

# **Requirements analysis for the development of a Nurse Resource Management System for Critical care**

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A dissertation submitted to the University of Dublin, in partial  
fulfilment of the requirements for the degree of Master of Science  
in Health Informatics

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## **Declaration**

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work, and has not been submitted as an exercise for a degree at this or any other university

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Grainne Lloyd,  
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## **Abstract**

This dissertation sets out to identify a best practice solution to the Nurse Resource management issues in the critical care setting and to provide system requirement specifications for an ICT solution that will help in meeting the needs of patients, nurses and managers alike. An evaluation of the current workflow processes related to nurse resource management in use in the critical care setting and a review of the related literature provides a basis for a systems requirements specification. The aim of developing a nurse resource management system is to provide the Critical care area with a computerised tool that can assist in matching the supply of nursing skills to the demands placed on the organization, i.e. the needs of patients, whilst promoting safe, patient centered quality care delivery.

The primary function of the system will be a nurse-patient allocation tool which will utilize all the data gathered, in relation to the patient population and the nurses available, to provide a decision support tool which will match nurses with patients. Central to a system that brings together nursing skills with patients needs is the provision of up to date patient data which can be utilized to determine the nurse resource requirements. The nurse workload scoring tool (TISS-28 score) and the patient care plan, imported from the CareVue® CIS, should provide the proposed system with this data. As well as providing mechanisms for allocating staff to ensure that the needs of the patients are being met and safety risks are being minimized, an effective nurse resource management system must also include an audit and reporting tool. In doing so, the proposed system will assist in long term workforce planning, recruitment and retention processes, ensure that appropriate employment conditions are met and that staff have access to training and professional development.

In summary, a nurse resource management system must address all aspects of nurse resource management, users need to be fully involved in the planning and development of such as system to maximize its potential to provide a resource management solution which will improve efficiency, reduce costs and improve quality of patient care delivery in critical care or indeed in any area in which the system is deployed for use.

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## **Abbreviations**

ABG	Arterial Blood Gas
BA	Business Administrator
CRRT	Continuous Renal Replacement Therapy
EPR	Electronic Patient Record
ENT	Ear, Nose and Throat
HDU	High Dependency Unit
HRM	Human Resource Management
HSE	Health Service Executive
ICU	Intensive Care Unit
IT	Information Technology
ICT	Information and Communication Technology
NA	Nurse Administrator
NF	Nurse Facilitator
CNM	Clinical Nurse Manager
PA	Payroll Administrator
PAS	Patient Administration System
SRS	Software Requirements Specification
SA	Systems Administrator
SN	Staff Nurse
UML	Unified Modelling Language
VLAN	Virtual Local Area Network
WTE	Whole Time Equivalent

## **Chapter 1: Introduction**

This dissertation researches the domain of requirements analysis for the development of an electronic nurse resource management system in critical care.

Nursing resource management is the process of determining nursing human resource requirements (supply) in the context of the demands placed on the service (service demand)

In this work, the author will endeavour to identify a best practice solution to the Human Resource management issues in critical care and provide system requirement specifications for an ICT solution that will help in meeting the needs of managers, nurses and patients alike.

The ultimate aim of developing a nurse resource management system is to provide the Critical care area with a computerised tool that can assist in matching the supply of nursing skills to the demands placed on the organization, i.e. the needs of patients, whilst promoting safe, patient centered quality care delivery.

*“One of the most challenging decisions in resource allocations in hospitals is how to allocate nursing duties on the basis of patients' needs.” Soliman (1998)*

## **Motivation**

The nature of the ICU environment is very much focused on dealing with real time situations, patients' needs are paramount - a patient's condition can deteriorate or improve rapidly, as such, the environment demands that staff think on their feet. ICU staff are very well trained and equipped to deal with responding to the dynamics of the critical care environment in terms of direct patient care.

Conversely however, anecdotal evidence suggests that nurse planning and administration issues in ICU have a much lower priority than direct patient care issues. This can and does lead to poor workload management which in turn has health and safety implications and an obvious effect on the quality of patient care delivered. In addition, it leads to demotivation of staff, increased levels of stress and ultimately burnout. The manifestation of this is high staff turnover and high levels of absenteeism. There appears to be a real need to encourage nursing staff in managerial positions to review their perspective on planning, particularly in relation to nurse resource management.

The author has worked in the critical care setting for a number of years. Since 2005 the Intensive Care unit has become an almost paperless environment, with the exception of the nursing resource management processes. The system tools currently in use in the unit are the CareVue® Clinical information system and the Patient Administration System (PAS), both systems hold valuable patient related data which could potentially be used in conjunction with a nurse resource management system to provide a nurse allocation tool. Allocating the right nurse to the right patient in the critical care area is the main purpose of the system being proposed.

There are three main processes that make up the current nursing resource documentation in St James's Intensive care unit.

- The nurse dependency scoring system
- The nurse assignment/ allocation system
- The nurse scheduling system

The assumption might be that these are elements that are highly dependent on each other in determining the nursing resources and skills base requirements in the critical care area, that they should undoubtedly be in some way linked to ensure that patients are receiving the best quality of care available from the right nurse, there is, however, currently, no connection between them, they are all completed and compiled manually and independently, as such, they stand out as areas that warrant further research. Patient centred quality care delivery is central to nurse resource management, therefore, nurse workload/ patient dependency, nurse assignment/ allocation and nurse scheduling should be addressed as a whole.

The aims of this research project are;

- To identify best practice in the area of nurse resource management.
- To elicit the requirements for a systems solutions based on best practice and identified user requirements.

The research undertaken consisted of a case study which was undertaken in the authors' workplace. This involved detailing the current workflow processes related to nurse resource management and also a survey of completed nurse dependency forms. The research also consisted of a literature review. The literature related to nurse workload/ patient dependency scoring tools, nurse scheduling, recruitment and retention issues and quality of care issues. The research undertaken led to a systems requirement specification which aims to address the nurse resource management issues and provide an efficient nurse-patient allocation tool.

The next chapter provides an overview of the main elements that make up the nursing resource management processes in the context of the critical care environment. This includes a case study, undertaken in the authors' workplace, which describes the domain in the context of its current IT infrastructure and applications in use. The case study also evaluates the current practices in relation to nurse resource management.

A review of the literature relating to nurse resource management and planning in critical care was undertaken to identify best practice and this is described in chapters 3 and 4. In the context of the research question, the literature review required the author to look at, nurse resource management and quality of care issues, critical care staffing, nurse workload scoring tools, nurse scheduling and skill mixing and matching.

Chapter 3 provides a detailed review of the literature related to the scoring tools available, their uses and validation. It also looks at the uses of an information system in the context of patient dependency and nurse workload scoring tools. This provides a background for identifying the best way forward in terms of requirements elicitation and evaluation of tools.

Chapter 4 reviews the literature on nurse resource management, looking at the current issues in critical care such as recruitment and retention of staff, nursing staff inexperience and quality of care. Nurse scheduling and allocation requirements are also looked at in the context of staff satisfaction and organizational needs. Finally, this chapter reviews a currently available computerized nurse resource management system and its limitations.

A systems specification outlines the requirements of a systems solution in chapter 5. The Unified Modeling Language (UML) will be used to describe the elements and functionality of the proposed system. The UML is a tool which uses symbols and diagrams to communicate a vision for the creation of a system. The UML helps developers to understand system requirements and has been applied in this context. The elements of the UML utilized to describe the system are use cases, class diagrams and functional analysis.

Chapter 6 is an evaluation of the proposed system, it looks at how the identified issues are addressed based on the research carried out and also concludes the dissertation.

## **Chapter 2: Background/ Context and Case Study**

This chapter will provide a background the research project.

It gives a brief overview of the domain, its clinical environment, the current IT infrastructure and the IT applications in use.

The chapter will also provide an introduction to the three main elements of nursing resource management;

- nurse assignment/ allocation.
- nursing workload and dependency scoring systems
- nurse scheduling

These processes will be reviewed in the context of their purpose and their current applications in the critical care environment.

A case study, undertaken in the workplace, describes the current practices in relation to nurse resource management documentation.

Nursing and administrative staff partook in interviews to;

- Determine the current workflows.
- Identify the organizational needs in relation to the development of an information system.

### **2.1 The Domain:**

St. James's Hospital is the largest acute general hospital in Ireland. It is situated in Dublin city centre. It has approximately 1000 beds. It is a major acute teaching hospital and is linked with Trinity College Dublin which has its' Health Sciences campus on site.

St. James's serves as a national centre for many specialties including Haemophilia, Bone Marrow Transplantation, Plastic Surgery and Maxillo-Facial surgery, regional services include Ear Nose and Throat surgery (ENT), Cardio-thoracic surgery, Vascular surgery and Haematology.

The Intensive care service provides critical support to all these specialties as well as providing a transfer and management facility for St. James's emergency department and for transfers from provincial hospitals.

### **2.1.1 The Clinical Environment**

The Intensive Care Unit within St James Hospital has 14 staffed general ICU beds. The unit is divided into 1 large 9 bed ward and 6 isolation cubicles. From January 2006 to end December 2006 there were 830 admissions to the ICU. The unit has had average bed occupancy of > 90% for the past 3 years and is currently going through a period of re evaluation in relation to the service level it provides to the patient group it serves. Most recent figures of bed occupancy has led to the HSE declaring the ICU in St James 'in crisis' as the occupancy rates were in excess of 110% in February 2007 and non designated ICU areas, such as the High Dependency Unit (HDU) and the Operating Theatres recovery room, were being used to manage critically ill patients. It is likely that the bed complement will increase significantly in the near future with plans afoot for major expansion.

The nursing staff complement in the ICU is currently 94 Whole Time Equivalent (WTE), this equates to 6.5 nurses per bed in the 9 bedded open unit and 7 nurses per bed in the isolation areas. This number accounts for nursing staffs annual leave, but not for maternity/parental leave/ staff on rotation to other areas or absences due to sick leave. The nursing staff turnover is currently over 20%. Nurse staffing costs account for a significant proportion of the ICU budget. Within this high cost environment effective human resource management is crucial.

### **2.1.2 IT Infrastructure/ applications**

The Information technology infrastructure in the ICU is well developed. The network infrastructure has been in place for 3 years and provides bedside access, via a bedside workstation and flat screen monitor, to a number of hospital networked applications. The network infrastructure in ICU was implemented for the introduction of the CareVue® application in September 2005 but has since provided bedside access to many more applications. The CareVue® network is segregated from the rest of the hospital network by means of a Virtual Local Area Network (VLAN). It is worth noting that the CareVue® application must reside on a VLAN for network speed and security reasons. As such, applications, all hosted remotely in the hospitals main IT department, have been individually chosen to be accessible from the bedside in ICU. Additional applications can be accessed if required but some network software modification is necessary to provide bedside access for new applications.

