ratio is an inappropriate assumption to make. Drug A costs $10 to produce and can be sold for $11 while drug B costs $10 to produce and can be sold for $10.50. If a cost to charge ratio is 10%, it could reflect the actual costs of drug A but would fail to show the actual costs of drug B. However, this method has the advantages of more increasing the precision of cost estimation because it defines unit charge of service that is more homogeneous than patient day and preserve information about the variability that is inherent in an individualized medical treatment.

The other method is Activity-Based Costing (ABC). Researchers must develop a comprehensive a list of activities and a standard unit of cost for each activity. The calculation of costs for each patient is then based on his or her care activities. If a patient requires twice as much EKG monitoring, and the standard unit cost of the EKG monitoring is $ 30, then the cost of monitoring for the patient is $ 60. In order to develop the cost of a patient episode, researchers must sum up the costs of all care activities which are provided in the episode (Edbrooke et al., 1997; Stevens, Hibbert, & Edbrooke, 1998). One of the advantages of this method is that it can be particularly useful in cases where patients use a broad range of services over a particular period. Furthermore, it can provide more accurate information about cost of care for each patient due to a costing method based on specific activities that generate costs. However, this method is complex to perform in that it requires continuous observation of costs that are incurred. Furthermore, deciding how minutely to define activities is not easy. One previous study used bedside computer system to better track time spent for each activity (Edbrooke et al., 1997). However, using computerization consumes extensive money to perform. Thus, one must always balance the value of more accurate information against the extra cost of collecting that information.

In the current study, the investigator selected a costing method based on both accuracy and practicality. The cost to charge ratio method was chosen because the estimation involves the use of more detailed measures of inputs such as physician service categories and workload units. Furthermore, the estimation result could reflect all resource costs incurred by the provider such as staff cost, consumable costs and costs of clinical services.

A Review of ICU Cost Studies

In this section, the investigator undertook a review of research literature that explored costs of intensive care and published between 1990 and 2005. Those studies are summarized below.

Shiell, Griffiths, Short and Spiby (1990) explored costs of adult intensive care units in two hospitals in the United Kingdom. Demographic data and details of clinical activities were extracted retrospectively from the records of 200 patients who were admitted to ICUs in Whiston Hospital or in Broomfield Hospitals. The costs of intensive care included the costs of drugs, medical procedures, laboratory tests, radiology services, and salaries paid to staff. Capital costs, overhead and the costs of subsequent hospital stay, out-patient attendances and visit to General Practitioners were excluded. The study found that the average cost per patient stay was £2,000 in Whiston and £2,280 in Broomfield. This is equivalent to £525 and £465 per in-patient day, respectively. The minimum cost per patient in both hospitals was £130 while the maximum was £22,150 in Whiston and £14,000 in Broomfield. Staff costs comprised 75% of total cost with nursing staff was responsible for 56% to 60% of the total cost. Costs of drugs, consumable items and diagnostic tests comprised 9%, 8% and 4% of the total cost, respectively. Patients in a high cost group, defined as the top quintile of costs within each hospital, were more likely to be elderly patients having a high severity of illness, and prolonged length of ICU stay.

Ridley, Biggam and Stone (1991) assessed costs of intensive therapy on an individual patient basis. The costs were divided into three main categories. First, fixed costs included opportunity costs of equipment and land. Second, semi-fixed costs included nursing staff and medical staff costs. Finally, cost of treatments consisted of costs of ventilator support, invasive lines, surgical procedures carried out in the ICU or operating theater, and drugs.

Results showed that there was wide variation in ICU costs. The average daily cost for a spontaneously breathing patient was £399 while that for a ventilated patient was £726. The mean total cost per patient was £1,980. The costs of intensive care were three to five times that for general ward care. The result also indicated that high total costs were associated with increased severity of illness, levels of intervention and ICU mortality.

Gilberton, Smith and Mostafa (1991) conducted a retrospective study of a sample of 120 patients suffering from respiratory and renal failure. Costs of intensive care included costs of drugs, medical procedures, laboratory tests, radiology services, salaries paid to staff and costs of services provided for ICU patients by other departments. Equipment used for the benefit of patients, depreciation and maintenance of the hospital building and administration also added to costs incurred in the ICU. The above costs were identified as variable and fixed costs. Variable costs were defined as the costs of drugs, medical procedures, laboratory tests, and radiology services. The remaining costs were identified as fixed costs and allocated among individual patients according to their length of stay in the unit. The authors found that the cost of intensive care represents approximately 3% of an annual hospital budget and the major cost in ICU (28%) was for provision of nurses. When salaries for other respiratory care and ICU basic services were added, the nursing care cost as a proportion of the total increased to 43.8%. Non-labor cost such as drug and radiology costs accounted for approximately 56%. The relationship between cost and mortality after critically illness was evaluated in this study. Findings showed that that a mean daily cost of care for non survivors was 48% higher than those for survivors.

Variations in ICU cost and non-ICU cost per day were found in a study by Norris, Jacobs, Rapoport and Hamilton (1995). The researchers examined cost per patient of a sample of 386 patients in a general medical and surgical ICU. Average direct daily costs in an

ICU and on a general nursing unit were derived. The direct costs included costs of diagnostic services, laboratory tests, nursing care, and rehabilitation service. Excluded from the study were costs of administration, operating room, and general depreciation. Direct costing components, excepting nursing costs, comprised costs of non-medical staff and such material used in the diagnostic imaging department and laboratory center. In terms of nursing costs, labor, material and overhead portions were included. Costs related to labor included those of nurses, unit clerks and other support staff. All material and overhead costs including nurse manger costs were incorporated into the nursing component. Nursing costs allocated to each patient are based on the actual times that the patient received nursing care. A modified version of the Medicus instrument was used to derive patient acuity scores. Daily scores were assigned to cases and daily nursing costs were assigned to each patient based on the proportion of total ward scores. Results indicated that differences in ICU and non ICU per day were between $1,200 and $1,300 for surviving patients. The ratio of ICU to non-ICU cost per day of the same patients was 6:1. This study suggested that net saving from moving a patient from ICU to non-ICU were roughly $1,200 per day for medical and surgical cases. However, clinicians must examine prospective benefits as well as costs. If health outcomes are not influenced, the saving from substitution is considerable.

Sznajder et al. (1998) reported costs of intensive care for 121 patients in 18 ICUs of the Assistance Publique-Hopitaux de Paris (AP-HP). The aim of the study was to define the burden of variable direct costs of care in ICUs, so fixed direct costs and indirect costs were not involved. The direct costs consisted of medical costs and staff costs. Medical costs include costs of drugs, blood products, supplies, tests and procedures; prices were taken from the national list and from hospital departments such as pharmacy and laboratory departments. Staff costs were based on the amount of nursing activities provided to each patient. Staff cost of each nursing activity was estimated through interviewing a nurse and a head nurse in each unit, and weighting it with per diem staff salaries. Total staff cost per patient was calculated by multiplying the number of nursing activities with the staff cost of each activity. The study showed that due to the variability of length of stay and severity of illness, the average cost of one patient varied by as much as fifty times (ranged from $1,000 to $46,000).

One prospective cost analysis was conducted by Dickie, Vedio, Dundas, Treacher and Leach (1998). The investigators collected data from 257 patients admitted to coronary care units (CCU), cardiac surgery units (CS), and general ICUs (GICU). Individual patient costs were calculated on a daily basis, and designed as variable and fixed cost. Variable costs included consumables and service usage (nursing physiotherapy, radiology and pathology staff costs). Nursing costs were calculated in proportion to a daily nursing dependency scores. Fixed cost included medical, technical and clerical salary costs, and capital equipment depreciation cost and assigned to each patient based on length of stay. Results demonstrated that nursing cost accounted for 42.8% of the total costs and 62.8% the variable costs. The mean variable daily cost ranged from £221 for CCU to £618 for GICU.

Studies concerning unit cost analysis regarding the cost of patients with exacerbation of chronic obstructive pulmonary disease, who are admitted to ICUs, have been carried out by Ely et al. (1999) and Bertolini, et al. (2005). The study by Ely et al. (1999) indicated that cost of ICU and non-ICU respiratory care for patients with chronic obstructive pulmonary disease (COPD) were higher than costs of care for other mechanically ventilated patients. The costs of bronchodilator medications and oximetric monitoring made up approximately 75% of the difference between mechanically ventilated COPD patients and patients who had other causes of respiratory failure, suggesting that increased cost of bronchodilators and oximetry may serve as target area for reductions in respiratory care costs. Another study by Bertolini et al.

