Delayed discharges from an adult intensive care unit (ICU)

Teresa Williams

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Delayed Discharges from an Adult Intensive Care Unit (ICU)

Author: Teresa Williams

Student Number

Edith Cowan University

Master of Health Science (by Research)

Principal Supervisor: Dr Gavin Leslie, RN, PhD, Post Grad Dip (Clin Nurs), FRCNA

Date of Submission: 15 March 2003
Declaration

I certify that this thesis does not, to the best of my knowledge and belief:

(i) incorporate without acknowledgment any material previously submitted for a degree or diploma in any institution of higher education;
(ii) contain any material previously published or written by another person except where due reference is made in the text; or
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Signed: [Redacted] Date: August 2003
Acknowledgment

The author wishes to thank the following people for their invaluable assistance:

- Dr Gavin Leslie, Coordinator, Nursing Professional Development Unit, Royal Perth Hospital / Associate Professor Critical Care, Edith Cowan University for his encouragement and support during this study.

- Ms Julien Harris, Business Manager, Critical Care Division, Royal Perth Hospital for providing information and support during this study.

- The shift coordinators in the intensive care unit at Royal Perth Hospital and

- The Executive of Royal Perth Hospital who provided access to data, research facilities and time release to conduct this study.
Abstract

Introduction
Maximising efficient and effective use of resources without compromising quality of care is essential in the current healthcare climate. Intensive care unit services are one of the most resource intensive and therefore expensive services within a hospital. Because intensive care unit services comprise a significant portion of hospital costs and resources, appropriate utilisation of intensive care units is imperative. The occurrence of delayed discharges and the reason for these delays is important as they impact on the efficiency and effectiveness of intensive care unit services. Patients who no longer need intensive care unit care block beds for impending admissions, unnecessarily utilise the costly and often scarce resources, and by remaining in a stressful environment may experience negative psychological and social effects detrimental to their well being.

Study Objectives
To determine to what extent delayed discharge from the intensive care unit occurs and ascertain the reasons for these delays.

Design
A prospective cross sectional design to determine the number of delayed discharges from the intensive care unit and reasons causing the delay. A discharge was considered to be delayed if the patient was not discharged from the intensive care unit within 8 hours of being deemed suitable for discharge by intensive care unit medical staff.

Setting
A level III intensive care unit with 22 beds (12 general and 10 surgical beds in 2 adjacent areas) in a metropolitan tertiary teaching hospital of 955 beds located across two campuses.

Sample
A prospective convenience sample of consecutive patients admitted over a 6-month period from September 2000 to March 2001. Exclusions were patients who died whilst in the intensive care unit and those patients who could be discharged prior to
Method
Intensive care unit medical staff informed nursing shift coordinators when patients could be discharged. The nursing shift coordinators completed the data collection tool on all patients discharged from intensive care unit. Admission and discharge times and APACHE II data (a predictive scoring system for ICU patient outcome) were recorded from intensive care unit records.

Results
There were 652 discharges, 468 patients were not delayed (71.8%), 176 were delayed (27.0%, 95% CI 23.9% – 30.7%) and 8 (1.2%) patients had no delay information available. There were substantial delays in discharging patients from the intensive care unit; for every 5 discharges that were not delayed, 2 patients would be delayed. Unavailable ward beds (81%) were cited as the main reason for delay in discharge. Delay time from the intensive care unit ranged from 0.2 hours (10 minutes) to 617.5 hours (3 weeks, 4 days, 17.5 hours). Mean delay time was 42 hours (1 day, 18 hours) and median delay time 21.3 hours. There was a statistical significance difference between non delayed and delayed patients for APACHE II score on admission ($t = -3.824$ (642), $p < 0.0001$) and worst APACHE II score in first 24 hours ($t = -5.123$ (642), $p < 0.0001$). There was also a statistically significant difference between delay from the intensive care unit and non delayed discharge by admitting diagnosis (chi sq (12) = 43.235, $p < 0.0001$); primary organ system failure (chi sq (6) = 14.231, $p = 0.027$); ward destination (chi sq (7) = 51.486, $p < 0.0001$); specialty (chi sq (23) = 43.371, $p = 0.006$) and day of eligible discharge (chi sq (6) = 34.008, $p < 0.0001$).

Conclusion
Discharge from the intensive care unit is delayed on average by 27% in the study hospital. These delays can be related to how sick the patient was, principle admitting diagnosis, discharge destination and weekend discharge. Reducing these delays would free up beds for other admissions, may result in a cost saving for the health care facility through more efficient resource utilisation and ultimately benefit patients by better managing the discharge process.
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CHAPTER 1

Introduction

Maximising efficient and effective use of resources without compromising quality of care is essential in the current healthcare climate. Intensive care unit services are one of the most resource intensive and therefore expensive areas within hospitals. Because intensive care unit services comprise a significant portion of hospital costs and resources, appropriate utilisation of intensive care units is imperative.

Intensive care units are dedicated areas within a hospital, providing special expertise and facilities to care for the critically ill. Intensive care services provide advanced therapeutic interventions using the highly developed knowledge and skills of its caregivers supported by advanced technology to provide observation, care and treatment of patients with life-threatening illnesses that are potentially reversible. Intensive care units aim to restore vital organ functioning in order to gain the time to treat underlying causes (Acute Health Division, Department of Human Services, 1997). The status of patients should be revised continuously to identify those patients who may be admitted to, and those who may be discharged, from the intensive care unit. Admission and discharge criteria should be used by the medical staff to guide this decision making process (Australian Council on Healthcare Standards, 1997; Faculty of Intensive Care, Australian and New Zealand College of Anaesthetists, 1997).

Discharge from the intensive care unit is just one part of the interrelated processes occurring during a patient’s continuum of care. Like any system, changes to one part may impact on other parts of the system. It could be postulated that delays in discharge may result from processes internal or external to the intensive care unit and these will impact on the patient’s continuum of care. Delays in discharge from the intensive care unit are potentially costly to health care facilities. Patients who no longer need intensive care unit care block beds for impending admissions, unnecessarily utilise the costly and often scarce resources, and by remaining in a stressful environment may experience negative psychological and social effects detrimental to their well being (Franklin & Jackson, 1983; Jacobs, van der Vliet, van Roozendaal, & van der Linden, 1983).

When considering the management of intensive care much attention has been focused on improving efficiency and effectiveness of the scarce intensive care unit resources. Intensive care unit utilisation, imbalance of supply and demand, admission and discharge criteria, rationing of intensive care unit beds, use of predictive scoring systems, control of intensive care unit costs and changing processes to better utilise the available intensive care unit resources have been explored. Discharge delay from the intensive care unit has received very little attention. Groeger et al. (1993) observed that 11% of critical care patients were delayed in their discharge out of the intensive care unit after considered ready for discharge. Both Levin and Sprung (2001) and Southgate (1999) noted a lack of vacant ward beds within the hospital may lead to delayed discharge of patients from intensive care unit thus blocking beds that may be used for patients requiring intensive care. Lack of intermediate care beds has also resulted in patients having their discharge delayed from the intensive care unit (Fox, Owen-Smith & Spiers, 1999; Southgate, 1999). A flow-on effect can also be observed where patients cannot be discharged from intermediate care beds to general hospital beds preventing the discharge of intermediate care-ready patients occupying intensive care unit beds (Acute Health Division, Department of Human Services, 1997). How well quantified these issues are remains to be explained.

The purpose of this study was to explore whether delays in discharge from an Australian adult intensive care unit occur and the reasons for such delays. Patients were deemed suitable for discharge from the intensive care unit by intensive care unit medical staff. Intensive care unit nursing staff primarily managed the discharge process. A prospective observational study, with no attempt to influence the discharge process, was used due to the exploratory nature of the research question.

Appropriate utilisation of intensive care units' resources is imperative to contain health care costs by improving the efficiency and effectiveness of intensive care unit services. If unnecessary delays in discharge from the intensive care unit occur, then health care providers need to determine the extent of the problem and identify the reasons in order that this problem may be addressed.
CHAPTER 2

Literature Review

2.1 Introduction

This review of the intensive care unit literature describes the current knowledge regarding the discharge of patients from the intensive care unit, thus providing a background into the issues involved and the impact that delay in discharge has upon this process.

In understanding the discharge process from the intensive care unit, it is important to consider the environment in which the discharge of patients from the intensive care unit occurs. Maximising efficient and effective use of resources without compromising quality of care is essential in the current health care climate. A description of the healthcare environment is followed by a deeper examination of intensive care unit services within this environment.

For there to be effective and efficient intensive care unit services, there must be an adequate supply of services to meet an appropriate demand. Demand for intensive care unit services often appears to outstrip supply. Factors that impact on the demand and supply of intensive care unit resources include how intensive care unit services are allocated, use of admission, triage and discharge criteria, role of intermediate care units and the influence of pressure on supply of intensive care unit beds when demand is not met. All these issues can influence the discharge process from the intensive care unit. Delays in discharge also impact on bed availability in the intensive care unit.

Intensive care unit services are one of the most resource intensive and therefore expensive services (Chalfin, Cohen & Lambrinos, 1995; Fakhry, Kercher & Rutledge, 1996; Henderson, 1997; Singer, Myers, Hall, Cohen & Armstrong, 1994). The benefits derived from intensive care unit care should outweigh the costs. Costs and benefits of intensive care unit care are briefly explored in the ensuing discussion in order to provide
an understanding of some of the issues involved and some of the options that are available to reduce costs and maximise resources. Delaying a patient’s discharge from the intensive care unit could possibly increase the costs of intensive care unit care.

Discharge from the intensive care unit, and the effect that the delay in discharge has from the intensive care unit is then considered. Discharge from the intensive care unit is but one part in the patient’s continuum of care. This process begins before the patient arrives at the hospital, continues as the patient moves through various departments including the intensive care unit and ends when the patient is discharged from hospital or death (Levin & Sprung, 2001). Change to any one factor within the complex system of interrelated factors may influence or may be influenced by any other aspect of the process. Consideration of all parts of this continuum of care are therefore fundamental to understand the discharge process and the interrelated factors that may delay a patient’s discharge from the intensive care unit. Delay in discharging impacts on economic, psychological and physical aspects of patient care.

Unavailability of hospital beds may result in a patient’s discharge being delayed from the intensive care unit. It has been suggested in the study hospital that unavailability of hospital beds is a prime reason for delay in patient discharge from the intensive care unit. One area that affects unavailability of beds is the health care facility’s bed management strategy. Ineffective bed management can affect a patient’s admission to, and discharge from the intensive care unit if beds are blocked in areas outside the intensive care unit. Problems in effectively managing beds within the health care facility may precipitate a delay in discharge from the intensive care unit.

2.2 Search Strategy

Several methods were used to identify relevant articles. A computerised literature search of online databases MEDLINE (1966 to 2003), EMBASE (1966 to 2003), CINAHL (1982-1996), and the Cochrane Library (1966 to 2003) was conducted. Searches were restricted to the English language, adults and humans. Relevant abstracts were reviewed and the articles identified from these assessed. The reference lists of all
articles were examined for additional papers not identified during the computerised search. Key words used for the search were "intensive care," "critical care," "utilisation," "length of stay", "discharge".

2.3 The Healthcare Environment

Healthcare systems address the health issues of individuals with widely differing physical, psychological and economic needs. Rational choices must be made among competing possibilities for the ideal distribution of health services that may result in conflicting ethical issues (Engelhardt & Rie, 1986).

Despite the great differences between developed nation health care systems, all have conflicting challenges with the rapidly changing financial, technological and political environments, rising expectations and the need to contain health care costs (Duckett, 1995; Henderson, 1997; Hensher, Edwards & Stokes, 1999; Knaus, Wagner & Lynn, 1991). As new therapies and technologies increase costs, the gap between what can be done and what can afford to be done widens, forcing health care providers to examine how resources are allocated (Barnett & Shustack, 1994). Appropriate utilisation of expensive resources is essential in the changing health care environment.

Governments have attempted to control the costs of health care by cutting global budgets or limiting payment for services with resultant structural and operational changes (Chen, Martin, Keenan & Sibbald, 1998; Henderson, 1997). There has been a worldwide reduction in length of hospital stays and improved efficiencies in developed countries (Comptroller and Auditor General, National Audit Office, 2000; Hensher, Edwards & Stokes, 1999). Slightly increased admission rates (substantial increase in the United Kingdom), average length of stay and number of beds per 1000 population consistently decreasing (especially in Scandinavia) and fairly static occupancy rates have occurred in selected Organisation for Economic Cooperation and Development countries (Hensher, Edwards & Stokes, 1999). This indicates a large increase in the throughput (Acute Health Division, Department of Human Services, 1997; Hensher, Edwards & Stokes, 1999). Although some developed countries have experienced reductions in admissions, the global trend is increasing admission rates and falling bed
numbers. There is probably no “right” number of beds provided, rather the focus should be on the development of flexibility to manage uncertainty and be capable of coping with surges in demand without creating the potential for further increased admissions through the operation of supplier induced demand (Hensher, Edwards & Stokes, 1999) or ineffective systems which result in increased re-admissions.

International comparisons of key indicators must be interpreted with care. There is no international consensus on concepts, definitions, and method of calculation in compiling health statistics. However, comparisons can demonstrate “important international trends in the way care is delivered and how hospital systems are changing and evolving over time” (Hensher, Edwards & Stokes, 1999, p. 848).

An indication of the affordability of the country’s health system is given by the relationship between expenditure on health services and Gross Domestic Product (Australian Institute Health and Welfare, 2000). Australia’s health services expenditure to Gross Domestic Product ratio increased from 8.3% in 1997-98 to 8.5% in 1998-99. This ratio has been growing slowly from 8.1% in 1991-92 to 8.3% in 1997-98. The higher than average real growth in expenditure between 1997-98 and 1998-99 of 5.3% combined with a slight slowing in Gross Domestic Product caused the ratio to increase significantly to 8.5% in 1998-99. The nominal growth rate for health services expenditure in 1998-99 (7.1%) was almost 50% higher than Gross Domestic Product growth of 4.8% (Australian Institute Health and Welfare, 2000). Labour accounts for approximately 80% of health costs (Duckett, 2000).

The demand for health care services will always exceed supply (Society of Critical Care Medicine Ethics Committee, 1994). Limitations on access to health care may be inevitable. The increasing demand for health care services, increasing health care costs, evolution of financially closed health systems and increasing prevalence and power mechanisms constraining health care expenses support this premise (American Thoracic Society, 1997). Explicit guidelines facilitate the fairest use of health care services in an environment of relative scarcity (Engelhardt & Rie, 1986; Kalb & Miller, 1989; Society of Critical Care Medicine Ethics Committee, 1994; Strauss, LoGerfo, Yeltatzie, Temkin & Hudson, 1986). The need to decide, when health care resources
are limited, as to who will receive them, is common to all health care systems.

Factors driving up demand and costs include increased access to health care, increased number and improved survival of patients with disproportionately high medical needs, increased use of new and expensive diagnostic and therapeutic modalities and the widespread belief of the power of medicine and the desirability of technological achievements (American Thoracic Society, 1997; Rosenberg & Watts, 2000; Zimmerman, Wagner, Draper & Knaus, 1994). Accountability for health outcomes and cost containment is essential within this health care environment.

### 2.4 Healthcare and the Intensive Care Unit

Within the health care environment, intensive care unit services utilise scarce health care resources. They are particularly expensive with costs continuing to grow (Buist, 1994; Cerra, 1993; Chalfin, Cohen & Lambrinos, 1995; Cullen, 1977; Fakhry, Kercher & Rutledge, 1996; Halpern, Bettes & Greenstein, 1994; Henderson, 1997; Jacobs & Noseworthy, 1990; Singer, Myers, Hall, Cohen & Armstrong, 1994). Since the intensive care unit inpatient costs is a significant proportion of the hospital budget, the efficiency of providing such care is a prime concern to health care planners (Cerra, 1993; Jacobs & Noseworthy, 1990). Efforts to improve the efficiency of intensive care units may significantly impact on reducing hospital costs (Cooper, Sirio, Rotondi, Shepardson & Rosenthal, 1999).

Intensive care units are seen as symbols of modern high technology medicine, responsible for the survival and successful recovery of a large number of critically ill patients. They are highly valued by survivors and their significant others and the significant others of non-survivors (Danis, Patrick, Southerland & Green, 1988; Fakhry, Kercher & Rutledge, 1996). However, specialities such as an adult intensive care unit which are perceived as very expensive yet benefit only a tiny proportion of the community are particularly vulnerable in a health care environment of increasing budgetary restriction (Henderson, 1997). New ways of practising intensive care medicine should bring into harmony tensions such as the benefit of individuals versus
that of the community, ethics, best clinical practice, compassion and fiscal reality (Cerra, 1993; Henderson, 1997).

Intensive care units service a heterogeneous population of patients with differing diagnosis and illness severity and varying unit arrangements (Knaus, Draper, Wagner & Zimmerman, 1986; Rubins & Moskowitz, 1988). Intensive care units concentrate sophisticated technology and expertise and require substantial investments in personnel, physical and emotional effort, space and equipment (Cullen 1977; Hanson et al., 1999; Vincent, 1990). Intensive care unit patients suffer from severe illnesses, multiple system dysfunction and often coexisting medical problems (Weissman, 1997). Large procedural and pharmacological costs associated with intensive care units are further increased because this patient population is susceptible to complications that prolong stays and alter outcomes (Hanson et al., 1999).

Intensive care unit resources refer not only to the beds, but also the professional staff and capacities of physiological monitoring and invasive diagnostic and therapeutic interventions (American Thoracic Society, 1997, p.1285). Intensive care unit care is an increasingly expensive speciality (Henderson, 1997). Whilst health care costs and expenditure have risen steadily, intensive care unit care costs have increased faster than other specialties (Edbrooke, Hibbert & Corcoran, 1999). Hospitals are treating more patients but the demand for intensive care is increasing at a greater rate suggesting that the demand may be generated from the hospital itself (Ridley, Burchett, Burns & Gunning, 1999). As medical and surgical technology increases and expertise improves, more patients, including those patients considered unsalvageable previously, receive care in intensive care units (Beck, Taylor, Millar & Smith, 1997; Lawrence & Havill, 1999). Rationalisation of acute care hospitals in the future towards institutions for major surgery, emergency medicine, and intensive care will promote an increasing importance of intensive care medicine to cater for the increasing population of seriously ill patients (Hillman, 1996).
2.5 Defining the Intensive Care Unit

"An Intensive Care Unit (ICU) is a specially staffed, and equipped, separate and self-contained section of a hospital for the management of patients with life-threatening or potentially life-threatening conditions" (Joint Faculty of Intensive Care, Australian and New Zealand College of Anaesthetists, 1997, p.1). The resources available for providing intensive care unit care vary widely throughout the world making interpretation difficult because terminologies vary considerably (Edbrooke, Hibbert & Corcoran, 1999; King’s Fund Panel, 1989).

Intensive care is often discussed under the umbrella of critical care. However, critical care not only includes intensive care units, but may also include coronary care, intermediate care (high dependency care, step-down or step-up units), recovery room, cardiothoracic units, emergency departments and other environments where critically ill patients are cared for and treated, with no internationally agreed definitions on what this care comprises (Acute Health Division, Department of Human Services, 1997; Williams & Clarke, 2001). Intensive care, being limited to the confines of a physical location within an intensive care unit, is challenged by flexible nurse staffing, medical emergency teams, mobile technology and the growth of subacute care for chronically ill patients (Rubenfield et al., 1999, p. 358).

The specific definition of an intensive care unit also varies considerably. Intensive care unit organisational behaviour fluctuates considerably both between units within a country and also between countries, challenging comparability between them (Angus, Sirio, Clermont & Bion, 1997). Variations include:

- definitions of intensive care
- size of intensive care units
- levels of care
- open or closed units
- staffing resources, nursing and medical
- number of admissions
- patient case mix
• occupancy rate
• mortality rate
• source of elective admissions
• cancelling elective procedure policy.
• percentage of mechanically ventilated patients

Variation in organisation structure may be demonstrated by the results from the European Prevalence of Infection in Intensive Care (EPIC) study which observed important differences exist in the organisation of individual hospital units in Europe. Differences in health care expenditure clearly account, in part, for the variability (Vincent, Suter, Bihari & Bruining, 1997).

2.6 Intensive Care Unit Bed Provision

There is great variation in intensive care unit bed numbers between countries and within different regions of a country. The number of intensive care unit beds not only depends on the definition of the intensive care unit (whether other types of critical care bed types are included or excluded), but also involves a number of factors including whether beds are open or closed, staffed or not staffed, provided with mechanical ventilators or not (Dobb, 1999). The classification of intensive care units is often made to the mean level of care provided and not from the maximum care provided (Moreno & Reis Miranda, 1998).

Angus, Sirio, Clermont, & Bion (1997) have listed intensive care bed numbers (beds per 100,000 population) in selected countries:

<table>
<thead>
<tr>
<th>Country</th>
<th>Beds (per 100,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>38.4</td>
</tr>
<tr>
<td>United States</td>
<td>30.5</td>
</tr>
<tr>
<td>Germany</td>
<td>28.6</td>
</tr>
<tr>
<td>Spain</td>
<td>14.8</td>
</tr>
<tr>
<td>Japan</td>
<td>11.8</td>
</tr>
<tr>
<td>Italy</td>
<td>9.4</td>
</tr>
</tbody>
</table>
Selected studies concerning intensive care unit services, summarised in Appendix A, demonstrate some of the variation that exists in intensive care unit services between countries. For example, intensive care unit patterns differ between Canada and the United States (Boulanger et al., 1993; Jacobs & Noseworthy, 1990; Rapoport et al., 1995). Utilisation of intensive care units was found to be 2½ times more in the United States compared to Canada and the average length of stay shorter in Canada than in the United States (Boulanger et al., 1993; Rapoport et al., 1995). With such a variation in use of resources, both patient selection approaches cannot be optimal to maximise efficient use of intensive care services (Zimmerman et al., 1988). In the United Kingdom; intensive care unit care comprises 1 to 2% of total bed numbers, whereas in the United States it may be as high as 20% (Bennett & Bion, 1999).

The United Kingdom has fewer intensive care beds than other countries in Western Europe and resources are stretched, with a higher proportion requiring mechanical ventilation and nurse patient ratios of one-to-one to compensate for this increased workload (Edbrooke, Hibbert & Corcoran, 1999; Singer, Myers, Hall, Cohen & Armstrong, 1994). Edbrooke, Hibbert and Corcoran (1999) observed hospitals with lower mortality rates admit less severely ill patients. In the United Kingdom, patients were more severely ill when they were finally admitted, disadvantaged by late intervention, and had a higher mortality rate (Bennett & Bion, 1999; Edbrooke, Hibbert & Corcoran, 1999; Ryan, 1996; Vincent, Suter, Bihari & Bruining, 1997). Differences in clinicians attitudes, societal pressure, means of healthcare funding and hospital facilities can all influence intensive care unit utilisation (Barnett & Shustack, 1994).

Comparing intensive care unit bed numbers is also challenging because the definition of total hospital beds varies and the data for the same reporting period differ (Acute Health Division, Department of Human Services, 1997). Intensive care unit beds are commonly counted per head of population and as a percentage of total hospital beds. Comparing intensive care unit beds per head of population means that only the numerator varies and thus is more meaningful in terms of interpreting supply and
Angus, Sirio, Clermont and Bion (1997) examined issues hampering international comparisons needed to solve shared concerns regarding appropriate delivery of intensive care unit services. Issues investigated included challenges with the denominator ("at risk" population), numerator ("intensive care unit treated" population), risk adjusted models, outcomes including mortality and morbidity and resource consumption. The authors found that the choice of study design, definition of at-risk populations and choice of appropriate measures of output and cost influence study outcomes. The differences within systems, which impede comparison, require appropriate sampling techniques and weights to reflect the existing variation in order to capture overall performance of the system. The authors believe that the development of large patient databases would facilitate design and assessment of intensive care services between countries. With the development of appropriate techniques, the resultant information may lead to wiser decision-making in the design and management of intensive care unit services (Angus, Sirio, Clermont & Bion, 1997).

### 2.7 Cost of Intensive Care Units

Intensive care unit services are expensive (Elliott, 1997; Glance, Osler, & Shinozaki, 1998; Gyldmark, 1995; Lawrence & Havill, 1999; Surgenor, et al., 1998). They are expensive because they employ a large number of highly skilled health care professionals and utilise sophisticated technology and other costly interventions. A prime factor in the rise of health care costs has been the increasing use of new technology (American Thoracic Society, 1997). There has been a trend for more complex therapies in increasingly older patients in tertiary care intensive care units with a concomitant increase in workload (Jakob & Rothen, 1997).

The amount of money spent on intensive care units varies between countries. However, comparing costs between intensive care units is challenging. Intensive care units in the United States account for 20% of total hospital charges and in Canada 8%
Compared with the United States are difficult as the challenges experienced by the United States to contain costs occur in a very different health care delivery system to that of Australia or other developed countries in the world. The United States tends to overuse and have an oversupply of technology combined in some cases with poorer outcomes (Acute Health Division, Department of Human Services, 1997). Although critical care resource consumption in other countries does not approach that spent in the United States, it continues to be disproportionately high when compared to other health services (Chalfin, Cohen & Lambrinos, 1995). The United States is reported to spend 1% compared to the United Kingdom's half percent of Gross National Product on providing intensive care (McPherson, 2001). In the United States, market forces moderate the cost of health care with competition encouraged by payers to improve service and lower cost.

Compared to many developed countries, the United Kingdom spends less on health care and intensive care is perceived as a neglected and under-resourced service (Edbrooke, Hibbert & Corcoran, 1999; McPherson, 2001). The contracting process in the United Kingdom makes it difficult to account for intensive care unit costs partly because it does not have multidisciplinary specialty status and it is difficult to isolate costs from the structure of the finished consultant episode (Bennett & Bion, 1999). This may change as intensive care as a specialty becomes increasingly recognised in the United Kingdom (Bennett & Bion, 1999). It is difficult to manage an intensive care unit with fewer than 6 beds and it is not cost-effective yet almost half the intensive care units in the United Kingdom have less than 6 beds (Vincent, Suter, Bihari & Bruining, 1997).

Most of the costing studies from the United States are not directly applicable to the Australian context (Elliott, 1997). Much of the direct patient care in Australian intensive care units is given by nursing staff in contrast to that of the United States which employs respiratory technicians and other ancillary staff to deliver care. In Australia, no-one knows how much public adult intensive care unit care really costs, with intensive care unit costs often included within the hospital episode (Henderson, 1997). Intensive care funding in Australia is a particularly sensitive issue (Duckett, 1998). The variation in system-wide use of intensive care cannot be fully explained by epidemiological and demographic factors with funding arrangements for intensive care units varying considerably across States (Duckett, 1998). Casemix funding for health
care was introduced first in Victoria in 1993-94, and since then most States have moved towards either casemix funding or using casemix to inform the budget setting process. The five States implementing casemix have adopted some common funding elements: all use AN-DRG-3; all have introduced capping, most commonly at the hospital level; and all ensure accuracy of diagnosis and procedure coding through coding audits (Duckett, 1998). Two funding models have been developed, the fixed and variable model and the integrated model. The national critical care weights that have been developed for version 3 of the Australian National Diagnosis Groups (AN-DRG) classification system are not without their critics. Hindle (1994) believes that the system is a poor predictor of intensive care costs and lengths of stay as there is wide variability within Diagnosis Related Groups when compared to other cost components. The Diagnosis Related Group classification is useful when managing complete inpatient episodes, but is of little relevance to managing intensive care (Hindle, 1994, p.10). Elliott (1997) questions how the number of weighted Diagnosis Related Groups were derived for the intensive care unit with some of the Diagnosis Related Groups assigned to intensive care never being clinically represented in the intensive care unit and the number of patients per Diagnosis Related Groups and length of stay not specified.

Intensive care unit costs may not be fully reimbursed by funding agencies. In the United States, the diagnosis-related group payer system fails to compensate fully for the costs of intensive care units (Gyldmark, 1995). The costs of a patient's diagnosis calculated as the average costs of treating a (usually) large number of patients, forms the basis of diagnosis-related group payment. However, patients admitted to an intensive care unit are admitted on their severity of the illness, not on a diagnosis. Their requirements are above the average, and hospitals may lose financial resources if funding is based on this system.

The cost for a given diagnosis in the intensive care unit is determined by the intensity of services provided, the length of stay in the intensive care unit and the number of admissions to the intensive care unit (Barnett & Shustack, 1994). To reduce intensive care unit costs per stay, the length of stay must be contained (Barnett & Shustack, 1994). Factors affecting intensive care unit discharge may be very subjective and include bed availability, quantity and quality of nursing staff on general wards, the
existence of intermediate care facilities, and the experience of the intensivists. Delays in discharging a patient from the intensive care unit add to a patient’s length of stay, and therefore it is not unreasonable to assume that delays would increase costs.

Intensive care unit costs are both direct and indirect. The direct costs include all time consumption (medical, nursing and other staff time), use of laboratory services, drugs, consumables, and services carried out in the unit, such as cleaning and patient administration. Direct costs attributed to a patient’s care in the intensive care unit may be variable or fixed. Variable costs depend on the workload and resources used whereas fixed costs are independent of the workload. Workload within an intensive care unit is highly variable and often unpredictable. Indirect costs include overheads such as power, water, infrastructure maintenance, capital assets and services provided by other departments such as radiology, laboratory and human resources. These hidden costs form a large percentage of the budget and must be accounted for when evaluating costs in the intensive care unit (Singer, Myers, Hall, Cohen & Armstrong, 1994). The single largest item of expenditure in the intensive care unit is staff costs (Duckett, 1998; Slatyer, James, Moore & Leeder, 1986). Of these, nursing staff accounts for the highest staffing costs (Barnett & Shustack, 1994; Edbrooke, Hibbert & Corcoran, 1999; Elliott, 1997). The use of nursing staff is dependent on the various activities of the intensive care unit, and thus includes a fixed and variable cost component. The casemix and severity of illness of admitted patients, unit policies and practices of care play a major role in determining the use of intensive care unit nursing staff (Moreno & Reis Miranda, 1998). To reduce the cost of human resources, workload redesign to improve efficiency whilst maintaining quality of care is important. A strategy that may prove useful is considering who performs the different tasks within intensive care unit services so that non-value-adding workload for patients is reduced (Barnett & Shustack, 1994). Large reductions in spending on pharmacy and consumables are unlikely to provide considerable savings on the total budget (Singer, Myers, Hall, Cohen & Armstrong, 1994).

Data on costs for any resource-consuming activity are indispensable to assess efficiency of services, and this applies especially for intensive care units (Jegers, 1997). However, the real costs of intensive care units are not commonly available and are difficult to obtain (American Thoracic Society, 2002; Edbrooke, Stevens, Hibbert,
Mann & Wilson, 1997; Henderson, 1997). Thus there is a need to achieve a method of obtaining accurate patient costings which allows resource usage to be identified for individual patients treated within different clinical specialties in the intensive care unit (Edbrooke, Stevens, Hibbert, Mann & Wilson, 1997). The lack of clinically applicable cost accounting models which reflect the true costs of intensive care unit care currently limit the possibility of demonstrating cost effectiveness (Buist, 1994). As the costs of intensive care continue to increase, more detailed analysis of resource consumption and outcomes will need to be undertaken in order to facilitate more efficient budget management (Chalfin, Cohen & Lambrinos, 1995; Edbrooke et al., 1999). The effect of marginal variations in the allocation of resources to specific activities in the intensive care unit can then be modelled (Elliott, 1997, p. 55).

### 2.7.1 Measuring Costs

Cost-effectiveness analyses in the intensive care unit are hampered by the lack of data on the effectiveness of intensive care unit interventions, the complex nature of conditions patients have in the intensive care unit, supportive therapies that may not be directed at the underlying condition, the difficulty in obtaining accurate costs data, and the lack of standardisation for measuring costs (American Thoracic Society, 2002). Long term outcomes more suited for cost-effectiveness analyses are often not collected; and the burden of critical illness on family members is difficult to define (American Thoracic Society, 2002).

Part of the difficulty in costing intensive care unit care lies in the fact that intensive care unit care is usually only part of an episode of care and may not be costed or funded separately. Intensive care unit costs may be buried in the overall cost of a hospital admission. Various methods of costing patient care in the intensive care unit have been used. These include the use of average costs from dividing total annual expenditure by patient throughput, the average cost per patient being assumed to mean equal use of resources (Byrick, Minderoff, McKee & Mudge, 1980), the use of severity of illness and workload scoring systems (Atkinson et al., 1994; Loes, Smith-Erichsen, & Lind, 1987; Zimmerman et al., 1993) and the use of billing systems (Finkler, 1982). These studies have identified the costs of intensive care in isolation, without considering
their application and validity in the strategic planning and management of services (Edbrooke, Stevens, Hibbert, Mann & Wilson, 1997). No system adequately costs intensive care unit services (Jegers, 1997). The relationship between charges and costs is weak and not an appropriate method to study intensive care unit costs (Jegers, 1997). When costs are directly calculated, the cost figures do not represent the same cost components (Gyldmark, 1995). In studies where the intensive care unit management or outcome is the priority or where the costs of different intensive care units are compared, only direct costs, that is, those costs directly attributed to the functioning of the intensive care unit rather than overhead costs, are relevant (Chalfin, Cohen & Lambrinos, 1995; Gyldmark, 1995; Jegers, 1997; Shiell, Griffiths, Short & Spiby, 1990).

Health care costing methods include clinical costing (bottom-up) which captures data at the point of service delivery (Elliott, 1997). The large amount of data collected and sophisticated costing information systems used are often beyond the capabilities of public hospitals in Australia (Elliott, 1997). Cost modelling (top-down approach) starts with the total costs of a service's operations, distributes via patient care cost centres to a casemix category to produce an estimated cost for specific diagnosis related groups (Elliott, 1997, p. 58).

Clermont, Angus, Linde-Zwirble, Sirio and Pinsky (1996), using total charges, weighted length of stay and a computerised Therapeutic Intervention Scoring System, adapted from the Therapeutic Intervention Scoring System (Cullen, Civetta, Briggs & Ferrara, 1974) believe that the measures to assess costs correlated well (see Appendix A, table A.2). The system was subsequently tested in another institution with the authors asserting its validity (Herr, Clermont & Angus, 1998). Weighted length of stay was considered by the authors as a valuable measure of costs because of its high performance, simplicity and wide availability. The computerised Therapeutic Intervention Score measured intensive care unit resources using data from hospital bills. Hospital bills are not an accurate measure of intensive care unit costs (Finkler, 1982), limiting the results of this study.

Studies that employ hospital bills, particularly American studies, to calculate the total costs of intensive care units are thwart with difficulty (Gyldmark, 1995). Hospital
bills are not sufficiently accurate to measure intensive care unit costs (Chelluri, Grenvik & Silverman, 1995; Finkler, 1982). This is because it is difficult to relate costs to activity and/or patient (Gyldmark, 1995). Different patient groups cannot be compared using costs based on estimated hospital charges as they fail to include adequate costing methodology relying frequently on average costs or charges (Edbrooke et al., 1999). In addition, the costs included in different hospital billing systems may vary and may not take into account all the costs associated with a patient’s care. They do not include costs for medical staff. Excluding fixed costs, patients’ costs may vary according to the amount of resources used. Acknowledging that the charges do not reflect actual costs, a cost-to-charge index may be used to adjust the charges but it is difficult to ascertain what the final cost figure actually represents (Gyldmark, 1995).

The use of hospital charges as a equivalent measure for actual costs is questionable with some authors believing that no relationship exists between hospital costs and charges (Chelluri, Grenvik & Silverman, 1995; Finkler, 1982). Using the average bed day price and multiplying this with length of stay per patient to calculate the intensive care unit costs per patient does not reflect patient-specific resource use (Gyldmark, 1995). It assumes that the resource use is constant during the entire stay in the unit, which is inappropriate. The first hours after admission to an intensive care unit may be very resource-intensive. However, after these initial activities, the resource use does not follow a uniform picture, as some patients quickly become stabilised requiring fewer resources while other patients require more and more resources. “The assumption of a constant cost per day makes it impossible to study the relationship between costs, therapeutic activity, and outcome, as costs only depend on length of stay and have no empirical or theoretical relation to other factors that influence resource use” (Gyldmark, 1995, p. 966).

A routine calculation of the cost of an individual intensive care unit patient is feasible using computerised patient data management system that stores all the activities of care delivered to an individual patient (Edbrooke, Stevens, Hibbert, Mann & Wilson, 1997). The activity based costing methodology determines the patient-related or direct costs of care for individual patients. The total costs of care for an individual patient are the sum of the patient related costs of care and a proportion of the non-patient-related costs associated with running the intensive care unit. It ignores hospital overheads. It
was not possible to ascertain how the cost of each activity was determined from this study report. The non-patient-related costs such as rates, utilities and energy were calculated by apportioning the total hospital bill by the percentage of floor area that the intensive care unit occupies. Nevertheless, it is a useful costing model. However, such sophisticated information systems required for data collection may not be available in many intensive care units. Data collection should occur within the staffing and budget constraints of an individual intensive care unit (Elliott, 1997).

2.7.2 Cost Comparisons

The costs per patient that are reported in the literature vary tremendously (Gyldmark, 1995; Surgenor et al., 1998). Some of the studies concerning intensive care unit costs are outlined in Appendix A, table A.2. There are substantial differences in the costs of treatment and care per patient in the intensive care unit. Gyldmark (1995) outlines several reasons for this including:

a) technological changes have affected costs in both a negative and a positive way;

b) patients vary between studies with regard to healthcare needs, severity of illness, age, diagnosis, and other characteristics. Some units treat only medical patients, while other units treat surgical patients or both types of patients. Patient case mix and variation in severity of illness should be adjusted in order to compare results across studies;

c) unit characteristics such as unit size, staffing, treatment policies, and research and training activities may differ widely and thus influence costs;

d) possibilities for treatment and care in the various units may be very different, and may thereby contribute to diversities in both the selection of patients treated and the therapeutic activity of the unit. Intensive care units that use state of the art equipment to provide more services may increase the cost of treatment (and improve outcome);

e) the method for costing services varies widely leading to methodological bias which may not reflect actual differences.
What the literature often fails to acknowledge is that intensive care units tend to care for the sickest patients, irrespective of admitting diagnosis. These patients are a heterogenous group and display a wide variability in terms of severity of illness and patient acuity. Intuitively, cost-effectiveness should vary according to casemix and acuity but most economic studies in critical care neglect this, grouping patients together (Chalfin, Cohen & Lambrinos, 1995, p. 956).

The consistency and quality of cost studies of intensive care units are problematic, hampering quality research and economic planning (Bone, 1995; Bone, McElwee, Eubanks & Gluck, 1993a). The methodologies for costing intensive care unit care are often flawed and fail to provide correct answers (Gyldmark, 1995). Methodological bias is often introduced as the studies employ different methods to measure costs. In addition, the costing methodology applied in many studies is wrongly specified in relation to the purpose and viewpoint of these studies (Gyldmark, 1995). This is in part due to the study questions not being adequately specified in many studies and the cost concept often not suited to the purposes of the study. Using standardised models for determining intensive care unit costs will improve intensive care unit costing studies (Clermont, Angus, Linde-Zwirble, Sirio, & Pinsky, 1996; Edbrooke et al., 1999; Gyldmark, 1995; Sznajder et al., 2001). Despite their complexity, a standardised costing model will facilitate better, faster, and more reliable costings, improving quality, facilitating best practice, proving comparability of studies, and their ultimate utility (Bone, 1995; Edbrooke, Stevens, Hibbert, Mann & Wilson, 1997; Gyldmark, 1995; Rie & Glessner, 1999; Weinstein, Siegel, Gold, Kamlet & Russell, 1996). Differences in resource use and/or outcome may be more systematically evaluated and thereby variations may be related to costs by whatever factor is left uncontrolled (Gyldmark, 1995).

2.7.3 Costs and Performance

The relationship between cost and outcome is complex (Slatyer, James, Moore & Leeder, 1986). The perception of intensive care as a costly specialty is based on a purely accounting approach (Sznajder et al., 2001). The allocation of resources should be related to outcomes in performance including long term survival, quality of life after
intensive care unit care and patient preferences (Weinstein, Siegel, Gold, Kamlet & Russell, 1996). Quality of life studies after intensive care have shown positive outcomes (Hurel, Loirat, Saulnier, Nicolas & Brivet, 1997; Jacobs, van der Vliet, van Roozendaal & van der Linden, 1988; Mundt et al., 1989). Performance measures such as the standardised mortality ratio based on physiological scoring systems such as Simplified Acute Physiology Score (SAPS) II (Le Gall, Lemeshow & Saulnier, 1993) allow broad comparisons between different intensive care units but not individual measurements (Barie, Hydo, & Fischer, 1996; Lemeshow, Klar & Teres, 1995; Bion, 1995; Schafer et al., 1990). The cost and quality of life after intensive care has received relatively little attention in the literature (Ridley, Biggam & Stone, 1994).

Slatyer, James, Moore & Leeder (1986) found in an Australian study into costs, severity of illness and outcomes in 100 intensive care unit patients that there was no evidence to suggest any association between costs and subsequent quality of life of survivors. They also noted there was a strong association between survival and total admission costs confirming 'high risk is high cost'. Although this study was conducted several years ago and the follow-up time was relatively short, one month post intensive care unit discharge, it is one of the few studies that has measured direct intensive care unit costs using an appropriate and accurate costing methodology that is still relevant today. Cost benefit analysis can relate allocated resources with outcomes to measure cost effectiveness. Cost effective analysis and cost utility analysis can be used to compare alternative health care options. Although intensive care is said to be expensive when compared to other health services, Sznajder et al. (2001) demonstrated a moderate cost benefit for intensive care units (see Appendix A, tableA.2).

Comparing outcome and performance between different intensive care units continues to be difficult because of enormous differences between case mix, severity of illness, comorbidities, social expectations, medical culture and recording methodologies (Bion, 1996; Knaus, Draper, Wagner, Zimmerman & Draper, 1993; Zimmerman et al., 1988). In the intensive care unit context, illness severity is likely to be the major determinant of outcome and cost. Severity standardisation of patients with critical illness, however, has proved more difficult than might have been expected (Henderson, 1997). There are a number of severity scoring systems, all have limitations and none are universally
2.7.4 Expensive Care?

Despite the widely held belief that intensive care unit care is expensive, not all people endorse that view, especially when consideration is given to the cost of other programs and the preventative, monitoring and early intervention functions of the intensive care unit in order to avoid morbidity and mortality.

Stockwell (1999) estimated costs using data from a study into the prevention of coronary heart disease with pravastatin in men with hypercholesterolaemia. He believes that the costs were not very different from that of intensive care units. Stockwell (1999) concluded that intensive care is not expensive compared with other treatments in the United Kingdom. Stockwell’s (1999) comparison of costs of a preventative public health strategy with the cost of intensive care may be challenged. The true intensive care unit costs were unsubstantiated estimates prohibiting a realistic comparison.

Gyldmark (1995) discusses the costs to a hospital of an intensive care unit. Intensive care units are assumed to save (or prolong) life for patients admitted to them. If critically ill patients are not admitted to the intensive care unit but survive they may have a prolonged length of stay due to failure to provide timely and appropriate intervention. Costs to the hospital may be greater from this increased morbidity than those incurred had the patient been admitted to an intensive care unit. As it is not known which patients would have survived, it is difficult to calculate the exact costs to the hospital of an intensive care unit (Gyldmark, 1995).

2.7.5 Reducing Costs

Adult intensive care touches the lives of very few whilst consuming a disproportionately high level of resources (Bashour et al., 2000; Henderson, 1997). Cost savings might be achieved by determining the factors involved in the allocation of intensive care unit resources. Detsky, Stricker, Mulley and Thibault (1981) attempted
to define the factors determining the allocation of resources to critically ill patients more precisely (see Appendix A, table A.3). The authors concluded that in the critically ill, prognostic uncertainty is important in determining resource expenditures. Predictive ability would improve when there is a better understanding of the natural history of specific acute illnesses and the effectiveness of specific intensive interventions (Detsky, Stricker, Mulley & Thibault, 1981).

Between 5 and 15% of patients successfully discharged from the intensive care unit subsequently die whilst still in hospital (Bion, 1995; Franklin et al., 1988; Ridley & Purdie, 1992; Rowan et al., 1993a; Rowan et al., 1993b; Snow, Bergin & Horrigan, 1985; Wallis, Davis & Shearer, 1997). Many of these patients had prolonged stays and used a significant proportion of intensive care unit resources. Fifty percent of health care resources have been estimated to be consumed by patients who die, most of who use intensive care unit resources even after it is recognised that these patients will die (Dawson, 1993). The mean cost of patients who die has been estimated as 75% greater than survivors in one Australian hospital (Henderson, 1997). Lawrence and Havill (1999) estimated that patients who died in the ward after discharge from the intensive care unit stayed twice as long in the intensive care unit and consumed more than twice the resources per patient than the group of survivors (see Appendix A, table A.15). Richter, Pajonk and Waydhas (1999) assert that only a small percentage of patients require surgical intensive care unit treatment of 30 days or longer, but these patients consume a substantial amount of personal and financial resources.

Patients who require prolonged stays in the intensive care unit are relatively few yet consume a disproportionate amount of total intensive care unit and hospital direct cost (Bashour et al., 2000). Patients with prolonged stay often have different outcomes to that expected. Many factors are involved in the decision to continue care. Zimmerman (1999) believes there is a need to recognise patients at risk from prolonged stay, re-evaluate those who are admitted to the intensive care unit and how short and medium term intensive care unit patients are cared for. More research is required to recognise patients at risk from prolonged stay early in their intensive care unit course so that less costly alternatives may be better utilised.
2.7.6 *Withdrawal of Care*

Life can be prolonged in the intensive care unit without improving long-term survival. Decisions to withhold or withdraw life support necessitate balancing two unattractive possibilities, failure to provide life support to patients who may have an acceptable functional outcome and failure to withhold or withdraw life support for those patients who have little likelihood of returning to an acceptable level of function. Short-term survival may result in unnecessary pain and suffering. The provision of futile care impacts on costly and scarce resources and is demoralising for intensive care unit staff (Nasraway, 2001). There is no widely adopted descriptive statement of futility (Helft, Siegler, & Lantos, 2000). Identifying the point when further care is futile is central to avoid prolongation of the dying process (see Appendix A, table A.1). It is determined by ‘gut instinct’, often based on years of experience from which intensive care unit caregivers can sense the point of hopelessness (Nasraway, 2001).

Withholding and withdrawal of treatment decisions are becoming more common as we strive to keep pace with our ability to keep patients alive whilst helping patients regain a reasonable quality of life (Barnett & Shustack, 1994; McLean, Tarshis, Mazer & Szalai, 2000; Prendergast & Luce, 1997). Prendergast and Luce (1997) estimate 90% of intensive care unit deaths are preceded by decisions to limit life-sustaining medical treatment (see Appendix A, table A.4).

Wong, Gomez, McGuire and Kavanagh (1999) observed that more than 80% of the intensive care unit day-one predictions of the risk of death were not sufficiently accurate to support withdrawal of therapy decisions (see Appendix A, table A.4). The predictions of those patients with a high probability of death by various scoring systems were more accurate for groups of patients rather than individual patients. Withdrawing intensive care based solely on prognostic scoring systems will result in some patients unnecessarily dying, as these predictive scoring systems do not have 100% specificity to predict outcomes. Including changes in physiological variables over time rather than just at admission should prove to be more accurate (Wong, Gomez, McGuire & Kavanagh, 1999). Glance, Osler and Shinozaki, (1998) found only a small proportion of survivors reach a threshold that would support decisions to withdraw therapy (see Appendix A, table A.4). The authors concluded that it was unlikely that the incremental
cost-effectiveness gained by using APACHE III (Knaus et al., 1991) scores as the basis to withdraw care was sufficient to justify their use. Zimmerman (1999) doubts that improved prognostic scoring systems are likely to substantially impact on overall utilisation of intensive care unit days. In the SUPPORT study to improve end-of-life decision-making and reduce the frequency of a mechanically supported, painful and prolonged process of dying, the group demonstrated that physicians do not make use of readily available daily probabilities which should track individual patients. For high probabilities study patients there was no reduction in intensive care unit length of stay or in “do-not-resuscitate” usage (The SUPPORT Investigators, 1995).

Decisions to withdraw treatment remain in the province of the intensivists but should be made by the intensivist and patient and/or significant others with the patient and their significant others having the right to choose their treatment options. Patient requests to withhold or withdraw life support should be respected.

The culture of the health care system may influence withholding and withdrawal of treatment decisions. The New Zealand population is amenable to forgoing futile life support therapy in the interests of dignity and reduction of suffering (Lawrence & Havill, 1999). Lawrence and Havill (1999) believe that treatment is withdrawn in a timely fashion in New Zealand intensive care units and done faster than in the United States. They asserted that their study supports this premise (see Appendix A, table A.15). Factors considered when determining benefit and futility for triage decisions include the likelihood of a successful outcome, the patients life expectancy in relation to the disease, anticipated quality of life and wishes of the patient or significant others (Society of Critical Care Medicine Ethics Committee, 1994).

When there is no hope of recovery, patients already admitted to an intensive care unit should not be automatically discharged unless it is acceptable to do so. Caring for patients in the intensive care unit who are dying is appropriate (American Thoracic Society, 1997). Continuing care of the patient in the intensive care unit when treatment has been withdrawn ensures that suffering is minimised during and after life support is removed. The therapeutic relationship among the patient, significant others and health care professionals is strengthened with continued intensive care unit care during a patient’s final hours.
2.7.7 “Not For Resuscitation” Orders

Recognising that a patient will not benefit from intensive care unit care because of their severity of illness may lead to the patient having a “not for resuscitation” or “do not resuscitate” order being issued. Such recognition leads to intensive care being restricted, reducing costs and alleviating suffering, allowing the patient to die with dignity. The difficulty arises in recognising those patients whose condition is terminal, and abiding with patient and their significant others wishes.

Cook et al. (2001) in an international observation study into cardiopulmonary resuscitation directives on admission to the intensive care unit found only 11% of critically ill patients had cardiopulmonary directives made within the first 24 hours of intensive care unit admission (see Appendix A, table A.5). As well as clinical factors, timing and location of admission may determine the rate and nature of resuscitation directives. Great variation occurred between countries, cities within countries and centres within cities. The authors believe that cultural patterns and professional practice patterns could be the reason for lower resuscitation directives in Australia and Sweden. To find out and honour preferences of critically ill patients, there should be widespread adoption of “individual led, culturally appropriate, locally adapted and effectively implemented guidelines that address resuscitation discussions” (Cook et al., 2001, p.1944).

Few studies have examined patient preferences after the doctor has informed them about the outcomes of cardiopulmonary resuscitation. Murphy et al. (1994) studied older patients' preferences regarding cardiopulmonary resuscitation and found that older patients readily understood prognostic information, which influenced their preferences with respect to cardiopulmonary resuscitation (see Appendix A, table A.5). Most patients over the age of 65 did not want to undergo cardiopulmonary resuscitation once the probability of survival after the procedure was explained to them (Murphy et al., 1994). McLean, Tarshis, Mazer and Szalai (2000) demonstrated a change in practice and variability between institutions with a trend in recent years toward greater withdrawal of treatment in the intensive care unit, consistent with a wider application of “do not resuscitate” orders (see Appendix A, table A.5). The use of “do not resuscitate”
orders, particularly early in the ICU stay, may be associated with significant reduction in resource utilisation for an identifiable group of patients (Rapoport, Teres & Lemeshow, 1996) (see Appendix A, table A.5).

Patients who have do-not-resuscitate orders should not be automatically excluded from admission to the intensive care unit (American Thoracic Society, 1997; Society of Critical Care Medicine Ethics Committee, 1994). The reasons for their admission however must be convincing. It is reasonable for patients, who have terminal, irreversible illnesses facing imminent death, to be refused admission to the intensive care unit (Society of Critical Care Medicine Ethics Committee, 1994).

2.7.8 Positive Effects

Economic pressures and financial constraints may have positive effects including streamlining of processes and structures and reduction of waste and redundancy so long as quality of care is not compromised (Chalfin, Cohen & Lambrinos, 1995). As many critically ill patients require a specialised intensive care environment, intensive care units are highly dependent on labour and capital and therefore relatively inflexible to financial cuts. Determining which patients will benefit most from intensive care unit services and those at high risk of high cost, may enhance cost-effectiveness and clinical efficacy of intensive care services. Cost effectiveness analysis can be used to help in rational decisions regarding priorities and setting sensible and clinically reasonable goals. This will facilitate comparisons to be made between intensive care services so that the greatest benefit for the most reasonable cost is achieved (Chalfin, Cohen & Lambrinos, 1995).

2.8 Benefits of Intensive Care Units

The investment of large amounts of resources in intensive care unit services, has resulted in questions being asked regarding costs versus benefits (Elliott, 1999). Intensive care unit practice patterns are being scrutinised at both the institutional and national levels to eliminate inefficiency, lower costs and improve clinical results.
(Elliott, 1999). Questions being asked include which patients benefit from intensive care units, to what degree and what are the costs versus benefit (Oye & Bellamy, 1991). It is essential that intensive care units develop structured and validated approaches to delivery of care to facilitate efficiency and effectiveness of services provided.

To assess and improve the quality of care in intensive care units it is necessary to understand how intensive care unit structure and care processes are related to clinical and economic outcomes (Pollack, Katz, Ruttimann & Getson, 1988). The concept of benefit is difficult to define. Costs are often stipulated in monetary terms whereas the probability of benefit and the degree of benefit regarded as worthwhile should be assessed in terms of clinical outcomes such as number of survivors, probability of survival or quality of life assessments (King’s Fund Panel, 1989; O’Brien & Rushby, 1990). Adequate evaluation of outcome on intensive care unit treatment has not kept pace with the development of intensive care units (Eddleston, White & Guthrie, 2000). Quality of life assessments occur infrequently in the intensive care unit literature and are of limited methodological quality (Black et al., 2001; Heyland et al., 1998). However, accurate assessment of patient outcomes after intensive care unit care is essential to justify the health care spending in this area. Determining who will benefit from intensive care unit admission and who will not benefit is the most cost effective use of intensive care unit resources (Barnett & Shustack, 1994, p.334).