Currently each bedside can access;

- CareVue® application
- Electronic Patient Record (EPR) which currently includes the hospital laboratory system and radiology images
- The Hospital Intranet
- The Hospital Patient Administration System (PAS)

### **2.1.3 CareVue® (The Clinical Information system)**

The CareVue® application is accessed via the bedside workstations. The users can document and store both automated and manually entered patient data. Automated data comes from other hospital systems remote to the bedside workstation (Foreign systems) including PAS, Blood Gas machine (ABGs), the Laboratory and radiology systems (EPR) and also from locally attached bedside devices including the patients' Ventilator and Haemodynamic Monitor.

The CareVue® system currently incorporates all ICU patient documentation.

The patient data is recorded in real time, primarily by nursing staff, and to a lesser degree, by medical staff and other multi-disciplinary team members.

With the introduction of the CareVue® clinical information system, the Intensive Care unit had become an almost paperless environment over the course of the last 2 years, with the exception of how nursing resource is managed. This continues to be managed through a manual documentation process.

## **2.2 Nursing Resource Documentation**

There are three main elements that make up the current nursing resource documentation in St James's ICU;

- The nurse allocation system.
- The patient dependency/ nurse workload scoring system
- The nurse scheduling system

These are currently manual processes. There follows an overview of each of these processes.

The author will firstly provide background information for each one and then discuss the specifics of the workflow processes they involve. In doing so, the author aims to identify the problems that are being experienced. This will assist in eliciting user requirements for an electronic system.

### **2.2.1 Nurse allocation/ assignment**

Nurse-patient assignment or allocation is a mandatory routine for all healthcare units. It is performed on a twice or thrice daily basis for every shift for the entire year.

At the beginning of a nursing shift, the nurse in charge of the previous shift assigns nurses to patients for that shift. In the critical care setting, this is usually one nurse to one patient. However, since some patients require more care than others, a second nurse with a lesser workload may be required to assist the nurse with the increased workload. Similarly, there can also be different skill levels within the group of nurse available for assignment so assigning the right nurse with the correct skills to each patient can reduce the workload. Geographical location of nurses is also a concern when allocating nurses to patients in ICU, the nurse in charge is responsible for ensuring that all physical areas of the unit are 'covered' with sufficiently experienced staff.

### **2.2.2 Nurse allocation workflow process in St. James's ICU**

The current workflow process was detailed on a flow sheet. (Figure 2.1)

The process was then discussed with the unit nurse managers directly involved in the allocation of nurses to patients with a view to;

- Identifying the problems with the current systems in place.
- Eliciting requirements for the development of an electronic system.

The workflow was agreed and problems identified as follows:

Currently a nurse-patient assignment is done manually in St. James's hospital intensive care unit.

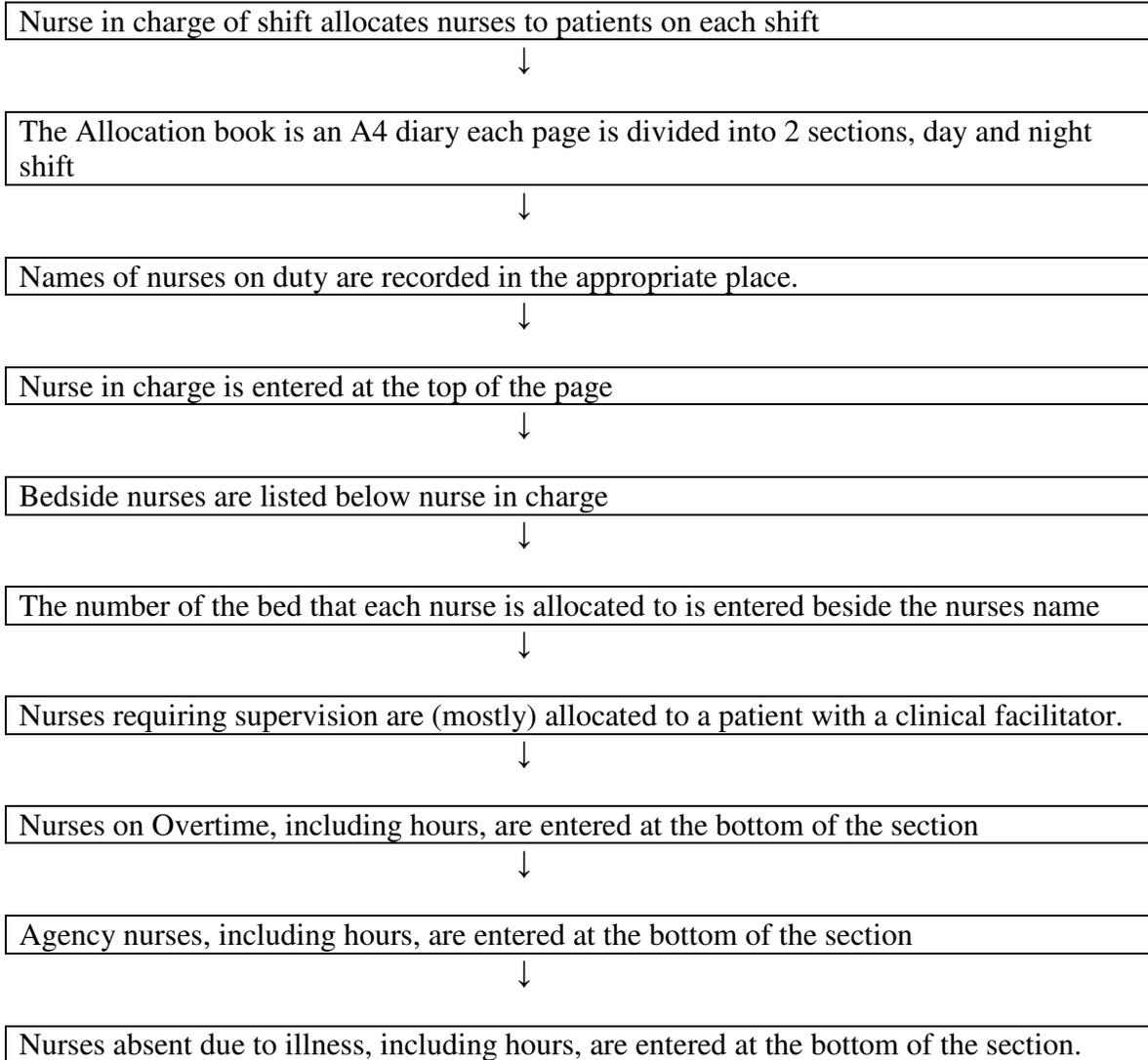
- Nursing staff are allocated to care for patients by the nurse in charge on the previous shift.
- Decisions to assign nurses to patients are based on the allocating nurses' knowledge of the nurse she is assigning; some staff may not be well known to the allocating nurse so the assignment may not be appropriate.
- Nurses are required to have completed various competencies prior to caring for Intensive care patients independently; this is not always the case.
- The nurse in charge is reliant on the allocated nurse voicing concerns in the event of inappropriate allocation - as each qualified nurse is accountable for their

nursing practice it is their responsibility to voice concerns over allocation issues. (An Bord Altranais, 2000) Allocating nurses are not fully confident that this happens.

- Geographical location of patients is also a consideration in relation to nurse allocation; as a result, senior, highly skilled and experienced nurses may be allocated to a patient that does not necessarily require their skill. For example, a patient may be considered low dependency but due to their physical location in the unit i.e. in an isolation room, for health and safety reasons, they are allocated a more experienced nurse - less experienced nurses are rarely allocated to isolated patients.
- As a result, the mix of experienced and inexperienced staff available in the open unit in ICU and in isolation areas may be disproportionate.

In addition, the current allocation of nurses does not have any apparent relationship with the dependency category of the patient as there is no reference to these scores when nurses are being allocated to patients.

**Figure 2.1: Nurse Allocation Workflow**



### **2.2.3 The Current Nurse Dependency scoring system**

The current system in use in St. James's Intensive care unit is the Patient category scoring system. This tool determines the dependency category of each patient and the number of nurses required to care for the patient population for the previous six hours. It is a paper based system which has been in use since 1994. The tool itself is a modified Scoring System derived from a systems used in the UK namely, Criteria for Care, Newcastle score (Ball and Gladstone, 1984) and from the Hospital Systems study Group (Jackson and McKague, 1979)

### **2.2.4 Patient Category Scoring System.**

The Literature review, Chapter 3, will provide a detailed review of patient category scoring systems in addition to the other patient dependency/ nurse workload tools available.

Patient category scoring tools are used in 55% of Intensive Care Units throughout the United Kingdom and are recognized as playing an important role in identifying nurse-patient ratio. (BACCN 2001).

The Patient category scoring system was first developed by the Hospital Systems study Group in 1979 (Jackson and McKague, 1979). The Criteria for Care Group in Newcastle polytechnic derived the Newcastle Score from the original scoring tool in 1984. (Ball and Gladstone, 1984). Since then, the original has been modified for use in many hospitals based on their individual units' requirements and patient population.

#### **How the category scoring system works:**

The dependency classification is based on the nurses' assessment for the previous 6 hours using a Dependency Scoring form (Appendix A). There are 6 determiners to be scored and an additional score for patients on Continuous Renal Replacement Therapy (CRRT).

A score is always given in each of the first three determiners, scores range from A to C. An 'A' score is given for the most independent patient and a 'C' score is given for the most dependent patient. These are:

Respiratory status: Is the patient maintaining their breathing spontaneously or requiring mechanical support?

Haemodynamic status: Is the patient maintaining their blood pressure and heart rate without mechanical or pharmacological support or are they dependent on support?

Neurological status: Is the patient alert and orientated or are they heavily sedated or confused and agitated?

Special procedures: This is scored if the patient has undergone a major procedure on or off the unit, such as transfer out for a CT scan or change of lines. If scored, this is always given a 'C' score

Drainage and elimination: This is scored if the patient has excessive bleeding/ fluid loss. If scored, this can be given a 'B' or 'C' score

Care of Relatives: This is scored if the patients' family/ friends require a lot of support; this may be due to bereavement, withdrawal of treatment or unexpected admission.

Again, if scored, this can be given a 'B' or 'C' score

A 'Tick' is given if the patient is on CRRT. All patients on CRRT are automatically a Category 4.

Each patient is categorized on a scale of 1 – 4 dependent on their combination of A, B and C scores.

Category 1 - Patient requires 0.5 Nurse Resource per shift

Category 2 - Patient requires 1.0 Nurse Resource per shift

Category 3 - Patient requires 1.5 Nurse Resource per shift

Category 4 - Patient requires 2.0 Nurse Resource per shift

The patient score is completed 6 hourly, retrospectively, by the nurse in charge of the shift. The scores are gathered on individual forms four times in a 24 hour period and entered onto monthly form once every 24 hours at 0600.

(St. James' hospital dependency working group, 1994.)

While the scores are gathered five times in a 24 hour period, it is the responsibility of one nurse manager to collate the information manually on a monthly basis and forward to the directorate office for further analysis.