(2005) indicated that COPD patients who have less severe and with pure respiratory failure could be successfully and less costly treated in the respiratory intermediate care units (RICUs). Results showed that without affecting their clinical outcomes total cost per COPD patient was lower in RICUs than in ICUs (745 vs 1507 Euro; $p < 0.001$). The results also revealed that each COPD patient admitted to an RICU instead of an ICU saved on average 10.5 nurses' working hours or saving of 205 Euro per patient. In addition, a significant lower cost in all items of costs, except drugs and nutrition was found. This accounted to a saving of 752 Euro of variable cost per patient.

It has been revealed that daily ICU care costs three to six times more than care provided on a general medical-surgical floor (Norris et al., 1995; Ridley et al., 1991; Shorr, 2002). Much of this increased cost may be due to interventions such as mechanical ventilation. Patients who require mechanical ventilation represent approximately 33% of all patients admitted to the ICU and incur a disproportionately high share of the total cost of ICU treatment (Esteban et al., 2002). Dasta et al. (2005) found that mechanical ventilation was associated with significantly higher daily costs for patients receiving treatment in the intensive care unit throughout their entire ICU stay. Daily costs were greatest on intensive care unit day one (mechanical ventilation, $ 10,794; no mechanical ventilation, $ 6,667), decreased on day two (mechanical ventilation, $ 4,796; no mechanical ventilation, $ 3,496), and became stable after day three (mechanical ventilation, $ 3,968; no mechanical ventilation, $ 3184).

In Thailand, there were studies determining unit cost of intensive care in two general hospitals. Daranond (1993) indicated that average annual cost of care in ICU of Chonburi hospital was approximately 12,025,313 baht or 4,059 baht per patient day. Results also revealed that the average cost of manage intensive care for a patient with COPD was the highest with 25,472.94 bath. Recently, Cook (2000) conducted a study to determine unit cost of care for patients admitted to surgical and medical ICUs of Pranangklao hospital and found that unit cost of ICU care was 3,911, 4,111 baht per patient day, respectively. However, unit cost analysis that indicates cost of intensive care in teaching hospitals in Thailand has not been well investigated.

There are several interpretations of these reviewed studies that have relevance to the current research. First, each study included different cost categories to measure costs of care in intensive care unit. Some studies included fixed and variable cost (Dickie et al., 1998; Gilbertson et al., 1991; Ridley et al., 1991; Shiell et al., 1990) while others included only variable costs (Norris et al., 1995; Sznajder et al., 1998). Thus, it is difficulties to make comparisons between the current study and previous studies.

Second, the reviewed studies have made a valuable contribution to a methodology for determining costs of care in ICUs. They suggested that if the purpose of the study has been to investigate the costs of hospitals of having an ICU, fixed cost components should have been included. If the focus of study has been to investigate the marginal cost or the costs of one additional days of care, these costs should have been included. The reviewed studies also reported data requirements for the calculation of intensive care costs. In order to estimate variable costs, most studies have frequently used cost categories, including nursing care; drugs; radiological service; laboratory and costs of treatments incurred to patients. They also used costs of administration, and depreciation of building and equipment to estimate fixed cost. There are three steps for assigning costs to patients. Total cost of administration and depreciation cost of building and equipment is apportioned to each patient's length of stay. Total nursing cost, which comprises the largest single element of costs, is apportioned according to actual times the patient received nursing care. Finally, the use of major disposable items, drugs, diagnostic tests and procedures are identified individually to each patient and costing using specific hospital prices and hospital average costs.

Third, these studies revealed that nursing care cost could be extracted from total hospital operating cost. Estimation of nursing cost would be performed with the following steps. First, nursing care cost per hour is computed by taking the sum of total nursing salaries and benefits, and dividing these by the total nursing hours worked in some period of time, such as one month. Second, a daily nursing care requirement derived from a nursing workload tool is computed for each patient. Lastly, patient care hours are converted to dollars by multiplying the number of nursing hours per patient with the nursing care cost per hour. This method can offer a measure of day to day variance in nursing costs. However, allocating the costs of nursing care may be problem, if the nursing workload instrument cannot reflect accurately nursing care hour requirements.

Next, a review showed that non-labor costs accounted for 56% of total ICU costs. Of those, the total cost of routine diagnostic tests e.g., laboratory and plain radiographs is more expensive than that of any single technological devise. However, the routine tests, medications and supplies including technological devices, each contribute substantially. Physicians, nurses and other health personnel who work in ICUs should thus be aware of the overuse of ICU procedures and technologies.

Lastly, cost saving should be achievable in ICUs. In support of this idea, reviewed studies suggested that healthcare providers working in the ICU might be able to reduce costs by promoting the use of interventions that result in reduced duration of mechanical ventilation. Furthermore, considerable saving could be realized if such less severe patients were provided in intermediate care units.

Length of ICU Stay

Lengths of ICU stay are defined as the number of bed days or the time interval from ICU admission to discharge (Berki, Ashcraft, & Newbrander, 1984; Woods et al., 2000). They have been used as a surrogate for resource utilization in ICUs, with hospitals having long average lengths of stay (LOS) considered relatively inefficient in the use of resources and those with low LOS considered as being efficient (Eagle et al., 1990; Wong, Gomez, McGuire & Kavanagh, 1999). ICU LOS could be determined by various methods. LOS calendar, which are estimated from subtracting date of discharge from date of admission, is the most frequently used to determine length of ICU stay (Marik & Hedman, 2000) and also used to estimate length of stay in hospitals of Thailand. This method has advantage of practicality as easily gathering data from existing documents. However, a problem with this method is that it is not an accurate method for calculating length of stay (Marik, & Hedman, 2000). The most accurate method of calculating LOS is by calculating length of stay in hours and then divided by 24; however, this method is difficult to perform and often impractical. The number of days at midnight census closely approximated the LOS in hours and should be used when ICU information system cannot calculate the exact LOS (Marik& Hedman, 2000).

Indeed, there is no generally accepted the definition of the term *prolonged-ICU stay*. Civetta, Hudson-Civetta, and Nelson (1990) defined long stays as those beyond the mean duration in their study i.e., five days or more. Madoff, Sharpe, Fath, Simmons and Cerra. (1985) and Buchman et al. (1994) defined prolonged care as being beyond seven days. Arabi et al. (2002) defined as prolonged those days in the ICU of more than 14 days, whereas Martin, Hill, Burns, and Chen (2005) considered an ICU stay of more than

21 days to be prolonged at teaching hospitals and more than 10 days at community hospitals. A study in Thailand, based on surgical patients admitted to Siriraj hospital, a university hospital, defined prolonged length of ICU stay as an ICU stay of more than three days (Kongsayreepong, Wongwisate, & Sodapuk, 2006). It is a fact that LOS distribution has been bell shape with a body containing many short stay patients and a tail containing a few patients with prolonged stay. Thus, defining prolonged ICU stay as being greater than the mean plus standard deviation might be a good cut-off for separating long stay patients from those with short stay (Weissman, 2000). For the present study, length of ICU stay refers to the number of days spent in an intensive care unit from admission to discharge and are also used to represent resource use in adult ICUs. Length of ICU stay was determined by LOS calendar according to have beneficial regarding generalization to other hospitals in Thailand. Analysis of length of ICU stay was based on the LOS distribution.

Prolonged ICU stays adversely affect the health status by increasing the risk of infection, complications and possibly mortality (Gilio, Stape, Pereira, Cardoso, Silva, & Troster, 2000). It also inevitably results in high resource utilization i.e., the number and type of personnel involved in delivery of care; the complexity of the procedures, tests, and other services provided; and the amount of care consumed (Thomas, Guire, & Horvat, 1997). Operationally, the number of beds occupied by prolonged-stay patients interferes with efficient patient flow through ICUs and results in cancellation of elective surgeries, leading to long waiting times (Weissman, 2000). A study that has examined long stay ICU patients has shown that while they account for less than 10% of the total ICU patient population, more than 30% of ICU resources are expended on this group (Stricker, Rothen, & Takala, 2003). Moreover, mortality is higher among prolonged stay patients than among short stay patients (Wong et al., 1999; Williams et al., 2002). Therefore, there is a need for decreasing a proportion of patients with prolonged stays in ICUs.