Admission to the intensive care unit requires that patients have significant medical need and that the intensive care unit care should provide patients with sufficient potential benefit with a decreased risk of death (American Thoracic Society, 1997; Bone, McElwee, Eubanks & Gluck, 1993a). There is much concern about the cost of catastrophic illness. Patients in the intensive care unit with the least chance of survival have been shown to consume the most intensive care unit resources (Detksy, Stricker, Mulley & Thibault, 1981; Sage, Rosenthal & Silverman, 1986). Many of these patients have poor outcomes raising questions about the appropriateness of allocation of resources to the critically ill (Schroeder, Showstack & Schwartz, 1981). Benefits from intensive care unit care should outweigh the significant costs involved with this care. Intensive care units should improve patient outcomes including decreasing mortality through their use of sophisticated technologies and treatments by specially trained personnel, without harming the patient (Sprung et al., 1999). Patients who have
irreversible conditions and will die after admission to the intensive care unit or conversely, patients admitted for monitoring purposes and will survive without intensive care unit care, should not be admitted to the intensive care unit (Bone, McElwee, Eubanks & Gluck, 1993a; Society of Critical Care Medicine Ethics Committee, 1994).

Deciding what is beneficial for an individual should be by mutual agreement wherever possible by the patient / their significant others and their health care professionals. Consideration of the benefits and burdens of intensive care unit care should be in relation to the patient’s values and life goals (American Thoracic Society, 1997). The primary duty of health care professionals is to work on behalf of their patient’s best interests and that these interests should be defined by the patient arising from the principles of medicine, beneficence, nonmalificence and autonomy. Although potential benefit of the intensive care unit or other care relates to how well the patient’s needs can be met, the patient ultimately determines whether the potential benefit of the intervention sufficiently outweighs its burdens (American Thoracic Society, 1997). Attitudes to intensive care unit care vary enormously between countries. Any definition of appropriateness of intensive care unit admission is likely to be subjective and highly conditional by cultural, personal and spiritual factors (Zimmerman et al., 1988).

Comparing benefits to costs is a largely under explored area. Sage, Rosenthal and Silverman (1986) believe the benefits of the intensive care unit are often assumed (see Appendix A, table A.6). Randomised control trials are inappropriate to test whether intensive care units provide a benefit compared to alternative care. Randomised controlled trials are typically regarded as the “gold standard” for evidence based practice (Black, 1996). No randomised control trials have been done demonstrating the advantages of intensive care compared to non-intensive care unit treatment for critically ill patients (Bone, McElwee, Eubanks & Gluck, 1993a; Gyldmark, 1995). This is in part due to the difficulty, if not impossibility, in randomising critically ill patients between intensive care units and non-intensive care units. There seems to be a consensus that intensive care units work and that such studies would be unethical (Bone, McElwee, Eubanks & Gluck, 1993a; Gunning & Rowan, 1999; Kerridge, Glasziou & Hillman, 1995; McPherson, 2001; Schafer et al., 1990; Sprung et al., 1999; Stockwell, 1999). Random allocation of critically ill patients
to different levels of care is likely to be complicated by the 'Hawthorne Effect' (Bion, 2001; Morris, Zaritsky & LeFever, 2000). The appropriateness of intensive care unit care is often judged on apparent unmet need and observed associations of prognostic indicators with mortality often being the measured outcome (McPherson, 2001). Dragsted, (1991 cited by Buist, 1994) believes the opportunity to demonstrate the benefit of intensive care units prospectively would be now considered unacceptable, as treatment of various conditions in the intensive care unit are now considered as standard for good medical practice.

Sznajder et al. (2001) found a moderate cost benefit in spite of casemix variation in their prospective study to evaluate patient outcome and efficiency of intensive care unit stays in 7 French intensive care units (see Appendix A, table A.2). Despite the variability and lack of standardisation, it would appear that a percentage of patients do benefit from intensive care unit services but it is virtually impossible to determine precise situations in which the intensive care unit definitively improves clinical outcome (Chaldfn, Cohen & Lambrinos, 1995).

Despite the number of intensive care units and their enormous cost, their impact on morbidity and mortality is under-evaluated (Rubins & Moskowitz, 1988). Few studies have quantified the benefit in prolonging meaningful life after discharge from the intensive care unit. Cost effectiveness analysis should include long-term survival and quality-adjusted survival (Weinstein, Siegel, Gold, Kamlet & Russell, 1996). Keenan et al. (2002) observed not only did intensive care unit patients have a greater severity of illness and higher risk of in-hospital mortality, they were more likely to die in subsequent years (see Appendix A, table A.6). It is difficult to determine the benefits these patients derived from intensive care. More importantly, for those who had improved short-term outcomes, were there long-term benefits? Further research is necessary to explore these issues.
2.9 Demand for Intensive Care Units

Intensive care unit care is costly, and the number of intensive care beds ultimately finite. The demand for intensive care unit care often exceeds supply (Society of Critical Care Medicine Ethics Committee, 1994). Allocating intensive care resources in the fairest way is challenged by the realities of cost containment and limitation of supply (Miller, 1994).

Demand for emergency and intensive care unit services fluctuate. Demand is often created by medical and surgical emergencies, which is only predictable in the very broadest sense. Higher admissions can be predicted for seasonal factors, but there is no certainty as to when and how many patients will require intensive care unit services (Edbrooke, Hibbert & Corcoran, 1999). Hospitals are treating more patients but the demand for the intensive care unit is increasing at a greater rate suggesting that at least some of the demand is generated from the hospital itself (Ridley, Burchett, Burns & Gunning, 1999). For example, in the United Kingdom, it was found that the demand for intensive care did not abate despite critical care beds increasing in numbers by 21.4%, services increased by 5% (Ridley, Burchett, Burns & Gunning, 1999) (see Appendix A, table A.7).

There is competing beneficence between the patient and the larger population. Public demand for this health care provision can outstrip supply that may lead to an apparent shortage in intensive care beds. Demand for intensive care is driven by consumers' expectations that intensive care unit care is superior, pursuit of health is a right and entitlement to intensive care unit care is assumed (Dawson, 1993). The demand for intensive care has partly arisen from public expectations that everything possible is being done for their loved ones and from a logical perception that it is more efficient to treat the critically ill in one area (Buist, 1994). This is a demand rather than supply problem, with intensive care taken as a standard of practice and not perceived as a scarce resource. The majority of patients and families are willing to undergo intensive care to achieve even one month of survival (Danis, Patrick, Southerland & Green, 1988).
The Acute Health Division, Department of Human Services, Victorian Government State Report (1997) outline several factors influencing intensive care unit demand including:

- the number of acute hospital beds decreasing (attributable to reductions in length stay due to advances in technology and throughput approaches to funding);
- increasing aging population;
- continued advances in treatment and technology;
- heightened community expectations;
- public health strategies, although these preventative measures are difficult to quantify.

As some services move to alternate care pathways, new sources of patient referral contribute to increasing demand. Demand for intensive care services appears to be independent of hospital size (Ridley, Burchett, Burns & Gunning, 1999). Service planners need to take note of the practices and specialities available within the hospital concerned rather than population demographics or national averages (Ridley, Burchett, Burns & Gunning, 1999).

Shortages in human and economic resources limit the ability to provide complete care to all who might desire it and has led to rationing. Rationing of intensive care unit beds has been common in the United Kingdom, Europe and the United States (Joynt et al., 2001; Kalb & Miller, 1989; Sax & Charlson, 1987; Sprung et al., 1999; Strauss, LoGerfo, Yeltatzie, Temkin & Hudson, 1986; Vincent, 1990; Zimmerman, Wagner, Draper & Knaus, 1994). Access to the specialist, high technological resource provided in the intensive care unit varies according to institutional abilities and priorities, community and hospital resources, prognosis, the patient and personal desires and the expected outcome of other competing patients (Knaus et al., 1991). Organisational and political factors may influence admission and discharge decisions. Sax and Charlson (1987) found that cardiac patients had a greater chance of being admitted to a medical intensive care unit than non-cardiac patients. Sprung et al. (1999) found that surgical patients had a greater chance of being admitted to the general intensive care unit than
non-surgical patients, hypothesising that this may be a result of the organisational structure of the intensive care unit.

Supply not meeting demand has posed challenges for several countries. Respondents of a questionnaire distributed to members of the European Society of Intensive Care Medicine found that admissions to 57% of European intensive care units were often limited by the number of beds available (Vincent, 1990). Because of the limited number of intensive care unit beds in the United Kingdom, intensive care units in the United Kingdom admit more severely ill patients than their European and American counterparts, putting greater pressure on intensive care unit beds and resources (Edbrooke, Hibbert & Corcoran, 1999). When fewer intensive care unit beds are available, fewer patients are admitted and these patients are more seriously ill (Singer, Carr, Mulley & Thibault, 1983; Strauss, LoGerfo, Yeltatzie, Temkin & Hudson, 1986). Data from a survey of intensive care unit services in Victoria support the perception that the provision of intensive care unit beds across the Victorian metropolitan area in 1997 was insufficient to meet existing demand. As a result, the Victorian government opened additional beds (Acute Health Division, Department of Human Services, 1997). Svenson, Besinger and Stapczynski (1997) conducted a retrospective review of a United States' university teaching hospital of Emergency Department patients subsequently admitted to a medical or surgical intensive care unit. They found that 30% of critically ill patients received treatment for prolonged periods in the Emergency Department due to lack of intensive care unit beds. Southgate (1999) believes that a similar problem exists in the United Kingdom despite differences in the health care systems and admission criteria preventing direct comparability between countries.

2.10 Allocating Intensive Care Unit Resources

Two main approaches are emerging to deal with challenges of the fairest way of allocating expensive and limited intensive care resources (Miller, 1994), as depicted in figure 2.1. Firstly, rationing which involves the allocation of scarce health resources among competing individuals. This requires the development of specific guidelines for
determining intensive care unit admission, triage and discharge. Secondly, allocating scarce intensive care unit resources in such a way as to improve the efficiencies of intensive care units to maximise resource utilisation. Hospitals should adopt intensive care unit utilisation strategies that either explicitly define formal rationing policies or take steps to avoid rationing (Kalb & Miller, 1989). Rationing may be avoided by increasing physical bed numbers, reducing demand by cancelling elective surgery, providing alternatives such as intermediate care units and earlier discharge for patients who no longer need intensive care unit care. In reality they may have to combine both.

Figure 2.1. Allocating Intensive Care Unit Resources.
Increased efficiency may occur with increased capacity utilisation (Levin & Sprung, 2001). However, if too many patients are admitted stretching resources to care for them properly then previous intensive care unit patients are put at risk (Levin & Sprung, 2001). Increasing the number of patients or increasing workload can also lead to errors, morbidity and increased length of stay (Levin & Sprung, 2001).

Insufficient bed numbers may not be the only issue causing demand to exceed supply. Patients may not be admitted to the intensive care unit because of staff shortages. Patients admitted to the intensive care unit need suitably qualified staff to care for them in a highly technological environment. Lack of suitably qualified staff may reduce the intensive care unit’s capacity to care for patients otherwise considered appropriate for admission. Staff to patient ratios are set to facilitate patient safety and provide adequate care. These standards should not be compromised when staffing is challenged.

Nursing shortages in intensive care units have been reported in several countries (Levin & Sprung, 2001; Tinsley & Hurst, 1990; Williams & Clarke, 2001). Tinsley and Hurst (1990) sent questionnaires to 50 randomly selected intensive care units in the United Kingdom. Only 20 units responded with the average number of beds being 5. It is difficult to know due to the small sample size and poor response rate whether these units were representative of intensive care units within the United Kingdom. Intensive care units in the United Kingdom have fewer beds than those in the United States or Australasia. Mean bed occupancy was reported as 3 with 28% of beds being closed due to nursing staff shortages (Tinsley & Hurst, 1990). Half of the respondents reported patients being refused admission at some time due to staff shortages. Staff shortages were common to all units. Under-use of intensive care unit services results in inefficient and less effective use of a scarce resource.

Staff shortages are not only restricted to the United Kingdom, but are being experienced in most developed countries. Williams and Clarke (2001) employed expert panel opinion to describe a clear, consensus driven methodology for determining the nursing requirements for the available intensive care unit beds to staff Australia’s intensive care unit beds. Guidelines for minimum standards for intensive care unit staffing in Australia and New Zealand have been developed (Australian College of
Critical Care Nurses Workforce Advisory Panel, 2002; Australian Council on Healthcare Standards, 1997; Faculty of Intensive Care, Australian and New Zealand College of Anaesthetists, 1997). The authors devised a calculation that could be used by health professionals, health administrators, policy advisers, governments, politicians and the wider community explaining the national supply and demand needs of intensive care units in Australia (Williams & Clarke, 2001). The authors believe that rather than an intensive care bed shortage, Australia has an intensive care nurse shortage (Williams & Clarke, 2001). They found a strong correlation between the number of intensive care unit nurses available (particularly critical care nurses) and the number of intensive care unit beds available at any given time (Williams & Clarke, 2001).

Appropriate recruitment strategies, and maintaining adequate levels of qualified staff remain a challenge for hospital management. To maximise efficiency, however, there must be sufficient qualified staff for the available intensive care unit beds.

2.10.1 Admission, Triage and Discharge Guidelines

Optimal use of the intensive care unit depends on appropriate admission, triage and discharge decision-making. Written policies defining admission, continued occupancy and discharge criteria should be required for all intensive care units (Marshall, Schwenzer, Orsina, Fletcher & Durbin, 1992). There is an ethical obligation for hospitals to provide intensive care unit care or its equivalent to all patients who are medically appropriate, or when demand temporarily exceeds supply, have adequate transfer policies to ensure timely intensive care unit admission (American Thoracic Society, 1997). Without appropriate admission criteria, inappropriate patients may be admitted who may utilise scarce resources preventing admission of the more critically ill, unstable patients. Formerly in the United States, where funding gave little incentive to curtail increasing intensive care unit services, intensive care was given to the sickest patients without thought for the potential reversibility of the patient’s illness or their potential to have a reasonable quality of life (Bone & Balk, 1988). With funding changes and increasing emphasis on cost containment, critical evaluation of intensive care services is now taking place (Halpern, Bettes & Greenstein, 1994; Noseworthy, Konopad, Shustack, Johnston & Grace, 1996; Taheri, Butz & Greenfield, 2000).
Triage is the process where the intensivist or admitting physician decides whether or not to admit the patient to the intensive care unit to facilitate effective use of available personnel and resources whilst at the same time offering the best possible outcome for the patient. It is based primarily on objective criteria and medical necessity, that is, the patient benefit from the treatment options offered in the intensive care unit (Levin & Sprung, 2001). Deciding which patients will or will not be admitted to intensive care units is a problem facing intensivists on a daily basis (Levin & Sprung, 2001). Prognostic uncertainty in individual cases endorses the rationale that intensive care units are more likely to result in better patient outcomes (Engelhardt & Rie, 1986). The underlying health status is important as well as the degree of physiological end-organ dysfunction in predicting the effectiveness of intensive care (Knaus, Draper, Wagner, & Zimmerman, 1985).

Admission to the intensive care unit may be influenced by a number of factors including pre-existing treatment preferences of the patient, severity of illness, reversibility of the acute disorder, the nature of any chronic disorder, clinician preferences, availability of intensive care unit beds, patient location within the hospital, influence of the requesting physician, the degree of suspicion for a particular diagnosis, the presence of a medical director (or other gatekeeping mechanism) and the anticipated quality of life (Bone, McElwee, Eubanks & Gluck, 1993a; Marshall, Schwenzer, Orsina, Fletcher, & Durbin, 1992; Oye & Bellamy, 1991; Sax & Charlson, 1987; Society of Critical Care Medicine Ethics Committee, 1994; Sprung et al., 1999; Teres, 1993). The intensivists' conflict of interest as the intensive care unit patient's advocate and as the institutional gatekeeper can be problematic for triage decision-making (Society of Critical Care Medicine Ethics Committee, 1994). In the United States, bed allocation for surgical services has been shown to be influenced by factors such as political power, medical provincialism and income maximisation rather than medical suitability (Marshall, Schwenzer, Orsina, Fletcher & Durbin, 1992).

Other determinants of admission include bed census (occupancy of the intensive care unit), availability of nursing care resources, economic considerations, ethical or moral considerations, physician treatment preferences and capability of the intensive care unit to provide minimum standards of care (Bone, McElwee, Eubanks & Gluck, 1993a). The ratio of intensive care unit beds to total hospital beds may influence the
number of patients admitted, with lower ratios leading to stricter admission criteria (Barnett & Shustack, 1994).

Ethical dilemmas arise of when to admit or discharge a patient when further admissions may occur and available intensive care unit beds are scarce (Engelhardt & Rie, 1986). The decision to discharge the patient from the intensive care unit to a less intensively supported and monitored environment is influenced by the acuity of the patient, nurse to patient ratios, and availability of medical support (Kramer, 2001). There may be an obligation to discharge patients with only borderline possibilities of benefit from intensive care unit management (Engelhardt & Rie, 1986).

Admission and discharge practices are modified when there is pressure on intensive care unit resources. Singer, Carr, Mulley and Thibault (1983) demonstrated that a temporary shortage of intensive care unit personnel resulted in a fall in intensive care unit bed capacity with physicians decreasing intensive care unit admissions and patients’ length of stay. Strauss, LoGerfo, Yeltatzie, Temkin and Hudson (1986) evaluated the extent to which bed availability affects decision-making in an intensive care unit, and found that patients admitted during times of bed shortage were on average, more severely ill than those admitted when many beds were unoccupied (see Appendix A, table A.12). Patients under crowded conditions were sicker and had a shorter stay than patients discharged when more beds were available. The relative risk of discharge was inversely related to empty bed availability, illness severity and age. Bed availability had no effect on rates of death in the intensive care unit, death after discharge or readmission to the intensive care unit. Although these studies are relatively old, they are still relevant today and have been supported by a more recent study that demonstrated that the number of available beds was an important factor in triage decision-making (Sprung et al., 1999). This prospective study assessed all patients triaged for admission to a general intensive care unit. Fewer patients were referred or admitted when the intensive care unit was full. Triage to the intensive care unit correlated with age, a full unit, surgical status and diagnosis when multivariate analysis was performed (Sprung et al., 1999).

Engelhardt and Rie (1986) believe that standards may be lowered when admitting patients to an intensive care unit where the medical and nursing capabilities
are under-resourced. This was not supported by Sprung et al. (1999) who found occupancy made no difference in mortality in the patients already admitted to the intensive care unit.

Few studies have been conducted into triage decisions in the intensive care unit, despite the significant impact on lives and the costs involved (Franklin, Rackow, Mamdani, Burke & Weil, 1990; Marshall, Schwenzer, Orsina, Fletcher & Durbin, 1992; Metcalfe, Sloggett & McPherson, 1997; Sax & Charlson, 1987; Strauss, LoGerfo, Yeltatzie, Temkin & Hudson, 1986). The studies that have been conducted often were performed more than ten years ago, were retrospective, did not evaluate all patients who were refused admission to the intensive care unit or did not consider the severity score of refused patients (Sprung et al., 1999).

The decision to admit a patient to the intensive care unit should be based on the concept of potential benefit. Definitions of futility and benefit are subjective, value-laden terms with little consensus on agreement and vary widely based on the goals of treatment and the likelihood of success (Society of Critical Care Medicine Ethics Committee, 1994). What the definition of benefit encompasses may vary between individual clinicians, hospitals and different regions and countries. Sprung and Eidelman (1997) assert that they should probably not be used for triage decision making. Rather, developing explicit triage policies and encouraging public debate would assist patients, families and doctors to make difficult triage decisions more easily. It is important to respect patient autonomy and patients should not be admitted to the intensive care unit if they clearly indicate that they do not wish admission (Smith & Nielsen, 1999).

Large differences in intensive care unit admission policies exist even within the same health care system (Angus, Sirio, Clermont & Bion, 1997). Local and national values and traditions, differences in practice styles, disease prevalence and overall health influence admission and triage decisions. A survey by the Society of Critical Care Medicine Ethics Committee found that many physicians did not always follow the specific guidelines for admission, triage and discharge in United States’ intensive care units (Knaus et al., 1991). They also found that the decision making process did not necessarily consider the expected benefits for admission into the intensive care unit.
Intensive care units in Australia vary in their admission and discharge policies (Acute Health Division, Department of Human Services, 1997). The Faculty of Intensive Care of the Australian and New Zealand College of Anaesthetists (1997) describes minimum standards for intensive care units including defined policies for admission, management, discharge and referral of patients. The Australian Council on Healthcare Standards has similar guidelines and state that policy documentation is fundamental to health care facility accreditation (Australian Council on Healthcare Standards, 1997; Faculty of Intensive Care, Australian and New Zealand College of Anaesthetists, 1997). A review of intensive care services in Victoria (Acute Health Division, Department of Human Services, 1997) found that while policies within Australia differ little their implementation varied, depending on the approach of the Director of the Intensive Care Unit and the approach of individual intensivists. Defining admission and discharge criteria for intensive care units was difficult and not always appropriate. Definitive exclusion criteria for intensive care unit care were not included in most of these policies (Acute Health Division, Department of Human Services, 1997).

Renewed efforts to define criteria for admission and discharge and standards of service provision in the United Kingdom have been fuelled by the frequent shortages of intensive care unit beds and recent expansion of high dependency units (Bennett & Bion, 1999). Southgate (1999) recommends that admission and discharge guidelines be adopted throughout the United Kingdom as a measure to ensure patients received timely intensive care unit care when it was needed.

It is important that experienced and qualified medical staff make admission decisions in order that patients fulfil the admission criteria required. In many intensive care units it is the intensive care unit consultant who considers the nature and severity of illness, the potential reversibility of the patient’s condition, the long and short-term probability of survival and the wishes of the patient and their relatives in determining admission to intensive care unit. This is in line with recommendations that the consultant in charge of the intensive care unit at the time should agree to all admissions (Acute Health Division, Department of Human Services, 1997; Smith & Nielsen, 1999). Consultation between the intensive care unit consultant and referring consultant may be employed in the admission of some patients whose conditions are not clear-cut (Clarke,
2000). Other factors may also be involved in the use of intensive care unit services that are beyond the control of intensive care unit such as the intubation of a patient prior to admission. The intensive care unit may have little choice but to admit these patients until assessment and possibly extubation is accomplished (American Thoracic Society, 1997).

Not all medical staff believe that the intensive care consultant only should decide admissions to the intensive care unit. Danbury (1999), in a letter to the British Medical Journal, discusses admission to the intensive care unit as being similar to that of the Medical Emergency Team where medical or nursing staff initiate the call for the team. If patients meet the set criteria, then the Medical Emergency Team should be called to assess the patient, discuss the patient’s condition with the patient’s consultant and decide future management. This will provide patients who are deteriorating earlier organ support. Danbury (1999) concludes that referral to the intensive care unit should not be limited to intensive care unit consultants. However, intensive care consultants have the knowledge and experience to understand the needs of referrals and patients already admitted to the unit. Smith and Nielsen (1999) believe the decision to admit should be delegated to trainee doctors only if clear guidelines exist on admission.

Early referral to the intensive care unit improves the chances of recovery. Delaying admission jeopardises the chances of full recovery, increases the risk of organ dysfunction, may increase length of stay in the intensive care unit and hospital, and may increase the cost of intensive care (Smith & Nielsen, 1999). Admissions may be delayed if beds are unavailable. Unnecessary delays in discharge from the intensive care unit may reduce the number of beds available for admitting patients.

The admission source influences patient outcomes in the intensive care unit. Rosenberg, Hofer, Hayward, Strachan and Watts (1999) observed that patients admitted from wards or transferred from another hospital experienced longer intensive care unit and hospital length of stays, higher mortalities and more intensive care unit readmissions (see Appendix A, table A.8). They were less likely to respond to treatment compared to patients admitted directly from the emergency department (Rosenberg et al., 1999). This may be due to lead-time bias which occurs when patients are partially treated before intensive care unit admission (Nouria et al., 1998). Substantial
differences in utilisation were found by Dragsted et al. (1989) when comparing outcome and utilisation in 2 Danish intensive care units. Although the measured severity of illness was similar, patients at one of the hospitals received significantly more therapy and had a higher mortality than the other hospital. The authors believe that because 35% of these patients had been transferred to the intensive care unit from other intensive care units, it created the possibility of an adverse selection and lead-time bias for these patients (Dragsted et al., 1989). The standardisation of timing of initial assessment is important to minimise lead-time bias (Beck, Taylor, Millar & Smith, 1997).

Institutions with higher intensive care unit availability may adopt less strict admission policies for patients whilst other units with lower intensive care unit bed availability may have more rigid admission criteria, discharge patients earlier and risk having higher readmission rates (Keenan, Doig, Martin, Inman, & Sibbald, 1997). The availability of intermediate care units, overnight recovery room ventilation and intensive care bed availability all impact on intensive care unit utilisation. When beds are in high demand, admission and discharge priorities may shift and, in most cases, patients requiring specialised technical intervention are given priority over patients requiring monitoring or those with poor prognosis (Acute Health Division, Department of Human Services, 1997).

The efficiency of the intensive care unit admission process should be able to be assessed by benchmarking with other similar health care facility intensive care units. Keenan, Doig, Martin, Inman and Sibbald (1997) conducted a review of the literature and compared these findings with their own data collection that revealed that there was insufficient data currently available to benchmark accurately (see Appendix A, table A.8).

2.10.2 Maximising Resource Utilisation

The second approach in allocating scarce intensive care unit resources is to improve the efficiencies of intensive care units to maximise resource utilisation. This may be accomplished by increasing availability or by decreasing demand for intensive care unit beds. Inappropriate admissions lead to a waste of resources. Being refused admission to the intensive care unit may result in transfer to another hospital, or
inadequate treatment and care on a general ward. Limited use of intensive care units represents a valuable waste of resources while excessive use places a potentially unnecessary strain on the system, increasing costs (American Thoracic Society, 1997; Groeger et al., 1993).

2.10.2.1 Increasing bed numbers

Increasing availability of intensive care unit services can be achieved by increasing intensive care unit bed capacity (refer to figure A.1). Wallis, Davies and Shearer (1997) found 20% of patients who died in hospital after discharge from intensive care unit were expected to survive. The authors concluded that the deaths might have been prevented by improved care provided in the intensive care unit and that ward care was suboptimal for patient needs (see Appendix A, table A.8). Lawrence and Havill (1999) found, however, no evidence in their study to support suboptimal ward care in their audit of deaths occurring in hospital after discharge from the intensive care unit in a mixed intensive care unit in New Zealand (see Appendix A, table A.2). International comparisons are challenging and the situation that applies to United Kingdom intensive care services may not be relevant in other countries.

Metcalfe, Sloggett and McPherson (1997) demonstrated a relative risk of death of 1.6 (95% CI 1.0-2.5) for patients refused admission to the intensive care unit, but concluded that the provision of more beds may not be the solution, rather altering admission and discharge policy was needed (see Appendix A, table A.8). The results of their study have been challenged (Buist, Cranswick, Morley, Duke & Ernest, 1997; Fielden, Parmar, McQuillan & Smith, 1997). Fielden, Parmar, McQuillan and Smith (1997) believe that failure to collect APACHE II (Knaus, Draper, Wagner & Zimmerman, 1985) data on the refusals was a considerable oversight, preventing case-mix adjustment. However, Metcalfe, Sloggett and McPherson (1997) argue that it was impossible to collect the data and that scoring methods were not available to accurately assess disease severity for clinical decision-making. Buist, Cranswick, Morley, Duke and Ernest (1997) questioned the validity of Metcalfe, Sloggett and McPherson's (1997) comparison of 2 groups matched only by intensive care referral with no
criteria listed to determine the appropriateness of intensive care unit referral. The observational cohort study was not designed to include case matching and although the assessment of referral was imperfect, Metcalfe, Sloggett and McPherson (1997) considered the inclusions important as they had not yet been properly addressed when comparing mortality risk among referred patients. Fielden, Parmar, McQuillan and Smith (1997) believe that patients who needed intensive care should have had the care taken to them whilst care to an appropriate unit was being arranged, minimising refusals to the intensive care unit. Buist, Cranswick, Morley, Duke and Ernest (1997) were also concerned that there was no description of the qualifications and experience of admitting clinicians, the subjective assessment made over the telephone and the subsequent outcome of these patients. They concluded that “there is no evidence from the study that adjustment of admission and discharge policy criteria is a better solution to the increased mortality than the provision of sufficient intensive care unit beds” (Buist, Cranswick, Morley, Duke & Ernest, 1997, p.883). Like many observational studies, Metcalfe, Sloggett and McPherson’s (1997) study challenged certain aspects of intensive care unit services, highlighting some of the difficulties of measurement and adjustment, and provided a starting point for further studies.

Parker, Wyatt and Ridley (1998) found increasing demand for intensive care unit beds but concluded that creating more beds does not solve the imbalance between supply and demand, rather it reveals the extent of pre-existing demand and results in only a small transient fall in occupancy (as noted in Appendix A, table A.8). Dawson (1993) believes that the problem cannot be alleviated by building more intensive care unit beds because the heart of the problem is an excess of patients presumed to be entitled to intensive care unit care, not a bed deficit.

Buist, Cranswick, Morley, Duke and Ernest (1997) believe that provision of more intensive care beds is required. The United Kingdom has acknowledged a shortage of intensive care beds with the government committed to increasing the number of intensive care beds provided (United Kingdom Department of Health, 2001). Data from the review of intensive care services in Victoria
supported the perception that the provision of intensive care beds across metropolitan area in Victoria was insufficient to meet existing demand. As a result, the Victorian government opened additional beds (Acute Health Division, Department of Human Services, 1997).

Health care facilities should correct imbalances between supply and need of intensive care unit beds (American Thoracic Society, 1997). If no intensive care unit beds are available, patients should receive an equivalent level of care, elective procedures may need to be postponed or the patient transferred to another intensive care unit facility. If shortages of intensive care unit beds persist despite their appropriate and efficient use, the American Thoracic Society (1997) recommends that they should be increased permanently. Limiting services that routinely use intensive care unit beds can decrease demand for intensive care unit resources. New programmes that would increase demand for intensive care unit beds should not be implemented unless sufficient resources are provided for the needs of the programme (American Thoracic Society 1997). Filling intensive care unit beds with patients who do not need intensive care should not be done just because there is a surplus supply in intensive care unit beds. Instead it is more prudent to decrease the overall number to improve efficiency (American Thoracic Society, 1997).

2.10.2.2 Increasing patient flow

If intensive care unit bed capacity is not increased, restricting admissions or reducing the length of stay may increase patient flow. Admission policies and use of less costly critical care facilities for appropriate patients has resulted in more appropriate use of intensive care unit resources. Intensive care unit resources are often used for patients with poor outcomes and in the monitoring and observation of low-risk patients who require little or no intervention (Buist, 1994). Gunn et al. (1996) studied utilisation of surgical intensive care units and observed that a significant amount of inappropriate utilisation of critical care units occurred, primarily on admission and after 7 days.

Sprung et al. (1999) found triage to the intensive care unit correlated
with age, a full unit, surgical status and diagnosis when multivariate analysis was performed (see Appendix A, table A.9). All patients admitted to the intensive care unit had improved survival compared with patients who were not admitted. Patients refused admission had higher APACHE II (Knaus, Draper, Wagner & Zimmerman, 1985) scores than did admitted patients. The frequency of admitting patients decreased when the intensive care unit was full (Sprung et al., 1999).

Length of stay is a measure that applies to all in-patients. Reductions in length of stay reduce hospital costs as well as patient financial and psychological costs (Jacobs & Noseworthy, 1990; Needleman, Buerhaus, Mattke, Stewart & Zelevinsky, 2001). In the United States, as a consequence of managed care, market forces and other economic factors, hospital length of stay has become the most important indicator used to control costs. It is a common outcome variable used to compare performance between hospitals (Becker et al., 1995; Classen, Pestotnik, Evans, Floyd & Burke, 1997; Knaus, Draper, Wagner, Zimmerman & Draper, 1993; Rosenthal, Harper, Quinn & Cooper, 1997). Hospital length of stay has markedly decreased during the last 15 years. A major impetus for this reduction in hospital stay in the United States was the introduction of Medicare’s diagnosis-related group based prospective payment system (Rogers et al., 1990; Schwartz & Mendelson, 1991). Mayer-Oakes, Oye, Leake and Brook (1988) assessed the impact of the United States’ Medicare prospective payment system on patient care and outcome by reviewing health records of 400 medical intensive care unit patients from 3 community hospitals. They found there was a 15-24% decrease in hospital stay with no change in adjusted mortality. Most developed countries, despite their differing funding arrangements, have experienced a decrease in hospital length of stay in response to economic constraints (Hensher, Edwards & Stokes, 1999).

Length of stay of an individual patient and the total days for a given intensive care unit are measures of intensive care unit resource utilisation. Reducing the length of stay purportedly yields large cost savings (Taheri, Butz & Greenfield, 2000). However, most ICU resources are consumed in the first 24
to 48 hours of stay, so increasing patient turnover may increase costs. Intensive care unit length of stay is influenced by illness severity. There is no standardised or uniform method of determining length of stay. Significant differences may exist because of the methods used to calculate and compare intensive care unit length of stay, therefore studies should identify the method used to determine length of stay (Marik & Hedman, 2000). Marik and Hedman (2000) assert that because the length of stay distribution was highly skewed, the geometric mean and median should be reported (see Appendix A, table A.9).

Attempts have been made to correct length of stay according to disease severity. Although APACHE II (Knaus, Draper, Wagner & Zimmerman, 1985) and APACHE III (Knaus et al., 1991) scores are predictive of group outcomes, they should not be used to predict or adjust for length of stay (Marik & Hedman, 2000).

Length of stay as an adequate measure for cost containment has been challenged. Taheri, Butz and Greenfield (2000) believe that the focus should be on process changes that better use capacity and alter care delivery in the early stages of admission. Taheri, Butz and Greenfield (2000) reviewed the differences among variable direct costs, fixed direct costs and indirect costs. The costing exercise addressed the variable direct cost component, adding nursing-related expenditure later. Most of health care expenses took the form of overhead or was incurred early in a patient’s stay. A breakdown by severity of illness would have been useful because a number of the patients were excluded as non-survivors (Barkun, 2000). Re-allocation of space or its resources if bed or whole unit were re-allocated was not factored into their analysis (Barkun, 2000). The authors concluded that reduction of length of stay was not the ultimate benchmark.

Reducing intensive care unit length of stay may be achieved by:

- structural changes, such as utilising intermediate facilities to facilitate earlier transfers from the intensive care unit;
- clinical changes including new surgical techniques and anaesthetic
practices, early discharge of patients who no longer need intensive
care and those who no longer benefit, and

- functional changes by changing surgical personnel, policy
revisions, and pressures to reduce the intensive care unit length of
stay (Rosenberg, Zimmerman, Alzola, Draper, & Knaus, 2000;
Weissman, 2000).

Significant reductions in the utilisation of intensive care unit days,
particularly for medium-term patients, have been achieved by benchmarking and
clinical process re-engineering techniques (Rosenberg, Zimmerman, Alzola,
Draper, & Knaus, 2000) without compromising patient outcomes (see Appendix
guidelines based on best evidence practice and feedback (Eagle et al., 1990;
O'Connor et al., 1996), care protocols, early inpatient rehabilitation, changes to
funding arrangements, improved intensive care unit management and other cost-
reduction strategies can reduce the length of stay and costs for intensive care
unit patients with a wide range of diagnoses. (Engleman, 1996; Marciniak et al.,
1998; Munin, Rudy, Glynn, Crossett & Rubash, 1998; Rosenberg, Zimmerman,
Alzola, Draper, & Knaus, 2000).

Changes in surgical practice have resulted in reduced length of stay or
eliminating the intensive care unit altogether. Clinical innovations that have
been associated with reduced length of stay in the intensive care unit include
changes in coronary artery bypass graft surgery and reperfusion surgery (Kilger
et al., 2001; Rosenberg, Zimmerman, Alzola, Draper, & Knaus, 2000; The
Global Use of Strategies to Open Occluded Coronary Arteries in Acute
Coronary Syndromes (GUSTO IIb) Angioplasty Substudy Investigators, 1997).
Patients having carotid endarterectomy and arterial surgery traditionally were
admitted to the intensive care for postoperative monitoring, are now often
nursed in general ward areas with no increase in morbidity or mortality (Cuypers
et al., 2001, Kraiss, Kilberg, Critch & Johansen, 1995; Morasch, Hodgett, Burke
& Baker, 1995). Although there are some groups of conditions / surgery no
longer requiring intensive care unit care post-operatively, innovative complex
medical / surgical techniques are being developed that do require intensive care unit services (Rosenberg, Zimmerman, Alzola, Draper, & Knaus, 2000). The increased complexity of treatment for conditions such as cardiogenic shock and subarachnoid haemorrhage need to be examined to ensure patient outcomes merit the increased complexity and length of stay (Rosenberg et al., 2000). The incorporation of high-cost treatment modalities into clinical practice requires evidence to determine the safety and efficacy of these treatment regimes and to support potential cost savings in such therapies (Edbrooke et al., 1999; Rosenberg, et al., 2000). These data are lacking.

The use of clinical pathways and standardised patient care protocols has resulted in decreased length of stay in the intensive care unit (Bertges et al., 2000; Cheng et al., 1996; Collier, 1997, Engleman, 1996; Jano, Palmieri, Harlin & Craver 1999; Katz & Kohl, 1996; Kollef et al., 1997; Reyes et al., 1997). Clinical pathways help map out the sequence of care that the patient will receive from admission to hospital until their discharge and post discharge. Many aspects of patient care are predictable and by using clinical pathways, the hospital is able to schedule in advance and coordinate the resources that will be needed. Clinical pathways promote efficiency, consistency and quality, optimising patient length of stay and contributing to the efficient use of hospital resources, thus avoiding duplication or delay in the provision of services.

Patients have been admitted to surgical intensive care units traditionally for short-term ventilatory support and to ensure adequate monitoring for potential complications. Except for the operating room, the intensive care unit is the most costly component of a cardiac surgery stay. Fast-tracking of Coronary Artery Bypass Grafting Surgery patients reduce costs of care by reducing length of stay without compromising clinical outcomes or patient satisfaction (Cheng et al., 1996; Ott, Gutfinger, Miller, Alimadadian & Tanner, 1997; Sirio & Martich, 1999). Postoperative intubation times and intensive care unit length of stay are minimised by:

- modification of operative anaesthetic practice,
- reorientation and coordination of the intensive care unit team,
• effective acute pain management, appropriate intensive care unit discharge criteria,
• post intensive care unit resource availability,
• patient and family education,
• monitoring of clinical outcomes and patient experiences.

Cardiac surgery “fast track” has provided insights into how the provision of traditional intensive care unit care may be replaced with alternative mechanisms and / or settings (Sirio & Martich, 1999). “Fast-track” protocols used for coronary artery bypass graft surgery, have been adapted for major vascular surgery and other major surgical procedures' postoperative management (Engleman, 1996; Reyes et al., 1997; Cheng et al., 1996; Collier, 1997).

Changes in organisational structure and intensive care unit management practices have resulted in decreased stay (Carson et al., 1996; Hanson et al., 1999; Rosenthal, Harper, Quinn & Cooper, 1997; Zimmerman et al., 1993). Zimmerman et al. (1993) assert that the best organisational practices amongst intensive care units were related to a patient-centred culture, strong medical and nursing leadership, effective communication and coordination, and open, collaborative approaches to solving problems and managing conflict (see Appendix A, table A.9). However, the payer status and influence of managed care in the United States was not found to influence casemix-adjusted length of stay (Angus et al., 1996).

Organisational changes have improved efficiency and reduced length of stay. Intensive care units typically have had two basic management approaches, open units managed primarily by non-intensivists and closed units, where the intensive care unit is managed by dedicated intensivists, skilled in the care of the critically ill. In Australia and New Zealand, intensive care has evolved as a separate specialty and dedicated intensivists can be found operating in closed units in which patients are admitted under the care of the intensivist who acts as director of clinical activities, gatekeeper and controller of resources in most
large centres (Henderson, 1997). This is in contrast to the United Kingdom where there are few full time intensive care consultants and to the United States where closed units are uncommon (Hanson et al., 1999). Groeger et al. (1993) found only half of the intensive care units in the 1706 surveyed United States hospitals were directed by physicians certified in critical care medicine. Studies have shown the advantages of closed units over open units (Carson et al., 1996; Hanson et al., 1999; Multz et al., 1998; Pronovost et al., 1999) (see Appendix A, table A.9).

Using full-time intensivists can reduce in-house mortality and improve efficiency of intensive care unit bed utilisation (Pollack, Katz, Ruttimann & Getson, 1988; Pronovost et al., 1999). Closed units provide continuity of care and consistency of documentation. Several aspects of care that could be potentially modified by closed units to decrease in-house mortality, complications and length of stay of post-operative of high-risk patients were demonstrated by Pronovost et al. (1999) including having dedicated intensivists and maintaining an adequate number of intensive care nursing staff each shift.

Strategies designed to limit excessive and unnecessary use of expensive intensive care unit resources are being sought (Rubins & Moskowitz, 1988, p. 863). Alternative care approaches can reduce intensive care unit length of stay by reducing or eliminating short intensive care unit stays. Identifying patients for whom major intervention would not be necessary is hindered with the inherent uncertainty regarding outcome for the individual critically ill patient (Detsky, Stricker, Mulley & Thibault, 1981). Intensivists attempt to identify those patients at high risk of subsequent clinical deterioration who might benefit from a longer intensive care unit stay or transfer to intermediate care (Barie, Hydo & Fischer, 1996; Oye & Bellamy, 1991; Wong, Gomez, McGuire & Kavanagh, 1999). Predictive scoring systems have been developed to assist this process (see Appendix B).

Decreasing length of stay may also be the result of patients being discharged early due to further demand to make the bed available for the next admission (Southgate, 1999; Strauss, LoGerfo, Yeltatzie, Temkin & Hudson,
Length of stay may be increased when patients cannot be discharged from the intensive care unit. The lack of vacant ward beds within the hospital may lead to delayed discharge of patients from the intensive care unit thus blocking beds that may be used for patients requiring intensive care (Southgate, 1999). Discharge delay for patients no longer requiring intensive care unit increases length of stay and costs. Franklin (1988, p. 272) questions the notion that readmissions or negative outcomes are not related to bed census:

"if and when the census approached 100%, then negative outcomes (non-intensive care unit deaths, post-discharge deaths and/or readmissions) outside the intensive care unit would ultimately increase".

Moyer (1994) found 5 factors influenced length of stay in the intensive care unit following Coronary Artery Bypass Graft surgery, including surgery performed on a Friday. This was significantly related to increased length of stay in intensive care unit, although the reasons for delay were not determined. However, it was noted that patients who had surgery performed earlier in the week were more likely to be discharged from the intensive care unit to make room for new admissions, whereas there was no pressure on beds for surgery performed on a Friday as there was no elective surgery performed on the weekend.

Rosenberg Zimmerman, Alzola, Draper and Knaus (2000) found that intensive care unit length of stay did not followed trends of decreased hospital length of stay in the United States (as noted in Appendix A, table A.9). This may be due to early discharge from hospital being seen as less risky than early discharge from the intensive care unit, and less opportunities to decrease length of stay because lack of suitable non intensive care unit beds (Groeger et al., 1993; Rosenberg et al., 2000). The influence of less studies being performed on reducing intensive care unit length of stay than hospital length of stay may have also impacted on intensive care units not following hospital trends (Rosenberg et al., 2000). Complexity, urgency and ethical issues involved with intensive care
unit admission and discharge may have forced economic issues to the background (Rosenberg et al., 2000). These authors assert that for patients admitted to intensive care units, the pressures associated with a decrease in hospital length of stay do not seem to have influenced the intensive care unit length of stay.

It is the quality of delivered care that is important. Health status, clinical outcomes and patient satisfaction are the primary purpose of health care. Careful monitoring of patient safety and outcome must accompany any effort to reduce the intensive care unit length of stay. Assessments of intensive care unit utilisation must focus on more detailed specific issues than just length of stay (Mazer et al., 1993). These include factors such as availability of intermediate care units, the intensive care unit management system, chronic health status, and the surgical procedures performed, if a utilisation management process is to effect improved resource use in critical care (Mazer et al., 1993, p.858). Focusing on process changes that better use intensive care unit capacity and alter care delivery will result in improved efficiency of intensive care unit resources. Determining which patients do not need intensive care unit care or which patients can be discharged earlier is essential. Intermediate care offers an alternative care pathway for patients who do not require the services provided by the intensive care unit.

2.11 Intermediate Care

Health is a continuum ranging from optimal health to life threatening critical illness. In recent times, hospitals have dichotomised care into general ward care and critical care, fragmenting this continuum of care (Ridley, 1998). The insidious development of mismatching care to the continuum of illness may be a contributory factor to intensive care unit bed unavailability, with intensive care unit beds occupied by patients not requiring intensive care services but requiring more care than that provided on a general ward. (Ridley, 1998).
When scarce intensive care unit resources are stretched, more acutely ill patients may have to be cared for on general wards. These patients require more specialised care than that provided on general wards but they lack the severity of illness usually requiring specialised intensive care unit services. Such deficiencies on the ward increase pressure for intensive care unit beds (Ridley, Burchett, Burns & Gunning, 1999). Patients may be cared for in the intensive care unit to compensate for inadequacies elsewhere in the hospital system, denying valuable resources for patients who will benefit more from the specialised intensive care unit services. Intermediate care can alleviate both the inadequate availability of intensive care unit facilities and the increased burden of care on general wards.

The development of intermediate care units (step down units and high dependency units), housed within the intensive care unit environment or geographically separate, has been brought about in part by pressure on intensive care unit beds (Goldfrad & Rowan, 2000). Intermediate care units may bridge the gap in care between the intensive care unit and general ward care (Bodenham & Klein, 1996; Goldhill & Sumner, 1998).

A number of studies have been conducted to examine the use of intermediate care units (Byrick, Mazer & Caskennette, 1993; Crosby, Gill & Rees, 1990; Crosby & Rees, 1994; Dhond, Ridley & Palmer, 1998; Durbin & Kopel, 1993; Fox, Owen-Smith & Spiers, 1999; Franklin et al., 1988; Kilpatrick, Ridley & Plenerleith, 1994; Kolleff, Canfield & Zuckerman, 1995; Lawless, Zaritsky, Phipps & Riley-Lawless, 1991; Leeson-Payne & Aitkenhead, 1995; Peacock & Edbrooke, 1995; Seneff, Bojanowsky & Zimmerman, 1999; Smith et al., 1999; Zimmerman, Wagner, Sun, Knaus & Draper, 1996; Zimmerman et al., 1999). The outcomes of these studies are summarised in Appendix A, table A.10. Many intensive care unit patients require only non-invasive monitoring at the time of admission and few of these patients subsequently require major intervention. The costs are high and the benefits are low for those patients in the intensive care unit who only require monitoring. Using intensive care unit beds for patients who require intermediate care results in sub-optimal use of resources (Acute Health Division, Department of Human Services, 1997). Leeson-Payne and Aitkenhead (1995) results from an intensive care unit audit (1992-1993) demonstrated that 10% of patients discharged from the intensive care unit had dependency scores that suggested
that intermediate care unit care would be more appropriate than discharge to a general ward. Henning et al. (1987, cited by Bone & Balk, 1988) demonstrated that 40% of medical intensive care unit patients and 30% of surgical intensive care unit patients in an United States’ study did not receive any active intervention when admitted for monitoring purposes. Zimmerman et al. (1999) observed that few step-down unit patients required transfer to an the intensive care unit (2.2%), but 5.2% of step down unit patients were readmitted to the step-down unit (see Appendix A, table A.10). The authors believe that there is considerable overlap in the characteristics of step-down unit and the intensive care unit patients admitted for monitoring. The similarities between these patients suggest that many intensive care unit admissions who need only monitoring and intensive nursing care could be cared for in step-down units (Zimmerman, et al., 1999). Reducing or eliminating intensive care unit admission for patients at lower risk for serious morbidity or mortality can increase availability of intensive care unit beds (Franklin et al., 1988; Charlson & Sax, 1988).

Intermediate care is particularly valuable for 3 groups of patients (Ridley, 1998):

- Patients who do not require the specialised expertise and invasive technology provided by the intensive care unit but need more specialised monitoring than available on the ward (Crosby & Rees, 1994; Kilpatrick, Ridley & Plenerleith, 1994);
- Patients who are ready to be discharged from the specialised care provided in the intensive care unit but not quite ready for general ward care;
- Patients who are deteriorating physiologically and requiring more critical care services than that provided on the ward in order that problems are anticipated before derangement occurs requiring intensive care unit care.

Intermediate care units provide an important half way function between the intensive care unit and the ward, facilitating more efficient use of resources with a greater level of intensive nursing care and technological monitoring than is possible on the general ward (Singer, Myers, Hall, Cohen & Armstrong, 1994; Ridley, 1998; Leeson-Payne & Aitkenhead, 1995; Zimmerman, Wagner, Sun, Knaus & Draper, 1996; Bodenham & Klein, 1996). Many patients with low severity of illness may be treated effectively in non-intensive care unit settings (American College of Critical Care
Medicine of the Society of Critical Care Medicine, 1998; Rosenthal et al., 1998; Southgate, 1999; Wallis Davies & Shearer, 1997). The more gradual step down in level of care made possible by having intermediate care units and less pressure to discharge patients may result in fewer patients being sent to the ward prematurely. Intermediate care may increase patient satisfaction with a less noisy environment and more liberal family visiting (Lawless et al., 1991).

The structure and availability of non-intensive care unit facilities determines the utilisation of intensive care units to a significant extent (Acute Health Division, Department of Human Services, 1997). Lack of intermediate care beds has resulted in patients having delayed discharge from intensive care unit utilising valuable intensive care unit resources (Fox, Owen-Smith & Spiers, 1999; Southgate, 1999). Alternatively, patients may be sent to wards rather than to the intermediate care unit when intermediate care unit beds are unavailable, and the level of care may be far from optimal (McQuillan et al., 1998; Kerridge, 2000). Intermediate care beds have been used in some health care facilities specifically for ward patients to compensate for deficiencies in care on the wards, making these beds unavailable for patients from the intensive care unit (Ridley, Burchett, Burns & Gunning, 1999). When patients cannot be discharged from intermediate care beds to general hospital beds, the transfer of intermediate care-ready patients occupying intensive care unit beds is prevented (Acute Health Division, Department of Human Services, 1997).

More intermediate care beds have been suggested to counter the recurrent cancellation of elective major surgery when an intensive care bed was unavailable (Bodenham & Klein, 1996; Peacock & Edbrooke, 1995). The authors suggested that the number of urgent transfers out of the intensive care unit would be reduced and the care of postoperative patients generally improved.

In hospitals with high elective surgical admissions, the benefits of opening an intermediate care unit are clear (Ryan, 1995). The opening of an intermediate care unit relieves pressure on the intensive care unit resources and increases flexibility. However, in other units with a relatively small proportion of elective surgery, more capacity in the intensive care unit may be required (Smith, Taylor, McQuillan & Nials, 1995). Edwards and Stockwell (1996) demonstrated no decrease in the bed shortage.
with sick patients continuing to be referred to the intensive care unit after the opening of an intermediate care unit (see Appendix A, table A.10). The authors concluded that the provision of an intermediate care unit did not decrease the need for intensive care unit admission. The severity of illness of patients admitted to the intensive care unit was increased.

These studies (Bodenham & Klein, 1996; Edwards & Stockwell, 1996; Peacock & Edbrooke, 1995; Smith, Taylor, McQuillan & Nials, 1995) demonstrate that there is a balance between the number of critically ill patients requiring intensive care unit beds and the number of intermediate care and intensive care unit beds required. For some hospitals, the development of an intermediate care unit will relieve pressure on intensive care unit beds or replace intensive care unit beds but in a third group additional intensive care unit beds as well as intermediate care unit beds will be required. Intermediate care units have not demonstrated a reduction in postoperative complications (Donnelly, Sandifer, O'Brien & Thomas, 1995). Identifying patients at high risk of early death or readmission to the intensive care unit may facilitate the selection of patients for intermediate care units. Guidelines for admission to intermediate care units have been developed (American College of Critical Care Medicine of the Society of Critical Care Medicine, 1998). Further studies are needed to examine the effectiveness of intermediate care.

Cost containment is a driving force for developing alternative care areas such as intermediate care units. Studies into the cost-effectiveness of intermediate care units should be encouraged to demonstrate their significantly lower cost (Singer, Myers, Hall, Cohen & Armstrong, 1994). Although costs between institutions are difficult to compare, costs within institutions give an indication of the difference in costs of care. The cost of an adult intensive care unit bed is nearly 4 times more expensive than a general ward bed (Donnelly, Sandifer, O'Brien & Thomas, 1995). Intensive care unit costs are almost treble that of intermediate care units (Crosby, Gill & Rees, 1990; Singer, Myers, Hall, Cohen & Armstrong, 1994). Krieger, Ershowsky and Spivack (1990) prospectively followed up all Medicare patients who were admitted to a United States pulmonary non-invasive monitoring unit and asserted that this facility could be effectively used as an alternative to the intensive care unit for selected pulmonary patients (see Appendix A, table A.10). Data were reviewed by Elpem, Silver, Rosen
and Bone (1991) for all patients admitted to a non-invasive respiratory care unit and
determined that the non-invasive respiratory care unit represented a cost-effective
approach to the care of a substantial number of patients requiring specialised respiratory
care (see Appendix A, table A.10). To help contain intensive care costs and optimise
intensive care unit resources, intermediate care options should be promoted (Lawless et
al., 1991). The limited growth of intermediate care units in the United Kingdom has
been slow and appears inadequate when compared to the potential demand (Edbrooke,
Hibbert & Corcoran, 1999; Ryan, 1996; Ryan, Bayly, Weldon & Jingree, 1997).

Intermediate care units may not be the whole solution to efficient utilisation of
intensive care unit resources, particularly if there is a high occupancy of the intensive
care unit with critically ill patients needing high levels of intervention. However,
intermediate care units can promote earlier intensive care unit discharge, facilitate
patient triage, decrease costs, and facilitate more efficient intensive care unit utilisation.
Intensive care unit readmissions may be reduced and hospital ward mortality rates
decreased (Rowan et al., 1993b). Inadequate ward facilities and ward bed unavailability
may be alleviated with the availability of intermediate care unit beds, potentially
reducing the number of patients having their discharge delayed from the intensive care
unit.