It is unclear as to whether this information is currently utilized for resource management. Although some of the nurse managers on the ground believe that resources are based on the data gathered by this methodology, on first investigation this appears unlikely given the backlog of un-collated data. For some months, the nurse manager with direct responsibility for collating the patient dependency data has been absent, the task of collating the data has not been delegated, and therefore the data remains uncollated at unit level. Completed daily dependency forms, from July 2006 onwards, are currently stored in box files in an office in ICU.

Further investigations reveal that the data collected prior to July 2006, which had been collated and sent to the directorate office for analysis, has never been inputted into any other system. The reason for this is that there is no system to enter this data into. An excel spreadsheet had been used up until 2004 but this does not appear to be available to the current user. So, the data that the nurse managers have been forwarding for analysis has remained in envelopes and folders for some 3 years now. In theory, the data collected should be very useful, however, as the data is not being utilized, it appears that effort is being expended for no good reason.

### **2.2.5 The Patient dependency scoring system workflow:**

The current workflow process was detailed on a flow sheet. (Figure 2.2)

The process was then discussed with the unit nurse managers and administrative staff directly involved in the collection of the data with a view to;

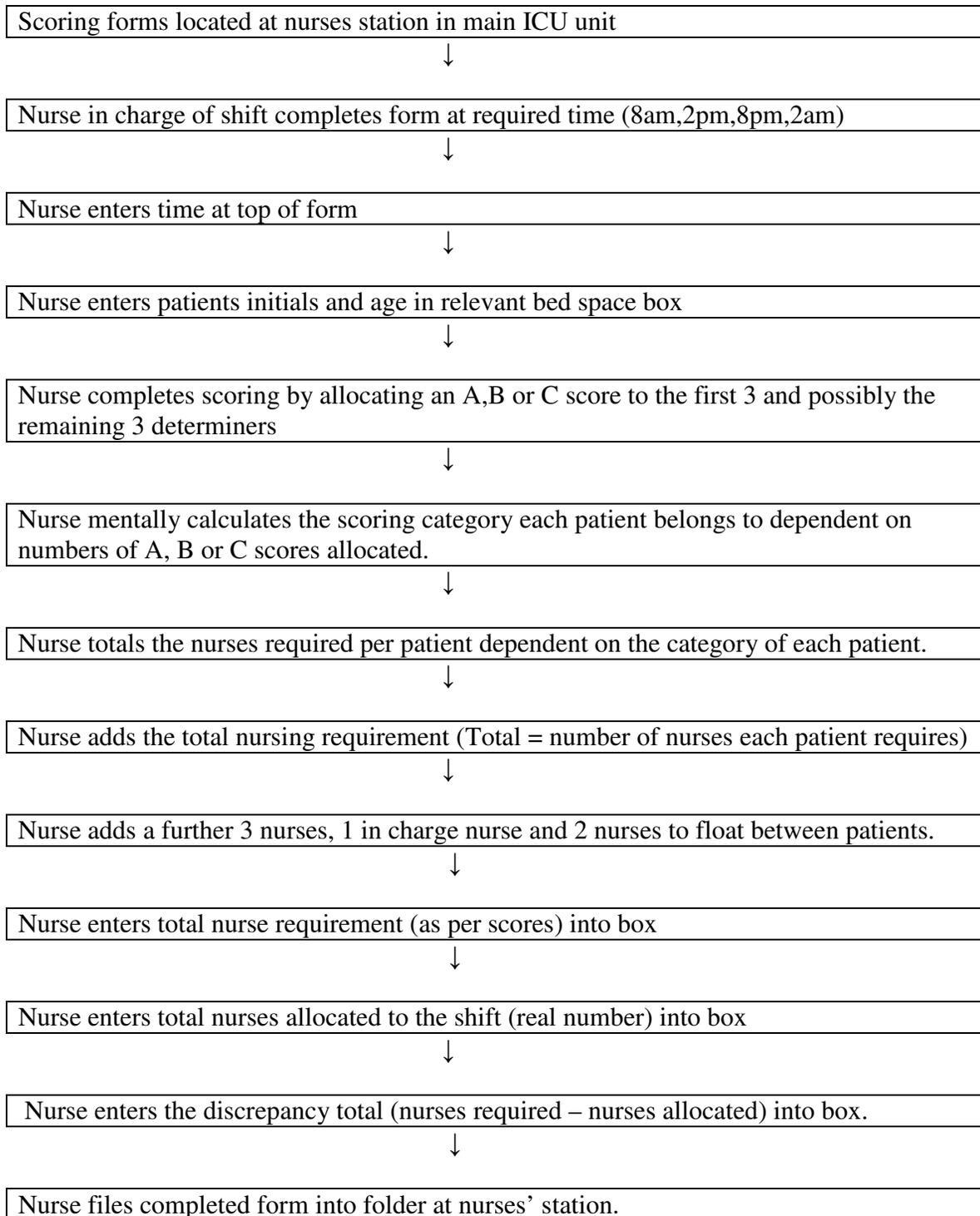
- Identifying the problems with the current systems in place.
- Eliciting requirements for the development of an electronic system.

The workflow was agreed and problems identified as follows:

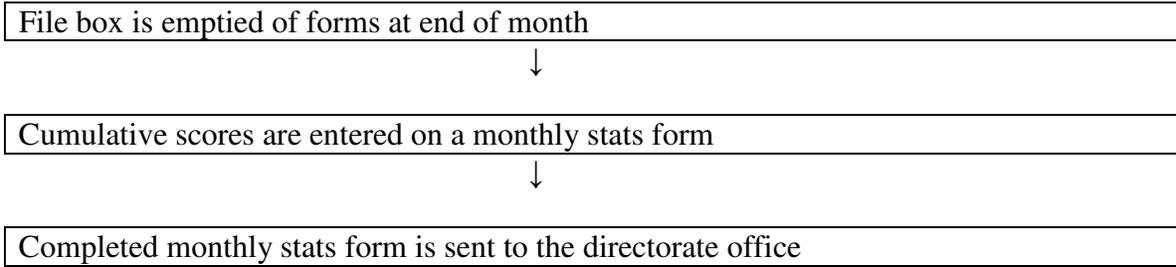
- The current system is cumbersome - manual completion of forms is required 5 times per 24 hour period. The time taken to do this is estimated to be 15 minutes per entry, this equates to 75 minutes per 24 hour period. This equates to 8.75 hrs per week. Forms are completed by a Clinical nurse manager so the cost of collecting this data can be estimated at 20% of CNM salary per annum which is equivalent to approx €10,000 per annum.
- The system appears to lack purpose and is seen as an inefficient means of collecting important data.
- The tool used (category scoring) is considered to be outdated and does not accurately reflect the nurse resource requirements. There are, consistently, large variations in the number of nurses scheduled and the number required (as per scoring tool).
- There is a large margin for error in the completion of the score. This can be in calculation of scores or staff numbers where the system is very open to human error.
- There are inconsistencies in scoring i.e. one nurse scores patient as a 'B' for their respiratory status on one shift; on the following shift the same patient is given a 'C' for respiratory status for no obvious reason.
- It is generally accepted that this tool needs to be reviewed and replaced with a scoring system that more accurately reflects the unit's nursing workload and resource requirements.

## **Figure 2.2: Patient Dependency scoring workflows**

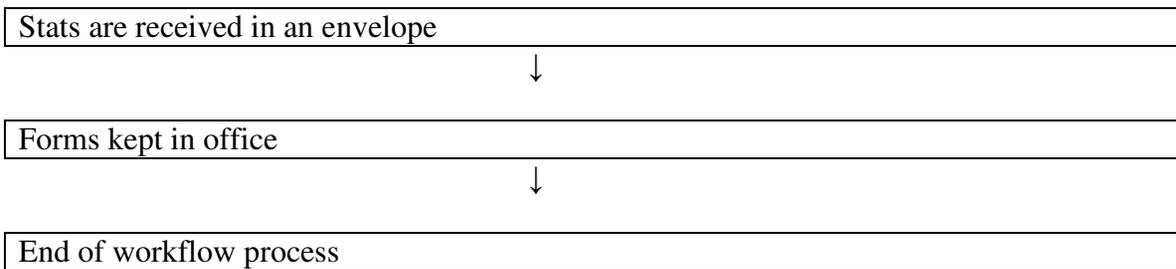
### **Shift workflow**



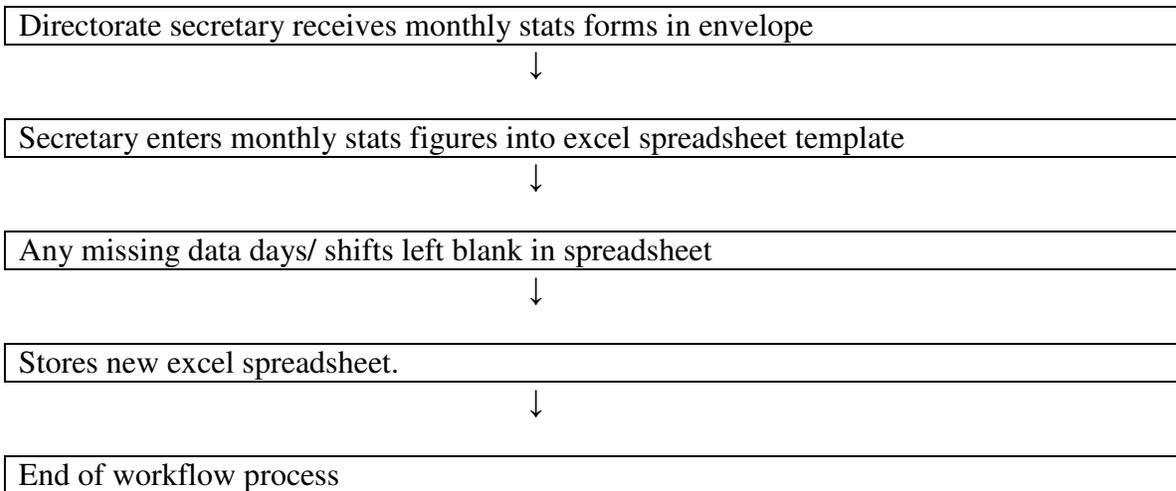
**Monthly dependency scoring workflow**



**Directorate Office workflow** (current)



**Directorate Office Workflow** (up until February 2006)



### **2.2.6 Sample of patient dependency data**

In addition to detailing and discussing the workflow process, a sample of completed dependency data forms, gathered over a one month period, were reviewed (Tables 1;2).