Studies on strategies to reduce lengths of ICU stay have been documented. The use of a nurses' protocol-directed weaning procedure was associated with reductions in the duration of mechanical ventilation and intensive care unit (ICU) length of stay in patients requiring more than 48 hours of mechanical ventilation (Ramachandran, Grap, & Sessler, 2005; Tonnelier, et al., 2005). In Thailand, one study conducted by Bumroongkit, Liwsrisakun, Deesomchok, Theerakittikul, and Pothirat (2005), indicating that patients in the protocol-directed weaning group had significantly shorter durations of mechanical ventilation compared to patients in the physician-directed group (5.89 ± 3.71 days in the protocol-directed group and 7.41 ± 5.54 days in the physician-directed group; $p < 0.05$). The ICU LOS was significantly shorter in the protocol-directed group (7.91 ± 4.71 vs 11.53 ± 7.80 days; $p < 0.05$). However, Krishnan, Moore, Robeson, Rand, and Fessler (2004) indicated that protocol-directed weaning might be unnecessary in a closed ICU with high physician and nurse staffing level and structured rounds. The researchers reasoned that more physician and nursing staff available could be provided to assess patient's readiness to breathe unassisted.

Another strategy to reduce lengths of ICU stay without deterioration of quality of care is the implementation of a structured multidisciplinary care model to care for ventilator-dependent ICU patients. A study conducted by Cohen et al. (1991) found that a management team consisting of an ICU attending physician, nurse and respiratory therapist could significantly decrease the number of days on mechanical ventilation ($p < 0.001$). A cost saving from this reduction was $1,303 per episode of mechanical ventilation. Henneman et al. (2001) conducted a study in medical ICUs in a teaching hospital and found that patients receiving an experimental collaborative approach to weaning had reduced length of time on mechanical ventilation by 2.7 days ($p < 0.06$) and length of stay in the ICU by 3.6 days ($p < 0.05$). The authors of these studies reasoned that the collaborative wean team provided increased communication and collaborative decision making among the healthcare providers working in the unit. This leaded to improve the process of care used for weaning patients from mechanical ventilation and resulted in large reductions in the duration of mechanical ventilation and costs of care.

Some studies have reported the success of protocols based on daily interruption of sedative-drug infusion on clinical and economic outcomes. Kress, Pohlman, O'Connor, and Hall (2000) found that continuous infusion of sedative drugs would prolong the duration of mechanical ventilation and length of ICU stay. Protocols in which sedative infusions were interrupted until the patients were awake, could shorten the duration of mechanical ventilation by more than 2 days and the length of stay in the ICU by 3.5 days. This might be due to the fact that stopping the sedative infusion for a period during each day has been a simple way to improve clinicians' ability to perform daily neurological examinations.

Factors Influencing Cost of Intensive Care and Length of ICU Stay

The impact of patient age, severity of illness, nutritional status, day and time of patient admission and nurse staffing level on costs of intensive care and the ICU length of stay were reviewed as follows.

Patient Age

A number of studies demonstrated that resource use and costs of intensive care decrease in elderly patients. Horn (1997) studied elderly patients admitted to ICUs in Germany and found that costs for older patients were lower than younger, although their treatment was not of a lesser quality. Ely et al. (1999) conducted a prospective cohort study to evaluate a sample of 300 medical and coronary patients requiring mechanical ventilation. Results illustrated that the cost of ICU care for patients over 75 years of age was lower than it was for younger patients ($p = 0.03$). There are no difference in ICU costs between older and younger patients ($p = 0.17$). However, after adjusting for severity of illness, ethnicity and sex, cost of both the ICU and the hospital stays were lower in elderly patients. Recently, Chelluri et al. (2003) conducted a prospective observational study to determine the association between age and hospital costs of 813 adults who received prolonged (at least 48 hours) mechanical ventilation. Results showed that age was associated with lower total hospital costs after controlling for sex, intensive care unit types, severity of illness, length of stay, insurance type, resuscitation status and survival ($p = 0.0001$). Moreover, age was significantly associated with hospital cost ($p < 0.01$), drug costs ($p < 0.01$), and radiological costs ($p < 0.01$).

Many factors may contribute to lower resource used and costs for the elderly. These include physician using age as a surrogate for comorbidity in deciding on treatments (Castillo-Lorente et al., 1997); older patients and their families preferring less aggressive care and fewer treatments (Chelluri et al., 2003; Ely et al., 1999); older patients admitted to an ICU being physiologically healthier and having fewer complications; and older patients having higher severity of illness and mortality resulting in fewer hospital days.

Although most of the recent research has shown a lower resource use in the older patients who are receiving intensive care, earlier studies did not show a consistent relationship between age and medical costs. Campion, Mulley, Goldstein, Barnett and Thibault (1981) found that after ICU admission, elderly patients received a greater number of interventions and support measures, such as intubation and mechanical ventilation, but suffered a higher mortality rate. However, the elderly patients in their study did not stay longer in the ICU or incurred greater hospital charges than the younger patients. Fedullo and Swinburne (1983) analyzed a series of specific costs, such as laboratory, radiological, and respiratory treatment costs. They found that these costs did not change with changes in the age of the patients. Their conclusion was that the cost of treating severe illness in elderly and younger patients was similar.

Patient age is also believed to be associated with length of ICU stay. However, study results that examine the relationship between length of ICU stay and patient age are mixed. A number of studies showed that older patients had higher ICU length of stay. Two studies in Thailand based on surgical ICU patients found that increasing age was a significant factor in prolonging ICU stay (Bunburaphong et al., 2001; Kongsayreepong et al., 2006). Among patients with acute myocardial infarction (AMI), Ruiz-Bailen et al. (2002) found that the mean ICU length of stay was positively related to age ($F = 52.8$, df 4, 54, $p = 0.025$). The mean length of stay was 3.6 ± 6.8 days for the under 55-year-old group and lengthened for each age group except for the over 84-year-old group. Another study conducted by Martin et al. (2005) demonstrated that prolonged stay patients were significantly older and had high admission severity of illness scores ($p < 0.01$). However, there have been other studies did not reach the level of statistical significance of the relationship (Campion et al., 1981; Chalfin & Carlon, 1990; Ely et al., 1999; Horn, 1997; Keenan et al., 2003; Somme, Maillet, Gisselbrecht, Novara, Ract, & Fagon, 2003).

Although the reasons for correlation or non-correlation between patient age and length of ICU stay are not presented by those researchers, it is well recognized that older patients require more time for functional recovery (Brosseau et al., 1996). In addition, increasing age is associated with increasing risk of acquiring nosocomial infections (Smith, 1989; Saviteer et al., 1988; and Emori et al., 1991). The consequence of the high prevalence of health problems may induce older patients to have prolonged ICU stay.

In summary, there is evidence that patient age is related to cost of intensive care and length of ICU stay. Older patients have lower costs than younger. The lower cost for older patients may be related to a preference of the patients, their families or healthcare providers. In terms of length of ICU stay, reviewed studies showed prolonged ICU stay in older patients. Physical health problems may account for longer ICU stay. However, patient age may not be an independent factor influencing cost of intensive care and length of ICU stay. There are some confounding factors that may account for the associations such as severity of illness, sex, and ethnicity.

Severity of Illness

Severity of illness is another factor that has a significant effect on cost of intensive care and ICU length of stay. Severity of illness has been defined as the degree and impact of change on health status of an individual as a result of illness or injury (Kreitzer, Loebner, & Roveti, 1982). It reflects current patients' physiologic functions as indicated by the most general and fundamental indicators of body functions such as vital signs, serum electrolytes, hematological findings, arterial oxygenation and levels of consciousness or neurological functioning (Iezzoni, 1994). Measures of severity of illness are used most commonly to predict risk of death for gravely ill patients. There are several tools for assessing severity of illness for critically ill patients such as the Acute Physiology and Chronic Health Evaluation (APACHE), the Simplified Acute Physiology Score (SAP), and the Sequential Organ Failure Assessment (SOFA). The first version of APACHE contains information on 34 physiologic parameters (Knaus, Draper, Wagner, & Zimmerman, 1985), but in producing APACHE II, Knaus and colleagues found that 12 physiologic parameters retained acceptable statistical performance. SAP and SOFA use fewer variables. SAP contains 11 physiology parameters, whereas, SOFA contains only six variables. The ability of these tools in predicting mortality was validated in adult intensive care units of many countries in Europe, North America and Thailand (Ferreira, Bota, Bross, Melot, & Vincent, 2001; Janssens et al., 2000; Knaus et al., 1985; Le Gall, Lemeshow, & Saulnier, 1993; Ranistha, Thanakitiwirun, Vilaichone, Thongyoo, & Permpikul, 2005). Results demonstrated that these tools performed well in such setting.