Having flexibility to convert intensive care unit beds to intermediate care unit
beds with lower staffing requirements during slack periods of demand would promote
more efficient use of available resources (Besserman et al., 1999). There is a need to
remain flexible between an allotment of intensive care unit and intermediate care beds
so as to accommodate periods of demand for intensive care unit beds (American
Thoracic Society, 1997).
2.12 Medical Emergency Teams

Intermediate units can provide suitable care for patients who are identified as becoming physiologically compromised by increasing the level of care these patients receive, thus preventing the necessity for an intensive care unit admission. However, there is an increasing worldwide awareness for critical care medicine to move outside the doors of the intensive care unit to improve the care of critically ill patients. Critical care 'without walls' may be provided by practising critical care nurses who follow up patients transferred from the intensive care unit to the wards. These outreach teams detect critical illness early and provide expertise and assistance in the care of seriously ill patients on the ward including post-intensive care unit patients, follow up and bereavement (Southampton University Hospitals NHS Trust, 2001).

The development of medical emergency teams has been influenced by a number of reports in the literature. Zinn (1995) reported on preventable deaths in 14,000 Australian hospitals. The care study found that preventable disabilities occurred in 1% of hospital admissions and deaths in 0.5% of admissions.

McQuillan et al. (1998) from their prospective confidential inquiry into the quality of care before admission to the intensive care unit concluded that quality of care before admission to the intensive care unit may influence outcome (see Appendix A, table A.13). The assessors believed suboptimal care had a substantial impact on individual morbidity, mortality and requirement for intensive care resources (avoidable admissions). The principal causes of suboptimal care were failure of organisation, lack of knowledge, failure to appreciate clinical urgency, lack of experience, lack of supervision and failure to seek advice. Clinically significant effects occur if appropriate referrals to intensive care are delayed, refused or transferred elsewhere. Better care before admission may reduce intensive care bed days.

McQuillan et al. (1998) recognised a number of limitations in the conduct of the confidential inquiry. These included the assessment of quality being difficult to define, reliance on subjective opinions of assessors as objective definitions were impractical, and lack of assessor agreement for group 3 participants. The intensive care unit is an area noted for objective measurement, and the subjective opinions of 2 assessors may
not be reliable, evidenced by the lack of agreement in 26 patients. The definition of suboptimal was not documented in the report, as the use of explicit definitions of what constituted suboptimal care was too difficult to set out. The research relied on implicit judgements of quality of care, the interrater reliability of which was uncertain (Walshe, 1999). McQuillan et al. (1999) argue that more assessors and greater training may not improve interrater reliability, as disagreement among experts is common. Walshe (1999) argues that this makes it difficult to reach a valid and reliable implicit assessment of the quality of care. Knowledge of the patient outcome could also influence judgement about the quality of care. The patients who had longer time to admission to the hospital and intensive care unit were more likely to receive suboptimal care. There was no information as to whether the delay was caused because of a lack of beds. However, McQuillan et al. (1999) assert that the delays in admission to the intensive care unit were caused by late referral and not bed availability. The authors believe that the intensive care unit has the responsibility to ensure that other critically ill patients receive timely and appropriate care. Interventions can begin on the ward prior to admission to the intensive care unit. The patient can be stabilised and transferred to another intensive care unit if beds are unavailable, the priority is appropriate intensive care rather than bed availability (McQuillan et al., 1999).

Several other limitations to the McQuillan et al. (1989) study may be noted including the limitations of power and outcome bias, small patient numbers and wide confidence intervals. The Acute Physiology and Chronic Health Evaluation (APACHE) II (Knaus, Draper, Wagner & Zimmerman, 1985) score may have been insensitive to detect the effect. The validity of standardised mortality ratios may have been compromised by lead time bias, where early resuscitation instigated in the intensive care unit may have improved physiology compared to delay in resuscitation for patients refused admission.

Wood and Smith's (1999) analysis of patients having cardiopulmonary arrests supported the results of the study conducted by McQuillan et al. (1998) (see Appendix A, table A.13). The authors suggested it was preferable to be proactive, either to expedite timely intensive care unit referral or to allow a dignified death for patients who are dying. When intensive care unit care would benefit patients, those patients should be referred early. In the other group of sicker patients where cardiopulmonary
resuscitation would not be successful, intensive care unit care would not be appropriate and the consideration of “do not resuscitate” orders would be more appropriate (Wood & Smith, 1999).

Schein, Hazday, Pena, Ruben and Sprung, (1990) reported a high incidence of clinical deterioration prior to cardiac arrest in the United States in a group of consecutive general hospital ward patients developing cardiopulmonary arrest. Patients developing arrest had predominantly respiratory and metabolic derangement’s immediately preceding their arrests. Their underlying diseases were generally not rapidly fatal. The authors concluded that the clinical deterioration in respiratory function or mental status that often precedes arrest plus the high mortality associated with arrest, should encourage efforts to predict and prevent arrest.

Vincent, Neale and Woloshynowych (2001) estimated that about 11% of hospital admissions in two United Kingdom hospitals were associated with an adverse event. Death, cardiac arrest, and unplanned admissions to an intensive care unit are serious adverse events. Most of these events arise in general wards and were usually preceded by signs of clinical instability (Nyugen, Hillman & Buist, 2001).

Buist et al. (2002) conducted a non-randomised study in an Australian 300-bed tertiary referral teaching hospital before and after the introduction of the medical emergency team. After adjustment for case mix, the introduction of the medical emergency team was associated with a 50% reduction of unexpected cardiac arrest.

Medical emergency teams are used to identify physiological deterioration and treat patients early by taking intensive care skills to where they are needed, thereby improving patient outcomes (Fletcher & Flavouris, 2000). Patients admitted from hospital wards to an intensive care unit have a higher overall mortality than patients admitted from other areas of the hospital. Identification of critically ill patients on the ward and early advice and active management are likely to prevent the need for cardiopulmonary resuscitation, improve outcomes and prevent deterioration to the extent that intensive care unit care is required (Bristow et al., 2000; Goldhill, Worthington, Mulcahy, Tarling & Sumner, 1999) (see Appendix A, table A.11). It makes clinical and economic sense to anticipate problems early, to intervene quickly
and to concentrate ill patients in specialised areas rather than have them scattered throughout the hospital (Ryan, 1996, p.654). Fletcher and Flabouris (2000) believe that the Medical Emergency Team is less restrictive and more sensitive in detecting sick patients than the patient-at-risk team described by Goldhill, Worthington, Mulcahy, Tarling and Sumner (1999). Changing emphasis from the traditional cardiac arrest team to a medical emergency team has resulted in earlier recognition of sick patients and prevention of cardiopulmonary arrest (Buist et al., 2002). Use of medical emergency teams should improve the efficiency and effectiveness of intensive care resources, but only future research will demonstrate their value.

2.13 Discharge

Intensive care units do not function in isolation in the process for caring for an acute critical illness (Teres et al., 1998). Decisions regarding discharge from the intensive care unit are influenced by a multitude of interrelated factors and influence other parts of the patient’s continuum of care. Each decision made in the patient’s continuum of care may be influenced by or in itself influence any other aspect of the process (Levin & Sprung, 2001). Patients should be constantly reviewed in the intensive care unit to determine whether they are ready for discharge (Levin & Sprung, 2001).

Discharge criteria used appropriately should facilitate timely patient discharge from the intensive care unit. The patient’s physiological status should have stabilised and the need for intensive care unit monitoring and care is no longer needed. Timing of discharge from the intensive care unit involves identifying those patients at low risk of subsequent need for intensive care unit care, who may be safely discharged from the intensive care unit, and those patients at high risk of subsequent need for intensive care unit care, who might benefit from a longer intensive care unit stay (Rubins & Moskowitz, 1988, p.867). Untimely discharge occurs if patients are discharged prematurely or patient discharges are delayed. The focus on discharge policies may be more reasonable than a focus on admission policies (Miller, 1994). Intensive care unit length of stay may be decreased by well-defined discharge criteria without quality of
care being compromised (Rosenberg & Watts, 2000).

Discharging a patient from the intensive care unit is a complex process involving many factors. The decision to discharge patients from the intensive care unit is based not only on clinical parameters, but also on prognosis, severity of illness, individual preferences and treatment needs (Engelhardt & Rie, 1986; Franklin, Rackow, Mamdani, Burke & Weil, 1990). They are also influenced by organisational factors such as resource demands, staffing, leadership, bed capacity, bed policies, national and international recommendations and care alternatives (Franklin et al., 1988; Matos & Fevereiro, 2001; Moreno, Reis Miranda, Sax & Charlson, 1987; Strosberg, 1993; Teres, 1993; Zimmerman, Wagner, Draper & Knaus, 1994). Using intensive care unit discharge status as a measure of intensive care unit performance is inadequate as it may be significantly influenced by discharge timing, especially for those patients transferred out to die in non-intensive care unit surroundings (Sirio et al., 1999). The increased use of skilled nursing facilities, rehabilitation centres and nursing homes demonstrates that long term evaluation of critical care is required post hospital discharge (Sirio et al., 1999).

### 2.14 Pressure on Intensive Care Unit Beds

Pressures for intensive care unit beds or variation in unit discharge policies can result in different discharge practices (Marik & Hedman, 2000). A patient in one hospital may remain and die within the intensive care unit whilst in another hospital, the same patient may be discharged to a ward or different facility. The efficiency and ingenuity of the nursing staff in obtaining ward beds, as well as the hospital census can affect intensive care unit length of stay (Marik & Hedman, 2000).

Several reports show that pressure on intensive care facilities has been growing (Bull, 1995). Pressure on intensive care beds may result in patients either being referred too late or discharged too early from the intensive care unit. Care may be less than ideal on overstretched wards. Delay or refusal in admission to or premature discharge from the intensive care unit has been associated with increased morbidity. Complications
may prolong hospital length of stay and increase costs. Unavailability of beds may also result in postponement of a patient’s surgery or transferring a patient to an alternate intensive care unit (Dobb, 2001). Pressure on intensive care unit beds may also result from staff shortages. Pressure for intensive care unit beds may have several consequences:

- Refusal of admission;
- Transferring patients to another facility;
- Premature discharge
- Increased readmission rates;
- Increased in-hospital mortality rates;
- Increased night discharges from the intensive care unit;
- Increased ward cardiac arrest rates.

2.14.1 Refusal of Admission

Many patients are commonly refused care in the intensive care unit (Bennett & Bion, 1999; Levin & Sprung 2001). Various studies have cited rates of refusal as 24% (Sprung et al., 1999), 26% (Metcalfe, Sloggett & McPherson, 1997), 38% (Joynt et al., 2001) and as high as 57% because no beds were available (Frisho-Lima, Gurman, Shapira & Porath, 1994, cited by Joynt et al, 2001). Little is known about denied or delayed admission originating from within the hospital or from other hospitals, although the consequences may be significant (Strosberg, 1993). The greatest benefit of the intensive care unit seems to be in the mid-range of the severity of illness (Levin & Sprung, 2001). Joynt et al. (2001) observed that patients refused admission to the intensive care unit were at an increased risk of mortality, particularly in the middle range of severity of illness. Patients who required but were refused intensive care unit admission were found to have an excess adjusted mortality when compared to similar patients admitted to the intensive care unit (Bennett & Bion, 1999; Joynt et al., 2001; Levin & Sprung 2001; Metcalfe, Sloggett & McPherson, 1997).

Different systems of triage operate including first come first served, or when demand exceeds supply, admitting patients whom would have the greatest medical
benefit. Admitting decisions should be based on expected benefit, with greatest benefit often measured by absolute survival or by the increment survival with intensive care. Factors associated with the decision to refuse admission of patients referred to the intensive care unit were age, diagnostic group and severity of illness (Joynt et al., 2001). Joynt et al. (2001) observed no association between available beds and admission decisions (see Appendix A, table A.13). The authors believed that this might reflect differences in the population and facilities studied. Lack of beds were the most common reason for refusal cited by Metcalfe, Sloggett and McPherson (1997) and Frisho-Lima, Gurman, Shapira and Porath (1994, cited by Joynt et al., 2001) but in Joynt et al.'s (2001) study, like Sprung et al. (1999), the major reasons for refusal were patients being too well or too sick. The disparities of these results may reflect differences in study design.

2.14.2 Transfer

The outcome for critically ill patients is influenced by timely access to definitive care. The apparent lack of intensive care unit beds has resulted in the transfer of critically ill patients to other hospitals, sometimes substantially distant from the originally intended admitting facility (Edbrooke, Hibbert & Corcoran, 1999).

The transfer of critically ill patients to different geographical areas should be avoided whenever possible as the transfer process can jeopardise patient outcomes (Dobb, 2001). However, inter-hospital transfers of patients requiring intensive care may be unavoidable when the patient requires a level of service or expertise, diagnostic service or therapeutic procedure that is not available at the transferring/primary hospital (Duke & Green, 2001).

While some inter-hospital transfers might be clinically justified, others may be due to intensive care units being overloaded and lacking beds (Cupples et al., 1997; Mackenzie, Smith & Wallace, 1997; O'Driscoll, cited in Chadda, 1995; Wallace, Davies & Shearer, 1997). Critically ill patients having acute inter-hospital transport risk delayed admission to intensive care unit, delay in definitive treatment and potential complications. Transfers made when the primary hospital is temporarily unable to provide the intensive care services required because of resource limitations has resulted
in patients having delay in admission to intensive care units with definitive treatment being delayed and increased morbidity (Duke & Green, 2001). Critically ill patients who are transferred may have longer lengths of stay in both intensive care units and hospital, have a higher predicted and actual mortality and use more resources than non-transferred patients (Acute Health Division, Department of Human Services, 1997; Butt & Shann, 1998). The patient's family may suffer additional social disruption if the intensive care unit to which the patient is transferred is further from their home (Dobb, 2001).

Duke and Green (2001) reported that the transfer group experienced a significant delay in admission to the receiving hospital's intensive care unit (5.0 [range 4.0-6.0] versus 3.0 [range 2.0-5.5] hours; \(p = 0.001\)), and a longer stay in the intensive care unit (48 [range 33-111] versus 44 [range 25-78] hours; \(p = 0.04\)), and the hospital (10 [range 3-14] versus 6 [range 3-13] days; \(p = 0.02\)). These length-of-stay increases were independent of outcome, diagnosis, age and hospital destination (see Appendix A, table A.14). However, the hospital mortality in the inter-hospital transfer group was not statistically significant from that in the non-transfer group.

Flabouris (1999) compared patient demographics, severity of illness and outcome of critically ill patients transported from peripheral hospitals to a regional tertiary referral intensive care unit with non-transported critically ill patients (see Appendix A, table A.14). Transported patients had a higher predicted mortality and longer intensive care unit stay than non-transported patients. Flabouris (1999) believes that associated resource utilisation and overall cost would be expected to be greater for transported patients.

Transport of the critically ill because of apparent intensive bed shortages has been of particular concern in the United Kingdom. Several reports highlight the problem (Bion, 1995; Dyer, 1995; Ryan, 1996; Wallace & Lawler, 1997). A seriously ill patient with emphysema was reported as being moved 3 times within 24 hours. His condition deteriorated requiring intensive care unit services. He waited for 6 hours before being moved to another hospital's intensive care unit and then was moved again where he subsequently died. The hospital reported that the patient, although critically ill, was the most stable patient and could be moved (Anonymous, 1995). Dyer (1995)
reported a patient with head injuries being flown 320 kilometres to another hospital after a telephone search failed to find a bed at the referral hospital and in the local district. He died following neurosurgical treatment.

Mackenzie, Smith and Wallace (1997) estimated that the number of critically ill patients requiring secondary transport to adult intensive care units in the United Kingdom in 1994 exceeded 11,000 patients (see Appendix A, table A.14). Life threatening complications may occur in critically ill patients when conventional ambulances are used for transport. Bion, Wilson and Taylor, (1988) conducted an audit of 50 consecutive transferred patients. Seven patients developed 8 serious complications during transfer. Complications were more common in patients attended by doctors inexperienced in the management of critically ill patients and not due to more severe illness among these patients. Complications during transport did not directly cause the death of any patient.

A partial solution offered for the problem was to make changes to the allocation of emergency beds in the United Kingdom. The London Emergency Bed Service has introduced an updated computerised register of available beds to facilitate the search for intensive care unit beds. This initiative should not be used to hide the scarcity of intensive care unit resources (Ryan, 1996). Intermediate care units and bed registers can help alleviate pressure on intensive care beds but not without more resources, as there are insufficient intensive care unit beds (Ryan, 1996; Edbrooke, Hibbert & Corcoran, 1999).

2.14.3 Premature Discharge

Appropriate use of intensive care unit beds is essential. Discharge from the intensive care unit at the earliest appropriate time should promote effective utilisation of intensive care unit resources and reduce intensive care costs (Cooper, Sirio, Rotondi, Shepardson & Rosenthal, 1999). The timing of discharge and discharge destination may be important factors in preventing complications post-discharge from the intensive care unit (Smith et al., 1999). Identifying patients at high risk of early death or readmission to the intensive care unit and using half way facilities such as intermediate care units may alleviate inappropriate discharge from the intensive care unit.
Patients should not be discharged prematurely to provide beds where medical care is inadequate for their needs in order to make room for a new intensive care unit admission or reduce costs. Studies indicate that the average severity of illness among patients admitted to intensive care units during periods of bed shortages increases (Singer, Carr, Mulley & Thibault, 1983; Strauss, LoGerfo, Yeltatzie, Temkin & Hudson, 1986).

The apparent premature discharge of patients from the intensive care unit has been a cause for concern. It has been estimated that 22-45% of intensive care unit readmissions are due to premature intensive care unit discharge (Baigelman, Katz & Geary, 1983; Franklin & Jackson, 1983; Snow, Bergin & Horrigan, 1985). Premature discharge of intensive care unit patients to general wards may result in readmission to intensive care with a worsening of the original disease process, increased costs, and an increased mortality rate (Durbin & Kopel, 1993; Franklin & Jackson, 1983; Snow, Bergin & Horrigan, 1985). Significantly higher severity of illness scores or therapeutic scores on the day of discharge have been reported for patients who died after discharge compared to those that survived (Daly & Bihari, 1995; Knaus, Draper, Wagner & Zimmerman, 1985).

Several studies have considered readmissions from the intensive care unit. Franklin and Jackson (1983) reported the mortality rate of this group of 36 readmissions was 58%, more than twice the overall mortality rate for all discharges from the ICU in the year of the study (see Appendix A, table A.15). Baigelman, Katz and Geary (1983) reported a readmission rate of 11.7% (as noted in Appendix A, table A.15). Prematurity of transfer out of a critical care unit may have been a contributing factor in 4.2% of the readmissions. The authors concluded that improved communication between physicians, nurses and therapists could probably decrease premature transfers that contributed to readmission. Snow, Bergin and Horrigan (1985) reported that 78% of discharges from the intensive care unit were deemed appropriate, that is not premature, but 62% of the patients had one or more warning signs, which might have alerted physicians to change treatment (see Appendix A, table A.15). In half of these patients the reason for readmission was related to the warning sign. Readmission was related to the original disease in 65% of the incidents, while a new patient problem initiated readmission in 38%. The most common new problems were cardiopulmonary
insufficiency and infection. All but one patient readmitted with pulmonary problems displayed retrospective evidence of clear warning signs before the original discharge. Proactive treatment may have prevented readmission to the intensive care unit. In an analysis of post-intensive care unit death, Henderson (1997) observed that 19% of deaths occurred in low-risk patients. Henderson (1997) asserts that this certainly reflected premature intensive care unit discharge due to intense bed pressure in the study hospital, which had insufficient critical care beds. The study hospital had no step down facility.

Readmission rates may reflect poor discharge making decisions (Smith et al., 1999). Smith et al. (1999) examined the effect of high levels of pre-intensive care unit discharge care, as assessed by the Therapeutic Intervention Scoring System (Cullen, Civetta, Briggs & Ferrara, 1974) on subsequent hospital mortality (see Appendix A, table A.10). Eleven percent of all intensive care unit discharges subsequently died in hospital. Because the mean Therapeutic Intervention Scoring System (Cullen, Civetta, Briggs & Ferrara, 1974) scores in patients readmitted to the intensive care unit were significantly higher than in patients who did not require admission, the authors believe that patients may have been prematurely discharged to the ward. More than 30% of readmissions in Durbin and Kopel's (1993) study were for a recurrence or worsening of the original condition (see Appendix A, table A.10). Emergency admissions to the intensive care unit from general wards were frequently more severely ill and had a higher mortality rate than patients admitted to the intensive care unit as a whole. Patients readmitted for the same problem had a higher mortality rate than patients admitted with a different problem. Patients readmitted to an intensive care unit had a higher mortality rate and increased length of stay. The authors concluded that these results might represent premature discharge in at least 30% of patients who were readmitted to the intensive care unit with a worsening of their condition. In a secondary analysis of a prospective cohort to look at factors predicting intensive care unit readmission (as outlined in Appendix A, table A.15), longer or more intensive care may have decreased the likelihood of readmission by improving the clinical severity of patients' illness (Rosenberg, Hofer, Hayward, Strachan & Watts, 2001). Data regarding acceptable readmission rates to the intensive care unit are still lacking. Prospective studies are needed to better define the patient population at risk.
In the context of the United Kingdom experience where intensive care unit bed shortages have fuelled rationing, premature discharge from intensive care unit may occur. Measures used to estimate premature discharge include mortality after discharge from intensive care unit. One study reports mortality after discharge from intensive care unit ranging from 6.1% to 16.3% (Rowan et al., 1993b). However, deaths may be a result of factors occurring before or after discharge from intensive care unit (Bion, 1995; Ridley & Purdie, 1992; Ryan, 1996; Wallis, Davies & Shearer, 1997).

Some literature advocates the notion that delaying patient discharge may actually improve patient outcomes for certain types of patients (Daly, Beale & Chang, 2001; Moreno, Reis Miranda, Matos & Fevereiro, 2001). It has been suggested that rationing scarce intensive care unit resources without adequate understanding of the implications if patients are discharged too early from intensive care unit may result in worse patient outcomes (Goldfrad & Rowan, 2000). Daly, Beale and Chang (2001) performed logistic regression analysis and modelling of data to predict risk of death before hospital discharge (see Appendix A, table A.15). If proved reliable and valid, intensivists could use this score to assist decision-making regarding which patients to discharge to maximise efficiency of the scarce intensive care unit resources. Mortality after discharge from the intensive care unit was reported as 12.4%. The discharge mortality of at-risk patients was estimated at being reduced by 39% if patients stayed an additional 24 hours in the intensive care unit. The authors believe that patients would benefit from an additional 48 hours in intensive care. None of the 20 intensive care units at the time of this study were in hospitals with high dependency units. Previous studies have found 25% of deaths after intensive care were "expected" at discharge (Wallis, Davies & Shearer, 1997).

It is a challenge to determine who would benefit from longer intensive care unit care (Daly, Beale & Chang, 2001). There is no supporting data that shows that an extra 48 hours in an intensive care unit reduced the risk of mortality. Of the 5 factors in the model (patient's age, chronic health points, intensive care unit length of stay, acute physiology score and cardiothoracic surgery), only normalisation of physiology would reduce the risk of mortality after discharge (Ingliss & Price, 2001). Cardiothoracic surgery (57% of the developmental model) used as a factor in the predictive model is atypical of most United Kingdom intensive care units. It may be either not possible or
take much more than 48 hours to reduce the risk in an individual patient; thus the extrapolation from a predictive triage model to conclusions regarding reduction in mortality and resource requirements for 48 hours longer stay is invalid (Ingliss & Price, 2001). No consideration of the relative timing of deaths after discharge was made (Ingliss & Price, 2001). Deaths, within 48 hours, may reflect precipitate discharge or communication problems whereas later deaths may be indicative of the standard of ward care. Information is needed to improve clinical decision-making. Clinical decisions in the intensive care unit are based on both intrinsic need and influenced by extrinsic factors in a dynamic system of patient care (McPherson, 2001). Prognostic scores do not explain all the intrinsic or extrinsic determinants of mortality in critically ill patients. Quality adjusted survival duration should be the most important outcome measure, rather than mortality (McPherson, 2001).

The cost of an additional 48 hours recommended by Daly, Beale and Cheng (2001) might not be reconcilable with the limited financial and physical resources available. Daly, Beale and Cheng’s (2001) results may not be useful for other contexts given the differences in defining intensive care, allocation of resources, differing clinical practices, utilisation of step down units and differences in standards of care received on general wards.

Continued evaluation of readmission rate, reasons for readmission, mortality rate and length of stay of patients subgroups will provide data for analysis of the appropriateness of utilisation of intensive care resources and the detection of possible premature intensive care unit discharge (Durbin & Kopel, 1993; Baigelman, Katz & Geary, 1983).

2.14.4 Increased Readmission Rates

When reducing intensive care unit utilisation and length of stay, it is increasingly important to identify those patients at high risk of returning to the intensive care unit (Rosenberg & Watts, 2000). The importance of intensive care unit readmission during the same hospital stay has been recognised and are used as an intensive care unit performance indicator (Australian Council on Healthcare Standards, 2002).
Readmission to the intensive care unit may indicate premature discharge (Baigelman, Katz & Geary, 1983; Daly, Beale & Cheng, 2001; Goldfrad & Rowan, 2000; Kirby & Durbin, 1996). Alternatively, it may reflect an inability to provide specific diagnostic, therapeutic or monitoring capabilities on a general ward, worsening of the initial problem, or the development of a new problem (Kirby & Durbin, 1996). The reason for readmission may also be less related to poor quality of care or premature discharge, and more likely a function of the patient's failure to respond to treatment (Rosenberg & Watts, 2000). Patients readmitted to the intensive care unit during the same hospitalisation may not respond to further intensive care (Rosenberg & Watts, 2000). Patients who were later readmitted to the intensive care unit tended to be sicker on their initial intensive care unit admission than those patients not readmitted (Cooper, Sirio, Rotondi, Shepardson & Rosenthal, 1999). This may reflect premature or inappropriate discharge from the intensive care unit (Cooper, Sirio, Rotondi, Shepardson & Rosenthal, 1999).

Pressure to create beds for patients with a greater critical care need may influence decisions to discharge patients early. Identification of patients at risk for readmission should allow the development of better management strategies (Durbin & Kopel, 1993). Some authors argue that readmission may suggest highly aggressive and excellent care (Angus, 1998; Cooper, Sirio, Rotondi, Shepardson & Rosenthal, 1999). These authors also suggest that hospitals with short intensive care unit stays may increase their readmission rates but have a lower risk of nosocomial and iatrogenic complications which may lower the risk of death overall (Cooper, et al., 1999, p.406).

In most cases, patients who die (excluding patients with "do not resuscitate" orders) or who are readmitted within 72 hours have been discharged too early (Franklin, 1988). Intensive care unit readmissions have been associated with worsening of the patient's original disease, incurring higher costs and indicating poor patient outcome (Durbin & Kopel, 1993; Franklin & Jackson, 1983; Snow, Bergin & Horrigan, 1985). Patients requiring readmission to the intensive care unit use more resources than intermediate care or general ward care. The associated morbidity and cost for patients who are readmitted, often as a result of the worsening of their original condition, are substantial (Durbin & Kopel, 1993; Franklin & Jackson, 1983; Kramer, 2001; Snow, Bergin & Horrigan, 1985). Preventing readmission by early recognition of
physiological deterioration may prevent the necessity of intensive care unit readmission. Rubins and Moskowitz (1988) determined that several clinical parameters could distinguish patients at high risk for unit readmission or unexpected death from survivors (see Appendix A, table A.15).

Chen, Martin, Keenan and Sibbald (1998) reported that nearly 5% of patients are readmitted to the general intensive care unit (as noted in Appendix A, table A.15). Readmitted patients had a higher risk of hospital death that may be underestimated by the usual physiological indicators on either initial admission or readmission. The low specificity of these indicators to predict which patients are at risk of readmission to the intensive care unit have not allowed the development of a useful prediction tool (Cooper, Sirio, Rotondi, Shepardson & Rosenthal, 1999).

Other studies indicate that readmission rates in the United States vary from 5-13% of all admissions (Baigelman, Katz & Geary, 1983; Durbin & Kopel, 1993; Franklin & Jackson, 1983; Kirby & Durbin, 1996; Rubins & Mosowitz, 1988; Snow, Bergin & Horrigan, 1985; Strauss, LoGerfo, Yeltatie, Temkin, & Hudson, 1986). Institutional factors and case mix are responsible for much of the variability in readmission rates but some of it may be due to different definitions of an intensive care unit readmission (Rosenberg & Watts, 2000). It is difficult to compare readmission rates between health care facilities because of differing hospital policies, unmeasured differences in patient populations, ratio of intensive care unit beds to total hospital beds, secular changes in intensive care practices over time, definitions of intensive care, casemix, emergency department activity and other medical resources located in the geographical area, inadequate risk-adjustment between readmission and control groups and the utilisation of intermediate care units (Baigelman, Katz & Geary, 1983; Chen, Martin, Keenan & Sibbald, 1998). The intensivists' individual discharge practices and patient preferences may influence intensive care unit readmissions (Rosenberg, Hofer, Hayward, Strachan & Watts, 2001).

Rosenberg, Hofer, Hayward, Strachan and Watts (2001) demonstrated that patients readmitted to the intensive care unit had significantly higher hospital morbidities and lengths of stay even after adjusting for severity of illness, diagnosis and comorbidities (see Appendix A, table A.15). Readmitted patients received longer
duration of treatment before their first intensive care unit admission and were sicker and more physiologically unstable both at the time of first admission and discharge. Adjusting for severity of illness, readmitted patients were more than 11 times likely to die and have hospital stays almost twice as long as non readmitted patients. The authors believe that status at discharge, rather than status at their initial admission, would be more relevant to evaluate risk of admission and the appropriateness of intensive care unit discharge. Rosenberg et al. (2001) did not evaluate expectations for patient outcomes and risk of readmission at the time of intensive care unit discharge, nor the influence of high bed census on discharge decisions, which would have strengthened the results of this study.

Other studies have demonstrated several diagnosis including respiratory diseases and gastrointestinal bleeding as well as higher acute physiology scores being associated with readmission (Chen, Martin, Keenan & Sibbald, 1998; Durbin & Kopel, 1993; Rubins & Moskowitz, 1988).

Escarce and Kelly (1990) demonstrated admission source as an important predictor of hospital death independent of the severity of illness (see Appendix A, table A.15). This was a strong predictor of intensive care unit readmission in Rosenberg, Hofer, Hayward, Strachan and Watts’ (2001) study. This may be due to a failure to respond to treatment (Rosenberg et al., 2001).

Hospitals that receive a high number of transferred patients may have worse than expected readmission rates, costs and outcomes than other health care facilities (Rosenberg, Hofer, Hayward, Strachan & Watts, 2001). Difference in care post intensive care unit discharge may influence readmission rates. Improved care after intensive care unit discharge may reduce readmission and decrease mortality rates (Rosenberg et al., 2001).

Some readmissions may be avoided by prolonging intensive care stay or improving discharge planning (Baigelman, Katz & Geary, 1983; Durbin & Kopel, 1993; Franklin & Jackson, 1983). Further studies are required to determine if patients at risk for readmission can be identified early to improve the outcome (Chen, Martin, Keenan & Sibbald, 1998; Rubins & Moskowitz, 1988).
2.14.5 *Increased In-Hospital Mortality Rates*

Intensive care unit mortality represents a personal and social tragedy for both the patient and their significant others but is also a poor economic outcome (Henderson, 1997; Smith et al., 1999). Few would accept spending a fortune on an intensive care unit patient who dies soon after discharge to the ward as good use of scarce resources (Henderson, 1997). Increased mortality rates after discharge from the intensive care unit may indicate premature discharge from the intensive care unit. Many patients in the intensive care unit are at significant risk of death and an essential function of the intensive care unit is to facilitate survival (Henderson, 1997). If a patient survives the intensive care unit care only to die subsequently on the ward, then the admission to the intensive care unit or the quality of care on the ward may be challenged.

Mortality data are easy and cheap to collect and accurate in that death is an unambiguous dichotomous variable. Crude death rates are dangerously unreliable and severity and case mix must be standardised (Henderson, 1997). Mortality even with severity adjustment remains an insensitive measure of intensive care unit quality (Dubois, Rogers, Moxley, Draper & Brook, 1987).

The mortality rate of patients admitted to the intensive care unit is much higher than other hospital patients and is therefore considered by some authors to be a sensitive, appropriate measure of outcome (Gunning & Rowan, 1999). Intensive care unit mortality rates may be used rather than hospital mortality rates because of the possible influence of differences in post unit treatment. Intensive care unit mortality rates however are subject to the individual discharge and triage decisions of intensive care units and therefore may not be considered as accurate as hospital rates. On the other hand, hospital mortality rates ignore the possibility that one hospital might have been able to discharge patients with short-term prognoses sooner than other hospitals. Death can result from many factors other than ineffective care including casemix, input such as staff and equipment, and processes of care such as the type, skill and timing of care provided (Gunning & Rowan, 1999). Both readmission and mortality rates are influenced by the other factors including comorbidities and care received after leaving the intensive care unit. In addition, some patients may be discharged to the ward with the expectation that the patient would die.
Henderson's (1997) analysis of post-intensive care unit death revealed that 19% of deaths occurred in low-risk patients. Henderson (1997) asserts that this reflected premature intensive care unit discharge due to intense bed pressure in a hospital, which reportedly had insufficient beds. The hospital had no step down facility. An intermediate care facility is cheaper than intensive care unit beds and has been shown to reduce mortality in at-risk patients (Franklin et al., 1988, Hillman, 1996).

Several studies have indicated a significant number of patients dying after intensive care unit discharge, but before leaving hospital. Figures range from 23% of all deaths to 31% of all deaths (Apolone et al., 1996; Goldhill & Sumner, 1998; Moreno & Morais, 1997b; Moreno, Reis Miranda, Fidler. & Van Schilfgaarde, 1998).

Wallis, Davies and Shearer (1997) found 20% of patients who died in hospital after discharge from the intensive care unit were expected to survive following intensive care unit discharge (see Appendix A, table A.8). They concluded that these deaths might have been prevented by improved care provided in the intensive care unit.

However, Lawrence and Havill (1999) found that very few patients died unexpectedly in the wards after discharge from the intensive care unit (see Appendix A, table A.16). There were no apparent treatment deficiencies. They did however suggest that there was some evidence in some patients that avoidable events had precipitated intensive care unit admission and may have contributed to death after discharge from the intensive care unit. There was no indication that patients had been discharged prematurely.

Factors inside the intensive care unit may be responsible for the high mortality rate (Moreno & Agthé, 1999; Smith et al., 1999). Discharge decisions should be based on a patient having their physiological status stabilised and no longer requiring intensive care unit monitoring or care (Task Force of the American College of Critical Care Medicine, Society of Critical Care Medicine, 1999). The nursing workload needed for each patient must be able to be provided outside the intensive care unit (Moreno & Agthé, 1999; Smith et al., 1999).
2.14.6 Increased Night Discharges from the Intensive Care Unit

The imbalance of supply and demand of intensive care services may be demonstrated by the increasing number of night discharges from the intensive care unit and the need to perform acute inter-hospital transfers of critically ill patients. Patients discharged at night may include those patients who may have been suitable for discharge during the day but unavailability of beds may have prevented their discharge. It may also include those patients nearly ready for discharge but kept in the intensive care unit for one more night, possibly due to concerns regarding adequate ward care during the night. Their night discharge is a consequence of pressure on intensive care beds.

Night discharges are increasing in the United Kingdom as a result of insufficient intensive care unit beds (Goldfrad & Rowan, 2000). Goldfrad and Rowan (2000) found a 2.2 fold increase in night discharges with 44% of patients discharged at night judged by clinicians to be fully ready for discharge compared with 86% of discharges during the day (see Appendix A, table A.17). These patients fared significantly worse than those discharged during the day with potential negative physical and psychological impacts for the patient.

2.14.7 Increased Ward Cardiac Arrest Rates

Pressure on intensive care unit beds may result in increased ward cardiac arrests. If patients are kept on wards and there is physiological deterioration but cannot be admitted to the intensive care unit because beds are unavailable, there is an increased risk of cardiac arrest.

Franklin et al. (1988) observed fewer cardiac arrests after the introduction of an intermediate care unit. Their intensive care unit effectively increased the ready availability of critical care services to those patients most urgently in need, alleviating unnecessary intensive care unit delays (American College of Critical Care Medicine of the Society of Critical Care Medicine, 1998).
2.15 Delays in Discharge

Discharge status is a critical factor in cost containment in the intensive care unit (Franklin & Jackson, 1983). Delay in discharging patients who no longer require intensive care unit care tie up beds unnecessarily and is not cost effective. Delaying discharge of less stable patients from the intensive care unit may result in patients staying in intensive care unit who may no longer require the services provided by the intensive care unit (Moreno, Reis Miranda, Matos & Fevereiro, 2001).

There is little written in the literature regarding delay in discharge or the impact from delay in discharge from the intensive care unit. Cost and benefits, allocation of resources, admission, triage and discharge criteria, intermediate care, premature discharge, the impact of readmission as an indicator of discharge decisions, withdrawal of treatment and other issues have occupied much of the intensive care unit literature. All these factors influence discharge decisions and delays in discharge from the intensive care unit may impact upon them.

In particular, the flow on effect for the intensive care unit because ward beds are unavailable has received very little attention. The lack of vacant ward beds within the hospital may lead to delayed discharge of patients from the intensive care unit thus blocking beds that may be used for patients requiring intensive care (Levin & Sprung, 2001; Southgate, 1999). Discharge delay for patients no longer requiring intensive care unit increases length of stay and costs.

Lack of intermediate care beds has resulted in patients having their discharge delayed from the intensive care unit utilising valuable intensive care unit resources (Fox, Owen-Smith & Spiers, 1999; Southgate, 1999). A flow-on effect can also be observed where patients cannot be discharged from intermediate care beds to general hospital beds preventing the discharge of intermediate care-ready patients occupying intensive care unit beds (Acute Health Division, Department of Human Services, 1997). If patients cannot be discharged home or to other facilities from the hospital and continue to occupy ward beds, the wards will not be able to accept the intensive care unit patient, causing patients to have their discharge delayed from the intensive care unit.
Groeger et al. (1993) conducted a survey to describe available resources and their utilisation in United States critical care units (see Appendix A, table A.18). Respondents indicated that 11% of critical care patients were delayed in their discharge out of the intensive care unit after considered ready for discharge. Half of the responding units had 1 or more patients awaiting discharge out of the intensive care unit representing 19% of patients in those units. In more than a quarter of units, there were critical care patients who could have been cared for in lower technology settings but could not be transferred due to lack of available hospital beds.

Discharge from the intensive care unit may increase patient satisfaction with a less noisy environment and more liberal family visiting (Lawless et al., 1991). However, patients experience stress when moving from the highly technical area of the intensive care unit where they receive one-to-one or one-to-two nurse to patient ratios in their care to a less monitored area in general wards. The stress of being discharged to the ward is not beneficial for the patients' or relatives' confidence at a critical point in their recovery (Thompson & Spiers, 1998).

2.15.1 Impact of Delays

Patients undergoing care in the intensive care unit often suffer psychological stress due to the ceaseless activity, the atmosphere of artificial lights and noises, and the continuously present threat of death (Jacobs, van der Vliet, van Roozendaal, & van der Linden, 1988, p. 217). Intensive care units are associated with emotional and psychological trauma, which is increased if patients spend too much time in the unit when they no longer require intensive care services (Franklin & Jackson, 1983).

Intensive care units may also be perceived as safe and familiar environments by some patients and their significant others, so that discharge from the intensive care unit may cause as much anxiety as admission (Coyle, 2001). This anxiety may induce stress or distress in some patients particularly if routines, environments and / or invasive monitoring are changed or ceased without adequate explanation. The detrimental effects can extend beyond the intensive care unit (Coyle, 2001). This anxiety should
not be used as an excuse to delay discharge from the intensive care unit. Rather, intensive care unit personnel should identify and meet the psychological needs of patients and their significant others when discharging patients, presenting discharge from the intensive care unit as a positive step. The apprehension and emotional upset should be emphasised as a natural experience (Coyle, 2001). Careful discharge planning and consideration of both the patient’s needs and their significant others are required to prepare them psychologically for what they are about to experience (Coyle, 2001).

Richter, Pajonk and Waydhas (1999) studied the outcome of all patients in a 4-year period with a length of stay in a surgical intensive care unit of 30 days or more in terms of quality of life, and to identify predictive factors for unfavourable outcomes. The authors hypothesised that the treatment in itself subjects the patient to a high degree of somatic, psychological and social stress. Of the 101 patients who fulfilled the inclusion criteria, 46 patients survived until follow-up and 41 of these patients were traced and participated in the study. While overall quality of life was satisfactory, there were some patients with unfavourable psychosocial outcome. Some patients, in particular after trauma, exhibit striking psychosocial problems despite satisfactory somatic treatment results. The authors concluded that patients at risk could be identified through self-reports about psychological status, quality of life, and social support and their problems positively addressed in rehabilitation efforts.

Patients should be discharged in a timely manner from the intensive care unit, not discharged prematurely because of pressure on intensive care unit beds. Nor should patients who are considered ready for discharge have their discharge delayed unnecessarily tie up beds, and using valuable material and human resources. Delays in discharge from the intensive unit increase the patient’s length of stay in the intensive care unit, increasing costs as well as impacting on a patient’s psychological wellbeing. This is not an efficient or effective use of intensive care services.
2.15.2 Cost of Delayed Discharge

Delayed discharges from intensive care unit impact on scarce intensive care unit resources. In a 2 year study in a neonatal intensive care unit examining delayed discharges not related to illness after infants were cleared for release, delayed discharges accounted for 480 patient days, a cost of US$226,298 in 1994 and US$262,431 in 1995 (Perlutter, Suico, Krauss & Auld, 1998). Perlutter Suico, Krauss and Auld (1998) believe that a considerable reduction in hospital stay and cost could be achieved by using a focused team approach and monitoring for potential discharge delays.

Doering, Esmailian and Laks (2000) collected clinical data on patients undergoing coronary artery bypass surgery during a six-month period to evaluate the predictive power of a perioperative mortality risk measurement (Parsonnet Score) and of early extubation in determining intensive care unit and hospital costs. They observed that non-clinical factors may contribute to hospital costs including patients assigned to a teaching service, living alone, restricted preoperative activity, lower socio-economic status and decreased weekend discharges. These results support the earlier study by Moyer (1994).

2.16 Bed Management

Financial management must occur hand in hand with appropriate planning of inpatient health services (Mackay & Millard, 1999). Health care providers are under constant pressure to achieve increased activity levels whilst reducing expenditures (Duckett, 1998). General and acute patient admissions to hospital have been increasing, whilst total number of general and acute beds have fallen (Comptroller and Auditor General, National Audit Office, 2000; Hensher, Edwards & Stokes, 1999). Hospitals have to balance ensuring the availability of beds against the efficient utilisation of expensive hospital resources (Comptroller and Auditor General, National Audit Office, 2000). In many areas, demand for inpatient beds exceeds availability. Cancelling elective surgery in the intensive care unit may occur for non-medical reasons, that is,
unavailability of beds or staff. The unavailability of intensive care beds may result in refusal of admission to or premature discharge of patients from the intensive care unit. The pressure on intensive care units beds has led to government inquiries into these services in the United Kingdom and Victoria (Acute Health Division, Department of Human Services, 1997). Unavailability of intensive care unit beds may occur as a result of inability to discharge patients to ward beds.

The demand for inpatient beds and bed occupancy levels may vary within a hospital and the intensive care unit at different times of the year, week or day. Annual bed occupancy rates do not reveal how these demands for these beds vary. Hospitals with average occupancy of higher than 85% experience regular bed shortages and periodic bed crisis (Comptroller and Auditor General, National Audit Office, 2000). Hospitals have to balance the demands of treating the unknown and variable number of patients and ensuring that sufficient but not excessive resources are available – sufficient beds with differing care needs, clinical and nursing staff and other facilities (Comptroller and Auditor General, National Audit Office, 2000). Intensive care unit bed management cannot be addressed in isolation from the wider hospital issues.

The management of beds in the intensive care unit is crucial in times when there is ever increasing pressure to do more with fewer resources. Blockage by ward beds or intermediate care beds being unavailable can lead to delays in patient discharge from the intensive care unit. This impacts on efficient and effective utilisation of intensive care unit resources.

In recognition of the need to reduce waiting times and improve health outcomes for patients, the National Demonstration Hospitals Program (NDHP) was established in 1994 as an initiative by the Commonwealth Department of Health and Family Services (Alexander, 2000; Commonwealth Department of Health and Aged Care, 1999). Phase 1 of the programme aimed to identify and overcome clinically inappropriate waiting times for elective surgery (Alexander, 2000). Substantial achievements included reduced length of patient stay, reduced unused operating room sessions and increased day surgery patient admissions (Commonwealth Department of Health and Aged Care, 1999). Despite these achievements, elective surgery was still frequently cancelled because of the unavailability of beds. This applied to intensive care units as well as
other surgical areas. Phase 2 was designed to identify and document principles for integrated bed management, addressing the management of all hospital admissions (Alexander, 2000). Pre-admission and discharge planning processes have a significant impact on entry and exit blocks to hospitals (Commonwealth Department of Health and Aged Care, 1999). A range of practices and facilities to improve the patient admission to hospital, care during their stay and to ensure patients are discharged in a timely and appropriate manner to receive, when necessary, ongoing care in the community have been developed (Commonwealth Department of Health and Aged Care, 1999; Comptroller and Auditor General, National Audit Office, 2000).

A key area to ensure quality patient care is effective and efficient bed management. Strategies to optimise the use of hospital beds and the patient’s continuum of care include centralising the function of allocating all hospital beds, integrating bed management to occur twenty-four hours a day, every day, and integrating bed management to link the needs of inbound and outbound patient traffic coordination (Commonwealth Department of Health and Aged Care, 1999). By integrating bed management, the management of all admissions, stays, transfers, and discharges by a hospital is achieved within a framework that integrates and coordinates all processes related to these activities (Alexander, 2000, Commonwealth Department of Health and Aged Care, 1999). An efficient organisation must be able to manage the two components of bed management, that is, management of the patient’s continuum of care and the management of the organisations bed resources, balancing the access demands of the emergency department, intensive care unit, elective and surgical patients to available beds (Alexander 2000; Commonwealth Department of Health and Aged Care, 1999). Intensive care units bed management needs must fit within this bed management framework. Inefficient bed management may result in intensive care unit beds being blocked because patients cannot be transferred to wards.

The goal of bed management is to balance the access demands of the emergency department and the elective surgical and emergency admissions to available beds (Commonwealth Department of Health and Aged Care, 1999). Emergency patients make up an increasing proportion of hospital admissions with the trend towards elective day admissions coordination (Comptroller and Auditor General, National Audit Office, 2000). The seasonal demands can be considerably different from year to year making
planning difficult for emergency admissions. Often these peaks in demand correspond with the winter months when influenza outbreaks coincide with higher staff sickness levels (Comptroller and Auditor General, National Audit Office, 2000). Developing and maintaining an efficient and effective patient flow is essential, 24 hours a day, 7 days a week. Patients having surgery on a Friday should not have to remain in the intensive care unit until Monday to be discharged to a ward bed.

Admitting the patient in an appropriate bed in a timely manner is challenging and complex. However, by using effective and efficient bed management processes, patients should be able to be discharged to ward beds quicker and more efficiently from the intensive care unit, allowing emergency and elective surgical patients to have access to the intensive care unit (Comptroller and Auditor General, National Audit Office, 2000).

2.17 Conclusion

Intensive care units strive to provide the highest achievable standard of care for all patients who need this care. They exist to provide close monitoring and frequent therapeutic interventions to patients who have actual, or are at risk for, rapid onset physiological instability from both the community and in-hospital populations. Rapid employment of labour intensive high technology is expected to provide best health care outcomes with less morbidity than routine hospital care but these benefits are purchased at great economic cost.

The discharge process is just one part of a patient’s continuum of care, with interrelated factors influencing all parts of the process. The patient must firstly be referred to the intensive care unit. Once a patient has been accepted into the intensive care unit, they should be assessed frequently and discharged when care in the intensive care unit is no longer of benefit to the patient (Levin & Sprung, 2001). Admission, triage and discharge criteria assist in this process. Discharge decisions will influence other aspects of the patient’s continuum of care.
When the number of patients requiring intensive care unit care is greater than the number of available beds, patient may be refused admission to the intensive care unit or patients may be discharged prematurely. Mortality is greater for non-admitted patients requiring intensive care unit care and for those patients whose admission is delayed (Joynt et al., 2001; Sprung et al., 1999).

A number of issues have been identified which lead to problems in capacity utilisation of intensive care units (Levin & Sprung, 2001). These include insufficient resource availability (insufficient beds and nursing staff), lack of resource pooling within the intensive care units within a hospital, lack of regional intensive care unit services, persistent admission of patients with no hope of surviving, inadequate methods to admit critically ill patients and to discharge patients no longer requiring intensive care unit care more quickly (Levin & Sprung, 2001).

If patients who no longer benefit from intensive care unit care cannot be discharged, intensive care unit beds are blocked and additional patients cannot be admitted. If patient cannot be discharged home or other facility from hospital the wards will not be able to accept the intensive care unit patient.

To date, there are few published studies that focus specifically on delayed discharges from the intensive care unit, although issues of cost, benefit, length of stay and admission / triage / discharge to the intensive care unit have been addressed. It has been noted from the studies reviewed (Groeger et al., 1993; Levin & Sprung, 2001; Southgate, 1999) that delayed discharges occur in intensive care units and that reducing these delays may result in a cost saving for the health care facility or release intensive care beds in a more timely fashion. However, the extent of delay in the Australian setting is not quantified, either in terms of the frequency of delay, duration of delay, or reason for delay. It is therefore proposed to determine whether delayed discharges occur and provide a deeper understanding of the reason for these delays.
CHAPTER 3

Materials and Methods

3.1 Introduction

As described in the literature review, delays to discharge form a part of the multiple problems associated with maximising efficiency of intensive care units (Fox, Owen-Smith & Spiers, 1999; Groeger et al., 1993; Levin & Sprung, 2001; Southgate, 1999). Locally, anecdotal evidence suggested that patients were delayed from being discharged from the intensive care unit (M. Hopkinson, personal communication, April 2000). Determining if delays occurred, how many patients this involved and the reasons for delay were the reasons for conducting this study. An observational design was selected as the most appropriate approach to answer the research questions. It is expected that this study will provide sufficient grounds to quantify the magnitude of discharge delay and associated reasons in one Australian intensive care unit, giving rise to guide intervention and further study in the area of intensive care management.

3.2 Purpose

The purpose of this study was to provide a deeper understanding of factors influencing delayed discharge from the intensive care unit, which may assist policy makers and health care facilities to address this problem.

3.3 Research Questions

1. Are patients delayed in discharge from the intensive care unit?
2. If patients are delayed in discharge, by how much is there discharge delayed?
3. If patients are delayed in discharge, is there any pattern to the delay?
4. What are the major factors associated with discharge delay?
3.4 Desired Outcomes

1. To collect discharge data from the study hospital’s intensive care unit.
2. To determine the magnitude of delays and any associated pattern of delay.
3. To determine the primary reasons for discharge delays from the intensive care unit at this hospital.
4. To investigate relationships between these factors and delayed discharges.
5. To develop a predictive model of delayed discharges from logistic regression analysis.

3.5 Setting

This study into delayed discharges from the intensive care unit was conducted in a West Australian tertiary teaching hospital of 955 beds, divided over 2 sites, with a central city campus of 694 beds and a suburban campus providing rehabilitation services with 261 beds. The city campus has an emergency department providing emergency services for both metropolitan and rural patients. Critical care services provided include an intensive care unit, an observation ward attached to the Emergency Department, high dependency area (10 beds), coronary care unit (5 beds), burns unit (5 beds), cardiothoracic unit (4 beds, available as a bay on the thoracic ward) and a monitoring room on the neurosurgery floor (4 beds).

The patient sample was drawn from the accredited level three, 22-bed intensive care unit (Australian Council on Healthcare Standards, 1997; Faculty of Intensive Care of the Australian and New Zealand College of Anaesthetists, 1997). The intensive care unit is a separate and self-contained facility, divided into 2 areas located on the same floor, geographically adjacent to each other – a general intensive care area (12 beds) and a surgical intensive care area (10 beds) for cardiothoracic surgery, neurosurgery, and overflow from the general intensive care area.

The intensive care unit is recognised for intensive care medical training by the Faculty of Intensive Care, Australian and New Zealand College of Anaesthetists and the
Royal Australasian College of Physicians (The Faculty of Intensive Care of the Australian and New Zealand College of Anaesthetists, 1996). A collaborative university program specialising in post graduate nursing education is also offered (Edith Cowan University, 2003).

### 3.6 Intensive Care Unit Patient Profile

The patient profile for the study hospital’s intensive care unit includes all patients requiring mechanical ventilation or advanced haemodynamic monitoring including patients with sepsis, shock, severe metabolic and acid-base disturbances, serious envenomation, multiple trauma and accidental or self poisoning. Elective admissions include cardiothoracic surgery (including cardiac transplants), major vascular surgery and major neurosurgery (including interventional neuro-radiology). Elective surgery is performed Monday to Friday, with only emergency surgery being performed on the weekend and these emergencies rarely include cardiothoracic surgery.