This sample group included 120 completed dependency scoring forms which had been completed and collected during November 2006. The month was selected randomly from the 2006 data available and confirmed some of the problems discussed during workflow analysis;

#### **Errors/ Incomplete forms (Table 2.1)**

- Of the 120 forms, 90 were found to be fully completed and correct.
- Of the 120 forms, 30 were found to contain calculation errors. There were two types of calculation errors identified. These were; errors in the calculation of patients number of A,B or C scores, if calculated incorrectly, this can result in the patient being allocated to the incorrect dependency group; errors in simple addition i.e. if there are 2 patients in care group 3, the nursing requirement of these 2 patients is 1.5. ( $1.5 \times 2$ ), so 3 nurses required. An error with this calculation results in the 'number of nurses required' being inaccurate.
- Of the 120 forms, 10 were found to have blank spaces left where data entry was required.
- Of the 120 forms, 5 were found to have both errors and blanks.

#### **Nurses Scheduled/ Required (Table 2.2)**

The nurse dependency form also includes data on the number of nurses scheduled/ required. The number scheduled is the real number of nurses on a given shift as entered

by the nurse in charge. The number of nurses required is the number of nurses that should be scheduled based on the patient dependency.

As can be seen in Table 2.2, there was a consistent negative discrepancy between the number of nurses required and the number scheduled.

The average number of nurses scheduled for each shift was 16.64

The average number of nurses required for each shift was 23.8

The maximum discrepancy on a shift was - 9.5 nurses

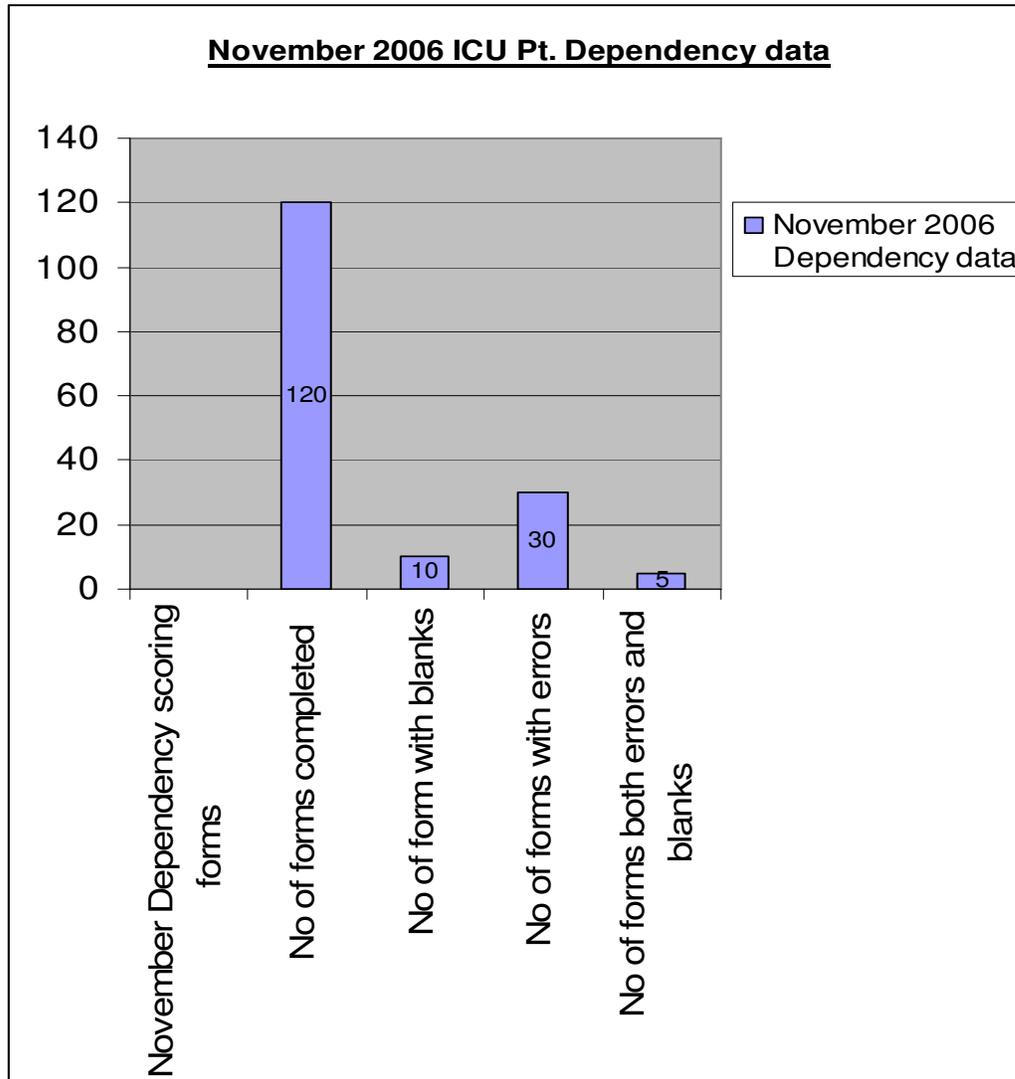
The minimum discrepancy on a shift was found to be - 4.5 nurses.

The average discrepancy on a shift was - 7.16 nurses.

These figures suggest that the ICU is understaffed on each shift by an average of 39.6%.

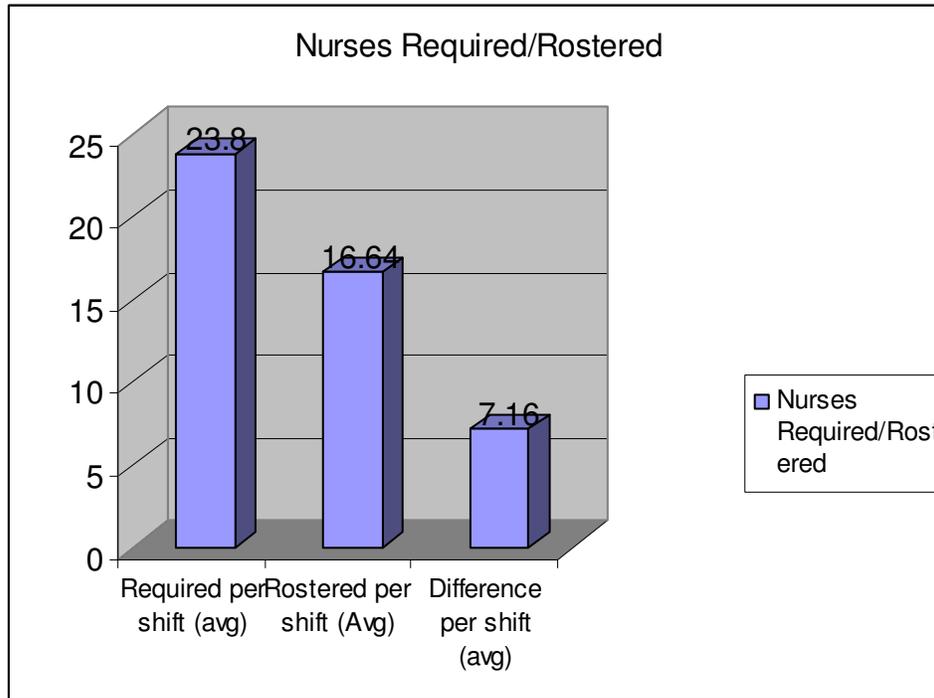
Overall, the current dependency scoring tool as it is currently used has been found to be inefficient, costly, inaccurate, inconsistent and in need of review. In addition, it is not a nurse allocation tool as it is completed retrospectively. The tool does not allow for shift planning in relation to nurse allocation and it does not, therefore, take any account of skill matching in relation to individual patients needs. On this basis, there is a case for looking at alternatives to the category scoring tool as a measure of nursing resource requirements.

**Table 2.1 Errors/ Incomplete forms**



<b>Dependency Forms ICU</b>		
<b>November 2006</b>		
No. of forms reviewed	120	100%
No. with errors	30	25%
No. with blank spaces	10	8%
No. with errors and blanks	5	4%

**Table 2.2 Nurses Required/ Scheduled**



<b>Nurses Required/ Scheduled/ Diff (Avg) ICU November 2006</b>		
No. of nurses required(avg)	23.8	100%
No. of nurses scheduled (avg)	16.64	60.4%
Difference (avg)	-7.16	-39.6%

### **2.2.7 Nurse Scheduling**

The goal of a scheduling system is to schedule the right combination of nurses for each shift and to deploy the nursing staff in such a way that staff resources are not overextended or wasted in tandem with allowing nurses to have a say in deciding how long they work, what days they work, and which shift they work. Scheduling nursing staff means weighing up a host of factors. It must take into account patients' needs, staff numbers, skill mix, nurses' shift preferences (requests), annual leave and overtime.

#### **The nurse scheduling workflow:**

The current nurse scheduling workflow process was detailed on a flow sheet. (Figure 2.3) The process was then discussed with the unit nurse managers directly involved in devising the schedule with a view to;

- Identifying the problems with the current systems in place.
- Eliciting requirements for the development of an electronic system.

The workflow was agreed and problems identified as follows:

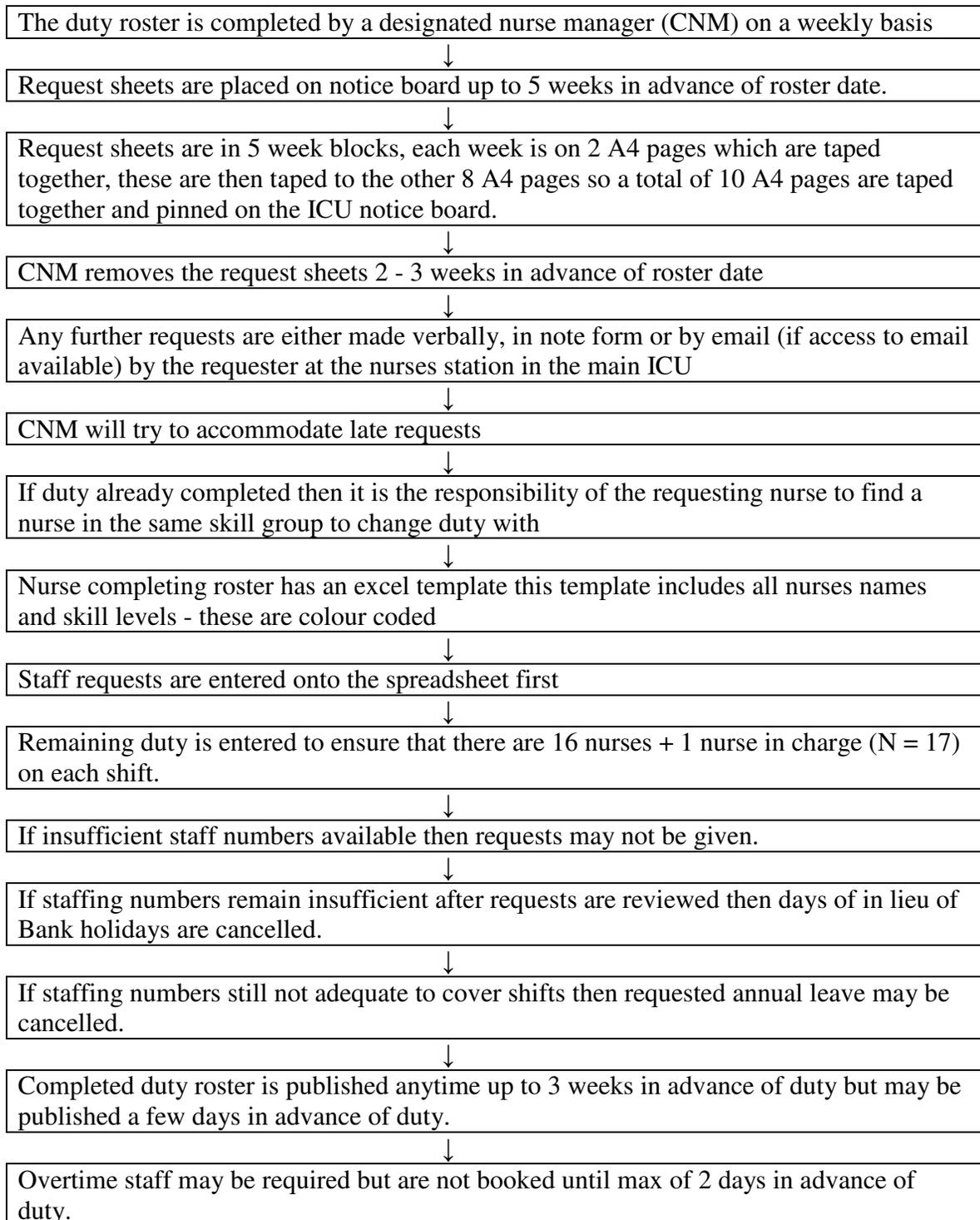
Nurse scheduling in St. James's ICU is currently a costly and cumbersome process which is difficult to manage.