Severity of illness has been reported as a major contributor to variation in costs of intensive care. Rapoport, Teres, Lemeshow, Avrunin and Haber (1990) explored relationship between severity of illness and costs of care in ICUs. The results showed that cost per patient day for survivors was increased with increasing severity of illness scores ($\beta = 37.22$; $p = 0.001$). For non-survivors, cost decreased as severity of illness scores rose ($\beta = -20.29$; $p = 0.05$). They also found that the relationship between severity of illness and cost was non-linear, as severity scores increased from low levels, costs increased at a decreasing rate, reached a plateau, and eventually declined. This may be that many of the sickest patients die early in the ICU course, thus, they are not costly as long-term patients. Another study reported that severity of patient illness, measured by the APACHE II system, was a predictor of variations in average daily costs ($\beta = 0.2$, $p < 0.001$) and one additional point in the APACHE II score added £8 to the cost for one day (Jacobs et al., 2001). The results of this study lead to the conclusion that severity of illness may not be responsible for a large portion of costs of care in intensive care units.

A number of recent studies demonstrated an association between severity of illness and patient costs in the first day of patient admission. Using different costing methodologies, results supported a statistically significant relationship. Ridley et al. (1991) conducted a retrospective study with 20 patients admitted to a general intensive care unit and showed that severity of illness, taken on admission, could be used to predict the costs of treatment for the first 24 hr ($\beta = 14.3$, $p < 0.05$). Edbrooke et al. (1997) examined the relationship between severity of illness and costs of ICU care for the first 24 hours of a patient's stay. Data from the bedside monitoring equipment and a central file server were collected. Patient costs were calculated by the activity-based costing methodology. Findings indicated a highly statistically significant correlation between severity of illness at admission and costs of care for the first date of admission ($p < 0.01$). Similarly, Stevens et al. (1998) conducted a retrospective study with 145 patients admitted to an adult general ICU. The investigator estimated daily costs of care by using the micro-costing methodology and found that the correlation between total costs of care and scores of severity of illness was poor ($p > 0.05$). However, the correlation between severity of illness and costs of care for the first 24 hours was statistically significant ($p < 0.001$).

Apart from the relationship between severity of illness and costs of intensive care, the effect of severity of illness on ICU length of stay has also been documented. Kanus, Wangner and Zimmerman (1993) conducted a study to evaluate variation in length of intensive care units. The investigators collected data from 54 ICUs in 40 hospitals in United States and found that patients with higher age and severity of illness had prolonged ICU lengths of stay ($R^2 = 0.15, p = 0.01$). Another study in Saudi Arabia showed that the group of patients who stayed in an ICU for more than 14 days had a significantly higher mean scores of severity of illness than the other ($p = 0.016$) and also reported that patients with low severity of illness or with very high severity of illness had a shorter ICU stay, probably because they required intensive care for a short period only, then they got discharged from the ICU or died early in the ICU course (Arabi, et al., 2002). Similarly, two studies based on patients admitted to surgical ICU in Thailand demonstrated a higher mean score of severity of illness, as measured by the APACHE II and SAPS II, was associated with a prolonged length of ICU study (Bunburaphong et al., 2001; Kongsayreepong et al., 2006).

However, contrasting findings were documented in some studies. Woods et al. (2000) collected data from 22 Scottish intensive care units over a 2-year period. Results illustrated no linear relationship between severity of illness and length of ICU stay. The authors noted that increasing mortality probability was associated with increased ICU lengths of stay until a predicted mortality of 50% and thereafter with a decrease. They also demonstrated a difference relationship between ICU survivors and non-survivors. For survivors there was a consistent increase in length of stay with an increasing severity of illness score. After a predicted mortality of 50%, length of stay had reached a plateau. The relationship for non-survivor was quite different in that the length of stay decreased when a predicted mortality was more than 30%. Marik and Hedman (2000) conducted a prospective cohort study with 750 patients admitted to medical and surgical ICUs of a community teaching hospital. When the relationship between severity of illness and ICU length of stay was examined, findings demonstrated a poor correlation between the various measure of length of stay and severity of illness. The last study reasoned that patients with a high severity of illness score would die early in the hospital stay. Another study based on a total of 10,900 critically ill medical, surgical and trauma patients indicated that medical conditions at 24 hours, specially, presence of coma, infection and ventilator dependency 24 hours were more important predictors of prolonged length of ICU stay (Higgins, McGee, Steingrub, Rapoport, Lemeshow, & Teres, 2003). Infection and ventilation at 24 hour both increased an excess ICU LOS by two- or four-fold ($p < 0.001$). Coma at 24 hours decreased the chance of prolonged ICU stay ($p < 0.001$), presumably because of the high mortality and the likelihood that decisions on withdrawal of support would be made more rapidly in critically ill patients. Their conclusion was that admission severity of illness was insufficient by itself to explain prolonged ICU that other factors, including medical conditions at 24 hour and organizational characteristics of the ICU, were also considered.

In summary, the factors that comprise the severity score e.g., heart rate, Pao_2 represent the most common and significant indicators of physiological equilibrium. If patients have high severity of illness scores, they should require more intensive treatments and nursing care for recovery. The reviewed studies showed inconsistent relationships between severity of illness, cost of intensive care and length of ICU stay. However, there is evidence to hypothesize that the highest cost and prolonged length of ICU stay may occur in the patients with the middle values of severity. Patients with low risk of death tend to spend a lower cost and short time in the ICU. Conversely, patients with extremely high probability of death are likely to demonstrate either rapid improvement with therapy or death early in the ICU stay.

Nutritional Status

Nutritional status is defined as the state of energy, protein and other specific nutrients in the human body (Royal College of Physician, 2002). It may reflect in either well-nutrition or malnutrition. The term *malnutrition* refers to a nutritional disorder status resulting from reduced nutrition intake or impaired metabolism (American Society for Parental and Enteral Nutrition, 1995). The state of impending under-nutrition, or increased nutrition risk, has also been included in the term (Coats, Morgan, Bartolucci, & Weinsier, 1993; Reilly, Martineau, Moran, & Kennedy, 1995).

The diagnosis of malnutrition is generally based on objective measurements of nutrition status. These include assessment of anthropometric, biochemical, immunological parameters, functional tests, and indirect noninvasive techniques, such as bioelectric impedance analysis. Anthropometric assessments consist of body weight, triceps skin fold and mid-arm muscle circumference. Patient's weight is the most important information in the initial assessment. Body weight, however, may not be a reliable factor in an ICU patient who has edema, ascites or fluid balance derangements (Bruun, Bosaeus, Bergstad, & Nygaard, 1999). Tricep- skin fold and mid-arm muscle circumference are of little value in the case of critically ill patients, in whom major changes in body composition are likely to alter the relationship between subcutaneous and total body fat (Manning & Shenkin, 1995). Laboratory tests can objectively detect nutritional problems in their early stages, before changes in weight occur or physical signs and symptom develop. When the primary objective of nutrition therapy is to preserve or restore body protein, assessment of this nutrition component is essential. Serum albumin is the laboratory measurement most frequently used to screen for nutritional problems. A serum albumin concentration 3.2 gram per liter is arbitrarily considered indicative of protein depletion. Other laboratory tests that are used to assess byproduct of protein catabolism are nitrogen balance. Since 90% of daily nitrogen loss resulting from protein catabolism is excreted in the urine, nitrogen balance can be computed for clinical purpose as nitrogen intake minus urine urea nitrogen plus 4 grams (Dudek, 2001). The 4-gram factor accounts for stool and skin losses. Patients who are catabolizing protein more rapidly than they are synthesizing protein have a negative nitrogen balance. Patients who are rebuilding protein stores have a positive balance. Most adults will have a zero nitrogen balance, meaning they are catabolizing and anabolizing protein at about the same rate. An additional laboratory test involves investigating nutritional problems on competence of immunization. Protein-calorie malnutrition decreases the total number of lymphocytes, which impairs the human integrity to flight infections (Green & Harry, 1987). Total lymphocyte counts of less than 2,000 cells per cubic millimeters or 25 % of total number of white blood cells is indicative of protein-calorie malnutrition. A variety of laboratory tests are used to assess nutrition status for critically ill patients. Serum albumin level may be good predictors of malnutrition in patients requiring mechanical ventilation (Huang et al., 2000) and critically ill patients with renal failure (Anderson & Wochos, 1982). Total protein level, albumin level and lymphocyte count may be a good predictor in critically ill patients undergoing elective surgery (Velanovich, 1991). However, these nutritional indices likewise need further examination in term of outcomes for ICU patients.