### 3.7 Admissions

There were 1395 cases admitted to the intensive care unit in the financial year ending 30 June 2001. Surgical admissions comprised 58.5% and medical admissions 41.5%. The primary admitting diagnostic groups were taken from data stored in the intensive care unit’s Acute Physiology and Chronic Health Evaluation (APACHE) II scores database. The admitting diagnostic groups for surgical and medical conditions are depicted in figure 3.1 and 3.2 respectively. Cardiothoracic surgery comprised the largest surgical group. Cardiothoracic surgery included coronary artery revascularisation, valve replacement, lung reduction surgery and cardiac transplant patients. In the medical group, cardiovascular failure was the most common and included hypertension, congestive cardiac failure, haemorrhagic shock / hypovolaemia, sepsis (any aetiology), coronary artery disease, post cardiac arrest, cardiogenic shock, dissection thoracic / abdominal aneurysm and rhythm disturbance with sepsis being the most common admitting diagnosis in this group (4.5% of all admissions). Respiratory
failure included asthma / allergies, chronic airways limitation (COPD), non-cardiac pulmonary oedema, pulmonary embolus, respiratory infection, respiratory neoplasm, post-respiratory arrest with respiratory infection being the most common diagnosis in this category (2.8% of all admissions). Neurological failure included seizure disorders and intracranial haemorrhage, subdural haematoma or subarachnoid haemorrhage. Other causes of organ failure included self drug overdose, diabetic ketoacidosis and gastrointestinal bleeding. Examining individual diagnoses, overdoses comprised the largest medical admitting diagnosis (5.7% of all admissions). Sepsis (medical and surgical) accounted for 5.7% of all admissions and trauma (both medical and surgical) accounted for 9.4% of admissions. Trauma included both multi trauma and head trauma.
Figure 3.1. Surgical Admitting Diagnoses

Figure 3.2. Medical Admitting Diagnoses
Despite daily fluctuations, bed occupancy (number of beds occupied) has remained stable over the past four years (figure 3.3). The bed occupancy (22 total beds) averaged 16.0 for the years 1997/98 to 2000/01, ranging from 15.5 to 16.6. For the same time period, mean bed days per case ranged from 4.0 to 4.4 and the Diagnostic Related Group weight ranged from 5.9 to 7.2 (mean 6.5).

![Graph showing ICU Bed Occupancy, Bed Days per Case and Weighted DRG for 1997/98 to 2000/01.]

Figure 3.3. ICU Bed Occupancy, Bed Days per Case and Weighted DRG for 1997/98 to 2000/2001.

The APACHE II score was used in this unit as a measure of the severity of illness (Appendix B). Severity of illness measures for patients in the intensive care unit measure the degree of illness and reflect the complexity of the disease process (Ridley, 1998). They are aimed at quantifying casemix and using the resultant score to estimate outcome. The Acute Physiology and Chronic Health Evaluation (APACHE), developed by Knaus, Zimmerman, Wagner, Draper and Lawrence (1981) in the mid 1970's included the acute physiology score, chronic health class and patient age. It was designed to provide indices that were reliable and physiology based to predict hospital mortality from measurements recorded from critically ill adults. Initially it was a
complex scoring system using 34 variables selected by a small group of clinicians that were thought to have some effect on outcome. These were reduced to 12 variables, published in 1985 (Knaus, Draper, Wagner & Zimmerman, 1985). The modified score takes into account the patient’s age, acute illness severity in the first 24 hours in the intensive care unit (representing the acute physiology score), chronic health, reason for admission to the intensive care unit and whether the patient had undergone emergency surgery immediately prior to the intensive care unit admission (Knaus, Draper, Wagner & Zimmerman, 1985). Over the past 4 financial years, 1997 / 1998 to 2000 / 2001, the admission and worst in 24 hours APACHE II scores have remained consistent, ranging from 11.9 to 12.1 for the admission score and 13.7 to 14.9 for the worst in 24 hours score (figure 3.4).

Figure 3.4. Admission and Worst in 24 Hours APACHE score for 1997 / 1998 to 2000 / 2001.
3.8 Admission Process

Patients are usually admitted from the emergency department, operating room or transferred from the wards within the hospital (figure 3.5). Some patients are occasionally transferred directly from other hospitals or doctors external to the hospital. Patients are referred from all parts of the state (particularly northern and eastern areas) and the Northern Territory, when specialised resources are unavailable (Clarke, 2000).

Requests for admissions are normally directed to the Intensive Care Unit Senior Registrar whose responsibility is to assess the case and arrange admission if required. If it is decided that admission is not required, the Senior Registrar should see the patient and where any doubt exists, the Intensivist must be contacted (Clarke, 2000).

Figure 3.5. Patient Admission Process
All patients are admitted under the appropriate Medical or Surgical Team and the Registrar of that particular team is notified and if possible should have seen the patient prior to admission to the intensive care unit.

The Intensive Care Unit Senior Registrar ensures that the Nursing Shift Coordinator of the intensive care unit has been informed of the pending admission including the patient’s problems and requirements prior to their arrival. The nursing shift coordinator arranges for a bed with the ward coordinator and/or clinical nurse specialist for the area, allocates staff to include admissions and potential and actual discharges and liaises with nurse managers informing them of these changes.

3.9 Discharge Process

Once a patient is considered fit for discharge, decided by the intensive care unit consultant, the Registrar of the team to which the patient has been admitted must be contacted and informed that the patient is deemed ready for discharge from the intensive care unit (Clarke, 2000). A flow chart of the discharge process is outlined in figure 3.6.

For the purpose of this study, patients discharged to the rehabilitation campus were deemed as being discharged from the hospital as these patients were discharged on the hospital’s computerised patient information system.

3.10 Staffing

Medical and nursing staffing complies with the recommended guidelines (Australian College of Critical Care Nurses Workforce Advisory Panel, 2002; Faculty of Intensive Care, Australian and New Zealand College of Anaesthetists, 1997). A multidisciplinary team with medical and nursing staff, physiotherapists, respiratory technicians, pharmacist, clerical staff, patient care assistants and a social worker, staff the intensive care unit. The medical director of the study hospital’s intensive care unit
Figure 3.6 Intensive Care Unit Discharge Process
works in full-time capacity sharing both clinical and administrative roles. Patients admitted to the intensive care unit are under the care of the Intensivist on duty. The intensive care unit medical staff are responsible for the patient’s medical care.

The medical staff are rostered on duty in 2 shifts per day. During the day, senior cover is provided by one Senior Registrar and two Intensivists with a separate Resident being assigned to the surgical area and a Registrar to the general area within the intensive care unit. During the night, an Intensivist and Senior Registrar cover both units. Separate Residents are assigned to the surgical area and general area within the intensive care unit. In addition, at night, a Cardiothoracic Surgical Registrar is rostered on-call for the surgical area within the intensive care unit (Clarke, 2000).

Providing adequately qualified staff is challenging in an environment with unpredictable workload and staff constraints. Ventilated patients have a minimum one to one ratio of nurse to patient, complying with the recommended guidelines (Australian College of Critical Care Nurses Workforce Advisory Panel, 2002; Faculty of Intensive Care, Australian and New Zealand College of Anaesthetists, 1997).

Nursing staff to patient ratios for intensive care unit patients are, on average:

- one Registered Nurse as nursing shift coordinator for each area, supernumerary for the entire shift;
- one admission (access) nurse allocated to accept prospective admissions and act as a resource;
- one to one nursing ratio for ventilated and compromised patients;
- one to two staffing ratio for patients ready or nearly ready for discharge.
3.11 Participant Sample

The participant sample was a prospective convenience sample of all patients admitted to the intensive care unit in the six-month period 18 September 2000 to 18 March 2001. Sample size of this study was not based on statistical considerations. However, the size of the sample collected assisted in minimising error and increasing precision. The time interval of 6 months was chosen to limit the influence of fluctuations in admission patterns.

- Inclusions:
  All consecutive patients admitted to the intensive care unit during the sampling period.

- Exclusions:
  Patients who died in the intensive care unit during the sampling period.
  Patients already cleared to be discharged to the ward prior to commencement of the study.

3.12 Design

A cross sectional design was chosen to determine the incidence of delayed discharges from the intensive care unit and to assess the contribution that unavailability of ward beds or other determinants had on causing the delay.

Formal research embraces both observational and experimental studies. Experimental methods (randomised controlled trials) are considered the gold standard for evaluation (Black, 1996). Randomised controlled trials supposedly guarantee unbiased treatment assignment (Liu, Anderson & Crowley, 2000). However, the experimental design was not appropriate to answer the research question in this study. A more useful design appropriate for the particular research question was the observational study design with data collected prospectively on a convenience sample of intensive care unit patients. Observational studies have the potential to evaluate health care and improve the scientific basis of how to treat individuals and organise
services, providing an important alternative to random clinical trials in the intensive care unit setting (Black, 1996; Bion, 2001). Each design has its strengths and weaknesses with mutual recognition of the complementary roles of the two approaches. Instead of regarding randomised controlled trials as the gold standard, they may be viewed as indicating the minimum effect of an intervention whereas observational studies offer an estimate of the maximum effect (Black, 1996). Although observational studies are considered weaker designs than randomised controlled trials, the design is suitable for the purpose of this study due to the exploratory nature. Limited available resources also influenced design choice. In this study, randomisation was inappropriate. The prospective approach to measuring delays minimised the likelihood of measurement error and missed data. As all consecutive participants were chosen in the sampling period, selection bias was minimised. Observational studies have threats to internal validity because of unrecognised confounding factors that may not have been evenly distributed between study groups but they often have high external validity because they demonstrate effectiveness of an intervention in everyday practice, maintaining the integrity of the context in which care is provided (Black, 1996).

3.13 Data Collection Tool

In order to collect appropriate data, the discharge processes for the intensive care unit were reviewed. The role of the nurse manager in the intensive care unit was integral in the management of bed utilisation in the study hospital and discussions were conducted to establish the processes involved and how they impact on bed utilisation in the intensive care unit. Following these preliminary discussions with the nurse manager, other experts in intensive care nursing within the unit were consulted. The data collection sheet was developed utilising a collaborative team approach involving the intensive care units’ nurse manager, clinical nurse specialist and nursing shift coordinators (Appendix C). The intensive care unit discharge process was mapped utilising information obtained during the development of the research proposal (Figure 3.6).
The data collection sheet was designed to ensure all elements were collected with minimal impact on nursing shift coordinators' time. The data collection sheet was modified from the existing bed list that was in use in the intensive care unit prior to the time of the study. The reason for this was that the existing bed list contained several relevant elements of data, including age, sex and specialty. The date and time of notification of proposed discharge, date and time of actual discharge, reason for delay if this time exceeded 8 hours and discharge destination were added. The modification of the bed list fulfilled its administrative functions whilst serving as a data collection tool for the study. It provided a simple method for the study's data collection, which utilised an existing data collection process and did not require a separate tool.

An 11-week pilot study (see appendix E) was conducted from 18 September 2000 to 3 December 2000 to determine the feasibility and appropriateness of the data collection sheet and make any modifications as required. There were 268 discharges from the intensive care unit during this period, not including 27 patients who were either discharged prior to commencement of the study or died in the intensive care unit. There were 203 (75.7%) patients who were not delayed, 58 (21.6%) patients delayed from discharge and 7 (2.6%) patients where delay status was unknown.

As a result of the pilot, the wording of notification time for discharge was altered to improve clarity and a dedicated folder to house the form during data collection introduced following discussion with shift coordinators. The pilot study was also useful in identifying the need for augmentation of training related to collection of data.

The tool was tested for interrater reliability during the pilot study. Interrater reliability is the extent to which multiple examinations of the same patient agree with one another (Polit & Hungler, 1995). No reports measuring delay in discharge have been published to date, thus there were no definitions to compare nor any established tools tested for reliability and validity available to use for this study.

Interrater reliability was tested between independent observers for the first two
weeks of the study (n = 41). The notification times recorded by the nursing shift coordinator were also recorded separately by the investigator. Five notification times (12%) differed. Investigating the process with nursing shift coordinators, misunderstanding of terminology was the reason cited for discrepancies. Modification of the terminology from “proposed” to “notification” time was suggested to rectify the problem. This occurred at week 2. Following further education, the repeat interrater reliability for weeks 8 and 9 was 100% (n = 51).

Validity assesses whether the data collection tool really measures what it proposes. There are several different types of validity. Face validity assesses whether the instrument looks as though it is measuring what it is supposed to measure, in this case, delays. Face validity was established from a panel of expert nurses (Nursing Coordinator, Nurse Manager and Clinical Nurse Specialist). The expert panel reviewed the tool to determine if the items included were suitable to obtain the data required to measure delays.

### 3.14 Method of Data Collection

In order to effect any change such as collecting discharge data, nursing shift coordinators need adequate information and time to adapt to the new processes involved. Education of nursing shift coordinators was conducted prior to commencement of data collection in collaboration with the Staff Development Nurses in the intensive care unit (Appendix D). The project was discussed, including the objectives and research question to be answered, the method that was to be used to gather appropriate information, the role of the shift coordinator and the investigator in the process. Further education was given to staff who needed clarification of the data collection tool or who were on leave during the initial education. Each nursing shift coordinator, identified from the roster, and intensive care unit ward clerk were given a letter explaining the study and a copy of the proposed data collection tool. One-to-one education was also conducted to ensure that shift coordinators and ward clerks involved in the study understood what data collection was required. Education
provided to nursing shift coordinators facilitated consistent and accurate data collection.

Trained nursing shift coordinators identified all participants who met the eligibility criteria for the study. The nursing shift coordinators were experienced senior intensive care unit registered nurses, with highly developed knowledge and skills in intensive care unit nursing. They were assigned to the role of nursing shift coordinator on a shift-by-shift basis to coordinate unit activities, act as a resource for the unit, mentor for staff, troubleshoot as required and manage human and material resources. A nursing shift coordinator is assigned to each of the general and surgical areas within the intensive care unit. The nursing shift coordinators liaise with each other, medical staff and the area and/or nurse manager to facilitate the smooth running of the areas and to facilitate and manage admission and discharge of patients from the intensive care unit.

Nursing shift coordinators were chosen to record the notification time and reasons for any delays on the data collection sheet, as they were the first to be informed of decisions to discharge patients. Being kept informed of any patient changes, nursing shift coordinators were in an ideal position to capture the required data.

Notification of discharge usually occurred at the medical staff's morning handover at 08:00 hours held in the medical meeting room to which the nursing shift coordinator attended. The proposed discharges were documented on the data collection sheet. Whenever the nursing shift coordinator was informed of a proposed discharge at other times, other than from the medical handover, these times were also recorded on the data collection sheet.

When the patient was discharged, the time of discharge and reason for delay, if the discharge occurred more than 8 hours after the notification time, were recorded on the data collection sheet.

The data collection sheets were placed in a dedicated folder behind each work
station in the general and surgical areas within the intensive care unit and collected by
the investigator each working day. These were checked for completeness. The
investigator followed up any missing data with the appropriate nursing shift
coordinator. Later in the study, an additional clinical nurse specialist was appointed
to the unit, and the clinical nurse specialists then assumed the role of bed management
for the unit. Missing data was also followed up with them when appropriate.

Several assumptions were made when collecting data when the notification
time was not documented.

Assumptions:

• If a patient was admitted to the intensive care unit following elective
  neurosurgical or cardiothoracic surgery, the earliest that they could be discharged
  from the intensive care unit would be the day following surgery. If patients were
discharged during business hours on the day following surgery, they were coded
  as no delay in this instance.

• If a patient was admitted to the intensive care unit, and discharged within eight
  hours, they were coded as no delay.

• Patients transferred to the rehabilitation campus were considered discharged from
  the acute care facility, as they were discharged on the hospital’s computerised
  TOPAS system.

• If the patient was discharged alive from the intensive care unit (regardless if they
died on a subsequent admission), the “alive” discharge was included in the data
  analysis.

Other data collected by the investigator included the number of intensive care
unit admissions and occupancy. The number of intensive care unit admissions was
collected from the Admission/Discharge register maintained by intensive care unit
ward clerks. Data from this register was entered onto the hospital’s computerised
patient information system. Discrepancies occurred between the two systems when
patients’ times of admission to intensive care unit were entered onto the computerised
system by the bed allocation centre that did not correspond to actual admission time (patient went to the operating room or other department prior to intensive care unit admission). Times were recorded from the intensive care unit register, as this was the most accurate record.

Data was also collected on bed occupancy as it may impact on utilisation and discharge processes within the intensive care unit. Data was collected from patient bed lists supplied by the intensive care unit ward clerks. Data on impending admissions was not collected. A summary of source data is outlined in table 3.1.

Table 3.1

Summary of Source Data

<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key</td>
<td>Unique identifier for each patient enrolled in the study</td>
</tr>
<tr>
<td>Patient Age and Gender</td>
<td>Routinely recorded by the intensive care unit ward clerks on the bed list.</td>
</tr>
<tr>
<td>Day, date and time of intensive care unit admission and actual discharge</td>
<td>Admission / Discharge Register kept by the ward clerks in the general and surgical areas within the intensive care unit.</td>
</tr>
<tr>
<td>Date and time of hospital admission and discharge</td>
<td>Information recorded from TOPAS, computerised patient information system.</td>
</tr>
<tr>
<td>Notification time of discharge</td>
<td>Nursing shift coordinators when informed by medical staff that a patient was eligible to be discharged from the intensive care unit recorded this time on the data collection sheet.</td>
</tr>
<tr>
<td>Ward destination information.</td>
<td>Admission / Discharge Register kept by the ward clerks in the general and surgical areas within the intensive care unit.</td>
</tr>
</tbody>
</table>
3.15 Definitions

Date and time of notification of proposed discharge:
The date and time that the medical staff notify the shift coordinator that the patient is eligible for discharge from the intensive care unit.

Non-delayed discharge
Patient is discharged from the intensive care unit within 8 hours of being deemed suitable for discharge.

Delayed discharge:
The patient is not discharged from the intensive care unit within 8 hours from the time of notification that the patient was eligible for discharge from the intensive care unit.

Discharge
For the purpose of this study, patients discharged to the rehabilitation campus were deemed as being discharged from the hospital as these patients were discharged on the hospital’s computerised patient information system.

Chronic patients
Chronic patients were defined as those patients exceeding fourteen days in the intensive care unit (Groeger et al., 1993).
APACHE II Score
The Acute Physiology and Chronic Health Evaluation (APACHE) II score is a measure of the severity of illness on admission developed by Knaus, Draper, Wagner & Zimmerman (1985) (refer to appendix B).

ICU Length of Stay
The length of time the patient stayed in the intensive care unit from the time of admission to the study hospital’s intensive care unit to the time of discharge from the intensive care unit. Discharge may be to another area within the hospital, an external health care facility or home.

Length of Stay to Notification
The length of time the patient stayed in the intensive care unit from the time of admission to the study hospital’s intensive care unit to the time of notification for eligibility for discharge from the intensive care unit.

Hospital Length of Stay
The length of time the patient stayed in the study hospital calculated from the time of admission to the time of discharge from the study hospital.

Occupancy
Percentage of intensive care unit beds occupied per total intensive care unit beds (n=22) available at time of patient discharge from the intensive care unit.

Medical Complications
Patients deemed suitable for discharge to the ward, and then sometime during the time period after 8 hours post notification whilst waiting for ward placement, medical staff deemed the patient no longer medically fit to be discharged from the intensive care unit.
3.16 Protection of Human Participants

The study was conducted as an observational non-interventional study. Ethical considerations were mainly concerned with confidentiality and data security. Patient identification numbers and names that were included on the data collection sheet were not attached to the data when the data were collated by the investigator on a spreadsheet. Breaches in confidentiality were minimised by having a single data collator and employing discrete processes of data management. All data were secured in a locked cabinet and access limited to authorised personnel.

Both the intensive care unit’s Heads of Department, medical and nursing, gave their approval for this study. Institutional reviews included approval from the Nursing Research Review Committee that monitors all nursing research in the study hospital. Data collection commenced in September 2000 following approval to commence a pilot study by this committee. The Nursing Research Review Committee approval to continue the study was granted in December 2000. Data collected during the pilot study was included in the study following analysis of the pilot data. Hospital ethics committee approval was not needed as the method of data collection was considered as a clinical audit. The research proposal was also submitted to the relevant university committee that reviews the ethics, motives and conduct of medical research.

3.17 Methods of Analysis

To investigate the relationship that the varying patient and other characteristics had to outcome, data were collected prospectively and statistical analyses of the data were performed utilising the Statistical Package for the Social Sciences (SPSS) version 10.0 software (Chicago, Illinios, 1999) and SAS version 8.2 (Cary, NC, USA, 1999-2001).

Descriptive analyses of the independent variables of the discharge data set were made. Data collected included age, gender, admission and worst in 24 hours
APACHE II score, admission date and time to hospital, admission date and time to the intensive care unit, date and time the patient was notified eligible for discharge from the intensive care unit, discharge date and time from the intensive care unit and hospital, occupancy in the intensive care unit at time of patient discharge, admitting diagnosis, admission source, primary organ systems failure, specialty. These were compared to delay status using univariate analysis.

Univariate analyses was used to test how strongly each intensive care unit variable was individually associated with observed delay in discharge from the intensive care unit. Pearson Chi square was used for data analysis and comparison for categorical data. The Mann-Whitney non-parametric test was used to test the difference in means for independence for interval data not normally distributed. The Student's \( t \) test was used for comparing means in normally distributed interval or ratio data.

- The outcome variable in this study was delayed discharge.
- Statistical Significance was set at \( p<0.05 \).
- All significant results were within 95% confidence limits.

The independent influences of these predictors on intensive care unit delays in discharge were evaluated using logistic regression. All the variables of intensive care unit discharge that demonstrated a significant (\( p<0.05 \)) difference in delay status in the univariate analysis were modelled using logistic regression to develop a predictive model for delayed discharge. However, primary admitting diagnosis was excluded because although statistically significant with delay status in univariate analysis, admission to the intensive care unit is often caused by a combination of factors (Loes, Smith-Erichsen, & Lind, 1987).

To find the predictive variables that best explained delay, a backward stepwise-selection procedure was performed (Knuiman & Divitini, 2002). All significant variables and their interactions were included in the first step. Non significant variables with the weakest association were removed one by one from the model until only variables with a strong association (\( p<0.01 \)) remained. The more
stringent $p$-value of 0.01 was chosen because of the large number of comparisons where one would expect a few variables to be significant due to chance even when no real association existed.

Model performance may be demonstrated in 2 independent samples, an estimation set used for model derivation and validation set used for model verification. The validation set must be independent from that used to develop the model. A validation set was unavailable for model development and the sample size too small to calculate split half validation for model development, hence only an estimation set was used in model development.

Model assessment includes measures of calibration and discrimination, which provide different and useful information about a model's performance, and both should be used routinely when evaluating models (Moreno, Apolone & Reis Miranda, 1998; Lemeshow & Le Gall, 1994). Calibration and discrimination were performed on the estimation data set. Measures such as sensitivity and specificity derived from a $2 \times 2$ classification table are of limited utility for the evaluation of model performance because they are based on a single probability cut point (Lemeshow & Le Gall, 1994) and were therefore not used.

Calibration evaluates the degree of correspondence between the estimated probabilities of delay produced by the model and the actual delay experience of patients. The Hosmer-Lemeshow goodness-of-fit statistic was used to formally test for calibration. It compares observed with expected number of delays and observed and expected number of non-delays within each stratum of patients.

Discrimination uses the area under the receiver-operating characteristic (ROC) curve to measure the ability of the test to correctly classify those who will and will not be delayed in their discharge from the intensive care unit. The higher the true-positive rate is relative to the false-positive rate, the greater the area under the curve. The ROC area of a model should exceed 0.70 (Lemeshow & Le Gall, 1994).

- Within the logistic multiple regression equation, the most significant and important variable was selected as day of the week.
• The predictive validity of this equation is documented by the close agreement of predicted delay rates with actual delay rates.
CHAPTER 4

Results

4.1 Study Sample Characteristics

There were 1395 admissions to the intensive care unit of the study hospital during the financial year ending 30 June 2001. The study into delayed discharge from intensive care was conducted over a 6-month period, 18 September 2000 to 18 March 2001 (182 days). Including deaths, there were 656 patient admissions to the intensive care unit during the study period (4 patients who died also had alive discharges during the study period, which were included in data analysis). The mortality rate of the intensive care unit for the study period was 7.8% of patients admitted. No adjustment has been made for severity of illness or case mix.

At the commencement of the delayed discharge study, there were 5 patients who were already eligible for discharge from the intensive care unit, these patients were therefore excluded from the study. During the study there were 51 deaths in the intensive care unit, these patients were also excluded from the sample. At the end of the study period, 1 patient was discharged from the intensive care unit on 19 March 2001. As this patient was eligible for discharge from the intensive care unit prior to the end of the study, this patient was subsequently enrolled. There were 609 eligible patients admitted to the intensive care unit during the study period once these exclusion/inclusion criteria were applied (table 4.1). These patients had a total of 708 admissions, including 40 patients who were admitted at least twice (6.6% of patients, n = 609). The study sample comprised 50.75% of all the admissions to the intensive care unit in the financial year 2000 / 2001.

The general and surgical areas within the intensive care unit were analysed as one unit because they were geographically adjacent to each other, and were staffed and equipped as one unit and patients were moved from one unit to another without being necessarily classified as suitable for discharge. Patients were often transferred between the general and surgical areas within the intensive care unit depending on
bed and staffing requirements. There were 28 patients moved to the general area from the surgical area and 59 from the general area to the surgical area within the intensive care unit. Nine of these patients were moved more than once, 1 patient having being moved twice on the same day and 1 patient was moved 3 times. Patients awaiting ward beds or nearly ready for discharge were often the patients to be moved from the general area to the surgical area within the intensive care unit. Patient moves between different bed spaces within the general or surgical area were not documented.

Table 4.1.

<table>
<thead>
<tr>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients admitted</td>
</tr>
<tr>
<td>Number of admissions</td>
</tr>
<tr>
<td>Deaths during study period</td>
</tr>
<tr>
<td>Other exclusions</td>
</tr>
<tr>
<td>Total number of patients discharged</td>
</tr>
<tr>
<td>Included patient discharges</td>
</tr>
</tbody>
</table>

The age, length of stay in the intensive care unit and hospital, occupancy at the time of patient discharge from the intensive care unit, APACHE II (Knaus, Draper, Wagner & Zimmerman, 1985) score on admission and worst APACHE II score in the first 24 hours of the intensive care unit admission for the study sample are summarised in table 4.2. The difference in mean and median length of stay reflects the high proportion of elective surgery admitted to the study hospital’s intensive care unit. This was also reflected in the APACHE II Scores. Surgical admissions accounted for 58%
of admissions (n = 380) with 70% of these surgical admissions being elective surgery (n = 264).

Table 4.2.
Intensive Care Unit Population Characteristics 18 September 2000 to 18 March 2001,

<table>
<thead>
<tr>
<th></th>
<th>Mean (Standard Deviation)</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>54 (18.6)</td>
<td>57</td>
<td>13 to 91</td>
</tr>
<tr>
<td>ICU length of stay</td>
<td>3 days, 21.5 hours</td>
<td>1 day, 20.1 hours</td>
<td>6.9 hours to 8 weeks, 5 days, 19.7 hours</td>
</tr>
<tr>
<td></td>
<td>(137 hours)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital length of stay</td>
<td>19 days, 0.6 hours</td>
<td>11 days, 21.1 hours</td>
<td>13.42 hours to 35 weeks, 1 day, 17.1 hours</td>
</tr>
<tr>
<td></td>
<td>(661 hours)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupancy a</td>
<td>79.8 (13.8)</td>
<td>81.8</td>
<td>41% to 100%</td>
</tr>
<tr>
<td>Admission APACHE II Score</td>
<td>11.3 (5.9)</td>
<td>10.0</td>
<td>0 to 35</td>
</tr>
<tr>
<td>Worst in 24 hours</td>
<td>13.5 (6.4)</td>
<td>13.0</td>
<td>1 to 38</td>
</tr>
</tbody>
</table>

*Percentage of ICU beds occupied per total ICU beds available at time of patient transfer*

The age of patients was much younger (mean age 49 years and median age 51 years) when elective surgery patients were removed from the analysis of all admissions in the sample (95% CI of the mean difference was -13.9 to -8.3, p < 0.0001). The average intensive care unit length of stay for this group of patients was also longer (5 days 8 hours; 95% CI of the mean difference was 66 to 107 hours, p < 0.0001). APACHE II scores were also worse for patient admissions when elective surgery patients were removed from the analysis (mean admission APACHE II Score 12.8; 95% CI of the mean difference was 2.8 to 4.6, p < 0.0001 and worst in 24 hours
APACHE II Score 15.3; 95% CI of the mean difference was 3.5 to 5.4, p < 0.0001). There was little change in occupancy (mean 79.4% and median 81.8%; 95% CI of the mean difference was -3 to 1.3, p = 0.426).

4.2 Age

The average age of the patients studied was 54 years (males 55 years and females 51 years, standard deviation 19 and 18 respectively). The median age was 57 years (male 60 years and female 53 years). The most common age (mode) was 62 years. The distribution of patient ages in ten-year groups is depicted in figure 4.1. The age of the study sample is skewed to the right of the graph with study patients aged between 51 and 80 years of age. The proportion of study patients who were 60 years of age or older was 46%. The study hospital is considered an adult hospital and the intensive care unit does not routinely admit patients under the age of 13 years.

Figure 4.1. Study Sample Age Classified into Ten-Year Age Groups.
4.3 Gender

Of the sample collected the majority of participants were male (ratio 1.6:1). Male patients comprised 61.5% (n=401) of the study sample and female patients 38.5% (n=251). There were significantly more male patients than female patients discharged from the intensive care unit during the study period (95% CI for difference in proportions, 0.15-0.31, p < 0.0001).

The male patients in the study sample were generally older than their female counterparts (figure 4.2). Using the Mann-Whitney non-parametric test to test for independence, a statistically significant difference in age existed between male and female patients (z = -2.991, 2-tailed significance p = 0.003).

Figure 4.2. Study Sample Gender by Ten-Year Age Groups of ICU Discharges.
4.4 Length of Stay

The average length of stay for patients in the intensive care unit in the study sample was 3 days and 22 hours (table 4.2). The median length of stay was 1 day and 20 hours. There were 98 (15%) patients in the study sample who stayed longer than 1 week in the intensive care unit. Chronic patients were defined as those patients exceeding 14 days in the intensive care unit (Groeger et al 1993). Using this definition, 33 patients or 5% of the study sample were considered chronic admissions. The longest length of intensive care unit stay was 62 days and the shortest stay was just under 7 hours (figure 4.3).

Figure 4.3. Study Sample Length of Stay (outliers and extreme values excluded).
4.5 Occupancy

The intensive care unit bed occupancy was defined using the following formula:

\[
\text{Occupancy} = \frac{\text{intensive care unit beds occupied}}{\text{number of available ICU beds at time of patient discharge}} \times 100\% 
\]

At the time of the study, the number of beds available in the intensive care unit in the study hospital was 22. An extra bed was available for in-house cardiac arrests or other medical emergencies, but this bed was not prospectively staffed or included in the occupancy denominator. Occupancy ranged from 41 to 100% with mean occupancy 79.8% and median occupancy 81.8%. Grouping occupancy into 10 percent groups, the percentage of time during the study these levels of occupancy occurred is depicted in figure 4.4.

Figure 4.4. Study Sample Occupancy at Time of ICU Patient Discharge Classified into 10 Percent Groups.
4.6 Source of Admission

Patients were admitted to the intensive care unit from the operating room, recovery room, emergency department, wards from within the study hospital or from external health care facilities. The source of admission is depicted in figure 4.5. The majority of patient admissions during the study period were from the operating room and the recovery room (n=376, 57.7%). The recovery room was identified separately from the operating room, with these patients being unplanned admissions to the intensive care unit. The study sample was similar to the patient population in the intensive care unit for the entire financial year 2000/01 during which 57.6% of patients were admitted from the operating room and the recovery room (95% CI for differences in proportions, −0.08 to 0.04, p = 0.496). Most surgical patients in the study sample were elective admissions (n = 264, 69.5% of surgical admissions). Comparing patients in the study sample with patients admitted to the intensive care unit for the financial year 2000/01, admissions from the emergency department were 24.8% / 21.6% (95% CI for differences in proportions, −0.11 to 0.05, p=0.430), other wards 7.7% / 10.1% (95% CI for differences in proportions, −0.11 to 0.06, p=0.617) and external health care facilities 9.8% / 10.7% (95% CI for differences in proportions, −0.10 to 0.08, p=0.843) respectively.

![Study Sample Admission Source](image-url)
4.7 Specialty

All patients were admitted to the intensive care unit with an admission specialty. Cardiothoracic surgery (n = 166, 25.5%) was the most common specialty for patients in the study group followed by neurosurgery (n = 125, 19.2%), general medicine (n = 117, 17.9%), vascular surgery (n = 54, 8.3%), general surgery (n = 49, 7.5%) and orthopaedic surgery (n = 32, 4.9%). Other specialties each had less than 3% of discharges per specialty (figure 4.6).

![Figure 4.6. Study Sample Admission Specialties](image)

4.8 Admitting Diagnosis

Diagnostic groups are based on APACHE II score data (appendix B and F). Medical diagnosis groups included respiratory, cardiovascular, trauma and neurological diagnostic failures. Self-drug overdose, diabetic ketoacidosis and gastrointestinal bleeding were grouped into none of the other causes of failure medical category whilst others included any condition not included in the preceding groups. Surgical admitting diagnoses included cardiovascular, trauma, respiratory,
neurological, gastrointestinal, cardio pulmonary bypass and others (not included in preceding categories). The study sample had a similar proportion of surgical admission diagnoses compared to the financial year 2000 / 01 population, 58.3% versus 58.5% respectively. Similarly, medical admission diagnoses accounted for 41.7% of admissions compared to 41.5% of the financial year 2000 / 01 population (figure 4.7 and 4.8). The only significant difference between admission diagnoses between the study sample and the financial year 2000 / 01 population was in the medical cardiovascular group (table 4.3).

Table 4.3.
Comparison of Diagnosis between Study Sample and Financial Year 2000/01 ICU Population

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Study group vs financial year 2000/01</th>
<th>95% CI for difference in proportions</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>54 / 154 8.5 / 10.7</td>
<td>-0.06 to 0.00</td>
<td>0.035</td>
</tr>
<tr>
<td>Respiratory</td>
<td>51 / 105 7.0 / 7.2</td>
<td>-0.01 to 0.03</td>
<td>0.415</td>
</tr>
<tr>
<td>Trauma</td>
<td>47 / 92 7.2 / 6.3</td>
<td>-0.01 to 0.03</td>
<td>0.383</td>
</tr>
<tr>
<td>Neurological</td>
<td>21 / 63 3.2 / 4.3</td>
<td>-0.03 to 0.01</td>
<td>0.261</td>
</tr>
<tr>
<td>Other failures</td>
<td>56 / 102 8.6 / 7.0</td>
<td>-0.01 to 0.05</td>
<td>0.110</td>
</tr>
<tr>
<td>Other</td>
<td>43 / 84 6.6 / 5.8</td>
<td>-0.01 to 0.03</td>
<td>0.383</td>
</tr>
<tr>
<td>Surgical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>118 / 259 18.1 / 17.9</td>
<td>-0.03 to 0.04</td>
<td>0.912</td>
</tr>
<tr>
<td>Respiratory</td>
<td>29 / 70 4.5 / 4.8</td>
<td>-0.03 to 0.01</td>
<td>0.316</td>
</tr>
<tr>
<td>Trauma</td>
<td>21 / 44 3.3 / 3.0</td>
<td>-0.01 to 0.02</td>
<td>0.826</td>
</tr>
<tr>
<td>Neurological</td>
<td>71 / 161 10.9 / 11.1</td>
<td>-0.03 to 0.03</td>
<td>0.882</td>
</tr>
<tr>
<td>GIT</td>
<td>14 / 47 2.2 / 3.2</td>
<td>-0.02 to 0.00</td>
<td>0.190</td>
</tr>
<tr>
<td>Coronary Artery</td>
<td>92 / 202 14.1 / 13.9</td>
<td>-0.03 to 0.03</td>
<td>0.917</td>
</tr>
<tr>
<td>Bypass Grafts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>35 / 65 5.4 / 4.5</td>
<td>-0.01 to 0.03</td>
<td>0.296</td>
</tr>
</tbody>
</table>
Figure 4.7. Admitting Medical Diagnosis, Study Sample and ICU 2000/01

Figure 4.8. Admitting Surgical Diagnosis, Study Sample and ICU 2000/01
4.9 Primary Organ Systems Failures

The most common primary organ system failures in the study sample were cardiovascular (39.1%), followed by neurological (32.8%) and respiratory (22.5%). Metabolic (2.3%), gastrointestinal (1.7%), renal (0.8%) and haematological (0.8%) organ system failures accounted for less than 6% combined (figure 4.9).

![Figure 4.9. Study Sample Primary Organ System Failures](image)

4.10 Discharges

In the study period, there were 609 patients who were discharged 652 times. Exclusions for the study were patient deaths and patients who had been deemed eligible for discharge prior to commencement of the study as previously noted (total exclusions n = 56 comprising 51 deaths and 5 patients eligible for discharge prior to commencement of the study). Any patient who was admitted to the intensive care unit during the study period and was discharged from the intensive care unit was included in the sample.
4.11 Discharge Destination

The wards in the study hospital were organised into seven divisions - Cancer, Cardiovascular, Critical Care Services, Gastrointestinal Services, Medical Specialities, Neurosciences and Surgical Specialties (table 4.4). The cardiovascular division included the cardiothoracic surgery ward, vascular surgery ward, cardiology ward and the coronary care unit. The critical care division included the intensive care units, high dependency area, emergency department observation ward, neurosurgical ward and orthopaedic ward. Most patient discharges were sent to the cardiovascular division (n=225, 35.0%) and critical care division (n=186, 28.5%). Together with medical specialties, these divisions accounted for 78.1% of patient destinations (figure 4.10).

Figure 4.10. Study Sample Discharge Destination by Division.
Table 4.4.
Discharge Destination by Division

<table>
<thead>
<tr>
<th>Division</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular</td>
<td>228</td>
<td>35.0</td>
</tr>
<tr>
<td>• Cardiothoracic surgery, vascular surgery, cardiology and coronary care unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical Care</td>
<td>186</td>
<td>28.5</td>
</tr>
<tr>
<td>• Neurosurgery and orthopaedic wards (also intensive care unit, high dependency area, emergency department observation ward. Patients would not be discharged to these areas)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical Specialties</td>
<td>95</td>
<td>14.6</td>
</tr>
<tr>
<td>• Seven medical wards including immunodeficiency unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgical Specialties</td>
<td>42</td>
<td>6.4</td>
</tr>
<tr>
<td>• Two surgical wards and burns unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Sources</td>
<td>37</td>
<td>5.7</td>
</tr>
<tr>
<td>• Included study hospital’s rehabilitation campus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>31</td>
<td>4.8</td>
</tr>
<tr>
<td>• Two wards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neurosciences</td>
<td>19</td>
<td>2.9</td>
</tr>
<tr>
<td>• Two wards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td>14</td>
<td>2.1</td>
</tr>
<tr>
<td>• Two wards and bone marrow transplant unit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.12 Readmissions

There were 609 patients (708 admissions) during the study period admitted to the intensive care unit. Of these 609 patients, 40 patients had multiple admission/discharges from the intensive care unit (table 4.5). Ten of these patients’ readmissions into the intensive care unit occurred within different hospital stays (1.6% of 609 patients). Thirty patients had readmissions during the same hospital stay (4.9% of 609 patients). The number of patients readmitted within 24 hours was 4 (0.56% of 708 admissions), including 1 patient who was discharged home from the intensive care unit in the morning and was readmitted the same evening. The number of patients readmitted within 48 hours was 11 (1.6% of 708 admissions) and within 72 hours 12 (1.7% of 708 admissions).

There were 30 patients who had 37 readmissions to the intensive care unit during the same hospital stay (5.2% of 708 admissions).

- Twenty-four patients had 1 readmission
- Five patients had 2 readmissions
- One patient had 3 readmissions.

Data collection did not include whether the readmission was planned or not.

Table 4.5.
Readmissions to the Intensive Care Unit

<table>
<thead>
<tr>
<th>Number of readmissions</th>
<th>Readmissions during same hospital stay</th>
<th>Multiple ICU admissions occurred within different hospital stays within study time period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>10</td>
</tr>
</tbody>
</table>

<sup>a</sup> one patient had one readmission during the same hospital stay and a second admission during a different hospital stay
4.13 Comparison of Non-Delay and Delay Sample Populations

The following results refer to discharges (n=644) grouped by delay status, that is, non-delayed or delayed patient discharges (discharges with delay status unknown have been excluded, n = 8). Patients deemed eligible for discharge from the intensive care unit who were not discharged within 8 hours were defined as delayed.

There were 468 patient discharges from the intensive care units with no delay (72.7%) and 176 patient discharges from the intensive care unit who had their discharge delayed (27.3%) (figure 4.11). There were substantial delays in discharging patients from the intensive care unit (95% CI 23.9% – 30.7%). The odds of a patient having their discharge delayed was 0.38, that is, for every 5 discharges that were not delayed, 2 patients would have their discharge delayed.

Figure 4.11. Study Sample Non-delayed and Delayed Discharges
4.13.1 Reason for Delay

Having determined that 27.3% of discharges from the intensive care unit were delayed, this group was then further analysed as to reasons for delay as listed in table 4.6.

Table 4.6.
Reasons for Delay

<table>
<thead>
<tr>
<th>Reason for Delay</th>
<th>Number</th>
<th>Percentage of Delays</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No ward bed</td>
<td>132</td>
<td>75.0</td>
<td>20.5</td>
</tr>
<tr>
<td>Ward bed delayed</td>
<td>10</td>
<td>5.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Medical complications</td>
<td>15</td>
<td>8.5</td>
<td>2.3</td>
</tr>
<tr>
<td>Environment</td>
<td>1</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>Lack of medical cover</td>
<td>1</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>Transport</td>
<td>1</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>No reason cited</td>
<td></td>
<td>5.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Closure of cardiothoracic ward</td>
<td>3</td>
<td>1.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>1.7</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>176</td>
<td>100%</td>
<td>27.3%</td>
</tr>
</tbody>
</table>

* Environment, such as no single room for patients requiring single accommodation

A possible confounding factor during the study period was closure of the cardiothoracic ward due to an outbreak of MRSA (patients with positive swabs for multi resistant methicillin staphylococcus aureus), which may have contributed to delays in discharge from the intensive care unit. Patients were not discharged from surgical area within the intensive care unit to ward beds unless alternative arrangements could be made. There were 3 patient discharges delayed during this period (1.71%). These patients could not be discharged to the cardiothoracic ward.
between 16 and 22 February 2001 and remained in the intensive care unit for 93.23, 116.68 and 213.60 hours. The average number of delays per day was one, therefore it is unlikely that the closure of the cardiothoracic ward significantly influenced the proportion of delays, however the length of stay in the intensive care unit for these patients was longer than expected.

4.13.2 Delay Time

The time patients' discharge was delayed from the intensive care unit ranged from 0.2 hours (10 minutes) to 617.5 hours (3 weeks, 4 days, 17.5 hours). Mean delay time was 42 hours (1 day, 18 hours) and median delay time 21.3 hours.

The longest delay time was due to medical complications preventing patients being discharged from the intensive care unit. When patients were deemed suitable for discharge to the ward, and then sometime during the time period after 8 hours post notification whilst waiting for ward placement medical staff deemed the patient no longer medically fit to be discharged from the intensive care unit, the patient's reasons for delay was coded as medical complications. Whilst this seems incongruous, categorising patient delay due to medical complications was subjective with different intensivist preferences influencing some decisions. Excluding patients who developed subsequent medical complications (n=15, 8.5% of 176 delays), 25% patient discharges were delayed (n=161). For this group, delay times ranged from 0.2 hours (10 minutes) to 437.7 hours (2 weeks, 4 days, 5.7 hours). Some of the patients who were delayed because of medical complications were later delayed due to no ward beds when they could be discharged. However, for the purposes of data analysis, only initial cause of delay was included (table 4.7).
Table 4.7.

Time in Delay

<table>
<thead>
<tr>
<th>Hours</th>
<th>Total</th>
<th>Mean (Standard Deviation)</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total delays</td>
<td>7,386.2</td>
<td>42.0 (70.8)</td>
<td>21.3</td>
<td>10 minutes to 3 weeks,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 days, 17.48 hours</td>
</tr>
<tr>
<td>Delays excluding medical complications</td>
<td>5,587.5</td>
<td>34.7 (49.5)</td>
<td>21.3</td>
<td>10 minutes to 2 weeks,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 days, 5.67 hours</td>
</tr>
</tbody>
</table>

Because most ward nursing shifts in the study hospital consisted of 8 hours, the delay time was grouped into 8 hourly time periods (table 4.8). Most delays in discharge from the intensive care unit occurred between 16 and 24 hours (36.4%) after the initial 8-hour waiting period. A delay in discharge within the first 8 hours was the next most common time period (21.0%).

Table 4.8.

Eight Hourly Delay Time Groups for Delayed Discharges from ICU

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 8 hours (after classification of delayed)</td>
<td>37</td>
<td>21.0</td>
</tr>
<tr>
<td>8 to 16 hours</td>
<td>14</td>
<td>8.0</td>
</tr>
<tr>
<td>16 to 24 hours</td>
<td>64</td>
<td>36.4</td>
</tr>
<tr>
<td>24 to 32 hours</td>
<td>9</td>
<td>5.1</td>
</tr>
<tr>
<td>32 to 40 hours</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>40 to 48 hours</td>
<td>17</td>
<td>9.7</td>
</tr>
<tr>
<td>48 hours to 168 hours (1 week)</td>
<td>27</td>
<td>15.3</td>
</tr>
<tr>
<td>More than 168 hours (1 week)</td>
<td>7</td>
<td>4.0</td>
</tr>
<tr>
<td>Totals</td>
<td>176</td>
<td>100</td>
</tr>
</tbody>
</table>
4.13.3 Analysis of Influencing Factors in Discharge

The non-delay in patient discharge from the intensive care unit group and delay in patient discharge from the intensive care unit group were further analysed to determine factors influencing the patient's delay status. Factors thought to influence discharge included the APACHE II score (a measure of the severity of illness, see appendix B), age, gender, admission source to the intensive care unit, admitting diagnosis, primary organ system failure on admission to the intensive care unit, occupancy, month, day discharge notified, discharge destination and specialty. From this analysis, factors significantly affecting delay status were identified and used in the development of a prediction model for delay in discharge from the intensive care unit.

4.13.3.1 APACHE II scores.

The APACHE II scores were significantly higher for patients who had their discharge delayed from the intensive care unit. The student's t-test for independent samples was used to compare means. There was a statistical significance between both the groups for admission APACHE II score (t = -3.824 (642), p < 0.0001) and worst score in first 24 hours APACHE II score (t = -5.123 (642), p < 0.0001). The sicker patients as defined by the patient's APACHE II score on admission to the intensive care unit and the worst in first 24-hour APACHE II score tended to be delayed from discharge from the intensive care unit (table 4.9, figure 4.12 and 4.13).

| Table 4.9. Mean APACHE II Scores, Non-Delayed and Delayed Discharges for ICU |
|---------------------------------|-|---|
| Mean admission APACHE II        | Non-Delay | Delay |
|                                 | 10.8      | 12.8  |
| (standard deviation)            | (5.8)     | (6.0) |
| Mean worst in 24 hours APACHE II| Non-Delay | Delay |
|                                 | 12.8      | 15.6  |
| (standard deviation)            | (6.2)     | (6.5) |
Figure 4.12. Admission APACHE II Score Comparing Non Delayed with Delayed Discharges from ICU.

Figure 4.13. Worst in 24 Hours APACHE II Score Comparing Non Delayed with Delayed Discharges.
4.13.3.2 **Age.**

Patients in the non delayed discharge group were slightly older than those in the delayed group with the median age of patients in the non-delayed patient discharge group being 57 years compared to 55 years in patients who had their discharge from the intensive care unit delayed. Using the Mann-Whitney non-parametric test to test for independence, no significant difference in age existed between non-delayed and delayed discharges ($z = -1.105$, $p = 0.269$). The age data was skewed left, towards the older age groups.

Male patients with no delay in discharge from the intensive care unit were older (median 61 years) compared to male patients who were delayed (median 56 years). There was no statistical significance when comparing medians ($\chi^2 (1) = 3.00$, $p = 0.106$). There was no difference in age of female patient discharges from the intensive care unit during the study period (median age 53 years).

When comparing ages in 10-year time periods (figure 4.14), least delays occurred in the 61 to 70 year old age group whilst most delays occurred in the 31 to 50 year old age group but these differences were not statistically significant ($\chi^2 (7) = 7.130$, $p = 0.415$).

![Figure 4.14. Age in Ten Year Age Groups, Non Delays Compared to Delayed ICU Discharges.](image-url)
4.13.3.3 Gender.

A higher proportion of female patients (n=76, 43.2%) had a delayed discharge from the intensive care unit compared to male patients (n = 100, 56.8%) (figure 4.15). Using Pearson Chi square, there was no statistically significant difference between male patients and female patients in their delay in discharge from the intensive care unit (chi sq (1) = 1.940, p = 0.164).

Figure 4.15. Study Sample Gender, Non Delayed Compared to Delayed ICU Patient Discharges.
When considering delays from the intensive care unit by source of admission, patients more likely to be delayed were admitted from external health care facilities and the emergency department, as depicted in figure 4.16. Least delays occurred when patients were admitted from the operating room (table 4.10). The difference between source of admission into the intensive care unit and delay from the intensive care unit did not reach statistical significance at the 5% level (chi sq (4) = 9.081, p = 0.059).

Figure 4.16. Admission Source, Non Delays Compared to Delayed ICU Discharges
Table 4.10.
Source of Admission to the Intensive Care Unit

<table>
<thead>
<tr>
<th>Source of Admission</th>
<th>Non-Delay</th>
<th>Delay</th>
<th>95% CI for Differences in Proportions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Room</td>
<td>259 (55.3%)</td>
<td>76 (43.2%)</td>
<td>0.04 to 0.21</td>
</tr>
<tr>
<td>Recovery Room</td>
<td>27 (5.8%)</td>
<td>10 (5.7%)</td>
<td>-0.04 to 0.04</td>
</tr>
<tr>
<td>Emergency Department</td>
<td>110 (23.5%)</td>
<td>50 (28.4%)</td>
<td>-0.13 to 0.03</td>
</tr>
<tr>
<td>Other Ward</td>
<td>32 (6.8%)</td>
<td>16 (9.1%)</td>
<td>-0.07 to 0.03</td>
</tr>
<tr>
<td>External Health Care Facility</td>
<td>40 (8.5%)</td>
<td>24 (13.6%)</td>
<td>-0.02 to 0.01</td>
</tr>
</tbody>
</table>
4.13.3.5  *Admitting diagnosis.*

The primary admitting diagnosis varied between non-delayed and delayed discharges from the intensive care unit (table 4.11, figure 4.17 and 4.18). Medical cardiovascular and respiratory failure, sepsis (both medical and surgical) and trauma (due to an increase in surgical trauma) were more commonly associated with a delay in discharge than non-delayed discharge from the intensive care unit. There was a statistically significant difference between admitting diagnosis and delay from the intensive care unit (chi sq (12) = 43.235, p < 0.0001).

Table 4.11.
*Medical Admitting Diagnoses Comparing Delays with Non-Delays in the ICU*

<table>
<thead>
<tr>
<th></th>
<th>Non-Delay</th>
<th>Delay</th>
<th>95% CI for Differences in Proportions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory</td>
<td>26 (5.6%)</td>
<td>24 (13.6%)</td>
<td>-0.13 to -0.03</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>37 (7.9%)</td>
<td>16 (9.1%)</td>
<td>-0.06 to 0.04</td>
</tr>
<tr>
<td>Trauma</td>
<td>33 (7.1%)</td>
<td>12 (6.8%)</td>
<td>-0.04 to 0.05</td>
</tr>
<tr>
<td>Neurological</td>
<td>19 (4.1%)</td>
<td>3 (1.7%)</td>
<td>0.00 to 0.05</td>
</tr>
<tr>
<td>Other Failures</td>
<td>35 (7.5%)</td>
<td>21 (11.9%)</td>
<td>-0.10 to 0.01</td>
</tr>
<tr>
<td>Other</td>
<td>29 (6.2%)</td>
<td>14 (8.0%)</td>
<td>-0.06 to 0.03</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>179 (38.4%)</td>
<td>90 (51.1%)</td>
<td></td>
</tr>
</tbody>
</table>
Figure 4.17. Comparison of Percentage of Surgical Admitting Diagnosis, Non-Delayed and Delayed Discharges from the Intensive Care Unit.

Figure 4.18. Comparison of Percentage of Medical Admitting Diagnosis, Non-Delayed and Delayed Discharges from the Intensive Care Unit.
4.13.3.6 Primary organ system failure.

The primary organ system failure most likely to be associated with a delay in discharge was neurological (34.7%), with cardiovascular (30.7%) and respiratory (26.7%) the next most common. Gastrointestinal, renal and metabolic accounted for 7.9% of primary organ failures in the delayed discharge group with no patients admitted with haematological primary organ system failure (figure 4.19). There was a statistically significant difference between primary organ system failure and delay in discharge from the intensive care unit (chi sq (6) = 14.231, p = 0.027).

Figure 4.19. Primary Organ System Failure, Non Delays Compared to Delayed ICU Discharges.
4.13.3.7 Occupancy.

The influence of bed occupancy on discharge rate was considered in regard to discharge delay / non-delay. Bed occupancy was defined using the following formula:

\[
\text{Occupancy} = \frac{\text{intensive care unit beds occupied}}{\text{number of total ICU beds at time of patient discharge}} \times 100 \%
\]

Occupancy ranged from 41 to 100% with mean occupancy 80.3% for non-delayed discharges and 78.2% for delayed discharges. Median occupancy however was the same, 81.8%. When comparing occupancy to delay status, there was no statistical significance using the Mann Whitney non parametric test (\(z = -1.914, p = 0.056\)). Occupancy was classified into 10 percent occupancy groups as depicted in figure 4.20. There was no statistical significance when comparing delay status with the 10 percent occupancy groups (chi sq (5) = 10.348, \(p = 0.066\)). However, when occupancy in the intensive care unit was between 40-70%, there was little variation between non-delay and delay groups. When occupancy exceeded 70%, delays in discharge increased. This trend reversed when occupancy exceeded 80%. There was a substantial decrease in delays as bed occupancy increased to maximum capacity.
Figure 4.20. Occupancy in Ten Percent Groupings for all Non-Delayed and Delayed Discharges.