Scheduling takes a CNM up to 2 days per week to complete. (Current cost approximately €20,000 per annum)

The current system can also be difficult to monitor. A few basic rules are applied to the schedule which staff are expected to abide by – i.e. night duty 5 weekly pro-rata. Not all staff abide by the rules and this can cause difficulty for all parties.

In general, staff appear to be dissatisfied with the current system, the schedule is frequently published just days before actual duty commences, as a result staff may not know on Friday what their roster is for the following Monday. Clearly this is not an acceptable situation - staff dissatisfaction is understandable in this context.

**Figure 2.3: Duty Scheduling Workflow**



### **Nursing Staff Payment Book Workflow:**

There are two payment returns books that must be completed on a per shift basis. The forms for these books are sent to ICU from nursing administration on a weekly basis. They are separated into two books. Book one contains personnel details on nurses that are paid on a monthly basis. Book two contains personnel details on nurses that are paid on a weekly basis. Both books contain weekly return forms; each page has a duplicate copy. This is depicted in figure 2.4.

#### The issues identified with this workflow process:

The main issue identified in relation to this particular workflow was the frequency of missing data. This appears to be due to the fact that it is the responsibility of each nurse to ensure that:

- Their name and personnel number details actually appear on the payment forms.
- The correct shift code is entered into the correct book for each shift they work or for leave taken in a weekly payment period.

In the event that missing data is not recognised prior to the payment forms being submitted to nursing administration department, who in turn forward the data to the payroll department, there can be problems with clarification of missing data and subsequent staff payment(s). This is another source of staff dissatisfaction. In addition, data duplication (in three departments) means that there is significant potential for erroneous entries to be made prior to data entry into the payroll system.

**Figure 2.4: ‘The Blue Books’ - Nurse Payment submission workflow**

There are 2 payment returns books that must be completed on a per shift basis.

The forms for these books are sent to ICU from nursing administration on a weekly basis.

They are separated into 2 books.

Book 1 contains personnel details on nurses that are paid on a monthly basis.

Book 2 contains personnel details on nurses that are paid on a weekly basis.

Both books contain weekly return forms; each page has a duplicate copy.

It is the responsibility of each nurse to ensure that her correct shift codes are entered each week. There are a variety of codes each representing a shift i.e. DJA9 = 0730 – 2100 shift.



Each Monday morning, the top copy of previous week’s returns forms are checked by designated nurse (CNM) and sent to nursing administration for entry onto the SAP system. The second copy remains in ICU. (Nurses are paid based on the information on these forms)



Nurses working Overtime shifts are entered on separate returns book each page has a duplicate copy  
The top copy is sent to nursing administration for entry into SAP system.  
The second copy remains in ICU.



Nurses working Agency shifts are entered in an Agency book.  
This is purely a record keeping exercise as agency payments are made based on forms submitted by agency nurse and signed by nurse in charge of shift and nursing administration.

### **2.3 Chapter conclusion**

This chapter has provided a background to the research project in the context of the nurse resource management structure currently in place in the domain, St. James's hospital ICU. Anecdotally, similar structures appear to apply to the majority of critical care settings. The author has failed to identify any critical care unit in Ireland that uses an integrated nurse resource management system. Overall, it is clear that nurse resource management issues need to be addressed at management level. All elements of nurse resource management, which have been looked at in terms of the current workflow practices, are in need of review.

The workflow processes as outlined have provided a basis for identifying the problems that currently exist and a means of ascertaining the requirements for a system solution. A computerized systems solution may go some way towards providing a more acceptable means of managing nursing resources in this setting. A proposed system requirements specification will be discussed in detail in Chapter 5; firstly, a review of the literature in Chapters 3 and 4 looks at critical care staffing, nurse workload measurement and nurse resource management in the critical care setting.

## **Chapter 3: Critical Care Staffing and Scoring Systems.**

Nurse resource management involves many processes. In particular, much has been written and many studies carried out in relation to nurse workload measurement and patient acuity and dependency scoring tools. This chapter reviews the literature related to acuity and dependency scoring tools, this is done in some depth, and the rationale for this is to identify the best available nursing workload / patient dependency scoring system for use in critical care. Identification of a tool will provide a basis for estimation of patients needs in relation to the provision of nurse resources and ultimately, best matching of nursing skills to patients needs.

In the context of this research and in trying to identify the best nurse resource management solution for the critical care area here is a recap of the issues that currently exist in the SJH domain.

Firstly, there is currently no computerised system in use for any part of nurse resource management. Secondly, the patient dependency system in use is ineffective - the data is not utilized in any useful way and, thirdly, all of the current manual processes including dependency data collection, nurse scheduling and nurse allocation are inefficient and incredibly expensive in human resource terms.

This literature review is divided over the next two chapters, chapter 3 and 4.

Chapter 3 is a review the literature related to critical care staffing, nurse-patient ratios, nursing workload and patient dependency scoring systems and tools used in critical care.

Chapter 4 reviews the literature related to nurse resource management in critical care.

The Literature in this chapter is reviewed under the following headings:

### **3.1 Critical care staffing and Nurse-Patient Ratios**

This section provides an overview of how the critical care area is staffed. It also looks at nurse-patient ratios, how they came about and how they are employed in the critical care setting.

### 3.2. Scoring Systems and Tools in critical care

This section introduces scoring systems in critical care. The following three sections will detail the tools currently available.

#### 3.2.1 Patient Classification/ Scoring tools

This section describes the Patient Classification scoring tools, their evolution, uses and limitations. The current manual dependency scoring system used in the domain is amongst these tools.

#### 3.2.5 Severity of illness scoring tools:

This section describes severity of illness scoring tools, their evolution, uses and limitations, the APACHE II score, which is currently calculated for all patients in the domain and almost entirely automated via the CareVue® system, is amongst these tools

#### 3.2.6 Nursing intensity measures.

This section describes nursing intensity measures, their uses and limitations, there are currently no such systems in use in the domain although the TISS-28 score, which will be discussed, is a feature of the, soon to be released, upgraded CareVue® application.

### 3.3 Computerised scoring systems.

This section looks at why computerisation of scoring systems is the only means of ensuring efficient and consistent calculation of scores.

### 3.4 Chapter conclusion

The following resources were utilized in reviewing the literature:

Online resources utilised were Medline; Pubmed; Springerlink; Cinahl; Blackwell synergy. The keywords used to search the online databases included, Intensive Care; Critical Care; Human Resource Management; Nurse Dependency; Nurse workload Scoring Systems; Nurse: Patient ratios; Models of Care; Care pathways; Quality of Care; Critical Care Information systems; Nurse allocation; Skill mix; Skill Matching; Nurse Scheduling; Clinical Information systems; Scoring systems have been in use since the early 1970s therefore literature dating from the early 1970s was reviewed. In addition, library resources utilised included Trinity College Library, St. James's Hospital School of Nursing Library and An Bord Altranais Library.

### **3.1 Critical Care Staffing and Nurse- Patient Ratios.**

Critical Care is a 24 hour a day, 7 day a week clinical service that requires the deployment of a sufficient number of appropriately trained and experienced specialist and support staff (DoH UK 2000a). The delivery of critical care services involves a range of staff working either exclusively in the specialty or providing input across hospital specialties. The range of staff, therefore, comprises medical staff, nursing staff, health care assistants, technicians and all other members of the multidisciplinary team. All these personnel are recognized as having a crucial role to play in caring for critically ill patients. Human resource is vital in the delivery of critical care, to enable sufficiently educated practitioners to safely deliver this service, key issues of recruitment and retention, education and training, workforce planning and leadership need to be addressed (DoH UK 2001).

In 2001, The British association of Critical Care Nurses (BACCN) issued a position statement on Nurse/ patient ratios in Critical care. In formulation of the statement the BACCN looked at the relationship between the discrete aspects of critical care practices and nurse-patient ratios. The research undertaken led them to several studies that have been carried out to determine the role of the critical care nurse. The 2001 BACCN position statement is aimed at users and providers of critical care services, the statement reads as follow;

- Every patient must be cared for in an environment which meets their individual needs
- It is the right of every patient in a critical care unit to be cared for by a registered nurse
- Every critical care patient should have immediate access to a registered nurse with a post registration qualification in their specific speciality.
- There should be a congruence between the needs of the patient and the skills and knowledge of the registered nurse delivering the care

- Unconscious, ventilated patients should have a minimum of one nurse to one patient
- The nurse- patient ratio in any critical care area should not go below one nurse to two patients
- Severity of illness scores, dependency scores and nursing workload measurement should not be used solely for the purpose of determining nurse-patient ratios.
- Flexible strategies should be deployed to ensure that the fluctuating demands of the patient are met.

This statement addresses many issues in relation to nursing resource management in critical care but the essence of the statement is that safety and quality of care delivery must be central to nurse management decision making. It also states that scoring tools can not be used in isolation when determining nurse-patient ratios as there are many other factors need to be considered when making allocation decisions.