Malnutrition is a serious problem for critically ill patients. Average energy intakes between 49% and 70% of requirements have been reported (Barr, Hecht, Flavin, Khorana, & Gould, 2004; Binnekade, Tepaske, Bruynzeel, Mathus-Vliegen, & de Hann, 2005; Krishnan, Parce, Martinez, Diette, & Brower, 2003; McClave et al., 1999;

Rubinson, Diette, Song, Brower, & Krishnan, 2004;). Giner et al. (1996) reported that 44% of patients in ICU were malnourished. More interestingly, Huang et al. (2000) studied patients admitted to the ICU of Taichung Veteran General Hospital in Taiwan and found that more than 90% of the critically ill patients with mechanical ventilation support were malnourished on the first day of patient admission. Proposed reasons for this are that critically ill patients using ventilators have an inability to express hunger and eat normally because verbal communication with others may interfere with the ventilators. Moreover, underfeeding was frequently due to elective stoppages for procedures and airway management or due to gastrointestinal intolerance (McClave et al., 1999; O'Leary-Kelley, Puntillo, Barr, Stotts, & Douglas, 2005). Inadequate oral nutrient intake (IONI) during the time of increased nutrition demand exacerbates protein-energy malnutrition. The longer the IONI periods, the effect of mucosal atrophy on delaying a return to mormal enteral nutrient uptake (Shaw-Stiffel, Zarny, Pleban, Rosman, Rudolph, & Bernstein, 1992).

Effect of malnutrition on variations of hospital cost and length of stay has been documented. Most of recent studies show a higher cost and length of hospital stay in malnourished patients. Early work by Epstein et al. (1987), who studied the relationship of nutrition status to LOS and total hospital charges in patients who underwent elective surgery, found that cost and LOS were higher in extremely underweight (body weight less than or equal to 75 %) patients. Patients who were extremely underweight had mean lengths of stay 40 % longer (30.1 vs 21.5 days) and total charges 35% higher ($26,447 vs $19,576).

Chima et al. (1997) studied the association between nutrition status and hospital cost. Patients were classified to be at risk or not at risk for malnutrition based on weight for height, serum albumin and history of weight loss. Results showed that mean hospitalized cost per patient was high in the at risk group (\$6,196 vs \$4,563, $p < 0.02$). Of these patients, 12% of at risk patients received enteral feed, while 4% of the patients not at risk received the feeding.

Two studies assessed the nutritional status of patients using subjective global assessment (SGA). Braunschweig et al. (2000) found that declines in nutrition status during hospitalization were associated with higher hospital charges (\$34, 336 vs \$ 45,762, $p < 0.004$), longer LOS (16 vs 19 days, $p < 0.03$) and greater risk of complication (50% vs 62%, $p < 0.03$). Isabel, Correia and Waitzberg (2003) illustrated that malnourished patients represented a mean daily expense of \$ 220 per patient compared to the \$ 138 per patient in the well nourished. This represented an increased cost of 60.5% for malnutrition. When the cost of medicines and tests were added using respiratory infection patients for comparison, the costs of care for malnourished patients rose three times when compared with the well-nourished patients.

In Thailand, Ritsri (2002) studied the effect of declines in nutrition status on outcomes in adult patients hospitalized in four medical wards. Nutrition status of the patients was assessed by using subjective global assessment (SGA). One hundred and forty-five patients were assessed for their nutritional status on admission, every seven days during hospitalization and on the discharge date. Fifty-eight patients (40%) were malnourished on admission. Twenty-five patients (17.2%) suffered from a lower nutritional status at discharge, regardless of their nutritional status at admission. Patients who suffered from a lower nutritional status during hospitalization had a significantly higher percentage of complications than those who did not (56.0% vs 23.3%, $p = 0.002$). In addition, LOS was significantly longer (16.8 vs 8.1 days, $p = 0.001$) and the hospital charge was significantly higher (68,076.04 vs 31,042.06 baht, $p = 0.001$) in the patients with lower nutritional status.

There is some published evidence that malnutrition status can affect length of ICU stay. Murray, Marsh, Wochos, Moxness, Offord and Callaway (1988) studied variables for assessment of nutrition to identify critically ill patients at increased risk for longer stay in ICU and for becoming ventilator dependent. The researchers enrolled 111 patients admitted to the medical and surgical ICUs. Results illustrated that serum albumin was negatively correlated with the number of ICU days ($r = -0.38$; $p < 0.001$). A low serum albumin was also inversely correlated with the number of hospital days and days on a ventilator. Another study, based on the assessment of nutritional status of patients using a level of serum albumin and a weight to height ratio, also reported that length of hospital stay was longer in malnourish patients, particularly during their stay in the ICU ($p = 0.06$) (Giner et al., 1996). A recent study including 200 medical ICU patients showed that nutrition support promoting the use of early enteral nutrition was able to improve lung function and even to reduce length of ICU stay (Barr et al., 2004). In contrast, delaying the initiation of nutrition support exposed patients to energy deficits that cannot compensated during the remaining ICU stay, this resulted in increasing length of stay and death risk in critically ill patients (Villet et al., 2005). Based on this evidence, accurately assessing nutritional requirements and monitoring the adequacy of nutritional intake in critically ill patients can help ensure that complications associated with malnutrition status are avoided. Although nutrition support, such as enteral feeding and total parenteral nutrition, will increase the use of resources in hospitals, it has been essential in hospitalized patients, especially those who are critically ill.

Many factors could be explained why malnutrition may contribute to increased length of stay and cost of care in hospitals. Malnutrition interferes with organs and systems of the human body and causes patients to present with impaired immune function, digestion and absorption (Bower, 1990). Muscle dysfunction, especially of thoracic muscles, might cause a higher incidence of pneumonia (Rochester & Esau, 1984). Malnutrition may contribute to prolonging mechanical ventilation. It decreases the regeneration of respiratory epithelium, and reduces the efficiency of respiratory muscle strength and ability to restore oxygen (Christman & McCain, 1993).

Unfortunately, disease and nutrition interact whereby the disease may cause secondary malnutrition, or malnutrition may adversely influence the underlying disease (Braunschweig et al., 2000). This makes it difficult to conclude that malnutrition alone leads to worse outcomes. However, evidence coming from Braunschweig and colleagues (2000) showed that a dose response association between changes in nutrition status and the major outcome variables remained when controlling for the presence of current diseases. Ljungqvist, Nygren and Thorell (2000) illustrated that an overnight fasting blood sugar in a well-nourished individual, a patient scheduled for surgery, led to peripheral insulin resistance. This appeared to contribute a simultaneous negative nitrogen balance in the postoperative period. Therefore, it may be assumed that malnutrition is one of the risk factors associated with poor outcomes in conjunction with other risk factors.

In summary, malnutrition is one of the most important factors that interfere in health and cause diseases. The negative impact caused by malnutrition on patient's outcomes has been reviewed and demonstrated that patients who suffered from a lower nutritional status during ICU hospitalization had a significantly higher percentage of complications, longer length of ICU stay and higher costs than those who did not. Because under-nutrition in critically ill patients tends to be a serious problem, knowledge of the extent of malnutrition in these patients is needed. Major studies investigating whether malnutrition influences length of stay and cost were limited to patient admitted to general units. Previous studies in intensive care units are insufficient and not very comprehensive. Thus, further research is needed to valid results and studies with intensive care units.