4.13.3.8 Month.

Seasonal factors could have contributed to variations in delays to discharge from the intensive care unit. The study time period included the end of winter and the summer months as well as the Christmas period. The study sample was analysed taking into account the number of patient discharges per month.

\[
\text{Daily Discharge Rate} = \frac{\text{Number of discharges in the month}}{\text{Number of days in that month}} \times 100\%
\]
The discharge rate per day varied from 3 discharges per day in September 2000 to 4 discharges per day in March 2001. The proportion of patient discharges per total monthly discharges was calculated using the following formula:

\[
\text{Monthly Rate} = \frac{\text{Number of discharges per group (non-delay or delay)}}{\text{Number of discharges per month}} \times 100
\]

Comparing discharge rates per months with delay status, most delays in patient discharges from the intensive care unit occurred in February 2001 (figure 4.21). There was no statistical significant difference between month and delay in discharge from the intensive care unit (chi sq (6) = 11.386, \( p = 0.077 \)).

![Figure 4.21. ICU Discharges per Month Comparing Non-Delayed and Delayed Discharges.](image-url)
Table 4.12
Daily ICU Discharge Rate Comparing Months for Non-Delay with Delayed Discharges.

<table>
<thead>
<tr>
<th>Month</th>
<th>Discharges per Monthly Total Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Delay</td>
</tr>
<tr>
<td>September 2000</td>
<td>13 3.0</td>
</tr>
<tr>
<td>(n=39)</td>
<td>(n=27)</td>
</tr>
<tr>
<td>October 2000</td>
<td>31 3.3</td>
</tr>
<tr>
<td>(n=101)</td>
<td>(n=79)</td>
</tr>
<tr>
<td>November 2000</td>
<td>30 3.9</td>
</tr>
<tr>
<td>(n=118)</td>
<td>(n=95)</td>
</tr>
<tr>
<td>December 2000</td>
<td>31 3.7</td>
</tr>
<tr>
<td>(n=116)</td>
<td>(n=84)</td>
</tr>
<tr>
<td>January 2001</td>
<td>31 3.1</td>
</tr>
<tr>
<td>(n=95)</td>
<td>(n=68)</td>
</tr>
<tr>
<td>February 2001</td>
<td>28 3.7</td>
</tr>
<tr>
<td>(n=103)</td>
<td>(n=64)</td>
</tr>
<tr>
<td>March 2001</td>
<td>18 4.0</td>
</tr>
<tr>
<td>(n=72)</td>
<td>(n=51)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>182 3.5</td>
</tr>
<tr>
<td><strong>n</strong></td>
<td>644</td>
</tr>
</tbody>
</table>

4.13.3.9  Day of proposed discharge.

It was noted anecdotally that patients who were not discharged by Saturday remained in the intensive care unit until Monday. The day of notification of discharge for the study period was therefore analysed for any significant relationship with delay status. For patients with no delay in their discharge from the intensive care unit, the most common day for notification
of discharge was Thursday (n = 97, 20.7%), followed by Friday (n = 94, 20.1%) and Tuesday (n = 89, 19.0%). For patients who had a delay in their discharge from the intensive care unit, the most common day of notification was Saturday (n = 34, 19.3%) followed by Tuesday (n = 33, 18.8%). There was a statistically significant difference between day of proposed discharge and delay from the intensive care unit (chi sq (6) = 34.008, p < 0.0001).

It can be seen from figure 4.22 that the proportion of delayed discharges compared to non-delayed discharges from the intensive care unit during the study period were greatest on Saturdays closely followed by Mondays. One confounding factor (not tested for) is public holidays, especially if they occur on Mondays, as discharges were most likely to then occur on Tuesday. There were 6 public holidays during the study period, 4 of which were Mondays.

Figure 4.22. ICU Discharge Non-Delays Compared to Delays by Day of Notification of Discharge.
4.13.3.10 Discharge destination.

The study hospital wards are grouped into clinical divisions (appendix G). Most of the discharges from the intensive care unit were to the cardiovascular division (34.9% of 644 discharges). This division includes cardiothoracic surgery, vascular surgery and the coronary care unit. The least number of delays (table 4.24) were to this division (40.6% of non-delayed discharges). Most delays in discharge were to the Critical Care division (26.7% of delays) and the Medical Specialities division (25.6% of delays). There was a significant difference between divisions in their delay in discharge from the intensive care unit (chi sq (7) = 51.486, p < 0.0001).
Table 4.13
Discharge Destination for Non Delayed ICU Discharges

<table>
<thead>
<tr>
<th></th>
<th>Number of Non-Delays &amp; Delays in Division</th>
<th>Percentage Non-Delays in Division</th>
<th>Percentage Delays in Division</th>
<th>Percentage Non-Delays per Total Non-Delays</th>
<th>Percentage Delays per Total Delays</th>
<th>Percentage Non-Delays per Total Discharges</th>
<th>Percentage Delays per Total Discharges</th>
</tr>
</thead>
<tbody>
<tr>
<td>External facilities</td>
<td>22/15</td>
<td>59.5</td>
<td>40.5</td>
<td>4.7</td>
<td>8.5</td>
<td>3.4</td>
<td>2.3</td>
</tr>
<tr>
<td>Cancer</td>
<td>6/8</td>
<td>42.9</td>
<td>57.1</td>
<td>1.3</td>
<td>4.5</td>
<td>0.9</td>
<td>1.2</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>190/35</td>
<td>84.4</td>
<td>15.6</td>
<td>40.6</td>
<td>19.9</td>
<td>29.5</td>
<td>5.4</td>
</tr>
<tr>
<td>Critical Care</td>
<td>137/47</td>
<td>74.5</td>
<td>25.5</td>
<td>29.3</td>
<td>26.7</td>
<td>21.3</td>
<td>7.3</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>19/10</td>
<td>65.5</td>
<td>34.5</td>
<td>4.1</td>
<td>5.7</td>
<td>3.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Medical Specialties</td>
<td>50/45</td>
<td>52.6</td>
<td>47.4</td>
<td>10.7</td>
<td>25.6</td>
<td>7.8</td>
<td>7.0</td>
</tr>
<tr>
<td>Neurosciences</td>
<td>10/9</td>
<td>52.6</td>
<td>47.4</td>
<td>2.1</td>
<td>5.1</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Surgical Specialities</td>
<td>34/7</td>
<td>82.9</td>
<td>17.1</td>
<td>7.3</td>
<td>4.0</td>
<td>5.3</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Patients are allocated a specialty related to their presenting diagnosis when admitted to a ward in the study hospital. Specialties with most delays in discharge compared to total discharges from the intensive care unit were general medicine (8.1%), cardiothoracic surgery (5.0%), neurosurgery (4.3%) and general surgery (2.3%). There was a statistically significant relationship between specialty and delay in discharge from the intensive care unit (chi sq (23) = 43.371, p = 0.006). The most common specialties for delays in discharges from the intensive care unit during the study period are listed in table 4.14.

Table 4.14.
Most Common Specialties Discharged from ICU

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Percentage of Total Discharges</th>
<th>Percentage of Delays per Specialty</th>
<th>Percentage of Delays per Total Discharges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiothoracics (n = 164)</td>
<td>25.5</td>
<td>19.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Neurosurgery (n = 124)</td>
<td>19.3</td>
<td>22.6</td>
<td>4.3</td>
</tr>
<tr>
<td>General Medicine (n = 117)</td>
<td>18.2</td>
<td>44.4</td>
<td>8.1</td>
</tr>
<tr>
<td>Vascular (n = 53)</td>
<td>8.2</td>
<td>13.2</td>
<td>1.1</td>
</tr>
<tr>
<td>General Surgery (n = 47)</td>
<td>7.3</td>
<td>31.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Orthopaedics (n = 31)</td>
<td>4.8</td>
<td>22.6</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Cardiothoracic surgery had the greatest proportion of discharges (25.5%), but General Medicine had the most delays in discharge from the intensive care unit for their specialty (44.4%) and per total discharges from the unit (8.1%).

Although the specialties neuro-spinal surgery (2 patients, 1 delayed),
respiratory (17 patients, 8 patients delayed) and diabetes (7 patients, 3 delayed) had high proportions of patients delayed to discharge, patient numbers in each of these specialties were very small and therefore not reported in table 4.14.

There were 15 patients delayed from discharge from the intensive care unit because of medical complications. Patients delayed because of medical complications most frequently occurred in the cardiothoracic specialty, which is consistent with total numbers admitted in the category (table 4.15).

Table 4.15.
Delayed Discharges from Medical Complications by Specialty

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Number (15)</th>
<th>Delay Range (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiothoracics</td>
<td>5</td>
<td>2.07 to 95.83</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>3</td>
<td>2.83 to 22.25</td>
</tr>
<tr>
<td>General Medicine</td>
<td>2</td>
<td>14.50 and 407.00</td>
</tr>
<tr>
<td>Burns</td>
<td>1</td>
<td>92.50</td>
</tr>
<tr>
<td>Neurology</td>
<td>1</td>
<td>186.15</td>
</tr>
<tr>
<td>Orthopaedic</td>
<td>1</td>
<td>93.65</td>
</tr>
<tr>
<td>Vascular</td>
<td>1</td>
<td>617.48</td>
</tr>
<tr>
<td>Plastics</td>
<td>1</td>
<td>303.50</td>
</tr>
</tbody>
</table>
4.13.3.12 Other factors.

In addition to the preceding analysis to determine significant influences on delayed discharges from the intensive care unit, review of the relevant literature demonstrated that the rates of night discharge and length of stay were influenced by intensive care unit admission and discharge decisions.

4.13.3.12.1 Night discharges

The number of discharges at night is an indication of the pressure on intensive care unit beds (Goldfrad & Daly, 2000). The definition of night discharge varies. Goldfrad and Daly (2000) used two definitions for night discharge:

- Out of office hours, discharges occurring between 2200 and 0659 hours
- Early hours of the morning discharges occurring between midnight and 0459 hours

However, a more useful definition of night discharge may be 2100 to 0659 hours as it represents the typical ward nursing shift at the study hospital. The night discharges are outlined in table 4.16. Most patients were discharged during the day (n=615, 95.5%) with 29 discharges (4.5%) occurring between 2100 hours and 0659 hours.

Table 4.16.
Night Discharges Comparing Non Delayed and Delayed ICU Discharges

<table>
<thead>
<tr>
<th>Discharges</th>
<th>No Delay</th>
<th>Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>0700 to 2059 hours (n=615)</td>
<td>449 (95.9%)</td>
<td>166 (94.3%)</td>
</tr>
<tr>
<td>2100 to 0659 hours (n=29)</td>
<td>19 (4.1%)</td>
<td>10 (5.7%)</td>
</tr>
<tr>
<td></td>
<td>468 (100%)</td>
<td>176 (100%)</td>
</tr>
</tbody>
</table>

There was no statistically significant relationship between night discharge between 2100 hours and 0659 hours and delay in discharge from the
intensive care unit (chi sq (1) = 0.782, p = 0.376).

### 4.13.3.12.2 Length of stay

Pressure on intensive care unit beds may result in premature discharge to the ward and reduced length of stay. Comparing intensive care unit length of stay between non-delayed and delayed patient discharges, the mean length of stay of delayed discharges was more than twice the mean length of stay for non-delayed patient discharges (table 4.17). Median length of stay for delayed patient discharges was more than three times that of non-delayed discharges. The Mann-Whitney non-parametric test was used to test for independence, which demonstrated a significant statistical difference in the intensive care unit length of stay between non-delayed and delayed discharges from the intensive care unit (z =-10.594, p < 0.0001).

**Table 4.17.**

Intensive Care Unit Length of Stay for Non Delayed and Delayed ICU Discharges.

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Delay</td>
<td>468</td>
<td>2 days, 23.6 hours (71.6 hours)</td>
<td>1 day, 3.1 hours (27.1 hours)</td>
</tr>
<tr>
<td>Delay</td>
<td>176</td>
<td>6 days, 6.7 hours (150.7 hours)</td>
<td>3 days, 8.1 hours (81.1 hours)</td>
</tr>
</tbody>
</table>

Excluding patients (n=15) who were delayed for medical complications, there was a substantial difference in the intensive care unit length of stay with mean length of stay for delayed patient discharges being more than double that of non-delayed patient discharges from the intensive care unit and median length of stay treble that of non delayed discharges (figure 4.18). Length of stay ranged from 6.9 hours to 5.7 days for non-delays and 19.1 hours 8.8 days for
delayed patient discharges.

Table 4.18.
Intensive Care Unit Length of Stay for Non Delayed and Delayed ICU Discharges, Patients with Medical Complications Excluded.

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Delay</td>
<td>468</td>
<td>2 days and 23.6 hours</td>
<td>1 day, 3.1 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(71.6 hours)</td>
<td>(27.1 hours)</td>
</tr>
<tr>
<td>Delay</td>
<td>161</td>
<td>6 days, 4.1 hours</td>
<td>3 days, 8.8 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(148.1 hours)</td>
<td>(80.8 hours)</td>
</tr>
</tbody>
</table>

However, it is more meaningful to measure the intensive care unit length of stay from the time patients are admitted to the intensive care unit until the time patients are deemed suitable for discharge from the intensive care unit. This length of stay should not be influenced by delay status. Calculating this intensive care unit length of stay from admission to eligibility for discharge (excluding medical complications) also demonstrated an increased length of stay for patients who were delayed from discharge compared to those patients whose discharges were non-delayed although not to the same extent (table 4.19).

Length of stay for patients who had their discharges delayed ranged from 1.7 hours to 8.8 days compared to 0.7 hours to 5.7 days for those patients whose discharge was not delayed. Using the Mann Whitney test to test for independence between discharges that were not delayed and delayed, the intensive care unit length of stay from admission to notification time was statistically significant (z = -3.848, p < 0.0001).
Table 4.19.
Length of Stay from Admission to ICU until Notification Time of Discharge for Non Delayed and Delayed ICU Discharges, Patients with Medical Complications Excluded.

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Delay</td>
<td>468</td>
<td>2 days and 19.2 hours</td>
<td>23.3 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(67.2 hours)</td>
<td></td>
</tr>
<tr>
<td>Delay</td>
<td>176</td>
<td>4 days, 9.4 hours</td>
<td>1 day, 19.3 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(105.4 hours)</td>
<td>(43.3 hours)</td>
</tr>
</tbody>
</table>

Using the Mann Whitney non parametric test, there was no statistical significant difference in length of hospital stay between non-delayed and delayed discharges ($z = -1.423$, $p = 0.155$). Hospital length of stay mean and median values are displayed in figure 4.20.

Table 4.20.
Hospital Length of Stay for Non Delayed and Delayed ICU Discharges.

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Delay</td>
<td>468</td>
<td>19 days, 6.7 hours</td>
<td>11 days, 12 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(462.7 hours)</td>
<td>(276.0 hours)</td>
</tr>
<tr>
<td>Delay</td>
<td>176</td>
<td>20 days, 6.7 hours</td>
<td>13 days, 4.9 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(486.7 hours)</td>
<td>(316.9 hours)</td>
</tr>
</tbody>
</table>
4.14 **Predictive Model**

Univariate and multiple regression techniques were used to reduce a large number of potential outcome prediction variables to a smaller subset (Rowan et al. 1994). Univariate analysis does not take into account possible confounding factors. To adjust for possible confounding variables, logistic regression analysis was undertaken to investigate the relation between combinations of factors and delay in discharge from the intensive care unit.

The predictor variables that were statistically significant at the 5% level of significance for a difference in delay status in univariate analysis were:

- admission and worst in 24 hours APACHE II scores
- day of notification of discharge
- primary admitting diagnosis
- primary organ system failure
- specialty
- discharge destination

The significant univariate variables, their interactions and squares were entered into the initial step of the logistic regression model using SAS (version 8.0, 1999-2001) and a backwards stepwise analysis was performed removing the least significant variables until only 4 significant variables remained in the model. The explanatory variables from the univariate analysis put into this model are outlined in table 4.21. Primary system organ failure was compacted from 7 to 4 categories – cardiovascular, neurological, respiratory and other (gastrointestinal, renal, metabolic and haematological groups were combined as all had small group numbers). This was still found to be statistically significant (p=0.029). Day of eligible discharge was regrouped into weekday (Tuesday to Friday) and weekend (Saturday to Monday), based on univariate analysis which demonstrated statistical significance between these two groups for delay status. (p < 0.0001). Specialty was compacted from 24 into 5 categories – medical specialties, cardiovascular surgery, surgical specialties, neurosurgery and orthopaedics (p < 0.0001). The number of discharge destinations was
reduced to 5 categories – medical specialties, surgical specialties, cardiovascular, critical care and external facilities and was statistically significant (p < 0.001). Discharges to the cancer division were included in the medical specialties division and discharges to the gastrointestinal division grouped with surgical specialties.

Table 4.21
Predictive Variables at Entry into Backwards Stepwise Logistical Regression Modelling for Delay.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Data Type</th>
<th>Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worst in 24 hours APACHE II scores, grouped</td>
<td>Categorical</td>
<td>1. 1-10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. 11-20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. 21 or more</td>
</tr>
<tr>
<td>Primary organ system failure</td>
<td>Categorical</td>
<td>1. Cardiovascular (CVS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Neuro</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Respiratory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Other</td>
</tr>
<tr>
<td>Day of eligible discharge, grouped</td>
<td>Categorical</td>
<td>Tuesday to Thursday</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Friday to Monday</td>
</tr>
<tr>
<td>Specialty</td>
<td>Categorical</td>
<td>1. Medicine Specialties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Cardiovascular</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Surgical Specialties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Neurosurgical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Orthopaedics</td>
</tr>
<tr>
<td>Discharge Destination</td>
<td>Categorical</td>
<td>1. Other</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Medical Specialties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Cardiovascular</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Critical Care</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Surgical Specialties</td>
</tr>
</tbody>
</table>
Because of the interdependence between admission and worst in 24-hour APACHE score, worst in 24 APACHE II score was used in the model. This was reclassified into 3 groups, 0 to 10, 11 to 20 and 21 or more. Although primary admitting diagnosis was statistically significant, it was not included in the model. It is closely related to primary organ system failure and specialty. Patients often have multiple diagnoses on admission to the intensive care unit and the primary admitting diagnosis may be confusing. However, compacting the diagnoses into three categories which are clinically important and less ambiguous – medical, elective surgical and non-elective surgical – was shown to be statistically significant (p < 0.0001) and this variable was included. Admitting diagnosis was also regrouped into 4 groups – medical, surgical, trauma and cardiovascular – and put into some of the regression models but was not as significant as regrouping into three categories. In addition, several other variables including age, gender and unit occupancy were added to different models during the model development process. Occupancy was included because it has been demonstrated to influence discharge decisions in other studies (Strauss, LoGerfo, Yeltatzie, Temkin & Hudson, 1986; Levin & Sprung, 2001).

The results from the analysis of maximum likelihood estimates and odds ratio estimates after comparing each variable in each class to their reference group are shown in table 4.22. After adjusting for confounding factors and effect modifiers, patients with high (21 or more) worst in 24 hour APACHE II scores have a significantly higher risk for their discharge being delayed compared to lowest APACHE II scores (p <0.0001, OR = 3.592, 95% CI 1.884 to 6.850). Non-elective surgical patients when compared with medical patients had higher odds of delay in discharge from the intensive care unit but this was not statistically significant (p = 0.0009, OR = 0.97, 95% CI 1.48 to 4.64). Elective surgical patients compared with medical patients had higher odds of being delayed but this was not statistically significant (p = 0.0895, OR = 0.50, 95% CI 0.93 to 2.91). There was no statistical significance in delay when comparing elective surgical patients with non-elective surgical patients (p=0.0969, OR = 1.60, 95% CI 0.92 to 2.78). Patients discharged to other wards or other facilities outside the study hospital (including home) had lower odds of having their discharge delayed compared to
Table 4.22

Analysis of Maximum Likelihood Estimates and Odd Ratio Estimates.

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1</td>
<td>-1.30</td>
<td>0.29</td>
</tr>
<tr>
<td>Worst in 24 Hours</td>
<td>1</td>
<td>1.28</td>
<td>0.33</td>
</tr>
<tr>
<td>Group 21 or more</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worst in 24 Hours</td>
<td>1</td>
<td>0.89</td>
<td>0.23</td>
</tr>
<tr>
<td>Group 11-20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worst in 24 Hours</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Group 0-10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summarised Diagnosis</td>
<td>1</td>
<td>0.50</td>
<td>0.29</td>
</tr>
<tr>
<td>Elective Surgical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summarised Diagnosis</td>
<td>1</td>
<td>0.97</td>
<td>0.29</td>
</tr>
<tr>
<td>Non-elective Surgical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summarised Diagnosis</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Medical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day Group</td>
<td>1</td>
<td>0.78</td>
<td>0.20</td>
</tr>
<tr>
<td>Sat to Mon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day Group</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Tues to Fri</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Division Group</td>
<td>1</td>
<td>-0.29</td>
<td>0.40</td>
</tr>
<tr>
<td>Outside</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Division Group</td>
<td>1</td>
<td>-1.28</td>
<td>0.37</td>
</tr>
<tr>
<td>Surg Specialties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Division Group</td>
<td>1</td>
<td>-1.84</td>
<td>0.33</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Division Group</td>
<td>1</td>
<td>-1.08</td>
<td>0.29</td>
</tr>
<tr>
<td>Critical Care</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Division Group</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Medical</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

patients being discharged to medical wards but this was not statistically significant (p=1.65, OR = 0.75, 95% CI 0.34 to 1.65). Being discharged to wards within the hospital all had lower odds of being delayed in their discharge when compared to medical beds and this was statistically significant (p values ranged from < 0.001 to 0.0895 to 0.0001).
The discrimination of the final model was measured by the area under the receiver operating characteristic curve (figure 4.23) which was 0.741 ($p < 0.0001$, 95% CI 0.698, 0.784). The calibration was measured by the Hosmer-Lemeshow statistic (Chi sq (8) 2.446, $p = 0.964$).

![Area under the Receiver Operating Curve](image)

**Figure 4.23.** Area under the Receiver Operating Curve.

The final model, after adjusting for confounding factors and effect modifiers, is depicted in table 4.23. APACHE II score, diagnosis group, day of eligibility for discharge and discharge destination were predictive for delay.
Table 4.23
Analysis of Effects in Model

<table>
<thead>
<tr>
<th>Effect</th>
<th>df</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; Chi Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worst APACHE II Group in 24 Hours</td>
<td>2</td>
<td>19.04</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Diagnosis Group</td>
<td>2</td>
<td>10.98</td>
<td>0.0041</td>
</tr>
<tr>
<td>Day Group</td>
<td>1</td>
<td>15.35</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Destination (division) Group</td>
<td>4</td>
<td>32.32</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>
CHAPTER 5

Discussion

5.1 Introduction

The purpose of this study was to determine whether delays in discharge from an adult intensive care unit occurred and if this was so, what the reasons for these delays were. Anecdotal evidence from the study hospital’s intensive care unit supported the premise that delays in discharge did occur but the extent and reasons for delay were not established. Delays in discharging patients from the intensive care unit are important because they may impact on the patient’s continuum of care, increasing health care costs and reducing the efficiency and effectiveness of intensive care unit services.

5.2 Delayed Discharges

The intensive care unit is used by only a small proportion of the population but is particularly expensive in its use of health care resources (Bone & Balk, 1988; Singer, Myers, Hall, Cohen & Armstrong, 1994). Intensive care unit care costs have increased faster than other specialties in health care. It is therefore important in today’s health environment to achieve positive patient outcomes whilst constraining health care costs by minimising inefficiencies and ineffectiveness in the delivery of intensive care unit services. Delaying a patient’s discharge from the intensive care unit once the patient has been deemed suitable for discharge by intensive care unit medical staff is an inefficient utilisation of valuable intensive care unit resources. The results of this study indicate that delays do occur in discharging patients from the intensive care unit in the study hospital and that these delays are substantial, both in the number of delays and the amount of time delayed.

During the 6-month study period, there were 652 discharges (609 patients) from the study hospital’s intensive care unit, representing approximately half (50.75%) the admissions for the financial year 2000 / 2001. A substantial proportion (n=468) of
these 652 patient discharges (27%; 95% CI 23.9% – 30.4%) had their discharge delayed from the intensive care unit during the study period, confirming the study hospital staff concerns. Discharge was considered delayed if the patient was not relocated from the intensive care unit within 8 hours of being considered eligible for discharge by intensive care unit medical staff. The 8-hour time period was chosen from expert opinion of senior nurses and bed managers in the intensive care unit as a reasonable time period to locate and discharge the patient to an appropriate destination. This means that for every 5 patient discharges not delayed, two patient discharges were delayed from the intensive care unit.

The study sample was very similar to the intensive care unit population for the financial year 2000/2001 in age, gender, APACHE II (Knaus, Draper, Wagner & Zimmerman, 1985) scores, primary admitting diagnosis and source of admission, thus minimising selection bias. Whether this representativeness translated into other years was not evaluated. The large proportion of surgical admissions to the intensive care unit was reflected by a substantial proportion of patients being discharged during the study from the cardiothoracic, critical care and surgical specialty divisions (70%). Many of these surgical admissions were for elective surgery (n = 264). As expected, the elective surgical patients were less severely ill than the other non-elective surgical and medical patient discharges, which was reflected in their lower APACHE II scores (mean admission and worst in 24 hours APACHE II score 11.3 and 13.5 respectively for elective surgical patients compared to 12.8 and 15.3 respectively for other patient discharges). There were 51 patients who died in the intensive care unit during the study period. These patient episodes were excluded from the study sample.

Discharge information was not recorded by nursing shift coordinators on 8 occasions. These patients have been excluded from the data analysis. There were 644 discharges for which the discharge status was known (468 patient discharges not delayed and 176 patient discharges delayed)

By far the main reason for the delay in discharge from the intensive care unit was lack of availability of ward beds, with no ward beds accounting for 75% of delays and delayed access to ward beds accounting for 5.7% of delays. Delay in a ward bed was defined as a bed being arranged on a particular ward for the patient from the
intensive care unit but the ward bed not becoming available to accept the patient from the intensive care unit in the allotted 8-hour time period. Lack of bed availability, that is, no ward beds available and ward bed delays, therefore accounted for nearly 81% of delays in discharge from the intensive care unit. There may be many reasons for bed unavailability within the complex interrelated health care environment. Bed management practices, unpredictable emergency admissions, ward discharge processes and unavailability of aged care beds may all contribute to the unavailability of ward beds (Alexander 2000; Commonwealth Department of Health and Aged Care, 1999; Comptroller and Auditor General, National Audit Office, 2000). Blockage of beds in areas outside the intensive care unit impedes patient discharge from the intensive care unit resulting in delays in discharge for patients from the intensive care unit.

Medical reasons accounted for 15 (8.5%) of the patient delays from the intensive care unit. Delay for medical reasons included patients who had been considered suitable for discharge, a bed was being sought for them, but a change in medical status subsequently developed and prevented discharge of the patient. Patients delayed because of medical complications most frequently occurred in the cardiothoracic specialty, which is consistent with total numbers admitted in the category. It cannot be determined from the available data if the patient should have been considered for discharge in the first place given the subsequent development of medical complications. Pressure on intensive care unit beds may encourage reducing the length of stay when fewer intensive care unit beds are available (Strauss, LoGerfo, Yeltatzie, Temkin & Hudson, 1986). This may result in premature discharge from the intensive care unit and may be a reason for early readmissions to the intensive care unit (Keenan, Doig, Martin, Inman, & Sibbald, 1997; Franklin & Jackson, 1983; Baigelman, Katz & Geary, 1983; Snow, Bergin & Horrigan, 1985). Patients who are discharged too early from intensive care unit may experience worse outcomes (Goldfrad & Rowan, 2000). Keeping patients an additional 24 hours in the intensive care unit has been suggested as a means of improving patient outcomes and reducing readmission to the intensive care unit (Daly, Beale & Chang, 2001). However, there is no evidence that retaining patients an additional 24 to 48 hours in the intensive care unit will prevent physiological compromise or alter patient outcomes (Ingliss & Price, 2001). During the study period, one patient admitted for septic shock, not included in data analysis, was deemed suitable for discharge but the discharge was delayed because no beds were available,
developed medical complications the next day and died the following day. Retaining this patient in the intensive care unit for an additional 48 hours did not result in a favourable patient outcome. Whether the development of medical complications indicated a premature decision to discharge a patient from the intensive care unit was not within the scope of this study. It could not be determined what the sequelae of events would have been for the patients delayed due to medical complications had these patients already been discharged to the ward. There were a substantial number of discharges from the intensive care unit delayed even when those patients who were not discharged due to medical complications were excluded (n = 161, 25% of discharges).

The environment (lack of single room because of infection control reasons), transport (transferring to another facility) and lack of medical cover each accounted for 1 delay. Other reasons accounted for 3 (1.7% of delays) delays including no psychiatric nurse being available and ward nursing staff with inadequate skills. In 10 delayed patient discharges, no reason was cited (5.7% of delays). Nursing shift coordinators were meticulous in completing notification times but less diligent in their recording of the reason for delays. The overwhelming number of delays due to bed unavailability suggests that improvement in bed management processes is essential to reduce delays from the intensive care unit.

Patients more likely to have their discharge delayed differed from patient discharges not delayed in a number of factors. These included demographic, physiological and organisational factors (p > 0.05).

The severity of illness of a patient admitted to the intensive care unit should, in theory, not have influenced delay status. Delay status should have been similar for all patients with no regard for their severity of illness as all patients were considered equally the same, that is, all were deemed suitable for discharge from the intensive care unit by the intensive care specialist. However, in practice, patients more likely to be delayed were those who had been more severely ill. The APACHE II scores can be used as a measure of the severity of illness on admission for intensive care unit patients (appendix B). Patients more likely to be delayed had higher admission APACHE II scores than those patients whose discharge were not delayed (mean admission APACHE II scores were 10.8 for non-delay and 12.8 for delay in discharge from the
intensive care unit, p <0.0001). The same trend was observed for worst in 24-hour APACHE II scores. Although discharge decisions were made using objective criteria, subjective factors may have influenced discharge outcomes for the patients who had been less sick (as measured by their admission and worst in 24 hours APACHE II score). Prior to a patient's discharge from the intensive care unit, clinical nurse specialists from the appropriate ward area visited the patient in the intensive care unit for assessment prior to their ward admission. Bias could have been introduced if patients who had been less sick or required fewer nursing resources on the ward were given preference for admission to the ward. Whether ward staff more readily accepted the patients who had been less sick or required fewer resources is unclear and was not determined in this study.

Similarly, there should be no distinction in length of stay between patients not delayed and those delayed in their discharge from the intensive care unit. It is important to be clear in the definition of length of stay that is being used in this context (Marik & Hedman, 2000). Measurement of length of stay from the time of admission to the intensive care unit until the time of patient discharge from the intensive care unit is inappropriate as this would have been influenced by patient discharge delay time. Rather, length of stay from the time of patient admission to the intensive care unit until the time the patient was considered suitable for discharge from the intensive care unit was used for this assessment. From the analysis of intensive care unit length of stay data, patient length of stay in the intensive care unit was longer for patient discharges that were delayed than those not delayed. Excluding those patient discharges delayed for medical reasons, the mean length of stay for patients eligible for discharge from the intensive care unit who were delayed was approximately twice the mean length of stay in the intensive care unit than for non-delayed discharges. There should have been no difference in patients' length of stay based on their delay status. It supports the APACHE II score data analysis that the sicker or more complex patients tended to be those who experienced delays in their discharge.

Other physiological factors found to be associated with delay in discharge from the intensive care unit included primary admitting diagnosis, primary organ system failures and specialty. These factors were interconnected in that the primary admitting diagnosis is related to the primary organ system failures and patients were allocated a
specialty related to their presenting diagnosis when admitted to the study hospital. All were statistically significant at the 5% level of significance (differences in delay status when compared with primary admitting diagnosis, \( p < 0.001 \), primary system organ failure, \( p = 0.027 \); specialty \( p = 0.006 \)).

Primary admitting diagnosis was statistically significant when comparing delayed to non-delayed discharges (\( p = < 0.0001 \)). Primary admitting diagnosis may be an imprecise prognostic determinant as it can be subjective and arbitrary depending on the diagnosis selected when several potential diagnoses exist. Regrouping this category into medical, surgical, trauma and cardiovascular admitting diagnoses or medical, elective and non-elective surgical admissions both were statistically significant (\( p < 0.0001 \)) in univariate analysis. In the final model, specialty (\( p = 0.78 \)) and primary system organ failure (\( p = 0.19 \)) were removed as their level of significance was greater than 0.05. Primary admitting diagnosis was retained in the model when it was classified as medical, non-elective and elective surgery (\( p = 0.005 \)). The \( p \) values for the other groupings were both 0.31, which with the multiple comparisons, may have been due to chance. There may have been some unrecognised interactions between specialty, primary organ systems failure and primary admitting diagnosis that forced their exit from the model. It is unclear why the odds of having a delay in discharge was reduced if the patient was a medical patient when compared to elective and non-elective surgery. This may be related to the diagnoses being changed during a patient’s stay in the intensive care unit with some patients undergoing surgery and requiring a surgical bed for discharge and other patients being reclassified as medical and requiring a medical bed upon discharge from the intensive care unit. The specialty of General Medicine had the most delays in discharge from the intensive care unit (44.4%) as well as per total discharges from the unit (8.1%). This was consistent with delays in discharge destination often being in the Medical Specialties division. Patients awaiting placement for aged care beds may have contributed to blocking of medical beds (Department of Health, Government of Western Australia, 2001). Less discharge delays may have been experienced by surgical specialties, particularly those with high proportion of elective procedures such as cardiothoracic surgery because beds were made available to accept discharges from the intensive care unit when new patients were transferred to the intensive care unit via the operating room.
Because the admission source has been shown to influence patient outcomes in the intensive care unit, it was assessed for its association with delay status. Lead-time bias has been shown to be associated with higher morbidity in the intensive care unit (Nouria et al., 1998). Patients admitted from wards or transferred from another hospital often experience longer intensive care unit and hospital length of stays, higher mortalities and more intensive care unit readmissions (Rosenberg, Hofer, Hayward, Strachan & Watts, 1999). In the study hospital, patients were admitted to the intensive care unit from the emergency department, operating room, recovery room, general ward or from another health care facility directly to the intensive care unit. When considering delays in discharge from the intensive care unit by source of admission, patients more likely to be delayed in the study hospital were those patients admitted from external health care facilities and the emergency department. This difference between admission source and delay status was not statistically significant at the 5% level of significance (p=0.59). It could be predicted that patients transferred from external health care facilities might be sicker patients with lead-time bias having an effect on patient morbidity and mortality. The same argument should not be applied to emergency department admissions, however. Least delays occurred when patients were admitted from the operating room. This was to be anticipated, as many surgical patients were elective admissions to the intensive care unit, having a bed previously allocated for admission. As patients were transferred to the operating room, vacating their ward beds meant that patients could be discharged from the intensive care unit to the surgical wards.

Organisational factors observed to be associated with delay in discharge included the day of notification of discharge from the intensive care unit and ward destination. Although the study hospital has 24 hour, every day service facilities, it was noted anecdotally prior to the study that those patients who were not discharged by Saturday often remained in the intensive care unit until Monday. In an United States’ study investigating factors related to length of intensive care unit stay following coronary artery bypass graft surgery, the investigators also found that patients who had their surgery performed on a Friday were delayed in discharge from the intensive care unit (Moyer, 1994). The study hospital was similar to the health care facility in Moyer’s (1994) study in that elective cardiothoracic surgery was performed Monday to Fridays. In addition, within the study hospital, admissions from the emergency
department were responsible for pressure on ward beds particularly at weekends. The emergency department had to be placed on diversion to other health care facilities on several occasions during the study period, often due to bed blockages within the hospital. Priority was given to placing emergency department patients, unless there was an impending admission for the intensive care unit. These pressures on hospital resources especially when hospital occupancy was at capacity may have influenced patient delays in the intensive care unit. Keeping patients in intensive care unit beds when there was no pressure on these beds whilst hospital beds were fully occupied was seen as a better alternative than to finding ways to discharge patients from the intensive care unit. Most delayed discharges occurred when the patient was eligible for discharge from the intensive care unit on a Saturday closely followed by Monday. One confounding factor may have been public holidays especially if they occurred on Mondays, as discharges were most likely to then occur on Tuesday. There were 6 public holidays during the study period, 4 of which were on Mondays.

More beds should be made available if delays in patient discharges from the intensive care unit are to be reduced, particularly medical beds and facilities to cater for weekend emergencies. Creating beds for surgical patients on Saturdays to facilitate discharge of these patients from the intensive care unit might help reduce these delays from the intensive care unit rather than waiting until Monday or Tuesday to discharge surgical patients.

It was speculated that the discharge destination would influence patient discharges from the intensive care unit. Discharge of patients was primarily to one of the seven clinical divisions, which included the patients’ specialty. Both discharge destination (p = <0.001) and the patient’s admitting specialty (p = 0.006) were statistically significant when comparing patient discharges with delay status. This is not surprising, as it is difficult to separate destination from specialty. Wards tend to group similar specialties within their area, promoting expertise in nursing care for particular kinds of patients and facilitating access for medical staff. Only when the beds in the division which included the patient’s specialty were unavailable, were other discharge destinations sought with surgical patients being discharged to surgical ward beds and medical patients discharged to medical ward beds. It was more difficult to place patients in ward beds outside their clinical division. If a particular division was
operating at or near full capacity with admissions exceeding discharges, particularly from the emergency department, there may be less manoeuvrability to accept patient discharges from the intensive care unit. Most delays in discharge were to the Critical Care division (26.7% of delays) and the Medical Specialities division (25.6% of delays). This reflects the large proportion of neurosurgical and orthopaedic patients who are often non-elective surgical admissions in the Critical Care division and medical admissions who comprise less than half of the total intensive care unit admissions yet have more delayed discharges. Medical division beds were often occupied with aged care patients who were unable to find suitable accommodation in aged care facilities (Department of Health, Government of Western Australia, 2001).

High occupancy reflects the increasing demand for intensive care unit services. There are a number of reasons for the increasing demand in this specialty including an aging population, reliance on continually changing sophisticated medical and surgical technology and high consumer expectations. The demands for these services often exceed supply resulting in pressure on intensive care unit beds (Society of Critical Care Medicine Ethics Committee, 1994). It may be therefore surmised that occupancy may sway discharge decisions. Admission and discharge practices may be modified with this increased pressure on intensive care unit resources. Data were therefore collected and analysed on intensive care unit bed occupancy at the time of patient notification of discharge. Occupancy was calculated as the percentage of beds occupied at the time of patient eligibility for discharge per total number of beds available (n=22).

Hospitals with average occupancy greater than 85% experience regular bed shortages and periodic bed crises (Comptroller and Auditor General, National Audit Office, 2000). It seems reasonable to suggest that when bed occupancy in the intensive care unit is at critical levels because of staffing issues or impending admissions, that patients are more likely to be discharged with fewer delays. Conversely, when there is no pressure for intensive care unit beds and the hospital is full, then discharging patients from the intensive care unit is not seen as a priority. Studies supporting this premise include Singer, Carr and Mulley (1983) who demonstrated that a temporary shortage of intensive care unit personnel resulted in a fall in intensive care bed capacity with physicians decreasing intensive care unit admissions and patients’ length of stay. Strauss, LoGerfo, Yeltatzie, Temkin and Hudson (1986) found that discharges were
more likely when there was pressure on beds. These authors observed that patients discharged when there was a bed shortage in the intensive care unit were sicker and had a shorter length of stay than patients discharged when more beds were available.

The occupancy in the study hospital’s intensive care unit exceeded 85% for 18 (69%) of the 26 weeks that were studied. Hence, for the majority of weeks during the study period, it was likely that there were regular bed shortages in the intensive care unit. There were 280 patient discharges (43.5%) that were eligible for discharge when occupancy exceeded 85%. Of these 280 patient discharges, approximately a quarter were delayed (n=68). The proportion of patient discharges that were delayed was greater (n = 108/364) when occupancy was less than 85%, that is, when there was less pressure on intensive care unit resources. This was not statistically significant (95% CI of the difference -0.12 to 0.01, p = 0.1288). More delays in discharge from the intensive care unit occurred when occupancy ranged between 81 and 90% and less delays between 91 to 100% occupancy, but this was not statistically significant (p=0.066). There was also no reduction in length of stay when occupancy was increased (Pearson correlation = -0.038, p=0.342). These results contradict the cited earlier studies. Different structure, organisation and clinical practices within the study hospital’s intensive care unit may have accounted for this. It is difficult to make comparisons between intensive care units when the definition of intensive care units and the care that is provided varies considerably. Intensive care unit services within the United States are very different to those in Europe or Australia (Acute Health Division, Department of Human Services, 1997). Even within Europe, there are substantial differences in units between Northern European intensive care units and southern European and United Kingdom intensive care units (Vincent, 1990). Collecting data on factors such as hospital occupancy, occasions of intensive care unit diversion and the influence of nursing staff shortages may have resulted in a more comprehensive representation of the effect of occupancy on discharge practices in the intensive care unit.

Seasonal factors could have contributed to variations in delays to patient discharge from the intensive care unit. The latter part of winter and the entire summer including the Christmas period were within the study time period. Winter tends to be busier than other times with increased hospital admissions due to winter influenza.
epidemics and staff shortages because of increased sick leave (Glaser et al., 2002). The pressure on intensive care unit and hospital resources due to winter influenza epidemics is experienced in other areas in the world and is not unique to the study hospital (Glaser et al., 2002; Comptroller and Auditor General, National Audit Office, 2000). Traditionally the Christmas / January period has tended to be quieter in activity than other months at the study site (Personal Communication L. Brearley, 2002). These trends were not observed during the study period. When adjusting months for differences in the number of days, there was no statistical significance in delay status in discharge from the intensive care unit (p = 0.77).

To adjust for possible confounding variables, logistic regression analysis was undertaken to investigate the relationship between the explanatory variables, confounders, effect modifiers and delay in discharge from the intensive care unit. A valid clinical prediction model may be developed by completely following up a representative group of patients, evaluating all potential explanatory variables, testing the independent contribution of each explanatory variable, and by ensuring that the outcomes were independent of the predictors (Randolph, Guyatt, Calvin, Doig & Richardson, 1998). Explanatory variables found to be statistically significant in univariate analysis were used in the development of the delay model. A backwards stepwise logistic regression analysis was undertaken to remove non-contributory explanatory variables. When a variable that is a significant univariate predictor of outcome is added to a multivariate model, and it fails to contribute significantly to the determination of outcome, it is no longer a predictive variable as it includes the same information as the first predictor (Randolph, Guyatt, Calvin, Doig & Richardson, 1998). When primary organ system failure and specialty were included in the model, neither achieved statistical significance at the 5% level (p=0.782 and 0.190 respectively). The explanatory variables for the predictive model for delay in discharge from the intensive care unit were worst in 24 hours APACHE II score; medical, non-elective and elective surgical groups; discharge destination and weekend or weekday eligibility for discharge. None of the other variables, such as month, occupancy or admission source or their interactions were statistically significant.

Any predictive model for patient discharge delays should have good discrimination and high calibration. When the outcome is dichotomous (discharge from
the intensive care unit delayed or not delayed), it is usual to apply a receiver operating
classifier (ROC) curve to test for discrimination. This curve is a plot of the true-
positive predictions against the false-positive predictions. A prediction model that
discriminates well generates a curve that passes close to the upper left-hand corner of
the receiver operating characteristic plot. The greater the area under the receiver-
operating characteristic curve, the better the discriminating power of the model. By
chance alone, this area would be 0.50. Developers of prediction models are typically
not satisfied unless the receiver operating characteristic area of a model exceeds 0.70
(Hosmer & Lemeshow, 2001; Lemeshow & Le Gall, 1994). The area under the
receiver operator curve for the delay predictive model was 0.741, which is moderately
good. Calibration was tested using the Hosmer-Lemeshow goodness of fit statistic, for
which a p-value greater than 0.05 indicates satisfactory fit. The model demonstrated
good calibration (p=0.964). Further evaluation is required to validate the predictive
ability of the delay model.

The confidence in a prediction model is limited until it is validated in a new
sample of patients (Randolph, Guyatt, Calvin, Doig & Richardson, 1998). There are
three ways to validate the model. The best method is to validate the model in an
entirely independent sample of patients but resource constraints at the time prevented
this from occurring in the study hospital. If the model assists in decision makers being
able to predict those patients likely to be delayed and they then implement strategies
from admission or pre-admission if possible to prevent patient delay, then collection of
a validation data set should be undertaken and the model tested and refined as required.
The second validation method is to randomly split the initial sample of patients into two
groups and use one group to develop the model and the other group to validate the
model. The sample size in this study was too small for this procedure (Hosmer &
Lemeshow, 2001). A third method (used mainly when there is a shortage of data) is to
use complex statistical techniques, such as "Bootstrapping" or "Jackknifing," that
repeatedly sample patients from the population and repeatedly test the accuracy of the
prediction model (Hosmer & Lemeshow, 2001). Because none of these methods were
used and the model has not been validated in another population, scepticism in the
results may be warranted.

Based on the odds ratios, weights may be assigned to the explanatory variables
so that predictions of whether a patient is likely to have their discharge delayed from the intensive care unit can be made. This information is probably more useful at the time of patient admission so that measures may be implemented to minimise the possibility of delay. The actual day when patients are ready for discharge will probably not be known at the time of admission, so a model without day group was developed. However, the area under the operator receiving characteristic curve was decreased when day group was excluded from the model. It decreased to 0.690 so that the model is not as good a predictor as the model that included day group. Because the predictive power of the model is decreased to below 0.70, the usefulness of the model, particularly as it has not been validated, is debatable. What the model does demonstrate is that, even after adjusting for confounders and effect modifiers, patients with higher APACHE II scores, able to be discharged Saturday to Monday, non-elective surgical patients or patients being discharged to the medical division in the study hospital are much more likely to have their discharge delayed from the intensive care unit.

5.3 Relevance

The prevalence of delays in this study was substantially higher than those reported in earlier studies (Groeger et al., 1993). As little work has been done in this area, it cannot be determined if other intensive care units experience a similar proportion of delays in patient discharges to that of the study hospital in today’s health environment. Although there is a paucity of information in the literature specifically related to delays in discharge from the intensive care unit, the study results do support earlier studies that do make reference to delays occurring in patient discharge from the intensive care unit (Groeger et al., 1993; Southgate, 1999; Sprung & Eidelman, 1997).

Groeger et al. (1993) reported that 11% of critical care patients were delayed in their discharge from the intensive care unit. This represents less than half the delays in discharge found in this study. The findings of the report were limited as the data related to the critical care population in the United States, which included a wider group of patients than intensive care unit patients in Australia and the data was collected several years ago. However, it is interesting to note that half of the responding units had one or
more patients with their discharge from the intensive care unit delayed representing 19% of patients in those units. Resources were used that could have been more productively allocated to patients needing the level of care available in these units.

Southgate (1999), in an examination of the issues related to being refused admission to the local intensive care unit in the United Kingdom, noted that the lack of vacant beds in general wards or the lack of availability of intermediate care facilities within the hospital may lead to delayed discharge of patients ready to leave the intensive care unit, thus blocking beds that might benefit critically ill patients. In this study it was not established whether delays in patient discharges resulted in potential patient admissions to the intensive care unit being refused because beds were blocked.

Sprung and Eidelman (1997) from their study into triage practices in the intensive care unit asserted that the utilisation of the intensive care unit was currently not efficient. They observed that a substantial proportion of patients that could have been discharged from the intensive care unit were unable to do so due to a lack of ward beds, intermediate care unit beds, and chronic care. By improving the effective and efficient use of intensive care unit resources, a better demand / supply balance should be achieved. The substantial number of patient discharges delayed principally because there were no ward beds observed in this study support the premise that the utilisation of intensive care unit resources is inefficient.

Improving efficiency and effectiveness of intensive care unit services was a prime mover in the development of admission, triage and discharge guidelines. Admission, triage and discharge guidelines exist to support intensivists in their decision-making processes. Many patients are commonly refused care in the intensive care unit (Bennett & Bion, 1999; Levin & Sprung 2001). This may be because patients do not fit the admission criteria or because beds are unavailable in the intensive care unit. Rates of refusal of admission to the intensive care unit cited in various studies were 24% (Sprung et al., 1999), 26% (Metcalf, Sloggett & McPherson, 1997), 38% (Joynt et al., 2001) and as high as 57% because no beds were available (Frisho-Lima, Gurman, Shapira & Porath, 1994, cited by Joynt et al., 2001; Metcalfe, Sloggett & McPherson; 1997). When there is pressure on intensive care unit beds, refusal of admissions may increase. Delaying patient discharge blocks beds for pending
admissions and may result in patients being refused admission to the intensive care unit who would normally be accepted. Future research to examine the number of refused admissions to the intensive care unit for patients who meet the admission criteria may serve as an indicator of the pressure on intensive care unit beds. Determining the proportion and significance of delayed patient discharges influencing refused admissions to the intensive care unit would be valuable.

Discharging patients in a timely manner not only frees up valuable resources but facilitates patients being transferred to a more orderly and comfortable environment, improving psychological wellbeing for the patient and their significant others (Franklin & Jackson, 1983; Thompson & Spiers, 1998). Prolonging a patient’s stay unnecessarily is a waste of valuable intensive care unit resources.

Patients must meet discharge criteria to be discharged from the intensive care unit. The intensivist, or their delegated representative, is the most suitably qualified person/s to make discharge decisions (Acute Health Division, Department of Human Services, 1997; Smith & Nielsen, 1999). Discharge criteria in the study hospital included those patients no longer requiring mechanical ventilation and able to protect their own airway or have their airway protected by a device such as a tracheostomy. Once a patient was considered fit for discharge, the Registrar of the clinical team to which the patient had been admitted was contacted and informed that the patient was deemed ready for discharge from the study hospital’s intensive care unit (Clarke, 2000). A balance is required between discharging a patient too early and risk the patient being readmitted to the intensive care unit, and the patient staying in the intensive care unit longer than necessary when the patient no longer needs the expert care provided by these units.

Readmissions to the intensive care unit may result from premature discharge of patients to the ward. Readmissions within the same hospital visit may be regarded as early or late. Early readmissions are often regarded as those within 72 hours post-discharge from the intensive care unit (Australian Council on Healthcare Standards, 2002). Patients discharged too early from the intensive care unit may be as a result from pressure for intensive care unit beds leading to readmission to the intensive care unit. Later readmissions are usually due to factors other than premature discharge from
the intensive care unit (Australian Council on Healthcare Standards, 2002). Identifying those patients who might benefit from additional intensive unit care is thwart with difficulty. What is an acceptable level of readmission to the intensive care unit has not yet been determined.

There were forty patients (6.6% of 609 patients) who had multiple re-admission/discharges from the intensive care unit during the study period. However, 10 of these patients (11 readmissions) were readmitted to the intensive care unit during a different hospital stay so their readmissions could not be attributed to premature discharge from the intensive care unit. Thirty patients had 37 readmissions to the intensive care unit during the same hospital stay (4.9% of 609 patients). The number of patients readmitted within 24 hours was 4 (0.66% of 609 patients), including 1 patient who was discharged home from the intensive care unit in the morning and was readmitted the same evening (this patient’s discharge from the intensive care unit was delayed from the previous day, so the patient was then considered fit to be discharged home rather than be discharged to a ward). The number of patients readmitted within 48 hours was 11 (1.81% of 609 patients) and within 72 hours 12 (1.97% of 609 patients). There was no adjustment for severity of illness or other confounding factors.

It may be thought that the shorter the ‘time-to-readmission’ for some of these patients may indicate that the decision to discharge the patient was premature and that this decision may have been brought about by pressure on intensive care unit resources. There is no way of determining this from this study. Certainly a few of these readmissions were planned. However, for those readmissions that were unplanned, it is unclear whether prolonging the patient’s stay in the intensive care unit may have prevented physiological deterioration. The influence of pre-existing conditions or care received on the ward may have influenced patient recovery after discharge from the intensive care unit. The proportion of readmissions thought to be due to premature discharges was not evaluated in this study. It could not be determined whether patients were discharged prematurely to make room for impending admissions or because there were staff shortages. Further analysis of readmissions was not plausible due to the small sub-sample size. Future studies may explore the relationship of readmissions to the intensive care unit with admission, triage and discharge decisions.
Another indicator of the imbalance of supply and demand of intensive care services may be demonstrated by measuring the number of night discharges from the intensive care unit. Night discharges are increasing in the United Kingdom as a result of insufficient intensive care unit beds (Goldfrad & Rowan, 2000). These patients fared significantly worse than those discharged during the day with potential negative physical and psychological impacts for the patient. Discharges at night may result from delays in discharging patients during day hours and then pressure of impending admission making discharge imperative at night. In these instances, beds were found for these patients when earlier they were unavailable.

The definition of night discharge varies. Goldfrad and Daly (2000) used two definitions for night discharge:

- Out of office hours, discharges occurring between 2200 and 0659 hours
- Early hours of the morning discharges occurring between midnight and 0459 hours.

However, a more useful definition of night discharge may be 2100 to 0659 hours as it represents the typical ward nursing shift at the study hospital. In the study, 29 discharges (4.5%) occurred between 2100 hours and 0659 hours. Considering Goldfrad and Daly (2000) observations of 2.7% discharges occurring at night in 1988-1990 and 6.0% in 1995-1998 in the United Kingdom, this would appear consistent across countries. However, this comparison must be made with caution as the United Kingdom data were based on shorter time frames.

5.4 Impact of delays

Intensive care units are costly and their resources limited both by material and human resources. Delay in discharge from the intensive care unit is needlessly wasteful, with beds being blocked for pending admissions. Delays in discharge have implications for practice as they impact on resource use. Not only were there substantial delayed discharges from the intensive care unit during the study period,
some of these delays were for extended periods of time. The amount of time patients' discharge was delayed from the intensive care unit ranged from 10 minutes to over 2 weeks with patient discharges that were delayed for medical complications excluded.

Grouping the delay time into 8 hourly time periods because most ward nursing shifts in the study hospital consisted of 8 hours, most delays lasted between 16 and 24 hours (36.4%), that is, 2 to 3 nursing shifts. The first 8 hours was the next most common time period for delay in discharge (21.0%). Although accurate costing cannot be done, delaying a patient’s discharge meant that additional intensive care unit nursing staff allocation was used for patients who no longer required these resources. The average cost of a full time equivalent nursing staff in the intensive care unit has been estimated by using the total dollars used for nursing divided by the total full time equivalent personnel used (Personal Communication L. Brearley, 2002). By using this calculation it has been estimated that in the study hospital the hourly nursing rate in the intensive care unit is AUD $30.77. The total number of hours patients were delayed (patients with medical complications excluded) was 5587 hours (161 patient discharges were delayed). Excluding the patients who were delayed less than 8 hours, as this was less than a complete 8-hour nursing shift, there were 127 patient discharge delays which comprised approximately 5500 hours in total, costing possibly AUD $169,235. Although these calculations are crude estimates of nursing costs involved, they give an indication that the cost of delayed discharges to health care facilities is enormous, considering ICU nursing hours alone.