### **3.2 Scoring Systems and Tools in critical care.**

In critical care, the gold standard ratio of nurse-patient has traditionally been 1:1; this has been endorsed over the years (ICS 1997, Mackinnon et al 1998). The intensive care society in England (ICS 1997) and the DoH (1996) set this minimum standard of a nurse-patient ratio of 1:1, for patients in need of care in an ICU. This calculation was based on the assumption that another nurse would be available to manage the unit. It was recognized that this 'standard' must be applied within the context of each unit (ICS 1997). For example, there may be situations when a patient is so seriously ill that one nurse would be unable to care for the patient on his/her own, and would require the assistance of one or more nurses for a period of time. Conversely, there may be occasions when a patient in ICU does not require the individual attention of one nurse.

For many years patient census, based on this agreed nurse: patient ratio, was the most commonly used method of calculating nursing workload in ICUs (Stilwell & Hawley 1993). Essentially this meant that the number of patients indicated the number of nurses required to care for them. However, nursing workload on a particular unit is also

determined by the severity of each patient's illness, the complexity of care required, general physical condition, and his/her social-psychological status. (Kirk, 1999)

The census approach entails counting patients and staff without taking full account of the changing needs of the patients or the level of experience of the staff. For example, unplanned emergency admissions and/or the unexpected deterioration of a patient's condition can result in a situation where staffing levels do not comply with the 'standard' ratio because the census driven system is too rigid to accommodate such changes. Conversely patients can improve rapidly following treatment and fewer staff may be required. Consequently, although the 'standard' ratio is clear, widely recognized, and accepted, it lacks flexibility and can lead to under or over staffing of ICUs.

As Anderson 1997, Stilwell 1992, Stilwell & Hawley 1993 and the DoH Audit commission 1999 concluded that the traditional 1:1 nurse-patient ratio does not provide enough flexibility to meet the needs of the service and in order to meet service demand, flexible staffing according to workload generated by patients is required.

The Department of Health in the United Kingdom Audit commission (1999) put forward recommendations for adoption of a flexible approach to critical care staffing, moving away from rigid staff: patient ratios by means of workforce calculation methods.

#### Workforce Calculation methods

The UK Department of Health (2000b) proposed that assessment of workload and future needs requires the collection of robust data, appropriate analysis reflecting activity, case mix adjusted outcome and cost. They state that the extension of existing datasets and a requirement to demonstrate their use to justify investment and evidence of a high standard of clinical care is essential.

Data collection and analysis must be recognized as an integral part of the delivery of critical care and an essential part of clinical governance and risk management.

It is essential that health service managers have timely and accurate nursing acuity data so that they may allocate appropriate funding and nursing resources as patient acuity

varies considerably within and between patient classifications, and across case-mix, ward design and geography, shift type, occupancy and nursing skill mix. (Plummer et al 2005).

### **3.2.1 Patient Classification/ Scoring tools**

A huge range of patient classification systems/tools are used in critical care units to inform workforce planning, however, they are not always applied appropriately. Many of these systems/tools were not originally developed for the purposes of workforce planning and so their use in determining the nurse-patient ratio required in critical care settings raises a number of issues for the organization and management of these services. (Adomat and Hewison, 2004)

According to Soloman (1997), Patient Dependency/ nurse workload scoring Systems, in different forms, can be used to provide information for staffing decisions and budgetary developments, they are powerful tools in hospital management and Solomon anticipated that their use would grow as hospitals everywhere came under pressure to reduce cost and improve the delivery and quality of health care to patients.

In analyzing the appropriateness of identifying optimal nurse-patient ratios, dependency and severity of illness scoring systems can be used to facilitate the process. However, the literature suggests that these systems have a number of deficits as it is widely accepted that they do not reflect the totality of the nursing workload within the critical care environment (Campbell et al 1997; Dickie et al 1998; Adomat and Hewison 2004)

The BACCN (2001) state that, although there has been a considerable amount of work undertaken within this area, the evaluation and development of appropriate tools for the measurement of nursing workload is very much in the embryonic stage and aimed at individual unit level.

In the context of this research project and in working towards identifying the best nurse workload/ patient dependency tool for use in a nurse resource management system, the literature relating to scoring tools was reviewed. This overview is limited to the most commonly used and validated tools used internationally. These systems fall into three broad groups, which are designed to categorize patients according to their nursing needs.

1. Patient dependency classification systems
2. Severity of illness systems
3. Nursing intensity measuring systems

### **3.2.2 Patient dependency classification in ICU/HDU (Appendix B)**

The patient classification system is the scoring tool which is currently in use in St. James's hospital ICU as discussed in chapter 2.

A patient dependency classification system is a strategy for categorizing patients according to the amount and complexity of their nursing care requirements. Classification of patients according to their needs was developed out of a desire to accurately determine the optimal staffing levels to meet these needs. (Fagerstrom et al, 2000)

In most classification systems, patients are grouped according to the amount of nursing work required. The purpose of a classification system is to assess patients, categorize them and then allocate them to groups with similar nursing needs. The patients in each group are then given a numerical 'score' to indicate the amount of nursing care they need.

There are a number of ways of categorizing patients, each one based on a different set of premises and assumptions. In 1990, the ICS in England (ICS 1990) recognized it was important to have a system to categorize patients according to their needs. As a result, most NHS Trusts in England began using first European intensive care unit (EURICUS-1) and developed the EURICUS-1 system (Miranda 1996).

The EURICUS-1 category system was claimed to predict the nurse: patient ratios required and this was confirmed for general use (DoH 1996). The system was designed to combine nursing intensity measures and physiological indicators as a basis for determining nurse: patient ratios. Patients are placed in one of the four categories of need described below.

Category 1: In this category patients are those who require close observation, but not necessarily the continuous presence of a nurse at the bedside. The patient is considered to be in need of HDU care. The expectation is that one nurse can care for two patients.

Category 2: Patients are those who require a nurse at the bedside continuously for 24 hours/day. It is generally accepted that patients in this group will form the majority of patients in an ICU, and be categorized as ICU. They will be very ill but will not require frequent interventions, which constitute a major addition to workload.

Category 3: These patients are seriously ill and will require a minimum of 1.5 nurses for a large proportion of the shift. It is generally assumed that for a majority of a span of duty two nurses will be required to care for the patient.

Category 4: Patients in this category are the most seriously ill and require the attention of two nurses for the majority of the shift. This category is rarely used as patients generally become stabilized and re-categorized into category 2 or 3, or deteriorate and die during the shift.

### **Limitations of Patient dependency classification systems:**

Patient category scoring systems have come in for criticism for not being truly reflective of nurse workload. For example, using the scoring system a category 1 patient may on paper require a 0.5 Nurse where the reality is that due to reasons not considered by the scoring system such as psychological care, the patient requires significantly more nursing

resources. In addition, the patient category system, like many of the other systems, is not a nurse allocation tool as it is completed retrospectively. This tool does not allow for shift planning in relation to nurse allocation and it does not, therefore, take any account of skill matching in relation to individual patients needs (Hughes, 1999).

Despite its flaws, the widespread use of this tool was confirmed in a survey carried out by the Royal College of Nursing (Royal College of Nursing 1999), which found that of 176 ICUs in England 55% used patient dependency scoring systems for estimating workload and therefore the number of staff required. However, because of the flaws outlined earlier, the system may not give an accurate assessment of the skill-mix required or reflect a realistic estimate of nursing workload undertaken. Moreover, the level of nursing experience can distort the classification, thereby adding to the system's unreliability.

One other factor not accounted for by such scoring systems is the time during the shift that additional workload occurs and this may be significant. For example, a new admission to ICU may require two nurses for a short while and only one nurse after the patient is 'settled'. If admissions are distributed evenly during the shift then one nurse may be sufficient. If several patients are admitted at the same time then one additional nurse may not be enough. This also applies to other categories of additional work.

The only way to detect an uneven distribution of workload is to measure workload more frequently than every shift, e.g. hourly. This is generally not feasible and consequently such scoring systems are a 'trade off' between accuracy and utility.

Although patient dependency scores are sometimes used to determine nurse: patient ratio requirements, they do not necessarily reflect the amount of time a nurse spends looking after a patient (Kirk, 1990). For example, patients who are extremely ill may be unconscious, immobile, and have all their physiological needs met by supporting technology, requiring minimal nursing time. On the contrary, a patient who is recovering may require a greater amount of nursing activity because he/ she are able to communicate

pain and discomfort. Also, patients who are conscious in an ICU may be frightened, anxious or distressed, requiring a greater nursing input for reassurance. (REF)

In summary, the literature suggests that patient dependency/classification systems can only provide a guide for estimates of nursing need. They cannot be used with accuracy to determine the nurse-patient ratio required. There has been little change over the years in the categorization of patients in ICU and the calculation of nursing staff required. It seems whichever methods each unit or ward uses to measure it, simple patient dependency is only one factor in determining staffing requirements (RCN 2003).

### **3.2.3 Severity of illness scoring tools**

Patients admitted to ICU/HDU can also be classified according to the severity of their illness, this information is frequently used as a basis for prognostic and nurse workforce planning. In an attempt to identify a patient's prognosis and overall ICU/HDU outcomes, a variety of scoring systems have been developed based on basic physiological values, focusing on severity of illness.

Severity of illness and morbidity scoring systems are used for predicting patient outcome and costing patient care. Nurse managers have also used some of the severity of illness scoring systems to calculate nursing dependency and overall nurse workload (Carr-Hill & Jenkins-Clarke 1995).

These scoring systems are based on either physiological or therapeutic measures. Points are assigned to these measures on a scale of increasing order of divergence from normal values (in the case of physiological variables), or an increase in complexity (in the case of therapeutic measures).

The points are calculated to give a severity of illness score for each patient. These indices accurately quantify the severity of illness and predict the overall mortality for a group of

patients. The scores can allow meaningful comparisons to be made between the severity of illness/therapeutic interventions and outcomes in different ICUs. This is in turn used as a basis to estimate the number of nurses required for specific patients and to 'cost' patient episodes. The most frequently used systems are the APACHE score, the SAPS II score and DRGs.

### **Acute physiological and chronic health evaluation score (APACHE II Appendix C)**

The APACHE II score is currently used in the domain, the score is mostly automated but does require some manual data entry by the medical staff.

The acute physiological and chronic health evaluation (APACHE), severity of disease classification was developed by Knaus et al (1981), in an attempt to classify prognosis groups of critically ill patients, by determining the success of different forms of treatment. APACHE II was later developed as a simplified, classification system using 12 acute physiological variables, which are weighted for degrees of abnormality by assigning ratings of 0 (normal), 1, 2, 3 or 4 (very abnormal). A score of 0 for one of the physiological parameters is in the normal range, whereas a score of 4 is abnormal. The initial score employs the worst values in the first 24 hours of intensive care, and then adds points for age and chronic health problems. The total is the APACHE II score.

Physiological variables refer to specific parameters such as the patient's blood potassium level or the patient's mean blood pressure. Physiological variables can be distinguished from therapeutic variables as therapeutic variables refer to treatments initiated as a consequence of altered physiological variables for example CRRT is a therapeutic variable, as is mechanical ventilation.