Day and Time of Patient Admission

Prior studies reported that patients admitted to a hospital on a weekend experience worse outcomes than those admitted on a weekday. Bell and Redelmeier (2001) found that patients with serious medical conditions, such as a ruptured abdominal aortic aneurysm, or acute epiglottis, are more likely to die in the hospital if they are admitted on a weekend than if they are admitted on a weekday. Similarly, Cram, Hillis, Barnett and Rosenthal (2003) demonstrated that the adjusted odds of death for patients admitted on weekends when compared with weekdays was 1.03 ($p = 0.005$). Among patients admitted on weekends, three diagnoses (cancer of the ovary/uterus, duodenal ulcer and cardiovascular symptoms) were significantly associated with increased mortality. Furthermore, increased mortality among weekend admissions was larger in teaching hospitals compared with non-teaching hospitals ($OR = 1.13$ vs. 1.03, $p = 0.03$). More recent findings showed that admission during nighttime shift or after 5.00 p.m. has increased mortality rate 21% ($OR = 1.21$, $p = 0.03$) (Hillson, Rich, Dowd, & Luxenberg, 1992).

There is some published evidence that day of patient admission and access to health care services can affect LOS. Sheng et al. (1993) assessed whether the lack of weekend cardiac test availability contributed to hospital discharge for low-risk chest pain patients. The results showed that patients with late-week admissions had a 19% greater LOS than did patients admitted earlier in the week (2.36 ± 1.87 vs 1.91 ± 1.21 days, $p = 0.10$, and with $p = 0.015$ after adjusting for severity of illness). A study based on stroke patients in Germany showed that LOS is associated with the day of the week that patients was admitted (Schmidt, Taeger, Buecker-Nott, & Berger, 2003). Among patients with acute exacerbation of COPD in Spain, de la Iglesia et al. (2002) indicated that weekend admission was associated with a prolonged length of stay, which they defined as more than three days ($OR = 4.17$; $p<0.05$). Another study in Singapore found that critically ill patients admitted on Friday, Saturday or Sunday stayed on average 0.31 days longer than those admitted on weekdays, after adjusting for sex, age, type of admission ($p < 0.001$). This study also indicated that patients admitted in the afternoons and after office hours had a longer LOS (Earnest, Chen, & Seow, 2006).

The effect of date and time of patient admission on outcome may be related to personnel and procedural issues. The number of nursing staff as well as the laboratory and diagnostic tests in acute care hospitals tend to be lower on weekends and non-office hours (Czaplinski & Diers, 1998; Lefton & Lefton, 1998; Tarnow-Mordi, Hau, Warden, & Shearer, 2000). In addition, people who work in hospital during these times often have less seniority and experience (Mckee & Black, 1992; Thorpe, 1990). Delays in the care of hospitalized patients may lead to increase length of stay, iatrogenic complication and costs. Carey, Sheth and Braithwaite (2004) conducted a prospective survey in a tertiary care university hospital. Data were collected on 2,762 patient days. Results showed that 13.5% of all hospital days were judged unnecessary for acute inpatient care, and occurred because of delay in needed services. Sixty three percent of these necessary days were due to non-medical service delays and 37% were due to medical service delays. The majority of non-medical services delays (84%) were due to difficulty finding a bed in a skilled nursing facility. Medical service delays were most often due to postponement of procedures (54%) and diagnostic test performance (21%) or interpretation (10%). Furthermore, nearly one fourth of unnecessary patient days (24% overall, 88 patient days) involved an inability to access medical services on a weekend day or Saturday or Sunday.

Although ICUs are organized with continuous coverage by consultants and a very high nurse to patient ratio, the reality of fewer staff and limited access to laboratory or diagnostic tools on weekend and non-office hours makes it unclear as to whether or not the effectiveness of intensive care is the same depending on the day and time that patients are admitted. Results of ICU studies that examine the effect of day and time of ICU admissions on outcomes are mixed. Some previous studies showed patients admitted to an ICU on weekends had a worse outcome when compared with those admitted on weekdays. For example, Barnett et al. (2002) conducted a retrospective study with patients admitted to 38 ICUs in 28 hospitals in the United States. They reported that patients admitted to an ICU on a weekend had 9% higher risk for death and longer mean ICU lengths of stay (4.4 ± 5.7 vs 3.8 ± 4.8 days, $p < 0.001$), compared with patients admitted on weekdays. Uusaro et al. (2003) conducted a cohort study using a national ICU database of 18 ICUs in Finland. The findings indicated that the risk of dying was higher in weekend admissions. Ensminger et al. (2004) determined the relationship between weekend ICU admission and the adjusted hospital rate of critically ill patients in a tertiary care academic medical center. Results were consistent with other researches that found that the mortality rate of patients admitted to surgical ICU on a weekend was higher than that of patients admitted on a weekday.

On the other hand, some studies failed to identify an association between admission days, the time of patient admission and outcome of patients admitted to ICU. Wunsch, Mapstone, Brady, Hanks and Rowan (2004) found that day and time of day of patient admission to ICUs were not associated with hospital mortality after adjustment for case mix. Morales, Peters and Afessa (2003) collected data from 6,034 patients admitted to medical ICUs over a 5-year period. Patients were divided according to the time of patient admission into daytime or from 7.00 a.m. to 5.00 p.m. and nighttime admission. They did not find an increase in hospital mortality rate or length of ICU stay in patients admitted to the ICU at nighttime. The suggestions from the last authors were that nighttime admission to an ICU was not associated with poor outcomes as long as adequate staffing and services were maintained. Uusaro et al. (2003) compared the rate of death among patients admitted on a weekday out-of-office hours with the rate among patients admitted during office hours. The results illustrated that mortality was not increased for patients who were admitted to ICU from 16.00 hours to 08.00 hours.

In conclusion, the first few hours following admission to a hospital are crucial because initial diagnoses and treatment plans are formulated during that period. Limited access to laboratory or diagnostic tools on the weekend may lead physicians to delay diagnosis as well as decide to implement important treatments. Furthermore, people work in hospital on weekends and out of office hours often have less seniority and experience than those who work on weekends and office hours. The reduction in these resources may be vulnerable to adverse effects and increased cost and length of ICU stay. However, there have been inconsistent results that examine the effect of day and time of ICU admissions on patient outcomes. The effect of day and time of ICU admissions on cost of intensive care is rarely found in the literature. Thus, the impact of day and time of ICU admission on outcomes, including cost and length of ICU stay, deserve much more investigation.

Nurse Staffing

Nurse staffing variables are commonly found in the research literature examining the impact of nurse staffing levels on patient mortality, patient falls, medical errors or other patient outcomes (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002; Kovner, Jones, Zhan, Gergen, & Basu, 2002; Mark, Harless, McCue, & Xu, 2004). These variables include the ratios of registered nurses (RNs) to patients, hours per patient day, staff hours, the ratios of RNs to other nursing staff and RN qualifications. Each of nurse staffing variables provides different information about how nurses are assigned to care for their patients and work with each another. Using RN to patient ratios, hours per patient day as well as staff hours provides information about the appropriate utilization of nurse staffing in terms of number of nursing staff per patient day. Skill mix, expressed as the ratio of RNs to other nursing staff, provides information about the appropriate utilization of nurse staffing in terms of workloads shared between RNs and non-RNs. RN qualifications, expressed in the ratios of the total number of RN years of experience to the total number of staff, indicate the efficiency of using registered nurses with more years of nursing experience. Theoretically, registered nurses with more years of nursing experience are expected to provide higher quality care and thus positively impact patient outcomes.

In an era of dwindling reimbursement and rising health care costs, hospitals have been compelled to restructure work environments to deliver health services at lower costs without decreasing the quality of health care (Heinz, 2004). As a result of restructuring and increasing attention to costs, hospitals have opted to decrease their overall labor pool, including the number of full time nursing positions (Kuenen, 1996; Norrish & Rundall, 2001). Efforts to enhance operational efficiency have led to changes in nurse staff patterns, including the employment of fewer RNs and the replacement of professional nurses with unlicensed assistive personnel (Barkell, Killinger, & Schultz, 2002). Significant cost reduction by reducing RNs was supported by recent studies. Hanrahan (1991) demonstrated significant cost reductions appear to be possible by replacing RNs with assistant personnel who are usually not trained in these disciplines prior to employment. Hamm Vida (1990) suggested that approximate $100,000 to $200,000 per annum was spent in non-nursing duties performed by registered nurses. Another report indicated that $ 20 per hour reduction could be saved by substituting a patient care assistant for a RN (Hesterly & Robinson, 1990). A more recent report has suggested that by using six RNs and eight nurse assistants instead of eleven RNs, a hospital could save approximately $40,000 in annual salary costs (Eastaugh & Reagon-Donovan, 1990). However, the size and skill of the health care workforce to adequately meet patients' needs has become a growing concern (Norrish & Rundall, 2001). Increased caregiver workload and declining numbers of RNs have threatened the quality of care and patient safety (Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky, 2003).