Not all nursing shifts comprise 8 hours. In the intensive care unit, casual and agency nurses, are often the staff employed to care for low acuity patients, tend to work 6 hour shifts. If patient stays extended over 2 shifts, the number of nursing hours may well be under-estimated in the above calculations. If patients could not be discharged to the ward, intensive care unit staffing needs took this into account so that additional nursing staff were provided for the shift. This was assessed on a shift by shift basis. Although it was possible in some instances to increase the number of patients per nurse ratio from one to one, to two or three to one, this was not always possible given the staff profile and patient casemix. One hundred and fifteen patients were delayed up to 24 hours, possibly requiring care in the intensive care unit for up to 3 nursing shifts. In addition, 61 patients were cared for longer than 24 hours each. This impacted on both
human and material resources. Shortages of intensive care unit nurses in the study hospital were similar to other Australian centres. Blocking intensive care unit beds with patients suitable for discharge from the intensive care unit did not accomplish the most efficient use of intensive care unit resources.

Estimating the true cost of delays is challenging, as the true costs of intensive care units are largely unknown. Accounting systems are often lacking the necessary functional capacity to cost intensive care services independently of other hospital costs. Different studies into costs of intensive care units have used different costing techniques such as hospital bills but unless appropriate standardised costing systems are developed, cost studies can be used only to monitor trends within an individual health care facility. Although average bed day costs are not an accurate method to cost or compare intensive care unit services (Gyldmark, 1995), they may provide a means for each hospital to examine their own costing trends. In the study hospital, average intensive care unit bed charges were more than four times the bed charges for a ward bed and more than double for intermediate care unit beds. The average daily cost of intensive care unit beds in the study hospital for the financial year 2000/2001 was AUD $1950 compared to AUD $735 for intermediate care and approximately AUD $300 for ward care (Personal Communication J. Harris, 2000). If the 115 patients who stayed for less than a day were charged an additional intensive care unit bed day because they could not be discharged to the ward, this can be estimated to cost an additional AUD $189,750 based on average intensive care unit bed charges during the study period. Of course this is a generalisation of the costs involved for these patient discharges but it does indicate that the costs are significant. In addition to these costs, the costs of the 61 patients who stayed in excess of 24 hours should be added to this value, making the cost of delayed patient discharges considerable. Although patients were not considered eligible for discharge unless able to be discharged to a ward (or other health care facility or home), the sicker patients who had their discharge delayed may have been more easily discharged to a step down unit had the facilities been available.

Intermediate care has been shown to provide less costly services whilst improving the efficiency of intensive care unit resources. Patients who require more advanced monitoring or a higher level of nursing care than that available on the wards may benefit from care in an intermediate care unit that is less costly than an admission
to the intensive care unit.

The influence of the lack of intermediate care facilities on discharge decisions in the study hospital is unclear. There were several intermediate type care units in use during the study. Patients recovering from neurological insults requiring higher dependency care than that provided on the general wards could be discharged to the 4 bed monitor area in the neurosurgical ward. Patients admitted from the Emergency Department could be admitted to the observation ward adjacent to the emergency department and monitored for a selected period of time before a decision was made as to the best destination for their particular severity of illness. Patients with serious cardiac conditions, which required cardiac monitoring were cared for on the coronary care unit. However, the principal high dependency area in the study hospital was adjacent to, but not part of the intensive care unit, and provided care for patients requiring a higher level of care and/or monitoring than that available on the wards. This included patients referred by the medical emergency team or certain high-risk post-operative patients. It makes sense to provide appropriate intermediate care units, which facilitate the efficient and effective use of intensive care unit resources. Lack of intermediate care beds may result in patients being admitted to the intensive care unit when less intensive care is required (Metcalfe, Sloggett & McPherson, 1997). Conversely, lack of intermediate care beds may result in patients having their discharge delayed from the intensive care unit because they no longer require intensive care unit services, but require a higher level of care not provided in general wards. This is not an efficient use of scarce intensive care unit resources.

In the study hospital, the high dependency area was used as a step up area from ward care rather than a step down unit for the intensive care unit. The high dependency area was closed several times during the study period, particularly on weekends, whilst patients were unable to be discharged from the intensive care unit to the ward. Using the high dependency unit for those patients who could not be discharged to a ward would be less costly than retaining patients in the intensive care unit, freeing up beds for those who would benefit from intensive care. In addition, patients being kept in the intensive care unit for additional time for monitoring because of inadequate levels of care provided on the wards could also be accommodated in these areas. It was unclear if some patients were deemed not suitable for discharge from the intensive care unit.
because ward coverage was felt to be inadequate and step down facilities were unavailable.

Reassessment of the role of intermediate care beds in the study hospital has commenced with the introduction of intensivists directing care in the high dependency area. This change has been implemented after completion of data collection so has had no impact on this study's results. Since the introduction of intensivists coordinating the high dependency area, some patients amenable to intermediate care are now being discharged to this area when a bed is required in the intensive care unit for a new admission. However, a true step down facility is not available. Where possible, patients requiring less intensive nursing care are nursed within the intensive care unit with nurse to patient ratios of 1 to 2 or 3 to optimise nursing staff resources. A balance needs to be sought between step up beds from the wards and step down facilities for the intensive care unit that makes the best utilisation of intermediate care and intensive care resources. Research into the optimal number of intensive care unit and intermediate care unit beds will provide valuable information for health care managers. Flexibility of intensive care services, including provision of these services outside the formal walls of the intensive care unit, will make better use of intensive care unit resources and improve patient services. This has been achieved in some hospitals where medical emergency teams, outreach nurses and facilities to expand intensive care and intermediate care beds when the need arises are employed (Hillman, 1996). Further achievements can be realised in the study hospital if there is more flexibility in the staffing between the intensive care unit and high dependency area.

Discharge practices are influenced by several other factors, often remote to the intensive care unit. These include the number of beds available, the proportion of elective and emergency admissions, the staff resources and community resources available. Ward beds being blocked by patients who could be cared for in less acute facilities may prevent the discharge of patients from acute ward beds thus preventing patients from being discharged from the intensive care unit in a timely and appropriate manner. Having a centralised bed management system, early planning for discharge and recognition of those patients who are more likely to be delayed are strategies that may address such issues.
The National Hospital Demonstration Programme is an initiative introduced by the Australian Government that looks at the patient's continuum of care with effective bed management as a priority (Commonwealth Department of Health and Aged Care, 1999). Different bed management models may be implemented to ensure seamless care from patient entry to discharge. Patients may be discharged from the intensive care unit when the intensivist considers the patient's condition no longer requires intensive care unit care, that is, there is no benefit for the patient in remaining in the intensive care unit. Discharging patients in a timely manner not only frees up valuable resources but facilitates patients being transferred to a quieter and more comfortable environment, improving psychological wellbeing for the patient and their significant others. Effective bed management practices will facilitate discharge from the intensive care unit with minimum delays, thus improving efficiency of intensive care unit services.

5.5 Future Research and Recommendations

Little research has been performed specifically looking at delays in patient discharge from the intensive care unit. However, as has been demonstrated, substantial delays do occur in the study hospital that are wasteful of intensive care unit resources. Crude cost estimates suggest that delays in patient discharge are expensive in an environment that is striving to contain health care expenditure. Future research identifying problems and testing possible solutions should be conducted if we are to reduce patient discharge delays from the intensive care unit.

Re-engineering of patient care processes to optimise health care resources needs to be undertaken. Intensive care units do not function in isolation in the process of caring for a critically ill patient. Discharge from the intensive care unit is one aspect of a complex interrelated system in the patient's continuum of care. Changes to any part of the system may influence other parts of the system. This process begins before the patient arrives at the hospital, continues as the patient moves through various departments including the intensive care unit and ends when the patient is discharged from hospital or death (Levin & Sprung, 2001). Decisions made during the process influence or may be influenced by any other aspect of the process (Levin & Sprung,
2001). Consideration of all parts of this continuum of care are essential to understand the discharge process and the interrelated factors that may delay a patient’s discharge from the intensive care unit.

Delays in discharge from the intensive care unit may put pressure on intensive care unit resources, limiting the effectiveness and efficiency of services provided. Research to establish the influence of delays on intensive care unit resources is needed. The apparent demand and supply imbalances that exist with intensive care unit services may be addressed if a better understanding of the factors involved can be described. This includes research into the number of patients refused admissions to the intensive care unit and the reasons for refusal. Research needs to be aimed at determining how to recognise those patients who need additional time in the intensive care unit and whether bed pressure influences discharge time.

Different strategies have been proposed in order to reduce the costs of intensive care unit services and maximise resources. Standardised methodologies need to be developed to cost intensive care unit services so that comparison with other units are feasible. By standardising methods of measuring costs to evaluate costs and benefits it may be possible to reduce ineffectiveness in the system. Delays are costly and being able to measure the costs associated with delay will give a better understanding to the problems that exist and strategies to overcome them.

Determining the effect of hospital occupancy on discharge processes, how often ‘diversion’ of patients from one critical care service to another critical care services occurs and the factors precipitating this process is essential if we are to optimise intensive care unit resources. Research into the most effective bed management practices and the most effective method to ensure adequate human resources both play vital roles in determining the efficiency and effectiveness of the intensive care unit. Research is being undertaken in these key areas (Alexander, 2000) and this should continue to be developed.

Reducing length of stay without compromising quality has been suggested to reduce costs. The impact of delays in reducing length of stay needs to be evaluated.
Reducing length of stay whilst maintaining quality of care is a challenging goal for health care providers. Reducing length of stay has been achieved by modifying practices, both in the intensive care unit and for particular patient groups using intensive care unit services. This includes changing techniques and therapies, using clinical pathways and clinical protocols, regionalisation and reducing the cost of human resources by workload redesign to improve efficiency whilst maintaining quality of care. Bed management practices and the impact of any changes to the system on other parts of the system need to be evaluated and recommended changes implemented so that the patient’s continuum of care is achieved in a timely and efficient manner. Preventing delays in discharge from the intensive care unit are an essential part of this process.

Because pre-existing intensive care unit patient discharge arrangements facilitate transfer to wards, preparation for discharge should commence from the time the patient is admitted to the intensive care unit. From the analysis of the data collected during this study, medical patients or non-elective surgical patients, patients who have higher severity of illness scores on admission or during the first 24 hours of admission to the intensive care unit or patients who are going to be discharged to medical wards are more likely to have their discharge delayed, so arrangements should be in place to ensure timely discharge for these patients from the intensive care unit. Better bed management practices so that patients discharged at the weekends have their discharge needs met are necessary to minimise delays and improve the efficiency and effectiveness of intensive care unit services. Clear guidelines and processes for discharge management from intensive care unit are necessary to facilitate transfer after hours and on weekends.

The impact of step down facilities on the use of intensive care unit services and delays from the intensive care unit should be evaluated to make the best use of intensive care unit resources. Step down facilities may avert delay in discharge and ameliorate high costs associated with discharge delay due to higher dependency demands of patients.
This study has several limitations. Limitations may be related to design and methodology. Being an observational study, the evidence may not be as convincing when compared to a randomised clinical trial. However, given the exploratory nature of the research question, the cross sectional design was considered appropriate. The prospective collection of data, the role of the investigator and the topical nature of the research question strengthened the study's results.

5.6.1 Reliability

Reliability is the degree of consistency or dependability with which the data collection tool measures delay in discharge. Most surveillance systems based on conditions reported by health care professionals are under-reported (Cates & Williamson, 1994). To minimise under reporting, education of relevant staff and day to day monitoring by the investigator were undertaken. This encouraged staff to comply with accurate data entry. The result was that delay status was collected on 644 patient discharges from a sample of 652 sample patient discharges. The excellent compliance of staff using the data collection tool was probably in part due to the motivation and interest in the research question. Staff took ownership of the problem and felt that the research would lead to identification of the problem and thereby a solution could be found to solve the problem.

5.6.2 Internal Validity

When the findings of a study can be shown to result only from the effect of the independent variable and not from effects of extraneous variables, then the study has internal validity (Polit & Hungler, 1995). Internal validity may be threatened by various forms of bias including selection bias, sample bias and information bias.
5.6.2.1 Selection bias.

Selection bias results from procedures used to select participants that lead to an effect estimate among participants included in the study being different from the estimate obtainable from the entire population theoretically targeted for the study (Rothman, 1986). Although selection bias may operate when using non-random sampling methods in selecting study participants, the convenience sample used for this study included all consecutive patients admitted to the intensive care unit (except deaths) in a 6-month period should have helped to minimise selection bias. Seasonal factors may have been overlooked, as a full winter cycle was not included.

5.6.2.2 Sample bias.

One of the limitations of this study may be that the sample is not representative of the general intensive care population at the study hospital.

For the financial year ending 30 June 2001 there were 1395 admissions to the study hospital’s intensive care unit. There were 708 admissions (609 patients) admitted to the intensive care unit during the study period once the exclusion/inclusion criteria were applied. The study sample comprised 50.75% of all the admissions to the intensive care unit in the financial year 2000 / 2001. The sample was similar to the intensive care unit population for the financial year 2000 / 2001. However, the sample was taken from September 2000 to March 2001. Seasonal influences may not have been captured from this 6-month time frame. The sample was not compared to other years and hence selection bias may have resulted in the sample not being representative of the intensive care population. To improve the design of this study to achieve power of 80% a larger sample size is required.

5.6.2.3 Information bias.

Bias can occur whenever there are errors in the classification of participants as delays or non-delays. If a patient’s discharge is classified as a delay, but it is not, then this could result in information bias. Close monitoring
by the investigator and ongoing education of shift coordinators minimised the chance of information bias.

5.6.3 **Confounding**

Confounding may be considered a mixture of effects leading to an apparent distortion of an effect that can influence the outcome. To be confounding, the factor must be associated with both the exposure and the outcome under study.

Bed occupancy may have impacted on discharge decisions. The influence of hospital bed occupancy, diversion of the emergency department and the intensive care unit were difficult to ascertain during the study. The emergency department in the study hospital recorded a number of emergency department diversions indicating that the emergency department was on 'bypass' on 30 occasions during the 11-week pilot study. The reasons for bypass included 14 (47%) of these occasions being due to exit or bed block, or a combination of another factor with exit or bed block. The intensive care unit did not have a reliable system in operation to record when the unit was placed on 'bypass'. Thus the influence of hospital occupancy as a confounding factor is unknown. Documentation of intensive care unit 'bypass' and hospital bed crisis continues to be problematic in the study hospital.

The predictive model was adjusted to account for confounders and effect modifiers using an appropriate statistical package (SAS, 1999-2001). Neither were found to influence the significant factors that were associated with a delay in discharge from the intensive care unit.

5.6.4 **Hawthorne Effect**

The Hawthorne effect is a threat to validity as the nursing shift coordinators may have been influenced to act differently due to the attention of discharges being studied. This may then interfere with the study and introduce bias into the results. Increasing staff awareness concerning delayed discharges may have produced the Hawthorne effect. Staff may be more conscious of ensuring timely discharge from the intensive care unit. Shift Coordinators are an integral part of the study for accurate and timely
data collection. Involvement of intensive care unit medical staff who ultimately make the decisions regarding discharge was minimal. Doctors were informed of the research project at the intensive care unit Clinical Review Meeting. To measure the Hawthorne effect, bed occupancy and average length of stay for the study period were compared to those measures for similar retrospective time periods. The study period was similar to other periods 1997 to 2001 (figure 5.1).

Figure 5.1.

No attempt was made during the study to influence the discharge decision process. Intensivists made the decision to discharge patients from the intensive care unit and the appropriateness of the decision was not within the boundaries of this study. The decision to discharge patients was made not only on medical grounds but was influenced by individual intensivist preferences. Different intensivists may be more cautious in discharging patients particularly at weekends or where it was perceived that medical cover was inadequate or other reasons not stated. Future studies exploring discharge practices may examine how different intensivists interpret discharge criteria. Only patients who were deemed eligible for discharge have their discharges classified as non-delayed or delayed, depending on their discharge time after their eligibility was determined.
5.6.5 *External validity*

The results pertain to the intensive care unit population at the study hospital. The study hospital’s intensive care unit is similar to other Australian adult level III intensive care units in tertiary hospitals that have emergency department facilities and perform cardiothoracic and neuro-surgical procedures. Whether the problem exists in other Australian intensive care units, the extent and the reasons for delays in these facilities is not clearly established from the literature. Local bias may result from performing the study in one hospital rather than involving several units. Nevertheless, this study gives valuable insights into the discharge practices at the study hospital but should not be generalised to other health care facilities.

5.6.6 *Other limitations*

Although randomised clinical trials are considered the gold standard in scientific research designs, they often cannot be ethically performed with critically ill patients nor are they the most appropriate design when exploring a topic where little research into the problem has been conducted. The research question was best answered by the more practical observational study design to explore whether delays in discharge from the intensive care unit existed, to provide evidence of the extent of the problem and possible causes of delays.
CHAPTER 6

Conclusion

The provision of health services in western society has in modern times become increasingly difficult as the public demand for expensive, sophisticated services must be balanced against limited financial resources and competing societal needs. Despite various cost containment measures being implemented, health care costs continue to increase. The intensive care unit is particularly expensive and is only used by a small proportion of the population. The costs have increased faster than other specialties in health care (Edbrooke, Hibbert & Corcoran, 1999). Appropriate utilisation of expensive resources is essential in the rapidly changing health care environment. Any factor that impedes efficiency, that is, providing intensive care unit services at minimal cost, and effectiveness with the best possible outcome, should be minimised (Dobb, 2001).

Because intensive care units utilise a large proportion of health care resources, it is important that there is rationalisation of intensive care unit services to maximise efficiency and effectiveness. An imbalance between supply and demand of intensive care unit beds exists which should be corrected (American Thoracic Society, 1997). Balancing scarce resources in an environment of fiscal constraints has resulted in some decisions that necessitate the prioritisation of intensive care unit beds whilst others limit access to particular scarce resources. The aging population, increasing sophisticated and expensive technology and increasing consumer expectations fuel this demand for intensive care unit services. Ultimately resources are finite. Ethical, economic, moral, social and legal considerations may affect the decision making process.

Strategies to compensate for apparent shortages of intensive care unit beds include increasing the number of physical and/or staffed/equipped intensive care unit beds, utilising guidelines for intensive care unit admission, triage and discharge, and using the available beds more effectively. Rationing of intensive care unit beds is common (Joynt et al, 2001; Sprung et al, 1999; Kalb & Miller, 1989; Vincent, 1986; Strauss, LoGerfo, Yeltatzie, Temkin & Hudson, 1986; Zimmerman, Wagner, Draper & Knaus, 1994). Admission, triage and discharge guidelines assist intensivists in their
decision-making as to which patients are suitable for admission to and discharge from the intensive care unit.

Intensive care units do not function in isolation in the process of caring for a critically ill patient. Discharge from the intensive care unit is only one part of a complex interrelated system in the patient's continuum of care. Changes to any part of the system may influence other parts of the system. Delays in discharging suitable patients from the intensive care unit impact on the patient's continuum of care. They are needlessly wasteful and costly, not only in monetary terms, but also in human and material resources. In providing seamless care, it is of great importance to discharge patients from the intensive care unit in a timely manner when these patients no longer benefit from intensive care unit services. This will facilitate admission of patients who may benefit from intensive care unit care and minimise the negative effects of the intensive care unit environment for patients who needlessly remain in the intensive care unit when this care is no longer required. Discharging patients in a timely manner not only frees up valuable resources but facilitates patients being transferred to a more orderly and comfortable environment, improving psychological wellbeing for the patient and their significant others.

What was evident from this study is that a substantial proportion of patient discharges are delayed from the intensive care unit in the study hospital. Over a quarter of discharges were delayed for more than 8 hours during the study period (median 21 hours), with some of these delays for extended periods of time (up to 3 weeks or more). The main reason for delay was due to unavailability of ward beds. This accounted for more than 80% of delays. This was not found to be related to age, gender, intensive care unit occupancy, admitting source or seasonal variations. Factors that influenced delay were severity of illness as indicated by admission and worst in 24 hour APACHE II scores and length of stay in the intensive care unit until considered suitable for discharge. Admitting diagnosis, primary organ systems failure, specialty and discharge destination are interrelated factors and all were significantly related to delay in discharge from the intensive care unit. Patients deemed suitable for discharge on Saturdays and Mondays were more likely to be delayed. Adjusting for confounding factors and effect modifiers, a predictive model for delay included the APACHE II score, whether the patient was a medical, elective or non-elective surgical patient,
whether they were discharged on the weekend and their discharge destination. Although a patient's discharge should be planned from the time of their hospital admission, it often cannot be determined when a patient in the intensive care unit may be discharged. Therefore, the day of discharge may be of little value in a predictive model. However, bed management practices are influenced by day of discharge. Clear guidelines and processes for discharge management from the intensive care unit are necessary to facilitate transfer after hours and on weekends. The hospital needs to function as a 24 hour day, seven days a week organisation.

Experience in this study highlighted delay problems with medical admission categories and subsequent ward bed availability for discharge. The perceived “sickness” of the patient during their intensive care unit stay and at discharge also appeared to delay discharge to the ward. High volume surgical patients with pre-existing discharge arrangements experienced proportionally less delay than other groups.

The average cost of a full time equivalent nursing staff in the study hospital's ICU was estimated as AUD $30.77 per hour. The total number of hours patients were delayed (patients with medical complications excluded, n=15) was 5587 hours. Excluding the patients who were delayed less than 8 hours, as this was less than a complete 8-hour nursing shift, there were 127 patient discharge delays which comprised approximately 5500 hours in total, costing approximately AUD $169,235. Although these calculations are crude estimates of nursing costs involved, they give an indication that the cost of delayed discharges to health care facilities is enormous.

The prevalence of delayed discharges in the study hospital indicates that this is a problem that needs addressing. Although the impact of delay was not fully evaluated in this study, delays must place a burden on intensive care resources. Research into bed management strategies will facilitate prompt discharge of patients to more suitable environments. Investigating the impact on admission, discharge and re-admission practices because of the failure to provide intensive care beds due to exit block should also be examined. Addressing the issues raised in this study will assist policy makers and health care managers to provide more efficient and effective intensive care unit services without compromising quality of care.
REFERENCES


intensive care. Critical Care Medicine, 28 (12), 3847-3853.


Black, N. (1996). Why we need observational studies to evaluate the effectiveness of


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Faculty of Intensive Care, Australian and New Zealand College of Anaesthetists (1997). Minimum Standards for Intensive Care Units. IC-1, Melbourne: Australian and New Zealand College of Anaesthetists.


King’s Fund Panel (1989). Intensive care in the United Kingdom: report from the
King’s Fund Panel. Anaesthesia, 44, 428-431.

associated with decreased mortality in patients re-admitted to the ICU. Respiratory
Care, 41, 903-907.

of disease classification system. Critical Care Medicine, 13 (10), 818-829.

Knaus, W., Draper, E., Wagner, D. & Zimmerman, J. (1986). An evaluation of
outcome from intensive care in major medical centres. Annals of Internal Medicine,
104, 410-418.

mortality and length of stay in intensive care units. Annals of Internal Medicine, 118,
753-761.

Knaus, W., Wagner, D., Draper, E., Zimmerman, J., Bergner, M., Bastos, P., Sirio, C.,
Risk prediction of hospital mortality for critically ill hospitalized adults. Chest, 100 (6),
1619-1636.


Epidemiological and Clinical Research. Perth: University of Western Australia.

with acute gastrointestinal haemorrhage admitted to a medical intensive care unit.
Critical Care Medicine, 23 (6), 1048-1054.


Moreno, R. & Agthé, D. (1999). ICU discharge decision-making: are we able to
decrease post-ICU mortality? Intensive Care Medicine, 25, 1035-1036.

fit of general outcome prediction models. Intensive Care Medicine, 24 (1), 40-47.

prospective, multicentre, Portuguese study. Intensive Care Medicine, 23 (2), 177-186.

mismatch between planning and practice. Chest, 113 (3), 752-758.

two outcome prediction models on an independent database. Critical Care Medicine,
26, 50-61.

discharge from intensive care: the impact of organ system failure and nursing workload
at discharge. Intensive Care Medicine, 27, 999-1004.

associated with randomized, controlled trials in critically ill children. Critical Care
Medicine, 28, 1152-1156.

Dimensions of Critical Care Nursing, 13 (4), 194-200.

Multz, A., Chalfin, D., Samson, I., Dantzker, D., Fein, A., Steinberg, H., Niederman, M.
utilization when compared with an "open" MICU. American. Journal of Respiratory
and Critical Care Medicine, 157 (5), 1468-1473.

Intensive care unit patient follow-up. Mortality, functional status, and return to work at
six months. Archives of Internal Medicine, 149 (1), 68-72.


O’Connor, G., Plume, S., Olmstead, E., Morton, J., Maloney, C., Nugent, W.,
Hernandez, F. (Jr.), Clough, R., Leavitt, B., Coffin, L., Marrin, C., Wennberg, D.,
Birkmeyer, J., Charlesworth, D., Malenka, D., Quinton, H. & Kasper, J. (1996). A
regional intervention to improve the hospital mortality associated with coronary artery

recovery after Coronary Artery Bypass Grafting: Is the elderly patient eligible? The


expressed demand. Anaesthesia, 53, 113-120.

dependency unit supports their effectiveness [Letter]. British Medical Journal 310,
1413.

reduce discharge delays in a neonatal intensive care unit. American Journal of
Managed Care, 4 (4), 548-552.

Pollack, M., Katz, R., Ruttiman, U. & Getson, P. (1988). Improving the outcome and
efficiency of intensive care: the impact of an intensivist. Critical Care Medicine, 16 (1),
11-17.


of life support from the critically ill. American Journal of Respiratory and Critical Care
Medicine, 155, 15-20.


Seneff, M., Bojanowsky, L. & Zimmerman, J. (1999). Improving ICU utilization by decreasing the frequency of admission and length of stay for low-risk monitor patients. Critical Care Medicine, 27, 155A.


## APPENDIX A

### Summaries of Studies Exploring Intensive Care Unit Services

**Table A.1**

Selected studies concerning intensive care unit (ICUs) services demonstrating how intensive care unit services vary between countries.

<table>
<thead>
<tr>
<th>Study/Purpose</th>
<th>Design</th>
<th>Sample</th>
<th>Results</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Boulanger et al. (1993).</td>
<td>Retrospective audit.</td>
<td>All adult motor vehicle crash victims admitted to trauma unit in Toronto, Canada, and trauma centre, Baltimore, Maryland in the United States July 1986 to July 1990.</td>
<td>Equivalent mortality rates with similar discharge dispositions (not statistically significant), but patients in the trauma centre in the United States were twice as likely to be admitted to the ICU and had longer intensive care unit stays ($p &lt; 0.01$).</td>
<td>Patients had similar motor vehicle injuries in Canada and the United States, but longer length of ICU stay in the United States. Problems with retrospective review limit generalisability.</td>
</tr>
<tr>
<td>Edbrooke, Hibbert &amp; Corcoran (1999).</td>
<td>Epidemiological exploratory study using a postal questionnaire.</td>
<td>Selected hospitals from 11 countries.</td>
<td>Number of critical care beds per 100 acute care hospital beds in 1999 varied widely in Europe, ranging from 1.17 in the United Kingdom to 9.23 in Germany.</td>
<td>The selection bias, small sample size and narrow time frame (6 weeks) limited the validity of the study. Voluntary surveys by questionnaire are limited including the fact that responses tend to be from the most motivated units. However, it provided a useful snapshot of intensive care units' capacity and functioning in Europe.</td>
</tr>
<tr>
<td>Study/Purpose</td>
<td>Design</td>
<td>Sample</td>
<td>Results</td>
<td>Comments</td>
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<tr>
<td>Jacobs &amp; Noseworthy (1990).</td>
<td>Retrospective audit.</td>
<td>All Canadian general hospitals from 1969 -1986, United State hospitals for the period of 1979-86.</td>
<td>Steady growth in Canadian utilisation from 1969 to 1986, with increased ICU patient days (17 to 42 days/1000 population). National costs for 1986 were estimated at $1.03 billion (Canadian), which was roughly 8% of total inpatient costs and 0.2% of Canada's gross national product (GNP). Utilisation trend data for the United States showed a rapid increase from 1979 through 1982 with slower growth after that. In the United States, ICU utilisation in 1986 was estimated at 108 patient days/1000 population. Total ICU costs were estimated at $33.9 billion (U.S.), which is 20% of all inpatient hospital costs and accounts for 0.8% of the GNP. ICU utilisation in the United States is 2.5 times that of Canada.</td>
<td>Both countries used a large and increasing amount of resources, especially in the United States. Reducing the number of beddays could reduce costs. True costs were estimates, based on the assumption that intensive care unit care was three times the cost of general wards. As no explicit cost data was used, true comparison is unlikely, however, the results indicate important trends in these countries' intensive care unit services.</td>
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<td>Rapoport et al. (1995).</td>
<td>Retrospective data analysis of hospital discharge data and existing data from an international study of severity of illness in ICU patients.</td>
<td>Adult general medical / surgical ICUs.</td>
<td>ICU days per million population 2-3 times higher in Western Massachusetts than Alberta. The primary reason was higher ICU incidence (percent of hospitalised patients treated in ICU) rather than a difference in hospital admission rate or length of ICU stay. Patients in the United States hospitals were less severely ill than those in Alberta. The medical costs in the United States were higher than Canada although Canada had a longer length of stay. United States health care was more technology intensive than health care in Canada but it was the extent to which the technology was used rather than the presence or absence of technology. Western Massachusetts hospitalised patients were more likely to be treated in the ICU than similar patients in Alberta with no difference in mortality rates.</td>
<td>Resource constraints were bound up with practice patterns and clinical treatment philosophy. Retrospective studies have challenges with omission of data and selection bias. Together with difficulties with international comparison, the validity of this study may be threatened. However, other studies have also found significant differences between the United States and other countries (Zimmerman et al., 1988; Acute Health Division, Department of Human Services, 1997; Jacobs &amp; Noseworthy, 1990; Rapoport, et al 1995; Boulanger et al, 1993).</td>
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<td>Zimmerman et al. (1988).</td>
<td>Prospective observational study</td>
<td>5,030 adult ICU admissions in 13 United States' hospitals and compared them with 1,005 consecutive ICU admissions in 2 New Zealand hospitals.</td>
<td>Similar national demographic and hospital patient characteristics. Substantial differences in patient selection among the United States and New Zealand ICUs that had similar technical and manpower capabilities and provided similar high quality intensive care. New Zealand designated 1.7% of their total beds for ICU compared to 5.6% in the United States' hospitals. The New Zealand ICUs admitted younger patients (average age 42 years) with fewer patients admitted with severe chronic health problems and post elective surgery. When controlled for differences in case mix and severity of illness, hospital mortality rates in New Zealand were comparable to the United States.</td>
<td>With such a variation in use of resources, both patient selection approaches cannot be optimal to maximise efficient use of ICU services.</td>
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<td>Clermont, Angus, Linde-Zwirble, Sirio, &amp; Pinsky (1996).</td>
<td>Retrospective audit.</td>
<td>1319 ICU admissions in the United States between 1994 and 1998.</td>
<td>The computerised TISS measured ICU resources using data from hospital bills. Weighted length of stay was considered by the authors as a valuable measure of costs because of its high performance, simplicity and wide availability.</td>
<td>Though derived differently, the measures correlated well. This system was subsequently tested in another institution with the authors asserting its validity (Herr, Clermont &amp; Angus, 1998). Hospital bills used to provide data on costs are not sufficiently accurate, limiting the results of this study.</td>
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<tr>
<td>Gyldmark (1995).</td>
<td>Review of 20 published cost studies</td>
<td>Adult European and American ICUs.</td>
<td>Costs per patient ranged between US$1,783 and US$48,435 (inflated to 1990 prices and converted to U.S. dollars where necessary, by using healthcare-specific purchasing power parities). Some studies calculated total hospital costs and it was not possible to calculate only ICU costs. Other studies calculated ICU costs or reported intensive care unit costs separately.</td>
<td>This lack of standardisation in costing ICU care makes it difficult to compare ICU costs.</td>
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<td>Surgenor et al. (1998).</td>
<td>Retrospective cohort study.</td>
<td>Multidisciplinary intensive care unit in an United States University Hospital October 1995 to September 1996.</td>
<td>Total hospital length of stay and costs were computed for each patient. Costs were divided into variable, fixed, and overhead. The average length of stay for intensive care unit patients was 16.7 days and non-intensive care unit patients was 8.3 days. The average cost per discharge for intensive care unit patients was $34,163, compared to an average cost per discharge of $11,968 for the non- ICU patients. Variable cost was a significant component of total hospital cost and may have represented an important area for cost reduction.</td>
<td>Significant variation in the relative contribution of variable cost to total cost with and without ICU admission. Further characterisation of this variation may enable reduction of cost while improving the process of ICU care. While direct comparison of costs between institutions, regions and countries is problematic, the results of this study indicate that ICU care is expensive and a lot more costly than those patients having care in other settings with similar diagnostic related groups.</td>
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<td>Sznajder et al. (2001).</td>
<td>Prospective study.</td>
<td>Seven French intensive care units (Paris area).</td>
<td>The mean ICU stay was US$14,130 (SD 6550) Non survivors US$ 19060 median 10590 Survivors US$12370, median 5780 Incremental cost-effectiveness ratio US$1150 per life year saved. Incremental cost-utility ratio US$4100 per quality adjusted life year saved. Substantial variation resulted from age, severity, diagnosis, number of organ failures and discount rate. In a calculated the cost-effective ratio for 176 stays, the results of suggested a moderate cost effectiveness in spite of casemix variation. Cost effective analysis and cost utility analysis could be used to compare alternative health care options.</td>
<td>Relatively small convenience sample and other selection bias may have influenced the results, limiting the validity of the study. The method of costing nursing and medical staffing costs may be problematic in this study as nursing costs were estimated from interviews of a nurse and head nurse in each unit. Consensus on costing methods would need to be agreed prior to further study.</td>
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Table A.3
Reducing intensive care unit (ICU) costs

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<td>Detsky, Stricker, Mulley &amp; Thibault (1981).</td>
<td>Prospective observational study.</td>
<td>Medical intensive care / coronary care unit</td>
<td>Short-term prognosis of patients at the time of admission was estimated in 5 prognostic groups.</td>
<td>In the critically ill, prognostic uncertainty is important in determining resource expenditures.</td>
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<td>To define the factors determining the allocation of resources to critically ill patients more precisely.</td>
<td>2025 consecutive admissions.</td>
<td>Relationship between this prognosis, the actual outcome and the resource expenditure during single hospitalisation were calculated.</td>
<td>The combined medical ICU and coronary care unit may be dissimilar to many ICUs.</td>
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<td>The care of non-survivors involved a significantly higher mean expenditure than did the care of survivors (p&lt;0.01).</td>
<td>Predictive ability may improve when there is a better understanding of the natural history of specific acute illnesses and the effectiveness of specific intensive interventions.</td>
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<td>Glance, Osler &amp; Shinozaki (1998).</td>
<td>Prospective observational study.</td>
<td>ICU patients who were predicted to have a high probability of death (more than 90%) after 48 hours.</td>
<td>Not using a prognostic scoring system as the basis for withdrawing care resulted in a slightly higher survival rate (87.2% vs. 86.85%) at a cost-per-death prevented of $263,700.</td>
<td>Unlikely that the incremental cost-effectiveness gained by using APACHE III (Knaus et al, 1991) as the basis to withdraw care was sufficient to justify their use.</td>
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<td>Prendergast &amp; Luce (1997).</td>
<td>Prospective study.</td>
<td>179 consecutive patients from 2 ICUs in the United States for whom a recommendation was made to withhold or withdraw life support.</td>
<td>Approximately 90% of ICU deaths were preceded by decisions to limit life-sustaining medical treatment. Futility was defined as the patient was considered to have no chance to leave the ICU. This occurred in 56% of cases whilst the other 44% of patients were estimated to have a 1 to 50% chance of survival. Almost all patients or their significant others agreed with the limits placed on care.</td>
<td>90% of patients who die in these ICUs now do so following a decision to limit therapy, representing major change in practice in these institutions over a 5 year period.</td>
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<td>Wong, Gomez, McGuire &amp; Kavanagh (1999).</td>
<td>Prospective descriptive design.</td>
<td>Canadian tertiary care medical-surgical ICU Neurosurgical, cardiac surgical and coronary care unit patients were excluded. 1960 consecutive ICU admissions</td>
<td>More than 80% of the ICU day-1 predictions of the risk of death were not sufficiently accurate to support withdrawal of therapy decisions. The prediction of those patients with a high probability of death by various scoring systems were more accurate for groups of patients rather than individual patients. Withdrawing ICU care based solely on prognostic scoring systems will result in some patients dying unnecessarily, as predictive scoring systems not 100% specific to predict outcomes. Including changes in physiological variables over time rather than just at admission should prove to be more accurate.</td>
<td>Improved prognostic scoring systems are not likely to substantially impact on overall utilisation ICU days. Only a small proportion of survivors reach a threshold that would support decisions to withdraw therapy.</td>
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Table A.5

"Not for Resuscitation" Orders in the Intensive Care Unit (ICU)

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<td>Cook, D. et al. (2001). To ascertain prevalence, predictors, and procurement pattern of cardiopulmonary resuscitation directives within 24 h of admission to the intensive-care unit (ICU).</td>
<td>Prospective cohort study.</td>
<td>2916 patients aged 18 years and older from 15 ICUs in four countries.</td>
<td>Of 2916 patients, 318 (11%; 95% CI 9.8-12.1) had an explicit resuscitation directive. In 159 (50%; 44.4-55.6) patients, the directive was do-not-resuscitate. Directives were established by residents for 145 (46%; 40.0-51.3) patients. Age strongly predicted do-not-resuscitate directives: for 50-64, 65-74, and 75 years and older, odds ratios were 3.4 (95% CI 1.6-7.3), 4.4 (2.2-9.2), and 8.8 (4.4-17.8), respectively. APACHE II scores greater than 20 predicted resuscitate and do-not-resuscitate directives in a similar way. An explicit directive was likely for patients admitted at night (odds ratio 1.4 [1.0 -1.9] and 1.6 [1.2 -2.3] for resuscitate and do-not-resuscitate, respectively) and during weekends (1.9 [1.3 -2.7] and 2.2 [1.5 -3.2], respectively). Inability to make a decision raised the likelihood of a do-not-resuscitate (3.7 [2.6-5.4]) than a resuscitate (1.7 [1.2 –2.3]) directive (p=0.0005). Within Canada and the USA, cities differed strikingly, as did centres within cities.</td>
<td>For most critically ill patients, cardiopulmonary resuscitation directives established within 24 h of admission to the intensive care unit are uncommon. There was an unknown proportion of patients who were not transferred to ICU because the patient or their significant others believed that ICU care was inappropriate. As well as clinical factors, timing and location of admission might determine rate and nature of resuscitation directives. Strengths include a large cohort, well-defined estimates, systematic and comprehensive data collection. Not generalisable because most centres were Canadian university affiliated teaching hospitals.</td>
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<td>McLean, Tarshis, Mazer &amp; Szalai (2000).</td>
<td>Retrospective chart review of 439 charts.</td>
<td>Medical/surgical/trauma ICUs in 2 tertiary care teaching hospitals. Patients dying in the medical/surgical/trauma ICUs between 1 Jan 1988 and 31 Dec 1988; and 1 Jan 1993 and 31 Dec 1993.</td>
<td>Withdrawal of support was much more common in 1993 than 1988 at both institutions. There was a trend in recent years toward greater withdrawal of treatment in the ICU, consistent with a wider application of “do not resuscitate” orders.</td>
<td>There were many differences between institutions, the result of many different factors that may include wider prevalent regional differences, and clinician practice.</td>
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<td>Murphy et al. (1994).</td>
<td>Interviews by doctors who took care of the patients during routine visits to the clinic.</td>
<td>287 out of a total of 371 patients at least 60 years of age who were eligible in one geriatric practice in Denver.</td>
<td>When asked about their wishes if they had cardiac arrest during an acute illness, 41% opted for cardiopulmonary resuscitation before learning the probability of survival to discharge. After learning the probability of survival (10 to 17%), 22% opted for cardiopulmonary resuscitation with only 6% of patients 86 years of age or older opting for cardiopulmonary resuscitation under these conditions.</td>
<td>Older patients readily understand prognostic information, which influences their preferences with respect to cardiopulmonary resuscitation. Most patients over the age of 65 did not want to undergo cardiopulmonary resuscitation once the probability of survival after the procedure was explained to them.</td>
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<td>Rapoport, Teres &amp; Lemeshow (1996).</td>
<td>Retrospective audit.</td>
<td>United States teaching hospitals in 4 north-eastern States.</td>
<td>About 12.8% of patients had “do not resuscitate” orders during their ICU stay, including more than half of non-survivors.</td>
<td>The use of “do not resuscitate” orders, particularly early in the ICU stay, may be associated with significant reduction in resource utilisation for an identifiable group of patients.</td>
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<td>6,290 consecutive ICU admissions to general adult medical and surgical ICUs 1989 to 1991.</td>
<td>Older and more severely ill patients had a higher percentage of “do not resuscitate” orders.</td>
<td>Most “do not resuscitate” orders were issued after 72 hours in the ICU, but many were issued during the first ICU day.</td>
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<td>Non-survivors with early (within the first 24 hours) “do not resuscitate” orders had shorter mean and median ICU and hospital stays than the comparison group of non- “do not resuscitate” patients.</td>
<td>The percentage of patients with very long ICU (more than 30 days) and hospital (more than 60 days) stays was smaller among “do not resuscitate” patients.</td>
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Table A.6
Cost Benefit Analysis of Intensive Care Units (ICUs)

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<td>Keenan et al. (2002).</td>
<td>Retrospective cohort study.</td>
<td>A total of 27,103 patients admitted to ICU and 41,308 (5% random sample) patients admitted to hospital but not to ICU in all hospitals in British Columbia, Canada, during 3 fiscal years, 1994 to 1996.</td>
<td>ICU admission was an important factor associated with hospital mortality (odds ratio: 9.12; 95% confidence interval: 8.34–9.96). However, the association between ICU admission and mortality after discharge was relatively minimal (hazard ratio: 1.21; 95% confidence interval: 1.17–1.27) The effect of age, gender, and diagnosis overshadowed this.</td>
<td>Although intensive care unit patients do not fare as well as the general population, their long-term mortality is not very different from that of hospital patients who are admitted to hospital but not the intensive care unit. The limitations of retrospective studies threaten the validity of these results but this was a well conducted observational study. There was no severity of illness score for non-intensive care unit patients which threatens the generalisability of these results.</td>
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<td>Sage, Rosenthal &amp; Silverman (1986).</td>
<td>Longitudinal</td>
<td>337 mixed medical / surgical ICU patients.</td>
<td>Mortality was nearly 37% for emergency surgical and medical patients and 14% for elective surgical patients.</td>
<td>Quality of life often not perceived in same way by older patients who are more accepting of their physical limitations.</td>
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<td>To evaluate the costs and benefits of ICUs with their aim of prolonging life and not merely postponing death by comparing severity of illness and intensity of therapy with survival and quality of life 16-20 months after discharge.</td>
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<td>Coronary artery bypass graft surgery patients were excluded as they differ fundamentally from the general ICU population.</td>
<td>Survival and life quality were related inversely to severity of illness and cost of treatment. Acute health on admission to the ICU predicted survival well, whereas chronic health and age were better predictors of life quality.</td>
<td>Post-discharge events are often determined by pre-existing factors. Predicting individual patient outcomes is still the province of the physician. The benefits of the ICU are often assumed. Inherent problems in accurately reflecting true costs due to the method of data collection and the data used to calculate costs. Costing methods for the intensive care unit are fraught with difficulty and are often estimates of true costs or indicate trends involved with costs. APACHE II (Knaus, Draper, Wagner &amp; Zimmerman, 1985) and use of hospital bill for costs limit study validity.</td>
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<td>Ridley, Burchett, Burns &amp; Gunning, (1999).</td>
<td>Retrospective observational study.</td>
<td>1 teaching hospital and 3 district general hospitals in East Anglia for a 5 year period from 1992 to 1996.</td>
<td>Although there was no increase in the size of these hospitals, hospital admissions and outpatient attendances increased by 5% each year. Despite critical care beds increasing in numbers by 21.4%, services increased by 5%.</td>
<td>There was a significant increase in critical care workload. Demand for critical care might have been generated from within hospitals. Increasing demand from changes in sources of referral, with alterations in service placing unexpected demands on intensive care unit services. Retrospective designs have problems with incomplete or missing data and concerns about the application of definitions used to categorise patients in different institutions. However, the large sample size in this study helped to limit this bias.</td>
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### Table A.8