Following treatment the acute physiological component score should decrease. For example, if a patient is admitted in a diabetic coma he or she will score 4 for blood sugar, level of consciousness and other physiological measures. However, following treatment

the scores may quickly return to 0. In the APACHE system the score of 4 (the worst score) would apply for the following 24 hours and staffing would be based on this.

APACHE II has been validated through its use with over 17 000 patients as a prognostic system for groups of patients. Although popular for its prognostic value, the APACHE score is sometimes used inappropriately for the purpose of calculating the number of nursing staff required. APACHE is primarily considered as a tool for outcome prediction as is widely used for this purpose. APACHE does not necessarily provide reliable information about nursing dependency classification and nursing workload, because prognostic and severity of illness scoring systems measure only the physiological stability of patients not their nursing needs. (Chellel et al 1995, Cho & Wong 1997)

### **Simplified acute physiology score II (SAPS II Appendix D)**

The simplified acute physiology score (SAPS II) (Le Gall et al 1993), is a system which converts the 'illness' score to a probability of hospital mortality. Fifteen significant variables were used to derive a total score. Multiple logistic regression analysis is used to calculate the overall prognostic score.

A benefit of this system is that the method of data collection is very simple and quick to use. Le Gall et al (1993) estimate that data can be collected for each patient in <5 minutes, because routine recordings of clinical observations are used, e.g. blood and urine samples from the patient. An updated version (SAPS III) was launched in 2004, this system takes into account changes in critical care practices as well as changes in software developments over the last 10 years, The score is easily automated and is available as standard on most ICU Clinical Information systems including CareVue®.

### **Limitations of APACHE/ SAPS II:**

The multifactorial aetiology of disease in ICU/HDU patients makes the SAPS II system more practical to use than APACHE II or III. It is also clear that SAPS II has

been useful in accurately predicting hospital mortality within the UK (ICNARC 1997). However, because of its design it is not suitable for calculating patient dependency in terms of nursing requirements or nursing workload measures. Yet some hospitals have used this diagnostic related system to predict the number of nurses required for forthcoming shifts (usually the next 24 hours) (Stilwell & Hawley 1993, DeGroot 1994a). The main problem with this is that patients could score very highly on the 15 physiological variables (indicating that they are very sick), and yet require minimal routine nursing input. Stilwell and Hawley (1993) recognize that SAPS II can provide useful case-mix information, which can inform workforce planning systems, but on its own merely provides physiological status data. Using SAPS II or other physiological scoring systems to classify dependency or nursing workload may result in simplifying assessments of nursing need.

### Diagnostic Related Groups (DRGs)

Other systems of measuring patient sickness levels include variations of diagnostic related groups. (DRGs, Green et al 1988). The DRGs are based on 475 mutually exclusive medical and surgical diagnostic categories. The DRG is determined by the 'Principal Diagnosis', or the main reason that the patient was admitted to hospital. Factors such as co morbidities, age and length of stay, are given scores that enable outcomes to be costed and retrospective acuity to be measured.

### Limitations of DRGs

The overall calculated DRG represents the cost for patient treatment and includes an assessment of workload. However, the 475 medical and surgical diagnostic categories were never tested against the nursing activity they generated. The reliability of estimating the workload generated from each diagnostic group is questionable. For example, an analysis by Fetter (1991) of 29 509 days of care demonstrated that for 12 842 patients medical diagnosis alone was not predictive of nursing workload, even for patients with 'routine', accepted diagnoses and treatments.

### **3.2.4 Nursing intensity measures**

Given that patient dependency classification systems and patient severity of illness scores do not accurately reflect the amount and category of nursing effort required to deliver optimal care, nurses have looked to their own activity as a source of information for the measurement of workload (Soeken & Prescott 1991, Bulechek & McCloskey 1992).

Attempts to classify patients as a basis for costing nursing care has led to the development of a variety of nursing intensity measures. Nursing intensity is a measure of the amount and complexity of nursing care needed by a patient. Examples of commonly used nursing intensity measures are;

#### **Nursing interventions classification (NIC Appendix E)**

The nursing interventions classification (NIC) was developed at the Iowa College of Nursing, in the USA (Bulechek & McCloskey 1992), with the intention of identifying common nursing interventions required for groups of patients. Seven main groups of nursing activities were identified

- Nursing diagnosis.
- Gathering information for a physician to make a medical diagnosis.
- Nursing initiated treatments.
- Physician initiated treatments.
- Daily essential function activities initiated by the patient/client/relative.
- Evaluation of nursing/medical treatments.
- Administrative and indirect care activities.

Each of these seven groups of activities was also made up of subcategories of interventions. Fourteen surveys were undertaken, which validated a total of 336 interventions confirmed by 483 nurse experts and consensus professional focus groups, as part of the Delphi methodology (Bulechek & McCloskey 1992).

The standardized list of 336 direct care nursing interventions was developed by randomly selecting 250 that were distributed to each of the 483 nurses in the study. Each member independently categorized an intervention label and rated each activity for how characteristic it was of the intervention (McCloskey & Bulechek 2000).

#### Limitations of N.I.C:

The intervention labels apply to nurses in all specialities and all care settings, regardless of expertise. However, different nursing skill levels in ICU mean that varying amounts of time will be needed to undertake each task, thereby rendering the system unreliable. A 'common' language for nursing intervention, which involves the 'average' time taken to undertake various tasks/interventions, as basis for calculating nurse-patient ratios is inappropriate. (Bulechek & McCloskey 1999)

In addition, nursing intensity measures such as N.I.C. although helpful in some areas of care, can fail to recognise the emotional labour and hidden workload that cannot be labelled as a task.(Bulechek & McCloskey 1999)

#### **The Therapeutic Intervention Scoring System: TISS-76 and TISS-28 (Appendix F)**

Cullen, Civetta, Briggs and Ferrara developed the Therapeutic Intervention Scoring System in 1974 with the double objective of measuring severity of illness at patient level and assessing the corresponding nursing workload in the Intensive Care Unit.

In 1981, the Acute Physiology and Chronic Health Evaluation (APACHE) scores made their appearance using severity of illness for benchmarking case-mix and predicting outcome. As a consequence of this, TISS was no longer used for measuring severity of illness while its indication for measuring nursing workload has remained unchanged.

The distinction between the TISS and APACHE scores (Acute Physiological and Chronic Health Evaluation) is that TISS includes therapeutic variables related to severity of illness where APACHE uses physiological variables

The original version of TISS used 76 variables, Over the decades since its development, several other versions of TISS have made their appearance (Cullen et al 1994) the 2 versions of TISS that are primarily used today are the TISS (which has 76 therapeutic variables and TISS-28 (a modified version of the full TISS with 28 variables). TISS can be used for evaluating the match between the number of nursing full time equivalents staffing a given ICU and the required number of full time equivalents in view of the number and the type of patients admitted to the unit. TISS measures severity and consumption of nursing manpower by allocating points which correspond to nursing resource utilization.

### Limitations of TISS

Miranda (2001) argued that the critics ignore the fact that the development of the instrument was largely based on the documented principle that severity of illness correlates significantly and almost linearly with nursing workload. In this way, if a patients condition were appropriately characterized by therapeutic items involving nursing activities (e.g. mechanical ventilation, dialysis, vasoactive support) several basic or associated nursing activities could be omitted from the score either for scientific or for operational reasons thereby reducing scoring cumbersomeness.

The TISS system was adopted up by nurse managers in the UK in the early 1980s because it appeared to reflect the nursing input required for different groups of patients and not merely their severity of illness score. In the UK, it was suggested that a class IV patient (Mechanically ventilated ICU patients) required a 1:1 nurse-patient ratio and that a grade E nurse who has a English National Board for Nursing Midwifery and Health Visiting (ENB) 100 certificate in critical care was capable of managing a patient scoring 40–50 TISS points (British Association of Critical Care Nurses 1995, ICS 1997.) Research following the introduction of TISS indicated that it is a valuable means of assessing care needs in an ICU and can be used for predictive purposes as a prognostic indicator (Reis-Miranda 1997). As such, the TISS score can be utilised to determine the

grade of nurse required to care for a particular patient based on the patients therapeutic needs.

Garfield et al (2000) investigated the use of the TISS and Nurse dependency scoring tool within the High Dependency environment within Norfolk and Norwich Hospitals. The TISS score proved to provide a more accurate reflection of nurse workload measurement.

The main benefit of TISS is the use of interventions that are easily recognized at the patient's bedside by the nurses however, acceptance of TISS is not entirely universal; this is largely because it measures medical interventions rather than nursing ones. This could be argued on the basis that the line between medical and nursing interventions in ICU becomes greyed and as such, a scoring tool cannot possibly only reflect nursing interventions in determining workload. Nurses need to be involved in the translation of the TISS points/class by identifying nursing requirements if this system is to accurately gauge nursing intensity (Reis-Miranda 1997).

Another issue with TISS is that some of the therapeutic items can be interpreted differently. For example, multiple infusion lines that run into one vein may be interpreted as multiple lines, yet the care for the infusion site itself will only take up the time needed to care for one infusion site. This limitation is more related to the users knowledge of the tool, training in its use is required to ensure that the scoring data is recorded consistently and accurately. (Garfield et al, 2000)

### **Nine equivalents of nursing manpower use score (NEMS Appendix G)**

In 1994, the foundation for research on intensive care in Europe (FRICE) began a large prospective survey of ICUs in Europe, subsidized by the European Commission.

A multidisciplinary team called EURICUS-1 undertook the study and the measurement of the daily nursing workload was one of the variables investigated.

A simplified version of TISS was used as a baseline, because of its applicability across Europe. As a consequence, the nine equivalents of nursing manpower use score (NEMS)

was developed. The original TISS-28 items were conflated into nine main categories, which were then tested by 3000 nurses in 89 ICUs in 12 European countries (Reis-Miranda et al 1997). As a result, NEMS is claimed to be a suitable therapeutic index to measure nursing workload in ICU, as well as being a means of comparing nursing workload between different ICU, and to predict and plan nursing staff allocation at the individual patient level.

### Limitations of NEMS

There remain issues related to objectivity and reliability that need to be taken into account (Reis-Miranda et al 1997). These include:

- Interpretation of nursing interventions which may compromise inter-rater reliability.
- Rater's experience affecting item scoring (McKeon 1996, Scholes & Moore 1997).
- Time consuming to use.
- Scoring is often retrospective.
- NEMs allocates patients to each of the 9-items, without taking into account the nursing workload required.