Reducing RN positions have been the subject of much discussion in the professional literature. Several studies examined the impact of a decreased number of RNs on patient outcomes, finding increased patient mortality, rates of failure to rescue, incidence of nosocomial infections, pressure sores, medical errors, and patient falls (Aiken et al., 2002; Cho et al., 2003; Kovner et al., 2002; Rogers, Hwang, Scott, Aiken, & Dinges, 2004; Sasichay-Akkadechanunt, Scalzi, & Jawad, 2003). Furthermore, findings have shown that reducing RNs was associated with decreased patient satisfaction (McGillis, Hall, Doran, & Pink, 2004).

The availability of RNs and professional nursing skills may also affect costs of care. In studies that analyzed the relationship between nurse staffing and hospital costs, increasing the number of RNs and providing more RN hours per patient day might contribute to improved patient outcomes, especially reducing nosocomial infection, pneumonia, and other healthcare complications, while in turn decreasing hospital costs (Behner et al., 1990; Cho et al., 2003; Lee, Yeh, Chen, & Lien, 1999; McGills et al., 2004; Schultz, van Servellen, Chang, McNeese-Smith, & Waxenberg, 1998). Significantly reduced overall costs by increasing the number of experienced nurses was reported by Bloom et al. (1997). The relationship of lower costs was explained in part by the higher efficiency of experienced staff. The investigators noted that hospitals with more experienced nursing staff had lower non-personnel costs. This would be because experienced nursing staff provided more efficient and effective health services as well as lower consumption of resources. Although increasing the number of RNs was positively related to increasing hospital expenditures, it did not significantly affect hospital profit. In contrast, greater non-registered nurse hours caused not only higher hospital expenditures but also lower profits as well (McCue, Mark, & Harless, 2003).

Nurse staffing levels may affect length of hospital stay. Increasing the number of RNs and providing of more RN hours per patient day was associated with a shorter length of stay among medical patients (Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky., 2002), patients with GI haemorrhage (Flood & Diers, 1988), acute myocardial infarction patients (Shultz et al., 1998) and patients with abdominal aortic surgery (Newhouse, Johantgen, Pronovost, & Johnson, 2006). The results in reducing length of stay were explained in part by the higher efficiency of nursing care activities. Adequate RN staffing levels creates good infection control practices and permits them to adhere to aseptic techniques and high standards of care (Cho et al., 2003; Schultz et al., 1998). Moreover, there was evidence that the workload of RNs tended to increase with the employment of unlicensed assistive staff due to the requirement for supervision and correction of errors (Mackinnon, Clarke, England, Burr, Fowler, & Fairservice, 1998).

Although recent studies provide evidence of an association between nurse staffing levels on patient outcomes, few have examined this relationship in the ICU setting at the unit level. Blegen, Goode and Reed (1998) examined the relationship between the proportions of hours for care delivered by the RNs and adverse events in 42 nursing units. Four of these units were ICUs. The ICUs had higher rates of decubitus, infections and medical errors than other units with a lower proportion of RNs.

The relation of structural characteristics to patient outcomes was previously examined. Thorens, Kaelin, Jolliet and Chevrolet (1995) investigated the impact of reducing nurse-patient ratios and the time taken to wean patients with chronic obstructive pulmonary disease from mechanical ventilation. Although this study was not based explicitly on a one-to-one nurse-patient ratio, its outcomes revealed that when the nurse-patient ratio was reduced, there was a dramatic increase in the time taken to wean patients. Reduction in the number of RNs has been shown to adversely affect nosocomial infection rates (Archibald, Manning, Bell, Banerjee, & Jarvis, 1997), and patient deaths (Tarnow-Mordi et al., 2000). Similarly, Kovner et al. (2002) found that patients who have surgery in hospitals with fewer RNs per patient have a greater risk of developing avoidable complications, such as urinary tract infections, pneumonia, thrombosis, and other pulmonary complications.

A number of studies examined the relationship between nurse staffing level, length of ICU stay and cost of intensive care. Pronovost et al. (1999) demonstrated that patients who undergone abdominal aortic surgery and who were cared in ICUs with lower nurse staffing levels was associated with a significant increase in ICU length of stay. A ratio of one nurse to three or more patients on the day shift was also associated with an increased likelihood of respiratory related complications and contributed to an increased length of ICU stay. Dang, Johantgen and Jenckes (2002) extended the above analysis by including nurse staffing on all shifts in ICUs and controlled nursing unit variables that were not examined in Pronovost's study. The study contributes to the growing evidence supporting the relationship between nurse to patient ratio and length of ICU stay. Similarly, Lassnigg et al. (2002) documented the length of ICU stay associated with patient to nurse ratio. Among patients who had undergone coronary artery surgery, valvular surgery, heart transplantation, thoracic aortic surgery or other cardiac interventions, a high patient to nurse ratio in the ICU was associated with an increased length of stay ($p = 0.0001$).

The importance of levels of nurse staffing on cost of intensive care has been highlighted in two recent studies. By using a observational cohort study performed in a surgical ICU, Amaravadi et al. (2000) found that median length of stay and direct hospital costs for patients with a night-time nurse to patient ratio (NNPR) of one or two patients (<1:2) was greater than those with a NNPR of three or more patient ratio (>1:2). The NNR of three or more patient ratio was associated with a 39% ($OR = 1.39$; $p < 0.001$) increase in LOS, a 32% ($ 4,810; $OR = 1.32$; $p < 0.001$) increase in hospital cost, approximate two times ($OR = 2.4$; $p < 0.01$) risk of pneumonia, and approximate four times ($OR = 3.6$; $p<0.05$) the occurrence of septicemia. The results of this study address a particular aspect of the impact of nursing on patient outcomes. Nursing care takes on an increased importance at night, when physician and ancillary service staffing is typically decreased. As the number of patients each nurse cares for increased, the time that devoted to each patient decreased. The decreased level of care from low nurse to patient ratios may lead to pulmonary and infection complications that may account for increased LOS and cost for postoperative patients. Recently, Dimick et al. (2001) reported the effect of nurse staffing levels on clinical and economic outcomes after hepatectomy. ICU nurse to patient ratios in a nigh-shift were not associated with mortality rates in ICUs. However, the occurrence of reintubation increased with a fewer RNs at night time ($OR = 2.9, p = 0.04$).

Some proponents of reduced nurse-to-patient ratios in intensive care argued that sophisticated monitoring equipments enable such a cost reduction. Monitor alarms might be viewed as a replacement, rather than an adjunct, to expert nursing surveillance. However, in a study undertaken in Australia, the investigators found that the majority of incidents (83%) such as reintubation, air way obstruction were detected by personnel visually checking the equipment, patient or chart. Monitor detection accounted for only eight per cent of critical incident reports (Beckmann, Baldwin, Hart, & Runciman, 1996). Similarly, a study undertaken in ICUs in Hong Kong showed that 51% of incidents were detected by direct observation, as opposed to 27% by monitor detection (Buckley, Short, Rowbottom, & Oh, 1997). This led the investigators to conclude that, despite the advances in technological expertise, there was still no substitute for properly trained professionals providing direct patient care (Beckmann et al., 1996; Buckley et al., 1997).

In summary, research examining the relationship between nurse staffing, cost and length of stay reflected that significant costs and length of stay reductions may be possible through the availability of nursing personnel in the health care setting. A sufficient number of RNs and appropriate staff mix employed may have prevented the patient adverse events that caused patients to stay longer than necessary. In addition, the increasing number of RNs may reduce cost of intensive care because RNs had higher levels of knowledge and skills to provide more effective health service as well as lowered patient resource consumption. However, most studies examining the relationship between nurse staffing, cost and length of stay were limited to patients admitted to general wards. Few studies in intensive care units where highly specialized areas of the hospital and widely different from general wards. Therefore, further research is needed to validate results and studies with intensive care units.