**Allocation of intensive care unit (ICU) resources**

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<tr>
<td>Keenan, Doig, Martin, Inman, &amp; Sibbald (1997).</td>
<td>Retrospective review</td>
<td>614 patients 30-bed in a multidisciplinary critical care unit at a university teaching hospital.</td>
<td>Compared demographic data, admitting diagnosis, APACHE II (Knaus, Draper, Wagner &amp; Zimmerman, 1985) and TISS (Cullen, Civetta, Briggs &amp; Ferrara, 1974) (&quot;active&quot; or &quot;non-active&quot;) daily with other studies that had similarly divided their patients. More patients admitted to study unit received active treatment (97.7%) compared to other studies in the literature (20-66%). A number of potential confounding factors were present, such as the availability of intermediate care units, overnight recovery room ventilation, and critical care bed availability between the index critical care unit and those described in the literature.</td>
<td>There was a lack of useful references for benchmarking the admission process to an ICU.</td>
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<td>Metcalfe, Sloggett &amp; McPherson (1997).</td>
<td>Observational cohort study</td>
<td>All referrals to 6 ICUs with different numbers of beds for a 3-month period.</td>
<td>Excess mortality in patients refused admission to the ICU, but concluded that the provision of more beds may not be the solution, rather altering admission and discharge policy was needed. 21% of patient refused admission to ICU deemed too ill to survive did survive whilst 16% of patients deemed to do well died.</td>
<td>The results of the study have been challenged (Fielden, Parmar, McQuillan &amp; Smith, 1997; Buist, Cranswick, Morley, Duke &amp; Ernest, 1997).</td>
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<td>Parker, Wyatt &amp; Ridley (1998).</td>
<td>Prospective observational study.</td>
<td>Norwich hospital over 4 years.</td>
<td>Increasing demand for ICU beds. Despite increasing the number of beds available, occupancy was not decreased with admissions increasing particularly in surgical specialties.</td>
<td>Creating more beds may not solve the imbalance between supply and demand, rather it reveals the extent of pre-existing demand and results in only a small transient fall in occupancy.</td>
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<td>Rosenberg, Hofer, Hayward, Strachan &amp; Watts (1999).</td>
<td>Prospective data collection of acute physiology score based on 17 physiological variables used in the APACHE III (Knaus et al, 1991) calculation, age, diagnosis, treatment status, amount of time treated prior to intensive care unit admission and admission score</td>
<td>4,684 adult medical ICU consecutive admissions in a large tertiary care hospital</td>
<td>Patients admitted from wards or transferred from another hospital differed significantly from patients directly admitted to the intensive care unit. These patients had higher Acute Physiological Scores on admission and at discharge, more comorbidities, experienced longer intensive care unit and hospital length of stays, higher mortalities and more intensive care unit readmissions. Independent of other factors, these patients had poorer outcomes than direct intensive care unit admissions. Even when accounting for lead-time bias and illness severity, poorer outcomes were predicted for admissions from the wards or another facility.</td>
<td>Patients admitted from wards or transferred from another hospital experienced longer intensive care unit and hospital length of stays, higher mortalities and more intensive care unit readmissions. Patients readmitted to medical ICUs had significantly higher hospital lengths of stay and mortality.</td>
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| Sprung et al. (1999).                                                        | Prospective observational study  | All patients triaged for admission to a general ICU | 24% of patients were refused admission.  
31 of the 92 patients refused admission were later admitted.  
Patients refused admission had higher APACHE II (Knaus, Draper, Wagner & Zimmerman, 1985) scores than did admitted patients.  
The frequency of admitting patients decreased when the intensive care unit was full.  
Triage to the intensive care unit correlated with age, a full unit, surgical status and diagnosis when multivariate analysis was performed.  
Hospital mortality was lower in admitted patients than those refused admission (14% versus 36% for those patients admitted later and 46% for those patients never admitted).  
Patients with good and bad prognosis were refused admission during the study.  
Patients whose APACHE II (Knaus, Draper, Wagner & Zimmerman, 1985) scores were more than 20 had improved survival from ICU.  
All patients admitted to ICU had improved survivals compared with patients who were not admitted. | Classification of patients into good or bad prognosis groups was problematic but the majority of patients were correctly classified. Patients with APACHE II (Knaus, Draper, Wagner & Zimmerman, 1985) scores of 11-20 benefited most from intensive care. Patients with an increasing severity of disease were admitted less frequently.  
As well as classification bias, the study was limited by selection bias. Only patients referred to ICU were included.  
Patients who may have benefited from ICU but not referred because physicians knew ICU was full or believed the patient was a marginal case might have been excluded, influencing these results.  
The results of the study may not be generalisable to other units. The study was conducted in a predominantly surgical intensive care unit, with a closed organisational structure and was capable of expanding intensive care unit bed capacity as the need arose. In other units with different environments, the results may have been different. |
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<th>Study/Purpose</th>
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<th>Results</th>
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<tr>
<td>Wallis, Davies &amp; Shearer (1997).</td>
<td>Observational study.</td>
<td>All patients admitted for a 5-year period in a 7-bed mixed ICU in the United Kingdom that admitted most types of patients except neurosurgical and cardiac surgical cases.</td>
<td>20% of patients who died in hospital after discharge from ICU were expected to survive. The deaths might have been prevented by improved care provided in the ICU and that ward care was suboptimal for patient needs.</td>
<td>No randomised clinical trials have been conducted to support these findings. The subjective nature of deciding whether patients were appropriately discharged was a limitation of this study. However, a number of observational studies support these authors’ findings. Lawrence and Havill (1999) however, found no evidence to support suboptimal ward care in their audit of deaths occurring in hospital after discharge from the intensive care unit in a mixed intensive care unit in New Zealand.</td>
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<tr>
<td>Bertges et al. (2000)</td>
<td>Retrospective audit.</td>
<td>University medical centre in the United States.</td>
<td>Resource use was reduced with no negative impact on the quality of care.</td>
<td>Adds to body of evidence supporting clinical pathways</td>
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<td>To evaluate modified clinical pathways to include selective use of ICU postoperatively for open repair of infra-renal abdominal aortic aneurysm repairs</td>
<td></td>
<td>Data collected over 6 year period.</td>
<td>Admissions to the ICU declined, average length of stay in the ICU decreased and hospital length of stay was almost halved.</td>
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<td>Carson et al. (1996)</td>
<td>Prospective cohort design</td>
<td>Medical ICU at a university-based tertiary care centre.</td>
<td>Closed ICU, the ratio of actual mortality (31.4%) to predicted mortality (40.1%) was 0.78.</td>
<td>Changing from open to closed intensive care unit format improved clinical outcomes.</td>
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<td>To compare the effects of change from an open to a closed intensive care unit format on clinical outcomes, resource utilisation, teaching, and perceptions regarding quality of care.</td>
<td></td>
<td>Consecutive samples of 124 patients admitted under an ICU format and 121 patients admitted after changing to a closed ICU format.</td>
<td>Open ICU, the ratio of actual mortality (22.6%) to predicted mortality (25.2%) was 0.90.</td>
<td>Patients in the closed intensive care unit had greater severity of illness, but their resource utilisation did not increase.</td>
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<tr>
<td>Cheng et al. (1996).</td>
<td>Prospective, randomised controlled clinical trial.</td>
<td>100 patients undergoing elective coronary artery bypass graft surgery.</td>
<td>Significant reductions in intensive care unit costs by 53% and the total cost of surgery by 25% when compared with late extubation were achieved. Reduction in cardiovascular ICU and hospital length of stay was also achieved with no increase in the rate or cost of complications.</td>
<td>Early extubation was found to improve resource use after this surgery.</td>
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<tr>
<td>Collier (1997).</td>
<td>Literature review in development of clinical pathways.</td>
<td>All Medicare patients undergoing vascular procedures. Carotid endarterectomy n= 112 Aortic or renal procedures n = 42</td>
<td>Length of stay, hospital costs, and morbidity, mortality, and readmission rates for the 4 most common vascular diagnosis-related group categories were compared with Medicare standards. Total inpatient cost savings when compared with Medicare reimbursement were US$1,256,000.</td>
<td>The results indicated that clinical pathways significantly improve the length of stay and decrease inpatient costs for major vascular surgical procedures while maintaining high standards of care.</td>
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<td></td>
<td>Prospective observational study.</td>
<td>Lower extremity revascularisation procedures n = 130</td>
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<td>Eagle et al. (1990).</td>
<td>Prospective study.</td>
<td>1145 consecutive admissions to 3 medical ICUs.</td>
<td>Hospital length of stay and intensive care unit length of stay decreased during feedback. Feedback was associated with an increase in the percentage of patients conforming to the management guidelines. During the 6-month follow-up, mortality and readmission rates were similar for patients admitted in baseline and feedback periods.</td>
<td>Adds to body of knowledge supporting use of practice guidelines.</td>
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<td>To develop consensus management guidelines for patients admitted with chest pain, pulmonary oedema, and syncope and use these guidelines to examine practice variation and the effects of physician feedback on decision making.</td>
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<tr>
<td>Hanson et al (1999)</td>
<td>Prospective cohort study</td>
<td>2 general surgical patient cohorts</td>
<td>Despite having higher Acute Physiology and Chronic Health Evaluation (APACHE) II scores (Knaus, Draper, Wagner &amp; Zimmerman, 1985) patients cared for by the critical care service spent less time in the surgical ICU, used fewer resources, had fewer complications and had lower total hospital charges.</td>
<td>Supports closed ICU format</td>
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<td>To compare 2 general surgical patient cohorts to determine if patients received more efficient care and better outcomes if actively managed by physicians directed by an intensivist with dedicated critical care provision at the bedside.</td>
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<td>Jano, Palmieri, Harlin &amp;; Craver (1999)</td>
<td>Case control study</td>
<td>Patients undergoing carotid endarterectomy during 1996 (Pre clinical pathway) were compared to those undergoing the procedure in 1998 (Post clinical pathway).</td>
<td>Average age was 67.3 +/- 9.6 years in the Pre clinical pathway versus 66.4 +/- 7.8 years in the Post clinical pathway group. Male to female ratio was 1.6 in both groups. Mean hospital length of stay was 6.7 +/- 4.5 days Pre clinical pathway and 1.9 +/- 1.0 days Post clinical pathway (p&lt;0.05), and ICU length of stay was 39.4 +/- 40 hours Pre clinical pathway versus 24.5 +/- 7.0 hours Post clinical pathway. 81% of Pre clinical pathway patients were on an average of 2 continuous infusion of vasoactive agents, while 91% of Post clinical pathway patients were on an average of 1.4 vasoactive agents. There was no difference in the number of complications between the groups.</td>
<td>Presented as abstract. The carotid endarterectomy clinical pathway resulted in decreased intensive care unit length of stay and resource utilisation as well as decreased hospital length of stay.</td>
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<tr>
<td>Kilger et al. (2001).</td>
<td>Prospective observational study</td>
<td>105 patients with 2-vessel disease consecutively scheduled for elective coronary bypass surgery in an university affiliated hospital in the United States.</td>
<td>Off-pump coronary surgery via the “Octopus technique” was superior to conventional coronary artery bypass grafting in regard to the course of patients in the early postoperative period.</td>
<td>Benefits for the patients and the entire healthcare system. Further studies are required to compare long term outcome after these procedures.</td>
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<td>Kollef et al. (1997)</td>
<td>Randomised, controlled trial.</td>
<td>2 medical and surgical ICUs in university-affiliated teaching hospitals.</td>
<td>Patients randomised to protocol-directed weaning had significantly shorter durations of mechanical ventilation compared with patients randomised to physician-directed weaning.</td>
<td>Protocol-guided weaning of mechanical ventilation, as performed by nurses and respiratory therapists, was safe and led to extubation more quickly than physician-directed weaning.</td>
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<td>To compare a practice of protocol-directed weaning from mechanical ventilation implemented by nurses and respiratory therapists with traditional physician-directed weaning.</td>
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<td>The hospital mortality rates for the 2 treatment groups were similar.</td>
<td>Hospital cost savings for patients in the protocol-directed group were less than hospital costs for patients in the physician-directed group.</td>
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<td>Marik &amp; Hedman</td>
<td>Prospective, cohort study.</td>
<td>Medical and surgical ICUs of a community teaching hospital.</td>
<td>The APACHE II (Knaus, Draper, Wagner &amp; Zimmerman, 1985) and APACHE III (Knaus et al, 1991) scores were significantly higher and the length of stay - exact was non-significantly higher in the nonsurvivors. There was a poor correlation among the length of stay - exact, log length of stay - exact, length of stay - exact of survivors, and length of stay - exact below upper 95th percentile with the APACHE II (Knaus, Draper, Wagner &amp; Zimmerman, 1985) and APACHE III (Knaus et al, 1991) scores.</td>
<td>Length of stay - midnight be used to record length of stay when a hospital / intensive care unit information system is unable to calculate the exact length of stay in hours. Because the length of stay distribution was highly skewed, the geometric mean and median should be reported. Although APACHE II (Knaus, Draper, Wagner &amp; Zimmerman, 1985) and APACHE III (Knaus et al, 1991) scores are predictive of group outcomes, they should not be used to predict or adjust for length of stay.</td>
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<td>(2000).</td>
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<td>Multz et al. (1998)</td>
<td>ICU admissions</td>
<td>Teaching hospitals</td>
<td>Intensive care unit and hospital length of stay were lower when &quot;closed&quot; (intensive care unit length of stay: prospective 6.1 versus 12.6 d, p &lt; 0.0001; retrospective 6.1 versus 9.3 d, p &lt; 0.05; hospital length of stay: prospective 19.2 versus 33.2 d, p &lt; 0.008; retrospective 22.2 versus 31.2 d, p &lt; 0.02). Days on mechanical ventilation were lower when &quot;closed&quot; (prospective 2.3 versus 8.5 d, p &lt; 0.0005; retrospective 3.3 versus 6.4 d, p &lt; 0.05).</td>
<td>Patient care is more efficient with a closed intensive care unit, and mortality is not adversely affected.</td>
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<td>To determine if a &quot;closed&quot; intensive care unit was more efficient that an &quot;open&quot; one.</td>
<td>retrospectively analysed before and after ICU closure at one hospital; prospective analysis in another open ICU nearby.</td>
<td>280 patients evaluated in both units in prospective investigation. 306 patients evaluated for the retrospective study</td>
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<td>O'Connor et al. (1996).</td>
<td>Regional intervention study.</td>
<td>All 23 cardiothoracic surgeons practicing in Maine, New Hampshire, and Vermont during the study period.</td>
<td>The observed and expected hospital mortality rates demonstrated a 24% reduction in the hospital mortality rate that was statistically significant (P = .001) when they were compared during the post-intervention period.</td>
<td>A multi-institutional, regional model for the continuous improvement of surgical care is feasible and effective. This model may have applications in other settings.</td>
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<td>To determine whether an organised intervention including data feedback, training in continuous quality improvement techniques, and site visits to other medical centres could improve the hospital mortality rates associated with coronary artery bypass graft (CABG) surgery.</td>
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<td>15,095 consecutive patients undergoing isolated CABG procedures in Maine, New Hampshire and Vermont during the study period.</td>
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<td>Pronovost et al (1999)</td>
<td>Observational study with</td>
<td>All Maryland hospitals that performed</td>
<td>In multivariate analysis adjusted for patient demographics, comorbid disease, severity of illness, hospital and surgeon volume, and hospital characteristics, not having daily rounds by intensivist was associated with a three-fold increase in in-hospital mortality (odds ratio [OR], 3.0, 95% confidence intervals [CI] 1.9-4.9). Not having daily rounds by intensivist was associated with an increase risk of cardiac arrest (OR 2.9, 95% CI, 1.2-7.0), acute renal failure, (OR 2.2, 95% CI, 1.3-3.9), septicaemia (OR 1.8, 95% CI, 1.2-2.6), platelet transfusion (OR 6.4, 95% CI, 3.2-12.4), and reintubation (OR 2.0, 95% CI, 1.0—4.1).</td>
<td>Abdominal aortic surgery is a relatively common procedure that is performed in a variety of acute care hospitals with different organisational characteristics, yet there are significant variation in the outcomes of abdominal aortic surgery patients in Maryland hospitals.</td>
</tr>
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<td>To determine whether organisational characteristics of intensive care units are related to clinical and economic outcomes for abdominal aortic surgery patients who typically receive intensive care unit care.</td>
<td>patient data collected</td>
<td>abdominal aortic surgery from 1994 to 1996.</td>
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<td>retrospectively and ICU data collected prospectively</td>
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<td>Rapoport et al. (2000).</td>
<td>Retrospective database study.</td>
<td>10,217 non-operative patients enrolled in IMPACT.</td>
<td>A pulmonary artery catheter was used for 831 patients (8.1%) in the intensive care unit. In multivariate analysis adjusted for severity of illness, age, diagnosis, and do-not-resuscitate status, full-time intensive care unit physician staffing was associated with a two-thirds reduction in the probability of catheter use (odds ratio [OR], 0.36; 95% confidence interval [CI], 0.28-0.45). Higher catheter use was associated with white race (OR, 1.38; 95% CI, 1.10-1.72) and private insurance coverage (OR, 1.33; 95% CI, 1.10-1.60). Admission to a surgical intensive care unit was associated with a 2-fold increase in probability of catheter use (OR, 2.17; 95% CI, 1.70-2.76) compared with either medical or mixed medical and surgical intensive care units.</td>
<td>Organisational characteristics of intensive care units, insurance reimbursement, and race, as well as clinical variables, are associated with variation in practice patterns regarding pulmonary artery catheter use.</td>
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- Large sample size.
- Bias resulting from retrospective study.
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<td>Reyes et al. (1997)</td>
<td>Prospective, controlled, randomised clinical trial</td>
<td>Four hundred and four consecutive patients were randomised to early extubation or conventional extubation.</td>
<td>Groups were comparable. 60% of patients were extubated within 11 hours of surgery resulting in a decreased length of stay in the intensive care unit and an increase in the percentage of patients discharged within 24 hours. There was no increase in clinically important postoperative complications.</td>
<td>Most low and moderate risk patients in whom cardiac surgery performed using coronary perfusion bypass with opioid anaesthesia can be extubated between seven and eleven hours after surgery. A greater number of patients can be discharged within twenty-four hours of surgery.</td>
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<td>Rosenberg Zimmerman, Alzola, Draper &amp; Knaus (2000).</td>
<td>Non-randomised cohort design.</td>
<td>42 ICUs at 40 United States hospitals during 1988-1990 and 285 ICUs at 161 United States hospitals during 1993-1996.</td>
<td>The mean observed hospital length of stay decreased by 3 days and no diagnosis was associated with an increase in hospital stay. The mean observed intensive care unit length of stay remained similar. Data analysis demonstrated a statistical significance but clinically inconsequential 0.11 reduction in aggregate casemix-adjusted ICU length of stay. 75% of the 65 ICU admitting diagnosis had no change in their adjusted for casemix mean ICU length of stay. There was a decreased length of stay for patients within 8 specific diagnostic groups, including patients with acute myocardial infarction, unstable angina, cardiac valvular surgery and patients with neuromuscular disorders. Increases in length of stay were found for patients within 8 specific diagnostic groups, including patients with subarachnoid haemorrhage and cardiogenic shock. ICU length of stay was also influenced by institutional characteristics and patient selection.</td>
<td>ICU length of stay did not followed trends of decreased hospital length of stay in the United States. Early discharge from hospital may be less risky than early discharge from ICU, and less opportunities to decrease length of stay because lack of suitable non ICU beds. The influence of less studies being performed on reducing ICU length of stay than hospital length of stay may have also impacted on ICUs not following hospital trends. Complexity, urgency and ethical issues involved with ICU admission and discharge may have forced economic issues to the background. Patients admitted to ICUs, the pressures associated with a decrease in hospital length of stay do not seem to have influenced the ICU length of stay.</td>
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<td>Zimmerman et al. (1993)</td>
<td>Prospective audit.</td>
<td>9 ICUs (1 medical, 2 surgical, 6 medical-surgical) at 5 teaching and 4 non-teaching hospitals.</td>
<td>Intensive care units with superior risk-adjusted survival could not be distinguished by structural and organisational questionnaires or by global judgment following on-site analysis. Superior organisational practices among these intensive care units were related to a patient-centred culture, strong medical and nursing leadership, effective communication and coordination, and open, collaborative approaches to solving problems and managing conflict.</td>
<td>The best organisational practices amongst these ICUs were related to a patient-centred culture, strong medical and nursing leadership, effective communication and coordination, and open, collaborative approaches to solving problems and managing conflict.</td>
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<td>Byrick, Mazer and Caskenette (1993)</td>
<td>Prospective</td>
<td>All patients admitted to a critical care unit in two 9-month study periods</td>
<td>The number of short stay patients increased dramatically (4-fold increase in intensive care unit admissions), with the unit having a significantly lower severity of illness. The reduction in triage flexibility negatively impacted on the ICU discharge processes. Facilities available outside the unit impacted on the critical care unit's utilisation. The intermediate care unit was re-opened following their study.</td>
<td>The closure of an Intermediate Care Unit impacted on an acute Critical Care Unit by increasing &quot;low risk&quot; admissions with utilisation of services by patients who required less nursing care. Intermediate care unit re-opened following this study.</td>
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<td>Crosby, Gill and Rees (1990).</td>
<td>Survey</td>
<td>University Hospital of Wales over 5 years since the establishment of a high dependency unit for the postoperative care of high-risk patients undergoing surgery. 611 patients admitted between 1 April 1988 and 30 March 1989</td>
<td>The unit was adjacent to but separate from ICU and emergency surgical admission ward. No medical admissions. Major vascular or gastrointestinal surgery 44% of patients, admissions directly from the operating room 87% of patients. Less than 5% of the patients needed transferring to the ICU. Mortality rate less than 2% The approximate nursing, treatment and diagnostic service costs in the high dependency unit were nearly 3 times less than the costs in ICU (£90 versus £262 per day).</td>
<td>High dependency unit is a &quot;staging post within a progressive patient care system which is necessary for those patients who do not need the comprehensive services of an intensive care unit but do need more specialised care than that provided on the wards&quot; (Crosby, Gill &amp; Rees, 1990, p. 311).</td>
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<tr>
<td>Crosby and Rees (1994)</td>
<td>Survey</td>
<td>8 United Kingdom acute general hospitals 7,945 “snapshot” assessments of patient dependency</td>
<td>Appropriate level of clinical care did not always match patients needs. Times when patients unable to be admitted to the intensive care unit owing to a lack of beds. The average need for high dependency beds was nearly 7%, ranging from half a percent at the University Hospital of Wales (dedicated high dependency unit) established several years earlier to nearly 14%. More than 50% of patients were inappropriately placed in terms of high dependency care.</td>
<td>Crosby &amp; Rees (1994) found some patients were cared for in intensive care units where scarce resources were used for these patients inappropriately and other patients were nursed on surgical wards where the level of care is insufficient. The authors concluded that the number of high dependency units was insufficient.</td>
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<td>Dhond, Ridley &amp; Palmer (1998).</td>
<td>Prospective observational study</td>
<td>Norwich hospital after the opening of a 6-bed high dependency unit</td>
<td>Reduction in cancellation of elective surgery Reduction of referrals from the general ward to ICU. Median APACHE II (Knaus, Draper, Wagner &amp; Zimmerman, 1985) score decreased from 15 to 13.</td>
<td>Cost implications are offset by improvements in quality of care.</td>
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<td>Edwards and Stockwell</td>
<td>Audit</td>
<td>All patients admitted to the adult intensive care unit</td>
<td>Demographic, diagnostic, severity of illness and outcome data compared for the 1994 / 95 period pre opening and 1995 / 96 period post opening. More patients were admitted in 1995/96 with higher APACHE III (Knaus et al, 1991) scores and predicted hospital mortality but lower actual hospital mortality The severity of illness of patients admitted to the intensive care unit was increased.</td>
<td>No decrease in the bed shortage with sick patients continuing to be referred to the intensive care unit after the opening of an intermediate care unit. The provision of an intermediate care unit does not decrease the need for ICU admission. The results suggested that the provision of adult ICU beds in the United Kingdom was inadequate.</td>
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<tr>
<td>Elpem, Silver, Rosen &amp; Bone</td>
<td>To identify characteristics of the patient population and to evaluate potential cost savings.</td>
<td>All patients admitted to a non-invasive respiratory care unit from 1 July 1987 to 30 June 1988.</td>
<td>During one year of operation, 136 patients were admitted to the unit, 107 of whom were mechanically ventilated. Overall, hospital costs for these patients exceeded payments by $1,519,477. Losses were greatest for mechanically ventilated patients and those for whom Medicare or Medicaid were the primary payors. Daily costs of care for mechanically ventilated patients were $1,976 lower in the non-invasive respiratory care unit than in the medical intensive care unit.</td>
<td>Non-invasive respiratory care unit represented a cost-effective approach to the care of a substantial number of patients requiring specialised respiratory care.</td>
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<td>Fox, Owen-Smith &amp; Spiers (1999)</td>
<td>Prospective</td>
<td>Adult ICU</td>
<td>No statistically significant difference was found in the TISS (Cullen, Civetta, Briggs &amp; Ferrara, 1974) between high dependency unit status patients managed on the intensive care unit and those managed on the high dependency unit. APACHE II (Knaus, Draper, Wagner &amp; Zimmerman, 1985) scores for high dependency unit-status patients significantly differed from intensive care unit patients. Hourly occupancy of the intensive care unit by high dependency unit-status patients decreased significantly and hourly occupancy of the intensive care unit by intensive care unit status patients increased significantly. Readmission rates were significantly lower.</td>
<td>Resources could be safely diverted from an intensive care unit to a high dependency unit with significant improvement in the efficiency of use of intensive care unit resources. One of the limitations of this study was the small sample size but again the results support similar studies.</td>
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<tr>
<td>Franklin et al (1988)</td>
<td>Observational study prior to and following the opening of an intermediate care unit.</td>
<td>Patients admitted to medical service for 12 months before and after an intermediate care unit was opened</td>
<td>Total admissions to the medical / coronary intensive care unit decreased by 7% as a result of a nearly 15% decrease in the admission of low-risk patients who did not require critical care services. Case fatality rate on the medical service decreased just over 13% in the year after implementation of the intermediate care unit. Decrease in mortality was accounted for by a 25% decrease in general ward deaths and a 38% decrease in ward cardiac arrests. No significant difference in the medical / coronary intensive care unit case fatality rate. The intermediate care unit provided more bed space availability in the medical / coronary intensive care unit for higher risk admissions including those patients who had been denied admission because of inadequate bed space. Fewer patients were delayed admission from the emergency department.</td>
<td>Admission of low-risk patients to intermediate care unit provided access for appropriate admission of higher risk patients to ICU. The study had several limitations challenging external validity. Measuring severity of illness would have provided more meaningful results whilst inclusion of coronary care patients are not typical of intensive care unit populations. Confounding factors such as changes in casemix were not accounted for in the study or changes in patient populations due to other phenomena not related to intermediate care occurring over time. Nevertheless, the findings from the study do support the idea that a 2-tiered system of critical care could be useful in optimising utilisation of limited and expensive resources (Charlson &amp; Sax, 1988).</td>
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<tr>
<td>Kilpatrick, Ridley &amp; Plenerleith (1994).</td>
<td>Retrospective study</td>
<td>Adult general ICU admissions in the United Kingdom between 1985 and 1989</td>
<td>40% of patients were admitted with a risk of hospital mortality of less than 10%. 77% of these low-risk patients were admitted for less than 3 days and their intensive care unit mortality was 7 per cent. Increasing numbers of patients were admitted for postoperative observation and monitoring.</td>
<td>Higher level of care was needed than that provided on general wards but at that time there was no satisfactory alternative to the ICU.</td>
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<tr>
<td>Kolleff, Canfield &amp; Zuckerman, (1995)</td>
<td>Inception cohort study</td>
<td>108 consecutive hospital admissions</td>
<td>26% of intensive care unit admissions were classified as low-risk for having poor outcomes. The 'low-risk patients' incidence for an ongoing gastro-intestinal bleed was less than 5% and their mortality was 0% compared to the high-risk group's mortality rate of 21%. Measurements of overall severity of illness were more important predictors of mortality rather than severity of actual gastrointestinal haemorrhage. Objective clinical criteria could be used to identify low-risk patients having favourable outcomes and potentially there was no need for intensive care unit services.</td>
<td>These patients could be cared more efficiently in an intermediate care area</td>
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<td>Krieger, Ershowsky &amp; Spivack (1990)</td>
<td>Prospective follow up study</td>
<td>All Medicare patients who were admitted to a United States pulmonary non-invasive monitoring unit between 1987 and 1988.</td>
<td>The overall cost savings were greater than $173,000, while high-quality medical care was maintained.</td>
<td>Non-invasive monitoring unit could be effectively used as an alternative to the intensive care unit for selected pulmonary patients.</td>
</tr>
<tr>
<td>Lawless, Zaritsky, Phipps &amp; Riley-Lawless (1991)</td>
<td>Postal survey</td>
<td>1988 of paediatric training programmes</td>
<td>Intermediate care offered highly skilled nursing care with similar technologies to those used in the ICU. Average daily bed charge was 40% less than the average daily charge in an ICU. Only 33% of these programmes had intermediate care units.</td>
<td>Intermediate care units were appropriate as they provide highly technical yet less expensive care for those intensive care patients considered to be “low-risk” of mortality but requiring monitoring or long term technical/intensive nursing support. Although conducted in the paediatric setting, the issues highlighted can be related to adult ICUs.</td>
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<td>Leeson-Payne &amp;</td>
<td>Prospective</td>
<td>Medical and surgical patients in an intense surveillance of 22 acute</td>
<td>8-bed high dependency unit was needed. Several patients were identified</td>
<td>High dependency unit would facilitate early intervention and prevent</td>
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<td>Aitkenhead (1995).</td>
<td>feasibility</td>
<td>wards over 2 weeks in a teaching hospital in the United Kingdom.</td>
<td>as having suboptimal care because of the lack of high dependency unit</td>
<td>subsequent ICU admission or favourably influence length of stay in</td>
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<td>To determine the feasibility of opening a high dependency unit.</td>
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<td>facilities. These patients took longer to recover and this may have</td>
<td>unit facilities.</td>
<td>hospital, long-term prognosis and ultimately cost.</td>
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<td></td>
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<td>resulted in an overestimation of the need for high dependency unit beds.</td>
<td>It was impossible to predict whether the condition of those patients</td>
<td>The short surveillance period (2 weeks) limits the validity of the study.</td>
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<td>requiring high dependency unit facilities in the study would have</td>
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<td>improved had there been a high dependency unit</td>
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<td>Peacock &amp; Edbrooke (1995).</td>
<td>Data from</td>
<td>A fall in cancellation of surgery to zero</td>
<td></td>
<td>Cost of high dependency bed is relative to size of the unit, costs</td>
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<td>the Royal</td>
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<td>reduced when the number of patients is increased with a minimal increase</td>
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<td>Hallamshire</td>
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<td>in staffing.</td>
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<tr>
<td>Seneff, M., Bojanowsky, L. &amp; Zimmerman, J. (1999).</td>
<td>Retrospective review of ICU day 1 hospital during clinical, physiological, and utilisation data.</td>
<td>ICU admissions at a university from 1989 and from 1994 to 1997.</td>
<td>The proportion of ICU low-risk monitor admissions significantly (p&lt;.01) decreased; from 40% in 1989 (prehospital units) to 30% in 1994 and 26% in 1997 (after step down units). The ratio of observed to predicted ICU stay for low-risk monitor patients also fell after step down units were available; from 1.0 in 1989 to 0.89 in 1994 and 0.82 in 1997. Between 1994 and 1997 there was no change in mean age (55.6 vs. 56.1 yrs.), comorbidities (14.7 vs. 14%), and APACHE III score (46.9 vs. 46.7), but the proportion of patients admitted for active treatment increased from 56% to 67%.</td>
<td>The availability of SDUs was associated with a significant reduction in low risk monitor admissions to the study hospital’s ICU. A modest improvement in ICU use was also achieved by reducing case-mix adjusted ICU stay for low risk monitor patients. These reductions in frequency and length of stay for low-severity admissions resulted in an increase in ICU utilisation for active therapy. Retrospective study threatens external validity.</td>
</tr>
<tr>
<td>Zimmerman et al. (1999)</td>
<td>Observational study</td>
<td>10,876 step-down units admissions at 49 hospitals during 1993-1997.</td>
<td>Step-down unit patients were more frequently elderly (54% vs. 87% &gt;65 yrs.) and non-operative (84% vs. 56%) compared with ICU patients. Although many step-down unit and intensive care unit monitor admissions had similar diagnoses, more step-down unit patients had a low severity of illness (93% vs. 87%). There was a low (&lt;10%) risk for active therapy for 83% of the step-down units patients and 76.8% of the ICU monitor patients. Few step-down unit patients required transfer to an ICU (2.2%), but 5.2% were readmitted to the step-down unit.</td>
<td>There is considerable overlap in the characteristics of step-down unit and ICU monitor patients. The similarities between step-down unit and ICU monitor patients suggest that many ICU admissions who require only monitoring and concentrated nursing care could be cared for in step-down units.</td>
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<td>Bristow et al (2000)</td>
<td>Cohort comparison study</td>
<td>All adult (14 years) patients admitted (50,942 admissions)</td>
<td>1510 adverse events</td>
<td>The study has not clearly demonstrated any difference in death rates associated with the MET system; they conclude there may be a reduction in unplanned admissions to the intensive care unit.</td>
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<td></td>
<td>after casemix adjustment</td>
<td>to three Australian public hospitals from 8 July to 31</td>
<td>Rate of unanticipated ICU admissions was less at the intervention hospital in total (casemix-adjusted odds ratios: Hospital 1, 1.00; Hospital 2, 1.59 [95% CI, 1.24-2.04]; Hospital 3, 1.73 [95% CI, 1.37-2.16]).</td>
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<td>December 1996.</td>
<td>No significant difference in rates of cardiac arrest or total deaths</td>
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<td>Significantly reduced rate of unanticipated ICU/HDU admissions at the medical emergency team intervention hospital after casemix adjustment</td>
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<td>Goldhill, Worthington, Mulcahy,</td>
<td>Prospective</td>
<td>All patients admitted to the intensive care</td>
<td>The incidence of cardiopulmonary resuscitation before intensive care unit admission was statistically significant with 3.6% of patients seen by the team and 30.4% for those not seen (p&lt;0.005). Of those seen by the team, 25% died on the intensive care unit compared with 45% of those not seen (not statistically significant).</td>
<td>The high percentage mortality in-patients admitted to the intensive care unit from the wards prompted the introduction of the patient-at-risk team. The aim of the Medical Emergency Team is similar to the patient-at-risk team. Many critically ill ward patients had abnormal physiological values before intensive care unit admission. Admission to a high dependency or intensive care unit would have been desirable for many of the patients assessed. Predefined physiological criteria were not able to reliably predict which patients would be admitted to the intensive care unit.</td>
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<tr>
<td>Tarling, and Sumner (1999).</td>
<td>study</td>
<td>intensive care unit from the wards during the study period</td>
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<td>To describe the patient-at-risk team to identify and manage seriously ill ward patients.</td>
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<td>Strauss, LoGerfo, Yeltazie, Temkin, &amp; Hudson (1986)</td>
<td>Physically divided units - medical ICU (5 beds), coronary care unit (5 beds) and surgical / trauma unit (8 beds).</td>
<td>Patients admitted during times of bed shortage were on average, more severely ill than those admitted when many beds were unoccupied. Patients under crowded conditions were sicker and had a shorter stay than patients discharged when more beds were available. The relative risk of discharge was inversely related to empty bed availability, illness severity and age. Bed availability had no effect on rates of death in the intensive care unit, death after discharge or readmission to the ICU</td>
<td>Physicians regularly ration ICU beds effectively by altering admission and discharge decision making</td>
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Table A.13
Refused admission to the intensive care unit (ICU).

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To evaluate factors associated with decisions to refuse ICU admission and to assess the outcome of refused patients.

Patients are at an increased risk of mortality, particularly in the middle range of severity of illness. Factors associated with the decision to refuse admission of patients referred to the intensive care unit were age, diagnostic group and severity of illness. No association between available beds and admission decisions. That may reflect differences in population and facilities studied.

Lack of beds were the most common reason for refusal in Metcalfe, Sloggett & McPherson, 1997 and Frisho_Lima et. In this study, like Sprung et al, the major reasons for refusal were patients being too well or too sick.

Degree of chronic illness, patient preferences and unit type may have threatened generalisability, however these results are similar to those previously reported. Did not study the problem of triage when the intensive care unit was full, that is, when triage is most difficult.

Elective surgery was excluded as they were eventually admitted. They used an unique code for refused patients.
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<td>McQuillan et al (1998)</td>
<td>Prospective confidential inquiry was based on structured interviews and questionnaires</td>
<td>Large district general hospital and a teaching hospital in the United Kingdom</td>
<td>Twenty patients (group 1) were well managed, 54 patients (group 2) received suboptimal care and in 26 patients (group 3), the assessors disagreed on the quality of management.</td>
<td>Quality of care before admission to ICU may influence outcome. Suboptimal care had a substantial impact on individual morbidity, mortality and requirement for intensive care resources (avoidable admissions). Causes of suboptimal care were failure of organisation, lack of knowledge, failure to appreciate clinical urgency, lack of experience, lack of supervision and failure to seek advice. Clinically significant effects occur if appropriate referrals to ICU were delayed, refused or transferred elsewhere. Better care before admission may reduce ICU bed days.</td>
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<tr>
<td>Wood &amp; Smith (1999)</td>
<td>Survey</td>
<td>47 consecutive patients who had cardiopulmonary arrests</td>
<td>47 consecutive arrests analysed, abnormal vital signs in 24 patients during the 24 hours before the arrest call was made.</td>
<td>Letter to the editor. Findings supported the results of the study conducted by McQuillan et al (1998). Preferable to be proactive, either to expedite timely ICU referral or to allow a dignified death for patients who are dying. When ICU care would benefit patients, those patients should be referred early. In the other group of sicker patients where cardiopulmonary resuscitation would not be successful ICU care would not be appropriate and the consideration of “do not resuscitate” orders would be more appropriate.</td>
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To identify the incidence of preventable physiological deterioration before cardiopulmonary arrest on general medical and surgical wards |

In over half the patients, premonitory signs of physiological deterioration were evident.
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<tr>
<td>Duke and Green (2001)</td>
<td>Retrospective case study</td>
<td>73 out of 75 inter-hospital transfers from metropolitan hospitals in Melbourne, Victoria, ICU services were not available in the transferring hospital.</td>
<td>Transfer group experienced a significant delay in admission to the receiving hospital’s ICU and a longer stay in the ICU and the hospital. Hospital mortality in the inter-hospital transfer group was not statistically significant from that in the non-transfer group.</td>
<td>Further studies with larger sample are needed to clarify the morbidity and mortality risk of acute interhospital transfer.</td>
</tr>
<tr>
<td>Flavouris (1999)</td>
<td>Retrospective review</td>
<td>Critically ill patients transported from peripheral hospitals to a regional tertiary referral intensive care unit with non-transported critically ill patients.</td>
<td>Of all the ICU admissions, 16% were transported. Transported patients had a different casemix, with significantly higher severity of illness measures, mortality and length of stay. Observed mortality of transported patients with sepsis, gastrointestinal disease or bleeding, intracranial haemorrhage and post respiratory arrest was less than that predicted whilst those with neurological disease, post cardiac arrest and overdose had a higher than predicted mortality. Transported patients had a higher predicted mortality and longer intensive care unit stay than non-transported patients.</td>
<td>Associated resource utilisation and overall cost would be expected to be greater for transported patients.</td>
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<td>Mackenzie, Smith and</td>
<td>Postal survey</td>
<td>278 general or mixed</td>
<td>Average of 23 patients was transported to each unit.</td>
<td>The authors estimated that the number of critically ill patients requiring secondary transport to adult intensive care units in the United Kingdom in 1994 exceeded 11,000 patients.</td>
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<td>Wallace (1997)</td>
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<td>ICUs</td>
<td>Most frequently quoted reasons for such transfers (not mutually exclusive) were lack of intensive care beds (63%), and/or lack of renal support services (23%) in referring hospitals.</td>
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<td>41% of respondents considered that arrangements for transfer were unsatisfactory.</td>
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<td>Baigelman, Katz and Geary (1983)</td>
<td>Retrospective chart review</td>
<td>Urban community teaching hospital. Patients admitted to a 5-bed respiratory care unit, 6-bed coronary care unit, 12-bed progressive coronary care unit and an 8-bed combined medical and surgical ICU during a 12-month period.</td>
<td>1069 admissions to the critical care units with 640 patients being at risk for readmission. The readmission rate was 11.7%. Prematurity of transfer out of a critical care unit may have been a contributing factor in 4.2% of the readmissions. Cardiac and respiratory problems were the major contributing causes for readmission. The survival rate for the premature and non-premature group was essentially identical.</td>
<td>Large number of readmissions attributed to coronary care unit patients, challenges the generalisability of results to a general ICU. Lack of detailed and specific documentation may be problematic with retrospective designs. No control group prevented conclusive analysis. Retrospective design did not allow data to be collected on how many discharges were perceived as premature so that an evaluation could be undertaken to evaluate potential criteria for increased risk of readmission. The process of decision-making criteria was not elucidated and subjectivity may have influenced results. Who reviewed the data not made clear. The authors concluded that improved communication between physicians, nurses and therapists could probably decrease premature transfers that contributed to readmission. They recommended the collection of more data regarding acceptable readmission rates; and prospective studies be conducted to better define the patient population at risk.</td>
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<tr>
<td>Chen, Martin, Keenan. &amp; Sibbald (1998)</td>
<td>Multicentre, cohort study</td>
<td>3 ICUs from 2 teaching hospitals and 4 ICUs from 4 community hospitals.</td>
<td>236 (4.6%) readmitted to the unit. Patients with gastrointestinal and neurological diagnoses had the highest readmission rate. Of the readmissions, 45% had recurrence of the initial disease, 39% experienced new complications, and 14% required further planned operation. Among patients readmitted for the same illness, cardiovascular and respiratory problems were the most frequent diagnoses. Of patients readmitted with a new diagnosis, 30% initially had gastrointestinal diseases, while respiratory diseases accounted for 58% of the new complications. Readmissions within 24 hours occurred in 27% of all readmissions. Patients requiring readmission had a higher hospital mortality rate (31.4%) compared with those not requiring readmission (4.3%, p &lt; .001), even after adjustment for disease severity score (odds ratio = 5.93, p &lt; .001).</td>
<td>Data obtained retrospectively from a registry database. Discharge physiological data and diagnosis not captured, warning of meaningful signs on initial intensive care unit discharge. No information regarding clinical decision making once the patient has been discharged from ICU. Patients who no longer will be considered for ICU (not for resuscitation orders) should be excluded from data analysis on readmissions. Readmitted patients have a high risk of hospital death that may be underestimated by the usual physiological indicators on either initial admission or readmission. Further studies are required to determine if patients at risk for readmission can be identified early to improve the outcome</td>
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<td>Daly, Beale and Chang (2001)</td>
<td>Retrospective study using logistic regression analysis and modelling of data</td>
<td>13,924 patients discharged from 20 ICUs in the United Kingdom between 1989 and 1998</td>
<td>Mortality after discharge from ICU 12.4%. In the validation set, the 34% of the patients who were identified as at-risk had a discharge mortality of 25% compared with a 4% mortality among those not considered at-risk. Comparing the high-risk discharged patients with those regarded as lower risk, the lower risk patients had a lower mortality. The discharge mortality of at-risk patients was estimated at being reduced by 39% if patients stayed an additional 24 hours in ICU. The authors concluded that patients would benefit from an additional 48 hours in ICU.</td>
<td>If proved reliable and valid, intensivists could use this score to assist decision-making regarding which patients to discharge to maximise efficiency of the scarce ICU resources. None of the 20 ICUs at the time of this study were in hospitals with high dependency units.</td>
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<td>Escarce and Kelly (1990)</td>
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<td>235 patients admitted directly from emergency department</td>
<td>The predicted death rate was the same as the actual rate for patients admitted directly from emergency department (25% vs 22%), but was less than the actual rate for patients transferred from hospital floors (38% vs 55%), the medical intermediate care unit (32% vs 59%), and other hospitals (21% vs 36%). Logistic regression analysis confirmed an independent association between the medical ICU admission source and risk of death. Suggest that APACHE II (Knaus, Draper, Wagner &amp; Zimmerman, 1985) score does not measure illness severity accurately in all patients admitted to ICUs.</td>
<td>Admission source is an important predictor of hospital death independent of the severity of illness.</td>
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<td>Franklin and Jackson (1983)</td>
<td>Prospective</td>
<td>512 medical ICU admissions during a 1-year period in the United States</td>
<td>36 readmissions within the same hospitalisation in that interval.</td>
<td>Further studies to identify high-risk and low-risk admissions and discharges will effect better use of intensive care</td>
</tr>
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<td>To identify those patients most likely to be readmitted to a medical ICU.</td>
<td>observational study</td>
<td></td>
<td>Excluding ICU deaths and short-term drug overdoses, these 36 readmissions comprised 12% of all patients discharged from medical ICU.</td>
<td>The mortality rate of this group was 58%, more than twice the overall mortality rate for the year.</td>
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<tr>
<td>Rosenberg, Hofer,</td>
<td>Secondary</td>
<td>4,684</td>
<td>Patients readmitted to ICU had significantly higher hospital morbidities and lengths of stay even after adjusting for severity of illness, diagnosis and comorbidities.</td>
<td>The authors believe that status at discharge, rather than status at their initial admission, would be more relevant to evaluate risk of admission and the appropriateness of ICU discharge.</td>
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<td>Hayward, Strachan</td>
<td>analysis of a consecutive</td>
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<td>Readmitted patients received longer duration of treatment before their first ICU admission and were sicker and more physiologically unstable both at the time of first admission and discharge.</td>
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<td>&amp; Watts (2001)</td>
<td>prospective admissions to a</td>
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<td>medical ICU.</td>
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<td>Adjusting for severity of illness, readmitted patients were more than 11 times likely to die and have hospital stays almost twice as long as non readmitted patients.</td>
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<td>The independent risk factor most associated with readmissions was the patient’s physiological severity of illness at the time of ICU discharge.</td>
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<td>Upper gastrointestinal bleeding, aspiration and infective pneumonia, respiratory failure and sepsis accounting for more than 50% of readmissions in both readmitted and control groups. Recurrence of the initial problem (41%) was more common among patients admitted within 72 hours than those readmitted after 72 hours. Sepsis was a common cause of readmission both as a recurrent and new diagnosis, but was consistently more likely to lead to ICU readmission after 72 hours.</td>
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<tr>
<td>Study</td>
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<tr>
<td>Rubins and Moskowitz</td>
<td>Prospective cohort</td>
<td>300 consecutive patients admitted to a medical intensive care unit</td>
<td>Of the 229 patients at risk, 37 (16%) experienced one or more unexpected unit readmissions or death.</td>
<td>Several clinical parameters could distinguish patients at high risk for ICU readmission or unexpected death from survivors.</td>
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<td>(1988)</td>
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<td>To identify clinical</td>
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<td>These 37 patients differed with respect to age, diagnosis, and severity of illness on admission compared to the patients without such complications. In addition, these patients were sicker on initial ICU discharge.</td>
<td>The results may not be representative of other units as the study was conducted in a veteran's hospital with a nearly all-male population. The authors believe that average length of intensive care unit stay, admission illness severity, proportion of patients requiring active treatment, hospital mortality and readmission rates compared favourably with other studies and hence minimise these limitations. The usefulness of this study's findings in individual discharge decisions is uncertain.</td>
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<td>variables associated with</td>
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<td>unexpected death or unit</td>
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<td>readmission following</td>
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<td>discharge</td>
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<tr>
<td>Snow, Bergin and Horrigan (1985)</td>
<td>Retrospective review</td>
<td>Multidisciplinary surgical ICU.</td>
<td>During a 1 year period, 721 admissions reviewed including 68 readmissions for 57 patients (9% of the total). Although 53 (78%) discharges were deemed appropriate, 62% of the patients had one or more warning signs, which might have alerted physicians to change treatment. In half of these patients the reason for readmission was related to the warning sign. Readmission was related to the original disease in 65% of the incidents, while a new patient problem initiated readmission in 38%. The most common new problems were cardiopulmonary insufficiency and infection. All but one patient readmitted with pulmonary problems displayed retrospective evidence of clear warning signs before the original discharge.</td>
<td>Limitations: Retrospective review Subjective assessment of which patient would not have benefited from a prolonged stay in the surgical intensive care unit. Old study</td>
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<td>Study</td>
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<tr>
<td>Lawrence and Havill (1999)</td>
<td>Prospective audit</td>
<td>Patients who died in the ward after discharge from ICU, in a New Zealand mixed medical / surgical / adult / paediatric ICU</td>
<td>Of the 99 patients who died in the ward after discharge from ICU, 60% were considered unsalvageable by ICU staff before discharge from ICU. Of the remaining 39 patients, only 5 were in the unexpected death group and at least 2 of these were considered unavoidable because of their pathology. The other 34 patients who died were all from a major risk group, and in the opinion of the authors, likely to die within a year. Estimated that patients who died in the ward after discharge from the ICU stayed twice as long in the ICU and consumed more than twice the resources per patient than the group of survivors.</td>
<td>Treatment is withdrawn in a timely fashion and done faster than in the United States was confirmed by this audit. There were no apparent treatment deficiencies. They did however suggest that there was some evidence in some patients that avoidable events had precipitated ICU admission and may have contributed to death after discharge from ICU. There was no indication that patients had been discharged prematurely. Very few patients died unexpectedly in the wards after discharge from the intensive care unit.</td>
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<td>Study</td>
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<td>Goldfrad &amp; Rowan</td>
<td>Survey</td>
<td>10, 806 admissions to 26 ICUs in the United Kingdom using the APACHE II (Knaus, Draper, Wagner &amp; Zimmerman, 1985) study database, 1988 – 1990 and for 22, 059 admissions to 62 ICUs using data from the Intensive Care National Audit and Research Centre’s Case Mix Programmed Database, 1995 to 1998.</td>
<td>There was a 2.2 fold increase in night discharges with 44% of patients discharged at night judged by clinicians to be fully ready for discharge compared with 86% of discharges during the day. These patients fared significantly worse than those discharged during the day with potential negative physical and psychological impacts for the patient.</td>
<td>The rising proportion of night discharges reflects increasing demand on intensive care beds. The discharge of patients from our ICU is also due to pressure on beds due to impending admissions.</td>
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### Table A.18

**Discharges from the intensive care unit**

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<th>Study</th>
<th>Design</th>
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<th>Results</th>
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<tr>
<td>Groeger et al (1993)</td>
<td>Postal survey</td>
<td>4,233 hospitals who had ICUs</td>
<td>Respondents indicated that 11% of critical care patients were delayed in their discharge out of ICU after considered ready for discharge.</td>
<td>Provide an introduction into the everyday workings of critical care units throughout the United States</td>
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<td>Half of the responding units had 1 or more patients awaiting discharge out of the ICU representing 19% of patients in those units.</td>
<td>Problems associated with postal surveys threaten validity</td>
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<td>Other patients were waiting to be admitted into critical care units, approximately 4% of all unit beds.</td>
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<td>A “backlog” existed in 21% of responding units with a potential for using 17% of their beds.</td>
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<td>6 to 12% of critical care patients, depending on unit type, required a different level of care using resources that could have been more productively allocated to patients needing the level of care available in these units.</td>
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<td>6% of critical care patients, occurring in 27% of units, could have been cared for in lower technology settings but could not be transferred due to lack of available hospital beds.</td>
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<td>In 14.9% of units, 2.6% of patients could not be transferred for other reasons including lack of adequate facilities for long term ventilator patients, unwillingness of family, guardians or physicians to authorise the transfer, or medico-legal reasons</td>
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APPENDIX B

Measures of Outcomes and Severity Scores

Introduction

Assessing patient outcomes is extremely challenging. To determine whether expenditures in intensive care result in significant prolongation of life and the provision of acceptable quality of life, patients must be followed and evaluated at appropriate intervals after hospital discharge (Bashour et al., 2000). Bias may result from confounding due to the tracking of patients over a long period of time, non-obligation for patients to participate and loss to follow up (Eddleston, White & Guthrie, 2000).

Exploring the relationship between patient outcomes and the structure and function of intensive care units requires extraction of data from large databases. Databases containing data from a representative sample of intensive care units can be used to identify their organisational characteristics and by of use of risk adjustment methods, can be used to evaluate the association of these characteristics with the health outcomes of interest (Randolph, 1999). These large databases are essential because randomly assigning patients to intensive care units with different organisational structures is logistically complex (Randolph, 1999).

The concept of patient outcomes is a complex function not only of services provided and other factors such as random events, but also of the patients’ clinical attributes, including severity of illness (Apolone, 2000). Severity of illness scores are very sensitive to population casemix, methods of data collection and implementation and to other determinants related to the specific setting of utilisation. Results must be reviewed judiciously when comparing studies of intensive care unit outcomes that demonstrate much variation in casemix as these studies may not be contemporaneous or derive casemix differently (Rowan et al., 1993a). The definition of casemix is given different meanings depending on background and purpose. Clinicians may refer to
casemix as attributes including clinical complexity, severity of illness, treatment
difficulty and need for intervention (Apolone, 2000). For administrators and regulators,
casemix may refer to resource intensity demands that patients place on the institution
(Apolone, 2000).

Continually increasing costs and the technical complexity of intensive care
services have fuelled the development of instruments to measure severity of illness,
prognosis and interventions. To achieve appropriate health outcomes, objective or
subjective measures must provide information that is reliable, valid and responsive to
real changes in health (Black et al., 2001; Hall, 1996). Because of the heterogeneity of
the general intensive care unit population, it is important to use generic outcome
measures across a broad spectrum of medical and surgical patients (Black et al., 2001).
Most of the measures that have been used in intensive care units are multiple item
scales that provide a total score as well as subscales that provide information on
particular patient aspects (Black et al., 2001). Although the outcome of adults who
have received intensive care unit care is widely reported, very few studies have
attempted to assess the measurement properties of the outcome used (Black et al.,
2001). Often those that have provide insufficient information to enable critical
consideration of the methods they have used (Black et al., 2001).

Traditionally mortality rates have been used as measures of patient outcomes
(Hurel, Loirat, Saulnier, Nicolas & Brivet, 1997; Kerridge, Glasziou & Hillman, 1995).
Using other outcome comparisons between critically ill patients could help to refine
intensive care unit selection criteria and improve the precision of clinical decision
making (Zimmerman et al., 1988). With governments focusing on achieving
measurable results and meaningful outcomes from health care services (Duckett, 1995;
Hall, 1996) information on the patient’s perspective should be measured as well as
technical or objective clinical parameters such as mortality and morbidity (Griner, 1973;
Hurel, Loirat, Saulnier, Nicolas & Brivet, 1997; Teres et al., 1998).

Quality of life is thus being recognised as an important component of patient
outcome. Health is a state of physical, mental and social well being, not only the
absence of disease. It is a broad concept that takes into account different dimensions of
function of individuals, their environment, their social and economic status and their
culture (Hurel, Loirat, Saulnier, Nicolas & Brivet, 1997). The patient’s preferences should be taken into account when considering an active and aggressive therapy when the long-term results may lead to an unacceptable quality of life. Interests in patients’ perspectives in the evaluation of health care has led to the development of numerous subjective measures of functional status, quality of life and patient satisfaction of effectiveness of intensive care unit services (Elliott, 1999). They use different criteria depending on the aim of the study and the population being studied. Health related quality of life instruments should be able to measure changes over time or measure differences between people (Heyland et al., 1998). Despite their validity and widespread use, these instruments provide minimal benefit in determining intermediate and long-term functional outcomes following intensive care (Elliott, 1999). Outcome data should be used to argue for adequate intensive care bed provision (Fletcher & Flavouris, 2000).

Many studies have evaluated the functional component or the professional activity when assessing quality of life (Hurel, Loirat, Saulnier, Nicolas & Brivet, 1997). Generic health questionnaires include most of the dimensions that should be studied, validated in various populations to enable comparisons between different populations including well and ill populations (Hurel, Loirat, Saulnier, Nicolas & Brivet, 1997).

The outcome variables used frequently in intensive care units to assess the quality and performance of intensive care units include:

- Mortality rates
- Length of stay
- Morbidity rates/quality of life
- Severity of illness
- Readmission rates
- Costs


**Mortality Rates**

The most important goal of intensive care unit activity is to decrease mortality (Fery-Lemonnier, Landais, Loirat, Kleinknecht & Brivet, 1995). Hospital mortality has been considered the gold standard as an outcome measure of intensive care. It is easy to measure and represents a very relevant clinical end point (Moreno et al., 1999). Mortality rates in intensive care units vary widely among institutions but are much higher than other hospital patients and are therefore considered a sensitive, appropriate measure of outcome (Gunning & Rowan, 1999).

Whether intensive care unit structure and care processes affect these outcomes is unknown (Pronovost et al., 1999). Intensive care units do not function in isolation in the process for caring for patients with an acute critical illness and comparisons of intensive care unit mortality and length of stay are directly affected by the growing use of intermediate care units and subacute or long term ventilator facilities not necessarily linked to an intensive care unit or hospital (Teres et al., 1998). Intensive care unit mortality rates are subject to the individual discharge and triage decisions of the individual units and may not be as accurate as hospital rates (Knaus, Draper, Wagner & Zimmerman, 1986). The mortality rate of patients admitted to the intensive care unit can result from many factors other than ineffective care including casemix, input such as staff and equipment, and processes of care such as the type, skill and timing of care provided (Gunning & Rowan, 1999). Factors that are difficult to quantify such as number and duration of organ systems failing, cardiopulmonary arrest, admission type (elective or emergency), steroid therapy or other immunosuppressives, cardiovascular disease and multi-system diseases may influence mortality rates (Ridley, 1998).

Because hospital policy can and does change the location of deaths, patients being discharged from the intensive care unit to die in other locations may result in significantly underestimated mortality in the intensive care unit (Moreno et al., 1999; Ryan, 1996). The possibility of influencing the intensive care units' discharge mortality is reflected in the United Kingdom where mortality rates range from 6 to 16% (Ryan, 1996). Hospital mortality is dependent upon physiological derangement and its trend, diagnosis, previous health status, age and previous treatment (lead-time bias).
Various characteristics such as age increase the risk of death before discharge from hospital after intensive care. Before comparing outcome, it is important to account for such characteristics. Franklin et al. (1988) believe that intensive care unit mortality rates may not be a particularly sensitive indicator of the effects of intensive care unit rationing because in their study to evaluate the overall effects on the case fatality rate when an intermediate care unit was opened, ward mortality decreased appreciably when intensive care units beds became available.

The standardised mortality ratio (SMR) is a statistic that has been used to measure intensive care unit effectiveness by comparing the ratio of observed or actual deaths to the number of predicted deaths to occur over a given time period (Buist, Gould, Hagle & Webb, 2000; Gunning & Rowan, 1999). The number of predicted deaths is determined by the use of severity scoring systems that have been validated using large groups of critically ill patients to estimate mortality rates. The use of standardised mortality ratio as a measure of intensive care unit performance has been questioned by some authors (Boyd & Grounds, 1993; Boyd & Grounds, 1994; Grounds & Boyd, 1997; Sherck & Shatney, 1996). Units that are performing badly or well may have the same standardised mortality ratio. A study conducted in an Australian level 3 intensive care unit to identify factors that were associated with the low mortality prediction (< 0.5) in hospital deaths was conducted using a retrospective case note audit (Buist, Gould, Hagle & Webb, 2000). The authors found there were other factors other than APACHE II score that may have contributed to intensive care unit patient outcome. These included pre-intensive care management and events occurring during the intensive care unit stay. Amongst low mortality prediction patients admitted to the intensive care unit age, a history of acute myocardial infarction, presentation to the intensive care unit after a cardiac arrest or patients with elevated creatinine levels and the development of acute renal failure and septicaemia during the intensive care unit admission were identified as being associated with hospital mortality. Hospital deaths on the wards also occurred more frequently with low predicted hospital mortality intensive care unit patients.

High post-intensive care unit mortality rates have been reported from studies in several different countries (table B1).
Table B1

<table>
<thead>
<tr>
<th>Study</th>
<th>Percentage</th>
<th>Country</th>
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<tbody>
<tr>
<td>Bastos, Knaus, Sun, Wagner (1996)</td>
<td>15%</td>
<td>Brazil</td>
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<tr>
<td>Goldhill &amp; Sumner (1998)</td>
<td>27%</td>
<td>United Kingdom</td>
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<td>Moreno &amp; Morais (1997b)</td>
<td>23%</td>
<td>Portugal</td>
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<tr>
<td>Rowan et al. (1993a)</td>
<td>35%</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>Rubins &amp; Moskowitz (1988)</td>
<td>22%</td>
<td>United States</td>
</tr>
<tr>
<td>Smith et al. (1999)</td>
<td>25%</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>Wallis, Davies &amp; Shearer (1997)</td>
<td>31%</td>
<td>Scotland</td>
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Smith et al (1999) found that patients with high Therapeutic Intervention Scoring System scores on discharge from the intensive care unit were associated with an increased risk of post intensive care in-hospital mortality. Mortality rates varied from 7.3% in patients with a pre-discharge Therapeutic Intervention Scoring System score of less than 10, to 21.4% in patients with a pre-discharge Therapeutic Intervention Scoring System score greater than 19.

**Length of Stay**

Intensive care unit length of stay is influenced by illness severity. Mortality is a reasonably unambiguous quantifiable outcome. There is no standardised or uniform method of determining length of stay. Significant differences may exist because the methods used to calculate and compare intensive care unit length of stay, therefore studies should identify the method used to determine length of stay (Marik & Hedman, 2000). Attempts have been made to correct length of stay according to disease severity.

**Morbidity**

Analysis of quality of life receives less attention than analysis of mortality rate.

Morbidity is a more relevant outcome than mortality in many cases (Antonelli et al., 1999). Morbidity, both physical and psychological, is relevant as an outcome measure as it potentially affects a patient’s quality of life with intensive care unit patients often complaining of altered sensation, prolonged weakness, fatigue, poor concentration, sleep pattern disturbances and significant hair loss following hospital discharge (Eddleston, White & Guthrie, 2000). Psychological effects may manifest themselves after discharge or several months later (Fernandez & Eddleston, 1996). Pre-existing factors may determine subsequent events once a patient is discharged from hospital. Measuring morbidity rather than mortality, the impact of intensive care unit care on the quality of life, intensive care unit length of stay and costs may be evaluated (Antonelli et al., 1999).

As intensive care unit patients are a heterogenous population, demonstrating that a new intervention significantly impacts on mortality may be difficult whereas individual organ function may benefit (Vincent et al., 1998). Measuring morbidity may assist in identification of different organ dysfunction disease patterns providing a better understanding of the processes involved (Vincent et al., 1998). Organ failure may prolong a patient’s stay in the intensive care unit, utilising increased resources hence morbidity is an important measure of outcome.

Eddleston, White and Guthrie (2000) prospectively assessed survival, morbidity (physical and psychological), quality of life, and employment status of a cohort of intensive care survivors up to 12 months after discharge from an university adult intensive care unit. At 3 months, 80% of all patients interviewed were satisfied with their quality of life. Three months after discharge, there was a low incidence of intensive care unit-related psychological or psychiatric illness distress as measured by the Hospital Anxiety and Depression scale score. There were high levels of fatigue, poor concentration, and sleep disturbance; the latter was more marked in women (p = .022). Improvement in all 3 symptoms occurred during the next 9 months. The authors concluded that assessment of outcome after intensive care unit stay must include quality of life measurements.
Differing perceptions of quality of life must be taken into account when assessing this outcome. The individuals and society's view of quality of life do not always correspond. Older patients are often more accepting of physical limitation and enjoy lifestyles that do not suffer greatly from the stigma of illness (Sage, Rosenthal & Silverman, 1986).

**Survival**

Data on long-term survival of patients admitted to intensive care unit and factors influencing their survival are needed in the development of admission to intensive care unit guidelines.

Survival is often a measure of outcome but any cohort of intensive care unit patients has a cumulative mortality with time. Age, diagnosis, chronic illness and socioeconomic factors may play a part in this complex issue (Eddleston, White & Guthrie, 2000). The time for survival curves to return to normal is unclear and limit the importance of survival data as a measure of outcome where patients, clinicians and politicians are concerned (Eddleston, White & Guthrie, 2000).

Ridley, Jackson, Findlay and Wallace (1990) examined the long-term survival of critically ill patients admitted to an intensive care unit to ascertain the effects of age, severity of illness and diagnostic category at admission on survival. Their retrospective observational study with prospectively gathered data on all patients admitted to the intensive care unit investigated 513 critically ill adult patients. Twenty-four percent died in the intensive care unit and 24% after discharge. They found that long term survival of intensive care unit patients was related to severity of illness and age. The outcome in the critically ill elderly was poor. The general medical condition of the patient probably influenced survival rates after intensive care. The authors concluded that long-term outcomes could be altered by careful selection of patients with acute reversible conditions. Differences in reported survival rates between countries may be due to differing practices in patient selection.
Scoring Systems

Introduction

Governments and society are increasingly asking questions concerning intensive care unit cost versus benefit (Hall, 1996; Oye & Bellamy, 1991). To help answer them, intensive care unit scoring systems have been developed. These models are based on rigorous research, however, they still need further refinement, with extended and improved measurement of outcomes and accurately costed intensive care facilities (Buist, 1994). Scoring systems are simple and have achieved face validity. It is easy to collect patient data at one place and time, namely intensive care unit admission, and obtain end point of vital status at hospital discharge (Teres et al., 1998, p. 196).

The wide range of severity illness scores has been developed for all ages, from infants to adults and all types of illness including sepsis and trauma. They are not only limited to the intensive care unit, for example, there is severity of illness scoring systems for surgical patients. Severity of illness measures for patients in the intensive care unit measure the degree of illness and reflect the complexity of the disease process (Ridley, 1998). They are aimed at quantifying casemix and using the resultant score to estimate outcome. “Severity of illness scores stratify critically ill patients, provide meaningful information in many clinical contexts and collate clinical practice” (Ridley, 1998, p. 1185). Most intensive care unit scoring systems relate some form of patient admission baseline data to derive a probability of survival at hospital discharge without accounting for the true personal and social impact of the disease (Buist, 1994).

Several types of scoring systems exist. They may be specific, used for certain types of patients or generic, used to assess all, or nearly all, types of patient (Gunning & Rowan, 1999). The scoring system may be anatomical, which provide fixed scores on the extent of injury or physiological, which assess the extent of injury on function and may change as the physiological response to disease or injury varies (Gunning & Rowan, 1999). It is necessary that the scoring measures assess the severity of patients at the moment of admission to the intensive care unit before any treatment is given. If
response to treatment is crucial for prognosis, it will be necessary to update the severity measure (Rué, Salvador Quintana, Álvarez, & Artigas, 2001).

Scoring systems may be used to stratify patients for randomised clinical trials (Gunning & Rowan, 1999; Lemeshow, Klar & Teres, 1995). Although randomised clinical trials are considered the gold standard in research, the benefit of intensive care units has not been studied by randomised clinical trials, as randomisation of care for the critically ill has been thought to be ethically unacceptable. Instead, outcome studies have been performed that pose fewer ethical dilemmas than randomised clinical trials. However, patients, casemix and severity of illness must be comparable when evaluating the results of these outcome studies. Scoring systems can be used for this purpose (Schafer et al., 1990).

Scoring systems may also be used for quality assessment of intensive care unit performance, for hospital reimbursement and for discussion on prognosis (Lemeshow, Klar & Teres, 1995). A more homogenous subset of patients may result if stratification is based on an accurate, objective estimate of the probability of death before hospital discharge.

Prediction of patient outcomes in critical care often relies increasingly on objective data rather than just clinical impression. Severity adjustment models such as Acute Physiology and Chronic Health Evaluation (APACHE) (Knaus, Draper, Wagner & Zimmerman, 1985), the Mortality Probability Model (MPM) (Lemeshow et al., 1993) and the Simplified Acute Physiology Score (SAPS) (Le Gall, Lemeshow & Saulnier, 1993) are widely accepted as good predictors for evaluating intensive care unit outcome and helpful to support physician judgement (Higgins, 2001). However, use of probabilities from these predictive models as binary predictors based on a cut point can be misleading for making treatment decisions for individual patients, even when model performance is good overall (Lemeshow, Klar & Teres, 1995).

Scoring systems have been criticised for having a number of limitations (Antonelli et al., 1999). They were developed for comparing health care quality between different intensive care units (Antonelli et al., 1999). However, treatment regimes can influence these scoring systems. There have been no studies to date clearly
demonstrating that severity of illness scores are invariant to the setting of applications (Apolone, 2000). Factors impacting on the performance of severity of illness scoring systems include inaccuracy in definition and data collection (Fery-Lemonnier, Landais, Loirat, Kleinknecht & Brivet, 1995), unmeasured clinical organisation and management factors (Apolone et al., 1996; Beck, Taylor, Millar & Smith, 1997; Moreno & Morais, 1997a; Moreno, Apolone & Reis Miranda, 1998; Nouira, et al., 1998) or unmeasured non-clinical organisation and management factors (Moreno, Reis Miranda, Fidler & Van Schilfgaarde, 1998).

Scoring systems may be considered valid when comparing outcomes in large numbers of unselected intensive care unit patients but can be inaccurate when applied to sub-populations (Murphy-Filkins, Teres, Lemeshow & Hosmer, 1996; Sherck & Shatney, 1996). They cannot predict outcome for individual patients as the models have been developed from large and heterogenous databases with the probability being based on an “average “ patient (Barie, Hydo, & Fischer, 1996; Bion, 1995; Le Gall, Lemeshow & Saulnier, 1993; Lemeshow, Klar & Teres, 1995; Schafer et al., 1990; Sherck & Shatney, 1996; Teres & Lemeshow, 1994). Some of the components for some of the scoring systems are not readily available. A degree of variability is inherent in scoring systems (Polderman, Christiaans, Wester, Spijkstra & Girbes, 2001). These authors found inter-observer variability of APACHE II scoring was 15% even after strict guidelines and a rigorous training program. Definition, translation and conversion ambiguities are all potential sources of inter-observer variability when using these systems (Fery-Lemonnier, Landais, Loirat, Kleinknecht & Brivet, 1995).

Debate still goes on as to whether intensive care unit resources should be utilised for patients who are unlikely to survive (Charlson & Sax, 1988). The development of scoring systems such as APACHE II and APACHE III to predict patient mortality have been suggested to rationalise the decision making process in determining which patients are unlikely to survive and not benefit from the high cost of intensive care (Charlson & Sax, 1988). Users of probability models, however, should be aware of what probability means, its strengths and limitations. Statistical validity for a scoring system does not mean it can predict the outcome of an individual patient. If 90% of patients are predicted to survive, the scoring system cannot predict the 10% who will not survive (Sherck & Shatney, 1996). The limitations are too great to make
significant clinical decisions for individual patients that would result in the denial or withdrawal of care (Lemeshow, Klar & Teres, 1995).

Carson and Bach (2001) evaluated the ability of four severity-of-illness indexes (the acute physiology and chronic health evaluation II, the simplified acute physiology score II, the mortality prediction model II, and the logistic organ dysfunction system) to predict mortality rates in 182 patients with prolonged critical illness in a long-term acute care facility. None of these indexes distinguished well between the patients who lived and the patients who died. Investigators and clinicians should use caution in using severity-of-illness measures developed for acutely ill patients to describe critically ill patients admitted to long-term care units (Carson & Bach, 2001). Because scoring systems predict outcome based on a limited number of independent variables, clinicians with knowledge of patient factors not included in predictive models may be better predictors for patients at the extremes (Higgins, 2001). Scoring systems fail to predict functional status or quality of life after critical illness (Ridley, 1998).

Physiological scoring systems have been used to predict outcomes for patients in the intensive care unit, but other factors may be important. Lead-time bias occurs when patients are partially treated before intensive care unit admission (Nouira et al., 1998). Substantial differences in utilisation were found by Dragsted et al. (1989) when comparing outcome and utilisation in two Danish intensive care units. Although the measured severity of illness was similar, patients at one of the hospitals received significantly more therapy and had a higher mortality than the other hospital. The authors believe that because 35% of these patients had been transferred to the intensive care unit from other intensive care units, it created the possibility of an adverse selection and lead-time bias for these patients (Dragsted et al., 1989). Patients transferred from another hospital or the general ward are less likely to respond to treatment compared to patients admitted directly from the emergency department (Rosenberg, Hofer, Hayward, Strachan & Watts, 1999). The standardisation of timing of initial assessment is important to minimise lead-time bias (Beck, Taylor, Millar & Smith, 1997).

The scoring system selected depends on the proposed use. The main criteria for selection should be accuracy (calibration and discrimination) reliability, validity and
methodological vigour. The complementary measures of calibration and discrimination provide different and useful information about a model's performance and both should be used routinely when evaluating models (Lemeshow & Le Gall, 1994). Discrimination is how well the scoring system model discriminates between an individual who has the outcome and one who does not. The discriminatory performance of statistical models work well in the middle ranges of mortality risk but clinicians are superior to prediction models at the extreme ends of a risk scale (Ridley, 1998). It is usually measured by the area under the receiver operator characteristic curve, and ranges from 0.0 to 1.0. Calibration is the accuracy of measurement for every interval of measurement by the severity scoring system. It refers to the correlation between predicted and actual outcomes. It is often tested using Hosmer and Lemeshow's goodness of fit statistic that compares observed with expected numbers of events within each decile of probability through the use of a chi-square-like statistic (Gunning & Rowan, 1999; Ridley, 1998; Teres & Lemeshow, 1998). A p-value greater than 0.05 indicates satisfactory fit. Poor calibration may mean that the care provided is above or below average or there is an unusual casemix, different from the population on which the model was developed (Le Gall, Lemeshow & Saulnier, 1993). Calibration and discrimination are now standard practice in the evaluation of a model (Moreno, Apolone & Reis Miranda, 1998).

Independent validation is needed in different populations before the general utilisation of these scoring systems. Variations may be due to casemix, local policies, quality of care, and quality of data collection that affect the performance of the equations used to predict mortality (Buist, Gould, Hagley & Webb, 2000; Moreno, Reis Miranda, Fidler & Van Schilfgaarde, 1998). APACHE, SAPS and MPM models have been extensively tested and validated for mortality prediction in intensive care unit patients (Knaus, Draper, Wagner & Zimmerman, 1985; Knaus et al., 1991; Le Gall, Lemeshow & Saulnier, 1993; Lemeshow & Le Gall, 1994). Although new versions of the severity systems are superior to the older versions, they may not be robust in intensive care unit patients in different medical and social environments (Nouira et al., 1998). Predictive models reflect the population characteristics and the medical culture of the country in which they were developed and may not be transferable to other health care systems (Beck, Taylor, Millar & Smith, 1997).
Scoring systems measure severity of illness whereas dynamic scoring systems provide prognostic guidance. There is a close relationship between these two concepts but they differ in the structuring and understanding of the same information. Severity of illness scoring systems are mathematical tools based on physiological variables to obtain a single value on a continuous scale that may not necessarily be linear. These systems stratify patients, allow comparison between patients, identify therapeutic need or outcome and form the basis for prognostic indices (Ridley, 1998). Prognostic systems are statistical models to predict hospital mortality of intensive care unit patients. They are largely derived from heterogenous intensive care databases. Transforming severity of illness scores by well-recognised mathematical rules produces prognostic indices. They have limitations in accuracy because of the statistical nature of their deviation and the heterogeneity of the reference populations (American Thoracic Society, 1997). A predictive system should be able to discriminate between patients who do not need intensive care unit care and those who will die despite the use of expensive resources but no matter how accurate the scoring system, they cannot predict outcome sufficiently accurately to affect the patient's management (Sherck & Shatney, 1996).

Although they have been extensively tested and validated for mortality-prediction of intensive care unit patients, predictive models should not be used for rationing in the intensive care unit (Le Gall & Lemeshow, 1991; Miller, 1994; Rodriguez, Wang & Pearl, 1997; Teres & Lemeshow, 1994). Severity of scoring is based on estimation of mortality, but measures of morbidity may be more appropriate in some cases (Antonelli et al., 1999). Only the SUPPORT (Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments) model addresses the end point of functional outcome (Rodriguez, Wang & Pearl, 1997; Wu et al., 1995).

Agreement between systems is not universal. When SAPS II was compared to MPM II 24 or APACHE II, it provided consistently superior estimates in calculating high probabilities for patients who died and low probabilities for patients who lived (Lemeshow, Klar & Teres, 1995).

The Simplified Acute Physiology Score (SAPS) II (Le Gall, Lemeshow & Saulnier, 1993) performed better than the Acute Physiology and Chronic
Health Evaluation (APACHE) II (Knaus, Draper, Wagner & Zimmerman, 1985) in a prospective Portuguese study, but the results demonstrated that it must be customised to analyse quality of care or performance data in the target population’s intensive care units (Moreno & Morais, 1997a). Five published studies (Apolone et al., 1996; Bastos et al., 1996; Beck, Taylor, Millar & Smith, 1997; Moreno, Reis Miranda & Fidler, 1998; Nouira et al, 1998) detail information on adult general severity models, using area under the receiver operator characteristic curve, as well as the goodness-of-fit test, using the Hosmer-Lemeshow technique. These studies are on new patients in different hospitals across international borders at a later time period giving a measure of external validity or transportability of the models. These studies show the same pattern-discrimination is good while calibration is poor (Teres & Lemeshow, 1998).

Severity of illness scores include The Acute Physiology and Chronic Health Evaluation (APACHE) I and II, Mortality Probability Model (MPM) and Simplified Acute Physiology Score (SAPS). Examples of commonly used dynamic scoring systems are the APACHE III, Mortality Probability Model II at forty-eight and seventy-two hours.

**The Acute Physiology and Chronic Health Evaluation (APACHE) Score**

The Acute Physiology and Chronic Health Evaluation (APACHE), developed by Knaus, Zimmerman, Wagner, Draper and Lawrence (1981) in the mid 1970's included the acute physiology score, chronic health class and patient age. It was designed to provide indices that were reliable and physiology based to predict hospital mortality from measurements recorded from critically ill adults. Initially it was a complex scoring system using 34 variables selected by a small group of clinicians that were thought to have some effect on outcome. The worst value for these variables recorded during the first 32 hours had their weights summed (the degree of abnormality ranging from 0 to 4 points) to form the Acute Physiology Score (Moreno & Morais, 1997a). These were reduced to 12 variables, published in 1985 (Knaus, Draper, Wagner & Zimmerman, 1985). The modified acute physiology score measures the worst value of 12 essential
physiological variables during the first 24 hours of critically ill adults in the intensive care unit (weighted from 0 to 4 points), the abbreviated chronic health class that reflects longstanding disability of body systems and age. They are combined to form the Acute Physiology and Chronic Health Evaluation (APACHE) II score (Knaus, Draper, Wagner & Zimmerman, 1985) which is a prospective measure that has predictive value for long term survival and quality of life, hospital care and discharge from hospital alive (Sage, Rosenthal & Silverman, 1986). This system soon became the most popular scoring system world wide in administration, planning, quality assurance, in comparing intensive care units and assessment of comparability in clinical trials (Moreno & Morais, 1997a). APACHE II (Knaus, Draper, Wagner & Zimmerman, 1985) scores and Simplified Acute Physiology Score (SAPS) (Le Gall, et al., 1984) estimate hospital mortality for groups of patients but are not sufficiently accurate to predict individual patient outcomes and have not been validated for use before admission (Carson & Bach, 2001).

APACHE II has been validated in the postoperative surgical population as a measure of patient acuity and patients have been compared from within a single unit and between units (Barie, Hydo & Fischer, 1996; Carson et al., 1996; Knaus, Draper & Wagner, 1986; Wong, Gomez, McGuire & Kavanagh, 1999).

In the United Kingdom, it has been found to be a reliable predictor of likely benefit, enabling comparisons of intensive care performance whilst minimising the effect of practice variations (Rowan et al., 1993b). Comparisons of patients refused admission to the intensive care unit to those admitted cannot be made readily since admission to the intensive care unit is required to obtain these scores (Metcalf, Sloggett & McPherson, 1997).

The usefulness of APACHE II in the surgical intensive care unit patient has been debated. Osler et al. (1998) believe that a risk stratification tool based on the International Classification of Diseases (9th revision) called ICISS is more accurate and much less expensive to calculate than the APACHE II score. Their study of 5,322 non-cardiac patients admitted to the surgical intensive care unit
compared both systems to predict outcomes (survival / non-survival, length of stay and charges). The authors assert that the ICISS should replace APACHE II in surgical intensive care units (Osler et al., 1998). The ability of APACHE II to predict outcome in intensive care unit trauma patients has also been questioned (McAnena et al., 1992; Vassar, Wilkerson, Duran, Perry & Holcroft, 1992). APACHE II may be useful in defining severity of disease in patients with acute-on-chronic medical conditions, but the system does not have an anatomical component, which is essential to assess the magnitude of acute trauma patients who are typically otherwise healthy (McAnena et al., 1992). The APACHE system significantly overestimated the risk of death in the lower ranges of predicted risk and underestimated the deaths in the higher ranges in a study of trauma patients in the intensive care unit (Vassar, Wilkerson, Duran, Perry & Holcroft, 1992). Although TRISS was not developed for intensive care unit trauma patients, the authors found that it tended to perform better than APACHE II in their sample.

The APACHE III (Knaus et al., 1991) system attempted to improve the precision of previous severity of illness scoring systems. It was developed from the APACHE I and II scoring systems to provide a severity of illness score by the application of multivariate logistic regression analysis. The multivariate logistic regression analysis explores the relationship between mortality rate and the weights of 17 physiological variables and a chronic health evaluation that includes immune status, age and disease category (Glance, Osler & Shinozaki, 1998). It was prospectively evaluated in 17, 440 patients admitted to 40 United States hospitals between 1988 and 1989 (Knaus et al., 1991). It provides an equation combining severity of illness score, a diagnosis selected from 78 diagnoses, and patient source prior to admission to the intensive care unit for the outcome prediction (Ridley, 1998). The probability of death before discharge from hospital may be estimated using APACHE III. The probability of death for each patient admitted to the intensive care unit are added together to calculate the expected mortality rate for the whole group. Because it is not in the public domain, its use has been limited (Moreno & Morais, 1997a).

To assess the accuracy and validity of Acute Physiology and Chronic
Health Evaluation (APACHE) III hospital mortality predictions, an independent consecutive sample of 37,668 U.S. intensive care unit admissions was assessed (Zimmerman et al., 1998). The authors claimed that the APACHE III accurately predicted aggregate hospital mortality. Further improvements in calibration could be achieved by more precise disease labelling, improved acquisition and weighting of neurological abnormalities, adjustments that reflect changes in treatment outcomes over time, and a larger national database (Zimmerman et al., 1998, 1317).

APACHE II has not been used at the time of discharge, but APACHE III is able to predict outcome on successive intensive care unit days and incorporates some of the same variables as APACHE II (Knaus et al., 1991).

Like other external validation studies of general intensive care unit scoring systems, APACHE III has shown good ability to assign higher probability of mortality to patients who die, but poor correspondence between the estimated probability and the actual mortality indicating poor fit (Bastos et al., 1996; Beck, Taylor, Millar & Smith, 1997; Nouira et al., 1998; Wood, Coursin & Grounds, 1999). The APACHE III risk predictions, consistently lower than the actual mortality, was found in virtually all risk groups and was particularly noteworthy in those patients in the low risk groups (Wood, Coursin & Grounds, 1999).

Pappachan, Millar, Bennett and Smith (1999) performed a validation study of APACHE III (acute physiology and chronic health evaluation) in 17 general adult intensive care units in the south of England (hospital size range 300 to 800 beds). They used a prospective, non-interventional, cohort design. From the 12,793 patients studied, the authors found significant excess in mortality after case-mix adjustment using the APACHE III system. There were significant differences in the casemix of patients in their study compared with those in United States APACHE III database. The authors believed that this was almost certainly due to a failure of the APACHE III equation to fit the United Kingdom data.
There was a significantly high standard mortality ratio (observed/predicted mortality ratio) in the United Kingdom hospitals. This may have been the result of either poor intensive care performance as compared with the United States or a failure of the APACHE III equation to fit the United Kingdom data (Pappachan, Millar, Bennett and Smith, 1999). Differences and perceived shortcomings in Pappachan, Millar, Bennett and Smith's (1999) system may have resulted from:

- less resource allocation;
- previous failure to recognise critical care as a specialty;
- fewer intensive care unit directors and dedicated training programs;
- the logistics of refusal/denial of admissions to the intensive care unit;
- early intensive care unit discharge with increased readmission rates; and
- the high requirements for interhospital transfer of critically ill patients, 7.7% in the United Kingdom compared to 2.3% in the United States (Wood, Coursin & Grounds, 1999).

All the above factors have influenced intensive care resources in the United Kingdom in recent times. However, international comparisons of intensive care unit data are fraught with difficulties (Angus, Sirio, Clermont & Bion, 1997). Alternatively, APACHE III may be unstable or inaccurate when applied cross-culturally (Teres & Lemeshow, 1994).

APACHE III has selection bias and case mix variability, lead time bias, and methodological problems which potentially render it unreliable for APACHE III performance comparison (Boyd & Grounds, 1993; Boyd & Grounds, 1994; Cowen & Kelly, 1994; Teres & Lemeshow, 1994). The potential differences in the original database and the population in question may lead to selection bias and case mix variability. APACHE II did not allow for accurate predictions in specific disease groups (Boyd & Grounds, 1993; Brown & Crede, 1995; McAnena et al, 1992) hence the development of APACHE III. However, it cannot predict mortality within a specific disease group (Wood, Coursin &
Grounds, 1999). Multiple disease groups (424) are re-grouped into seventy-eight disease categories for which predictive equations exist. Severity, not outcome, can be measured among patients within the same disease group (Wood, Coursin & Grounds, 1999).

APACHE III is used with very different population groups when comparing the United States and United Kingdom data sets. In the United States, the APACHE III data was validated using 17,440 patients from 40 hospitals, including 14 tertiary care centres, and 26 had medical school affiliations (Wood, Coursin & Grounds, 1999). In the United Kingdom, 12,793 patients were evaluated, 94% from district general hospitals and only 6% were from one teaching centre, the size of which was not reported. The case mix was also significantly different: older men; greater comorbidity; increased incidence of ward to intensive care unit transfer; fewer patients directly admitted from the emergency department; and more emergency surgical patients (Pappachan, Millar, Bennett & Smith, 1999).

One of the main disadvantages of APACHE II (Knaus, Draper, Wagner & Zimmerman, 1985) is its failure to compensate for lead-time bias. Lead-time bias and pre-intensive care unit treatment bias, can significantly contribute to the underestimation of mortality, evident in APACHE II (Dragsted et al., 1989; Escarce & Kelly, 1990; Goldhill & Withington, 1996; Rapoport et al., 1990). APACHE III allegedly corrects for this shortcoming by accounting for the patients' pre-intensive care unit location, although the actual statistical weight remains unpublished and unknown (Wood, Coursin & Grounds, 1999).

Errors in diagnostic labelling and data collection remain problematic with APACHE III (Knaus et al., 1991) which requires a single diagnosis in each patient (424 diseases placed in 78 disease categories). Disease labelling may be different in the United Kingdom significantly impacting upon the mortality prediction (Wood, Coursin & Grounds, 1999).

Any predictive system requires accurate and reliable data collection. The high degree of interobserver reliability by utilising trained and dedicated data
collectors in the development of APACHE II is difficult to replicate in this era of cost containment (Wood, Coursin & Grounds, 1999). The APACHE III system provides daily prognostic estimates during the first seven days in the intensive care unit. As APACHE III retains this essential data collection plus 5 new physiological variables, the error may possibly be further magnified, particularly, in this study where no attempts to correct "illogical, extreme or unlikely values" were performed.

Applications of the APACHE database developed in the United States have shown reasonable correlation to international populations (Castella, Artigas, Bion & Kari, 1995; Knaus et al, 1982; Wong et al., 1995; Zimmerman et al., 1988). An increased standardised mortality ratio in Brazil and Tunisia was ascribed to lack of technology and senior physicians and nurses, respectively (Bastos, Knaus & Zimmerman; 1996; Nouira et al., 1998). Results from the United Kingdom have been mixed. (Beck, Taylor, Millar, & Smith, 1997; Goldhill & Withington, 1996; Rowan et al., 1994). Further studies are required to identify if factors within the United Kingdom’s health care system corrupt the validity of APACHE to this population.

The Mortality Probability Models (MPM)

The Mortality Probability Models (MPM) II system includes models to measure severity at admission, and at 24, 48 and 72 hours after admission (Lemeshow et al., 1993). It was based on the SAPS II database collected from 6 intensive care units in 4 United States teaching hospitals (Moreno, Reis Miranda, Fidler & Van Schilfgaarde, 1998). The Mortality Probability Model has its basis in multiple logistic regression techniques but uses nominal data and generates a probability of death directly and not a score which then requires conversion (Ridley, 1998).

Rué, Salvador Quintana, Álvarez, and Artigas (2001) used a prospective inception cohort design to refine the prognosis of critically ill patients using a statistical model that incorporates the daily probabilities of hospital mortality.
during the first week of stay in the intensive care unit. Fifteen adult medical and surgical intensive care units in Spain comprising a total of 1,441 patients aged 18 years or more had prospective data collection during the stay of the patient in the intensive care unit. Data collected included vital status at hospital discharge as well as all variables necessary for computing the Mortality Probability Models II system at admission and during the first 7 days of stay in the intensive care unit. During the first week in the intensive care unit, most patients are discharged and the overall hospital mortality rate and the mean of the Mortality Probability Model II system models increases progressively over the initial seven days in the intensive care unit. During this initial week in the intensive care unit, the most important predictor of hospital mortality is severity on the current day. The Mortality Probability Model II system models slightly overestimated mortality in the study group of patients. The authors concluded that to have an accurate measurement of the prognosis, it is necessary to update the severity measure. The best estimate of hospital mortality was the probability of death on the current day. Severity on admission and on previous days did not improve the assessment of prognosis. Severity scores were not accurate enough to predict individual patient outcome if the scores were measured at a single point in time or if they were measured daily.

The Mortality Probability Model is the only score that can be used for intensive care unit triage as it is calculated at admission and is treatment independent (Ridley, 1998).

It has been argued that in the Australian context, the mortality prediction model is superior to the APACHE model with substantial theoretical, practical and financial advantages for adult patients being care for in the intensive care unit (Shann, 1999).

Mortality Probability Model II coefficients were developed for patients staying in the intensive care unit forty eight and seventy two hours by adjusting the constants, not the existing coefficients, for the variables that are used for the twenty-four hour score. This supports the notion that patients not improving are actually deteriorating with poorer chance of survival.
Simplified Acute Physiology Score (SAPS)

A simpler version of APACHE I, known as the Simplified Acute Physiology Score, widely used in Europe, was published by Le Gall et al. in 1984 (Moreno & Morais, 1997a). The Simplified Acute Physiology Score (SAPS I) was based on 13 routinely collected variables, age and the use of mechanical ventilation (Le Gall et al., 1984). It aimed to simplify severity of illness scoring and to improve interobserver reliability. Mechanical ventilation and urine output may be dependent on treatment and therefore their use weaken the score (Ridley, 1998).

The Simplified Acute Physiology Score (SAPS II) was developed and validated in a cohort of 12,997 patients from 110 European and 27 North American hospitals (Moreno, Reis Miranda, Fidler & Van Schilfgaarde, 1998). It used multiple regression techniques consisting of 17 variables including 12 physiological variables, age, type of admission and 3 chronic disease variables which reflect immunocompromised patients but does not include a coefficient for admitting diagnosis. Although it was designed as a pure physiological-based system, by including 3 underlying chronic conditions, calibration and discrimination were considerably improved (Le Gall, Lemeshow & Saulnier, 1993). The worst values for all variables are collected during the first 24 hours after admission to the intensive care unit, weights are summed to produce the Simplified Acute Physiology Score (SAPS II). It requires conversion to generate a mortality probability (Ridley, 1998). Collecting the data is quick and simple with the variables readily available and no special blood samples required.

The discriminative power of Simplified Acute Physiology Score (SAPS) decreases over time with the power of discrimination being acceptable in patients who stay in the intensive care unit five days or less. Clinical and non-clinical aspects during the patient’s stay in the intensive care unit represent a complex variable that influences performance negatively over time.
Schafer et al. (1990) prospectively acquired data in 941 patients staying greater than twenty-four hours in a medical intensive care unit to determine the relevance of scoring on intensive care unit admission by the following methods of outcome prediction: Acute Physiology and Chronic Health Evaluation (APACHE II), Simplified Acute Physiology Score (SAPS), and Mortality Prediction Model (MPM). The authors concluded that the estimation of risk on admission by the three methods investigated might be helpful for global comparisons of intensive care unit populations, although the lack of disease specificity reduces their applicability for severity grading of a given illness. The authors assert that the inaccuracy of these methods makes them ineffective for predicting individual outcome; thus, they provide little advantage in clinical decision-making. They have an advantage over Therapeutic Intervention Scoring System, as they are measurable data reflecting pathophysiological aberrations. The Therapeutic Intervention Scoring System is useful to quantify interventional expenditure.

Moreno, Reis Miranda, Fidler and Van Schilfgaarde (1998) evaluated the performance of the Simplified Acute Physiology Score (SAPS II) and the admission Mortality Probability Model (MPM0) in a large independent data base from 89 intensive care units from 13 European areas. They found that these models did not accurately predict mortality and concluded that results of studies using these general outcome prediction models must be interpreted with care if not validated in the target population.

Apolone et al. (1996) assessed the validity of Simplified Acute Physiology Score (SAPS II) in a cohort of 2202 consecutive patients admitted to 99 Italian intensive care units (ICU). The authors observed that the Simplified Acute Physiology Score (SAPS) II maintained its validity only after appropriate adaptation (first-level customisation). This may have been due to differences in unmeasured case-mix, methods of application, or quality of care delivered (Apolone et al., 1996). However, these findings suggest like other studies that caution is needed before implementing the standard Simplified Acute Physiology Score (SAPS) II scoring system parameters outside formal research projects (Apolone et al., 1996).
Sequential Organ Failure Assessment (SOFA)

The Sequential Organ Failure Assessment (SOFA) measures morbidity because morbidity may be a more suitable indicator of intensive care unit efficiency and can be used to calculate intensive care unit resource utilisation. Prognostic scoring systems do not predict the patients with intermediate scores who will survive and those who will not despite this patient group often having a prolonged and costly stay in the intensive care unit (Vincent et al., 1998).

The Sequential Organ Failure Assessment (SOFA) was developed as a descriptive score for organ failure through a consensus process by a group of clinicians in December 1994 (Vincent et al., 1996). Organ failure is a continuum of alterations, a dynamic process and the degree of dysfunction varies with time (Vincent et al., 1998). It was developed to find a simple, objective method to describe individual organ failure in a form that ranged from mild dysfunction / failure through to severe failure and that would evolve during a patient’s critical illness (Moreno et al., 1999). As therapeutic interventions vary between different hospitals and within the same facility, using them in scoring systems limits the validity of such scores. Parameters that are readily available in the critically ill population should be used in a scoring system (Vincent et al., 1998). The Sequential Organ Failure Assessment (SOFA) was validated in a large population of 1449 critically ill patients. It is composed of scores from 6 organs systems, respiratory, cardiovascular, hepatic, coagulation, neurological and renal, and graded from 0 to 4 depending to the degree of dysfunction / failure. The score distinguishes between dysfunction / failure on admission, that which develops during intensive care unit stay and the total insult that the patient suffered (Moreno et al., 1999).

Antonelli et al. (1999) assessed the ability of the Sequential Organ Failure Assessment (SOFA) score to describe the evolution of organ dysfunction / failure over time in trauma patients in 40 intensive care units in 16 countries. The authors concluded that the Sequential Organ Failure Assessment (SOFA) score reliably describes organ dysfunction / failure in this population of trauma
patients. They believe that regular and repeated scoring may be helpful for identifying categories of patients at major risk of prolonged intensive care unit stay or death (Antonelli et al., 1999).

Moreno et al., (1999) prospectively evaluated the performance of total maximum sequential organ failure assessment (SOFA) score and a derived measure, delta SOFA (total maximum SOFA score minus admission total SOFA) as a descriptor of multiple organ dysfunction/failure in 40 intensive care units from Australia, Europe, North and South America. The total maximum sequential organ failure assessment (SOFA) score and a derived measure, delta SOFA (total maximum SOFA score minus admission total SOFA) the authors assert can be used to quantify the degree of dysfunction/failure already present on admission to the intensive care unit, the degree of dysfunction/failure that appears during the patient’s stay in the intensive care unit and the cumulative insult suffered by the patient (Moreno et al., 1999). The authors contend that it is these properties make it a good instrument to be used in the evaluation of organ dysfunction/failure (Moreno et al., 1999).

**Other Scoring Systems**

Unlike other scoring systems obtain data on admission or within the first 24 hours, the Riyadh Intensive Care Program algorithm uses daily individual physiological data to estimate a physiological threshold, that once is breached, is associated with certain death (Atkinson et al., 1994). It assumes that individual mortality threshold varies with age and previous chronic health. It does not generate a probability. Atkinson et al. (1994) found that predictions based on this algorithm were highly specific but not particularly sensitive.

Trauma scoring systems include the RTS, ISS, TRISS and ASCOT, of which, TRISS is the most widely used. Like other scoring systems they have their limitations (Antonelli et al., 1999). None of these scores, like APACHE and SOFA can be used to predict outcomes for individual patients. The ability of APACHE II to predict outcome in intensive care unit trauma patients has been disputed by some authors (McAnena et al., 1992). Antonelli et al. (1999)
believe that the SOFA score may be useful for assessing the evolution of organ failure over time in trauma patients in the intensive care unit.

The Logistic Organ Dysfunction System (LODS) is based on calculations to assess organ failure in the intensive care unit (Le Gall, Klar & Lemeshow, 1996). It differs from SOFA in that the score is calculated and validated on the day of admission (Antonelli et al., 1999). Both the relative severity among organ systems and the degree of severity within an organ system are taken into account with the Logistic Organ Dysfunction System (Le Gall, Klar & Lemeshow, 1996).

Daly, Beale and Chang (2001) developed a prospective scoring system based on physiology and other measurements recorded on the patient’s day of discharge from the intensive care unit to predict risk of death before hospital discharge. Using multivariate analysis of five variables: age, end stage disease, physiology, length of stay and cardiothoracic surgery, a triage model was developed, which identified patients at risk from inappropriate discharge. By appropriate discharge of patients from intensive care, beds are vacated facilitating admission of other more critically ill patients. The score also predicted the capacity needed in intensive care units to avoid the discharge of high-risk patients. Organ dysfunction as a predictor of the response to treatment and survival are not specifically designed for early probability modelling.

*Therapeutic Intervention Scoring System (TISS)*

The Therapeutic Intervention Scoring System, developed in 1974 (Cullen, Civetta, Briggs & Ferrara, 1974), introduced measurement of nursing workload into clinical practice (Moreno & Morais, 1997). The Therapeutic Intervention Scoring System (TISS) was developed to quantify the severity of illness of a patient in the intensive care unit based on the type and amount of treatment the patient receives since a more critically ill patient, of whatever diagnosis, usually needs more treatment (Cullen, 1977). It was purported to
measure workload and cost on a daily basis in intensive care unit patients. The score has been subsequently expanded and modified. It was subjected to a major revision in 1983 and now comprises 76 selected intensive care unit therapeutic activities (Moreno & Morais, 1997). The Therapeutic Intervention Scoring System (TISS-76) is used mainly for the quantification of nursing workload and the calculation of nursing staff requirements. The modifications were specifically supposed to improve the sensitivity of the score in reflecting staff activity (Dickie, Vedio, Dundas, Treacher & Leach, 1998). Individual patient variation depends on the version of Therapeutic Intervention Scoring System used. Dickie, Vedio, Dundas, Treacher and Leach (1998) recommend that until there is standardisation of the Therapeutic Intervention Scoring System in different units, the version of Therapeutic Intervention Scoring System used should be documented.

The Therapeutic Intervention Scoring System has been used and recognised worldwide since 1974 to compare the utilisation of nursing manpower between groups of patients. It has also been used as a tool to determine management policy. The tool is cumbersome and time-consuming with its seventy-six selected therapeutic parameters. It does not reflect patient care activities of nurses with some agitated patients consuming a great deal of nursing time having low Therapeutic Intervention Scoring System scores whilst stable critically ill patients scoring high on the Therapeutic Intervention Scoring System requiring many interventions and monitoring but less nursing supervision (Dickie, Vedio, Dundas, Treacher & Leach, 1998). Modified versions of the therapeutic intervention scoring system (Therapeutic Intervention Scoring System – 28 and Nine Equivalents of Nursing Manpower) have been developed to overcome these shortfalls.

A positive correlation has been shown between the Therapeutic Intervention Scoring System and total admission costs (Dickie, Vedio, Dundas, Treacher & Leach, 1998; Slatyer, James, Moore, Leeder, 1986). Dickie, Vedio, Dundas, Treacher and Leach (1998) conducted a study to determine whether the Therapeutic Intervention Scoring System reliably reflects the cost of the overall intensive care unit population, subgroups of that population and individual
intensive care unit patients. They performed a prospective analysis of individual patient costs and compared them with the Therapeutic Intervention Scoring System in an adult, twelve-bedded general medical and surgical intensive care unit in a university teaching hospital. The study found a strong linear correlation between the Therapeutic Intervention Scoring System and individual intensive care unit patient costs. This linear relationship was between variable costs and the Therapeutic Intervention Scoring System. The authors recommend that fixed costs not be included in the calculations of costs per Therapeutic Intervention Scoring System points. By adjusting the Therapeutic Intervention Scoring System for length of stay on admission and discharge days an improved Therapeutic Intervention Scoring System per cost correlation resulted. Results from testing subgroups led the authors to imply that the Therapeutic Intervention Scoring System could be used as a financial tool in the intensive care unit. However, they recommend further validation studies be conducted as intensive care units differ in financial, organisational and staffing practices. The nursing care costs accounted for over 40% of costs but quantifying the relative dependency of each patient and apportioning costs was subjective and lacked consistency.

The overall mean daily costs and the average total cost of the intensive care unit in Dickie, Vedio, Dundas, Treacher and Leach’s (1998) study were similar to those found in previous studies with the mean intensive care unit variable cost of non-survivors being greater than survivors (Noseworthy, Konopad, Shustack, Johnston & Grace, 1996; Ridley, Biggam & Stone, 1993). The larger proportion of non-survivor costs to those of survivors in Noseworthy, Konopad, Shustack, Johnston and Grace’s (1996) study may be attributed differences in length of stay.

These results demonstrate that Therapeutic Intervention Scoring System reliably measures overall intensive care unit population costs as well as those of the subgroups coronary care unit, cardiac surgery and general intensive care unit (Dickie, Vedio, Dundas, Treacher & Leach, 1998). However, the relationship between Therapeutic Intervention Scoring System and cost is less reliable for the individual patient.
The therapeutic Intervention Scoring System use in many intensive care units has been limited because of its problems with reliability due to different interpretations of some of the 76 items and the amount of time taken to carry it out (Moreno & Morais, 1997). A simplified version of the system (TISS-28) was proposed by Reis Miranda et al. in 1996. This was developed using advanced statistical techniques on a random sample of 10,000 records and cross-validated on another random sample of 10,000 records from the same database. Validity in clinical practice was assessed in 1820 pairs of TISS-76 and TISS-28 items in 22 Dutch intensive care units demonstrating an excellent relationship between TISS-28 and nursing workload (Moreno & Morais, 1997).

Moreno and Morais (1997) evaluated the performance of the Simplified Therapeutic Intervention Scoring System on an independent database to determine its relation with the Therapeutic Intervention Scoring System in the quantification of nursing workload in intensive care. The multicentre prospective study was conducted in 19 intensive care units in Portugal. The database was completely independent from the one used to develop and validate the system. The results indicated that the TISS-28 could replace the TISS-76 for the measurement of the nursing workload in Portuguese intensive care units. The study did not address the amount of time needed to carry out the scoring system nor the imprecision of some of the definitions. However, the authors believe that using 28 rather than 76 items should alleviate some of these problems (Moreno & Morais, 1997a).

The Therapeutic Intervention Scoring System has limitations as it does not include independent nursing activities such as patient hygiene, knowledge deficits, continuous observation, technical problem solving (Ferguson, 1992; cited by Elliott, 1997).

*Nine Equivalents of Nursing Manpower (NEMS)*

The simplified score was developed from the Therapeutic Intervention Scoring System. It provides an objective and reproducible measure of nursing
workload related to the various intensive care unit patient activities (Reis Miranda, Moreno & Iapichino, 1997). It is a reliable and valid scoring system that is recommended for use in multicentre intensive care unit studies, nursing management to evaluate and compare intensive care unit workload and "the prediction and planning of nursing staff allocation of workload at the individual patient level (Reis Miranda, Moreno & Iapichino, 1997).

**Conclusion**

The main measure of outcome from the intensive care unit should be a measure of survival that is adjusted for quality rather than focusing on mortality. The intrinsic determinants of mortality in a dynamic system cannot be explained entirely by prognostic scores. Basing the main determinant of actual risk of hospital death on a physiological score does not accommodate the complex processes involved in the discharging decision process that may change under different influences on the individual clinical decision. Experienced clinicians assess the risk and possible benefit for individual patients that are not accounted for in prognostic scoring. Understanding the determinants of death in the critically ill is needed to determine when a patient is at high risk. Like other critical health-care decisions, where there is legitimate doubt, validation of the scoring system and random allocation to assess benefit are required. Predicting how any individual patient will do remains the province of the physician (Meyer et al., 1992; Sage, Rosenthal & Silverman, 1986).

General outcome prediction models were introduced 20 years ago, initially for the prediction of the outcome of individual patients and then the valuation of intensive care units. The general adult intensive care unit (ICU) severity measures (Acute Physiology and Chronic Health Evaluation [APACHE], Mortality Probability Model [MPM], and Simplified Acute Physiology Score [SAPS]) have dominated the severity of illness literature. APACHE II continues to be the most widely cited system. Trauma scores, lung scores, multiple organ failure models, cardiac surgery risk stratification models, and many sepsis measures have been developed, based on physiological variables. Models have also been based on complex statistical algorithms include
neural nets, chaos theory, Bayesian logic, and survival analysis, but the most predominant models are multiple logistic regression techniques as manifested by the methodology employed by the general severity of illness models (Teres & Lemeshow, 1998).

Despite risk-adjusted severity of illness measurements having gained widespread acceptance in general medical and surgical intensive care units, they have not successfully achieved field or external validation. Several practical questions arise regarding evaluation of quality of care across multiple institutions including standardisation of time to start measuring the major critical episode and identifying which particular intensive care unit admission should be counted (Teres et al., 1998). There are now problems using hospital discharge to decide vital status when ventilator dependent patients are transferred to chronic or subacute care facilities (Teres et al., 1998).

There may be other approaches to reduce the residual "noise" in severity systems. One is to focus on casemix (Murphy-Filkins, Teres, Lemeshow, & Hosmer, 1996). Another approach has been proposed which defines the time when intensive care starts as acutely ill patients are moved through the system to better define the episode of critical illness (Teres et al., 1995).
Appendix B References


Apolone, G. (2000). The state of research on multipurpose severity of illness scoring systems: are we on target [Editorial]. Intensive Care Medicine, 26 (12), 1727-1729.


and limitations. Australian Critical Care, 10 (2), 55-63.


acute physiology and chronic health evaluation: a physiologically based classification
system. Critical Care Medicine, 9, 591-597.

new way to assess organ dysfunction in the intensive care unit. ICU Scoring Group.
Journal of the American Medical Association, 276 (10), 802-810.

Medicine, 19 (7), 857-858.

score (SAPS II) based on a European/North American Multicentre Study. Journal of
the American Medical Association, 270 (24), 2957-2963.

Le Gall, J-R., Loirat, P., Alperovitch, A., Glaser, P., Granthil, C. Mathieu, D. Mercier,
patients. Critical Care Medicine, 2, 975-977.

care patients: useful, misused, or abused? Intensive Care Medicine, 21 (9), 770-776.


Mortality Probability Models (MPM II) based on an international cohort of intensive
care unit patients. Journal of the American Medical Association, 270 (20), 2478-2486.

length of stay. Critical Care Medicine, 28, 2090-2093.

Invalidation of the APACHE II scoring system for patients with acute trauma. The
Journal of Trauma, 33 (4), 504-506.


Randolph, A. (1999). Reorganizing the delivery of intensive care may improve patient


# APPENDIX C  DATA COLLECTION SHEET

## INTENSIVE CARE UNIT BED LIST

**INTENSIVE CARE SURGICAL**  
Date:  

<table>
<thead>
<tr>
<th>Bed</th>
<th>UNIT NO</th>
<th>Name</th>
<th>Age</th>
<th>Rel</th>
<th>Adm</th>
<th>Con</th>
<th>Diagnosis</th>
<th>VMO</th>
<th>Fin</th>
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</tr>
</tbody>
</table>

**Delay Discharge Codes:**  
1. No ward bed  
2. Ward bed delayed  
3. Medical complications  
4. Environment eg no single room  
5. Lack of medical cover  
6. Transport  

**Other data:**  
A. Nursing staff crisis  
B. Nursing staff inadequate staff skill mix  
C. Pending ICU admission (state how many)  
D. RPH Bed Crisis (completed by N/M or N/C)
APPENDIX D

Data Collection Tool Instructions

- The data collection tool is the modified bed list. A copy of the bed list is given to the Shift Coordinator each time it is printed by the Ward Clerk.

- ICU Shift Coordinators, please enter the time when medical staff inform you that the patient may be discharged to ward.

- When completing the bed list, please use patient’s ID rather than bed number, as patient beds often change during a shift.

- If the patient is not discharged from ICU within 8 hours from the time of notification of the proposed discharge, then record the reason for delay using the code at the bottom of the bed list.

Definitions:

- **Date and time of notification of proposed discharge:**
  The date and time that the appropriate medical staff notify the shift coordinator that the patient is suitable for discharge from ICU.

- **Delayed discharge:**
  The patient is not discharged from ICU within 8 hours from the time of notification of the proposed discharge.
Reasons for delay in discharge are:

Delay Discharge Codes:

1  No ward bed
2  Ward bed delayed
3  Medical complications
4  Environment eg no single room
5  Lack of medical cover
6  Transport
7  Other, please specify

Other data:

A  Nursing staff crisis
B  Nursing staff inadequate staff skill mix
C  Pending ICU admission (state how many)
D  RPH Bed Crisis (completed by ICU Nurse Manager or Nursing Coordinator)
APPENDIX E

Preliminary Studies: Pilot Study Delayed Discharges from an Adult Intensive Care Unit

Purpose

The purpose of the pilot study was to determine the feasibility and appropriateness of the data collection tool and make any modifications as required.

Methodology

The data collection tool was developed utilising a collaborative team approach involving the Nurse Manager, Clinical Nurse Specialist and ICU Shift Coordinators. The data collection sheet, modified from the bed list previously used in ICU, includes date and time of notification of proposed discharge, date and time of actual discharge, reason for delay and discharge destination (appendix C).

An 11-week pilot study using the data collection sheet with ICU Shift Coordinators was commenced on the 18 September 2000 following education of shift coordinators and ward clerks.

Data collected included the number of ICU admissions, ICU bed occupancy and discharge data. If there is a discrepancy in discharge times between bed lists completed by the shift coordinator and that documented in the Admission / Discharge Register, the time entered in the Admission / Discharge Register was used, as this data is the official hospital record.
Definitions

- **Date and time of notification of proposed discharge**
  The date and time that the appropriate medical staff notify the shift coordinator that the patient is suitable for discharge from ICU.

- **Delayed discharge**
  The patient is not discharged from ICU within 8 hours from the time of notification of the proposed discharge.

Participants

The sample was drawn from patients in a tertiary teaching hospital of 955 beds, divided over two sites, one campus has 261 beds and the other campus where the ICUs are located has 694 beds. There are two ICUs on the same floor adjacent to each other – General ICU (12 beds) and Surgical ICU (10 beds) for cardiothoracic surgery, neurosurgery and overflow from General ICU. Elective surgery is performed Monday to Friday, with only emergency surgery being performed on the weekend and these emergencies rarely include cardiothoracic or neurosurgery.

Sample

All patients admitted to General or Surgical ICU in the eleven-week period.

- **Inclusions:**
  All patients admitted to intensive care (General and Surgical)

- **Exclusions:**
  ICU patient deaths
Results

- Number of ICU admissions 298
- Number of ICU discharges 294
- Number of patients excluded 27

(Five patients excluded as they were pending discharge prior to commencement of the study and 22 deaths)

- Total inclusions 267

Table 1
Discharge Delays

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delay &gt; 8 hours</td>
<td>55</td>
<td>20.6</td>
<td>20.6</td>
<td>20.6</td>
</tr>
<tr>
<td>No delay</td>
<td>195</td>
<td>73.0</td>
<td>73.0</td>
<td>93.6</td>
</tr>
<tr>
<td>No data available</td>
<td>17</td>
<td>6.4</td>
<td>6.4</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>267</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Table 2
Delay Time in Hours

<table>
<thead>
<tr>
<th>time delayed</th>
<th>N</th>
<th>Valid</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Valid</td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>Range</td>
</tr>
<tr>
<td></td>
<td>53</td>
<td></td>
<td>32.3774</td>
<td>31.7964</td>
<td>166.75</td>
</tr>
</tbody>
</table>

Time in delay calculated to nearest quarter hour for each patient discharge delay.
Assumptions

- If a patient was admitted to ICU following elective neurosurgical or cardiothoracic surgery, the earliest that they could be discharged would be the day following surgery. They were coded as no delay in this instance.

- If a patient was admitted to ICU, and discharged within eight hours, they were coded as no delay.

Limitations

Reliability

Reliability is the degree of consistency or dependability with which the data collection tool measures delay in discharge. Accuracy was measured by the investigator comparing Shift Coordinators documentation with actual time (following medical handover). In the pilot study, 5 times differed from actual notification time and
including the 7 discharges that did not have delay information recorded, the accuracy rate was 95.52%. Education of Shift Coordinators was conducted to maximise compliance with data collection and consistency in reporting. In addition, comparing data from the data collection tool with the Admission / Discharge Register and review by the investigator enhanced reliability. The pilot study assisted in improving reliability by identifying problems with data collection. Changing the wording on the data collection tool improved shift coordinators' understanding of what was required for data collection. The number of discharges that did not have delay information recorded during the study was 8 (1.2- %) discharges.

**Internal Validity**

When the findings of a study can be shown to result only from the effect of the independent variable and not from effects of extraneous variables, then the study has internal validity (Polit & Hungler, 1995).

**Issues Identified Affecting Data Collection:**

**Data Collection Tool**

The pilot study identified the necessity to change the wording on the data collection sheet. The bed list with the revised wording is found in appendix C. Data collection was problematic for week 4 and week 7, with notification times of discharges not being documented 9 and 5 times respectively for those weeks. Modifying the data collection sheet did not influence outcome. Data collection improved when staff were reminded to collect data. This was done during week 5 and weeks 8 to 11.

Some shift coordinators and ward clerks believed that a dedicated folder for the incomplete bed list would enhance data capture. This change was introduced towards the end of the pilot study.
Education

The pilot study was also useful in identifying the need for augmentation of training related to collection of data. Although staff were informed about data collection techniques, follow up education of shift coordinators on a day by day basis by the investigator improved data collection with 100% data compliance weeks 8 to 11 of the study.

Outcome

Project re-submitted to Nursing Research Review Committee.
APPENDIX F

Coding for Apache II Score

ADMISSION SOURCE

• Operating Room
• Recovery Room
• Emergency Department
• Other Ward
• External Health Care Facility

ADMITTING DIAGNOSIS

Medical
• Respiratory
• Cardiovascular
• Trauma
• Neurological
• Other Failures - self drug overdose, diabetic ketoacidosis and gastrointestinal bleeding
• Other - any condition not included in the preceding groups

Surgical
• Cardiovascular
• Trauma
• Respiratory
• Neurological
• Gastrointestinal
• Coronary Artery Bypass Graft Surgery
• Others - not included in preceding categories.
PRIMARY ORGAN SYSTEM FAILURE

- Cardiovascular
- Neurological
- Respiratory
- Gastrointestinal
- Renal
- Metabolic
- Haematological
# APPENDIX G

## Discharge Destinations

<table>
<thead>
<tr>
<th>Division</th>
<th>Clinical Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular</td>
<td>Cardiothoracic surgery, vascular surgery, cardiology and coronary care unit</td>
</tr>
<tr>
<td>Critical Care</td>
<td>Intensive care unit, high dependency area, emergency department observation ward, neurosurgery and orthopaedic wards</td>
</tr>
<tr>
<td>Medical Specialties</td>
<td>Seven medical wards including immunodeficiency unit</td>
</tr>
<tr>
<td>Surgical Specialties</td>
<td>Two surgical wards and burns unit</td>
</tr>
<tr>
<td>External Sources</td>
<td>Included study hospital’s rehabilitation campus</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>Two wards</td>
</tr>
<tr>
<td>Neurosciences</td>
<td>Two wards</td>
</tr>
<tr>
<td>Cancer</td>
<td>Two wards and bone marrow transplant unit</td>
</tr>
</tbody>
</table>