Conceptual Framework of the Study

Donabedian's structure-process-outcome (SPO) model (1966, 1980, 1988, 2003) served as the foundation for the conceptual model of this study. The SPO model has been recognized to be a useful framework in health service research including patient outcomes. The model introduced three major approaches to assessment of quality: structure, process and outcome.

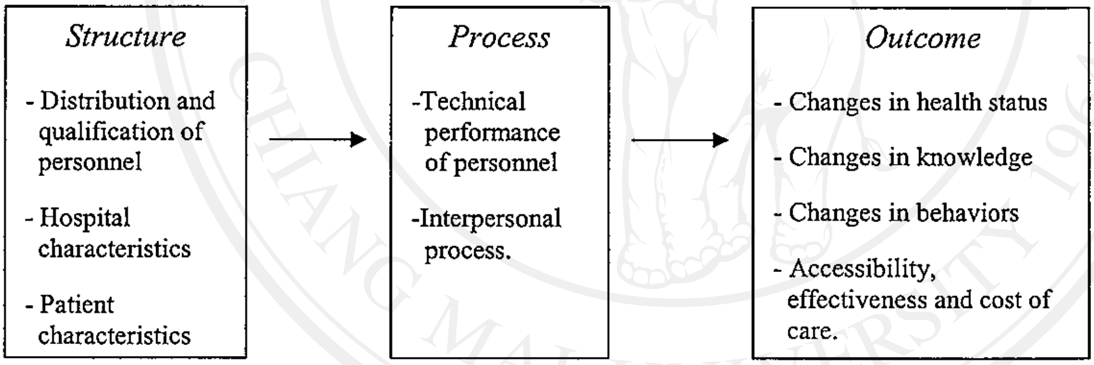

Figure 1: Donabedian's structure-process-outcome (SPO) model

As shown in Figure 1, elements of structures are defined as the relatively stable characteristics of the service: the distribution and qualifications of personnel, and hospital characteristics, such as number, size, equipment; and geographical distribution of hospitals and other facilities. It also includes client characteristics, such as age, gender, and severity of illness. Taken together, these elements of the structure constitute the environment of care. Structure is relevant to quality in that it increases and decreases the probability of good performance. The existence of better elements of structure, i.e. a sufficiency of resources and appropriate organizational system, is the most important means of protecting and promoting the quality of care.

Process of care refers to a set of activities that go on within and between practitioners and patients. There are two aspects of the treatment process rendered by physicians and other health professionals: a technical aspect and an interpersonal aspect. Technical performance depends on knowledge and skill in implementing procedure and is judged according to the practice which is known or thought to produce the best improvement in health. The interpersonal process refers to the human interaction which occurs between providers and patients as well as among providers. The judgment of quality is not inherent to the characteristics of the process itself. It derived from a relationship, established in advance, between process and outcome.

Outcome is defined as a consequence attributable to antecedent care which are taken to be the desired or undesired state, resulting from structures and care process. Outcomes of medical care are defined as changes in health status, knowledge, behavior, and various aspects of care including accessibility, effectiveness and costs. Further, he asserted that structure, process and outcome measures are not independent but are linked in an underlying framework. Good structure should promote good process and good process in turn to promote good outcome.

The interrelationships of concepts in the SPO model allow the investigator to identify the potential relationships of the variables interested. As shown in Figure 2, patient characteristics--patient age, severity of illness, nutrition status-- are recognized as structure variables of the study. These characteristics are hypothesized to influence care provided by health care professionals and in turn to affect the outcomes of care costs of intensive care and length of ICU stay.

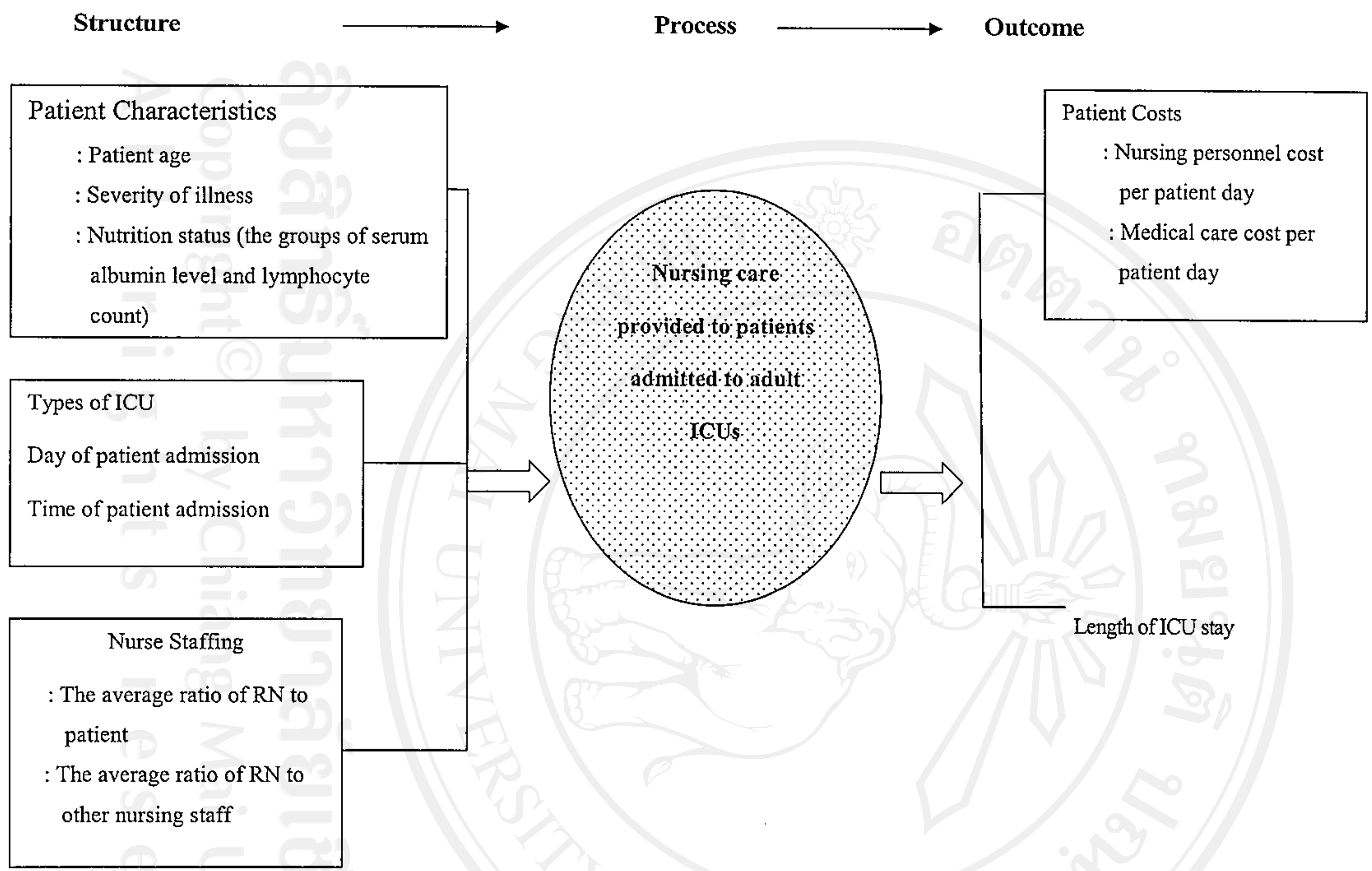

Figure 2: Conceptual framework of this study

Four organizational factors-- types of ICU, day of patient admission, time of patient admission and nurse staffing --are also recognized as the structural elements of the SPO model and related to outcomes of the study. Admission to an ICU on weekend and/ or non-office hours is hypothesized to increase costs of care and length of ICU stay. The effects on costs of intensive care and length of ICU stay may be related to personnel and procedural issues. Staffing level and facilities in hospitals tend to reduce on weekend and non-office hours. The reduction in these resources may lead physicians to delay diagnosis and providing important treatments. This causes patients to get worse and worse and need extensive resources and times for recovery. In terms of nurse staffing level, reviewed studies have shown that increasing the number of registered nurses to patient and the proportion of registered nurses to other nursing staff may contribute to reduce cost of care and length of ICU stay. The relationship between nurse staffing and outcomes has been explained in part by the higher efficiency of nursing care in the ICU. As the numbers of RN increase, the times that they can devote to each patient increase, and result in reducing patient's complications and decreasing LOS and costs of care.