According to Reis-Miranda et al, 1997, the main limitation with NEMS is in the way it is used. Although it employs a system similar to that used in TISS-28 it is linked to the patient's severity of illness, treatments and interventions and consequently not suitable for measuring the nursing input. When used inappropriately NEMS will understandably have a poor discriminative power in informing estimates of workload at the individual patient level. (Miranda et al 1997)

### **System of patient related activities score (SOPRA Appendix H)**

The Intensive Care National Audit and research centre (ICNARC) in the U.K. devised the System of Patient Related Activities score (SOPRA) in 1998. This system was developed through professional consensus and shifted the focus from interventions to activities relating to the patient and their family. The SoPRA dataset evolved from discussions

within the working group and from critical care staff feedback. The score is a 24 hour score, integrating activities over the day. Data collection starts at midnight and is updated at the end of every shift and finally at 23:59. A calendar day is defined as 00:00 to 23:59 or part thereof. The list of activities includes all the major activities undertaken on adult Intensive care units. Each activity is 'weighted' as agreed by consensus by the Working Group. In total, there are 69 activities in the SoPRA score, each with a corresponding weighting.

#### Limitations of SoPRA:

The SoPRA scoring tool is intended to indicate the degree of care necessary when caring for a critically ill patient. This scoring tool is limited to use within the UK, it has not been found to be used outside of the UK. A study carried out by Vaja et al in Leicester General Hospital in 2000 looked at the correlation between TISS, Nurse dependency scores and the pilot version of SoPRA. The study concluded that despite having many common factors there was no correlation between TISS and SoPRA and Nurse dependency scores and SoPRA. Nurses expressed a preference for the SoPRA score as it was found to be more specific and less suggestive than TISS. It was also felt to be more representative of current Intensive Care practice. This was however a small isolated study and SoPRA has not been sufficiently well validated to be deemed reliable.

### **3.3 Computerisation of Scoring Systems**

Information systems in the health care industry have evolved from an administrative to a strategic orientation. They are now commonly used, not only to enhance productivity but also to improve effectiveness and create a competitive edge. Health care organizations have even secured enormous strategic advantages by using Information Technology to radically transform many of their operations (Venkatraman 1996; Porter et al 1986; Clemons 1985;)

Solomon (1998) stated that experience had shown that manual Patient scoring systems lacked the ability to process and provide information fast enough. In addition to this, he said that manual calculations were overcome with the effective utilization of advances in computing technology and that scoring systems were particularly suitable for automation since their essence is too complex to handle manually. He stated that automation of these systems was essential in view of their critical role and their inherent complexity.

According to Soloman (1998) hospitals nowadays should justify the numbers of staff they require to provide quality care and they should also maintain an accurate database for staffing levels, budgeting and cost containment. Manual scoring systems are expensive to develop and implement and they also require constant monitoring after implementation to ensure reliability and validity (Wong 1995). Another weakness of the manual system is its use of patient classification, which is limited to that moment in time and can only reflect the state of dependency for that period (Hay et al 1988, Hoffman et al 1986), however, the need to extract timely, accurate and relevant information from growing data sets and the desire to identify and leverage specific expertise have helped to stimulate technological progress in automated systems. This is particularly relevant to policy makers and practitioners in the field of health care planning and human resource management (Soloman 1998). Furthermore, their integrity against cheating by inflating patient dependency levels can not be guaranteed. In addition, the manual systems are slow to use for predicting staffing requirements, especially in crisis situations. Over the past 2 decades, the automation of manual systems has emerged as a viable method for supporting decision-making. (Broderick et al 1992) but little attention has been given to the application of automated Patient Dependency Systems in hospital resource management. Furthermore, their importance in hospital management has been underestimated. Automated systems technology has already delivered significant commercial benefits and is now useful, easy to use, and reliable. (Dos Santos 1991)

Automated Systems have the ability to transform manual and laborious operations into a set of executable routines, which can produce a particular conclusion. Therefore, they

offer the best mechanism for storing, updating, retrieving, and manipulating data for patients' care. (Solomon 1998)

The inefficiency of the manual calculation of daily staffing requirements for each unit. Using appropriate systems solutions, these predictions can be made faster and more accurate, in addition, they can broaden the scope of the data collection process which can help to satisfy other organizational needs and help in improving the quality of patient care delivery.

Also, since Information Technology has matured, hospitals can no longer afford not to make use of technology to utilize and control their resources more efficiently. The majority of scoring tools require quite complex calculations this in turn requires the development of a set of computational algorithms suitable for programming in a Patient scoring system. (Solomon, 1998)

### **This type of lengthy and complex calculation is best performed using computers**

Solomon (1998) suggests that, regardless of the scoring tool in use, (TISS/ NEMs/ SoPRA/ Patient Category score) or the way in which it is applied, the calculations, even though they may appear in some cases to be simplistic, still require calculation which we know is best performed by computers. Computerized systems are best suited to address the computational issues related to the calculation of scores to ascertain patient dependency and nursing workload.

Clinical Information systems such as CareVue® have already successfully integrated a scoring tool. The current version of CareVue® includes a semi-automated APACHE II scoring tool. The upgraded version, due for release in 2007, will include a TISS-28 scoring tool. The availability of an automated TISS-28 would prove to be a major benefit going forward. Interfacing capabilities between CareVue® and the proposed system should allow completed TISS scores to download automatically to a nurse resource management system for evaluation in relation to resource allocation.

### **3.4 Chapter Conclusion**

Existing patient category/dependence systems are not entirely effective in accurately gauging the necessary nurse-patient ratios in ICUs. The inclusion of direct and non-direct nursing care linked to individual patients may provide a more accurate assessment of nursing requirements (Adomat 2001).

Currently nurses in ICU use systems to categorize patients that are imprecise, and which do not accurately gauge the level of nursing input to patient care. There is a need to recognize the level and intensity of nursing input required, regardless of the original category assigned to the patient. If the needs of patients in ICU are to be met a more reliable way of determining the number and skill level of nurses will have to be developed.

Severity of illness scores such as APACHE, SAPS II and DRGs can only inform clinicians of the potential prognosis of patients and cannot be relied upon as a basis for calculating nurse staffing levels in ICU. They can, however, be used to assess the likely benefit of ICU care for patients in relation to overall prognosis and costs related to ICU care.

Currently, TISS and NEMs are the most well validated of the nursing intensity measurement scoring tools and although not skill matching systems, when used correctly, they can provide nurse allocation and planning decision support. Although TISS has its limitations, there does not appear to be a 'perfect' scoring tool. TISS appears to be the most well validated of all the nursing intensity measures. As such, if used correctly and consistently, TISS could provide a solution to workload measurement in critical care. In the context of the domain, the updated version of the CareVue® system, which will be rolled out in late 2007, incorporates an automated TISS-28 score. This could represent a very useful basis for determining patients needs if utilized in conjunction with a nursing resource management system.

The DoH (2001) concludes that effective organization and delivery of services means that the right number of nurses with the knowledge and skills appropriate to the level of service is provided. Effective workforce planning, recruitment and retention and education and training are crucial to ensuring that the nursing resource matches demand.

It is understandable therefore that managers may turn to a variety of dependency or categorization systems to assist them in the management of patient through-put and the nursing workforce. What is required is an integrated scoring solution, the solution cannot look at the calculation of nursing workload in isolation, it must also go some way to assisting in the determination of best allocation of available nurse resources based on the needs of the patient population.

Essentially, an effective system solution must be multifactorial, accounting for all elements of nurse resource requirements and providing more than a scoring tool. The TISS-28 score appears to be the current best fit available for informing nurse resource management and in providing a basis for workload measurement in moving forward towards developing a nurse resource management system.

## **Chapter 4: Nurse Resource management.**

This chapter looks at the literature related to nurse resource management in terms of quality of care, health and safety issues, nurse scheduling, nurse allocation and allocation and nurse resource management systems.

4.1 Quality of care issues in critical care

4.2 Recruitment and retention of staff in ICU

4.3 Health and safety issues related to staffing

4.4 Nurse Scheduling in critical care

4.5 Nurse allocation and Nursing Skill Mix/ Match in critical care

4.6.1 Nurse Resource Management systems.

4.6.2 Trendcare® system

4.7 Chapter conclusion

### **4.1 Quality of care issues in critical care**

During the past decade, an increasing demand for nursing personnel combined with a limited supply has been reported in critical care services both in North America and Europe (Bion and Bennett 1999, Ewart et al 2004). Limited supply has been attributed to difficulties in recruiting and retaining nurses and, especially in critical care areas, to a shortage of qualified nurses with specific qualifications and skills (Odam 2000, Harrison and Nixon, 2002). As regards demand, this has been attributed mainly to the increasing numbers of patients admitted annually to ICUs (Ridley et al, 1999). The cost per day in ICU has been estimated to be much higher than in general hospital wards and a high proportion of this budget is consumed by nursing staff costs (Harrison and Nixon, 2002, Parviainen et al, 2004). The imbalance between supply and demand and the high cost critical care environment has rendered imperative the need for systems used for the appropriate allocation of nursing resources (Kiekkas et al, 2007). The necessity of measuring nursing workload is highlighted not only by increases in patient care demands but also by the fact that nursing workload is closely related with patient safety and quality of care (Kiekkas et al, 2007). Health service provision by nature is labour intensive and

human resource costs are estimated to account for as much as two thirds of total expenditure (World Health Organisation, 2000). Accordingly, health systems worldwide are searching for new ways to contain expenditure while ensuring quality and managing risk. Within this context, staffing levels and skill mix are recognized as central elements of cost and are now considered the primary determinants of quality (Buchan et al 2001).

#### **4.2 Recruitment and retention of staff in ICU**

Human resource is vital in the delivery of critical care; to enable sufficiently educated practitioners to safely deliver this service, key issues of recruitment and retention, education and training, workforce planning and leadership need to be addressed (DoH UK 2001).

The recruitment and retention of nursing staff in critical care remains a high priority in management terms. In an international study by Williams et al (2001) nurse staffing in critical care was found to be one of the most important issues of concern in Europe, the USA and Asia. An Australian survey of critical care nurses undertaken by Darvas and Hawkins (2002) reported that good management within a unit, ability to self roster by nurses and having an active role in patient care issues were important retention issues for critical care nurses.

A recently published Department of health funded study (2007) suggests that over half of young female nurses plan to leave their current positions. The study, carried out by Professor Geraldine McCarthy of University College Cork, was conducted through questionnaires and involved 352 registered nurses at ten hospitals throughout Ireland. The report shows that hospitals have trouble retaining the best and most capable young nurses with specific problems keeping experienced staff from critical care environments. Almost 20% planned to leave positions in critical care and lack of job satisfaction was cited as the most significant factor in deciding to leave (Burke, 2007). Inadequate staffing is a major stressor in critical care and as such can result in poor job satisfaction. Inadequacy

does not necessarily relate to numbers, but also to the skills and knowledge base that staff possess in relation to the needs of patients. (Jasper, 2007)

### **4.3 Health and safety issues related to staffing**

Currently, a chronic shortage of qualified nurses is contributing to industrial instability across the health sector and continues to raise both professional and public concern about the quality of care delivered to people in hospitals and the risks associated with staff shortages (Buchan and Shocalski 2004).

According to a study by Tarnow-Mordi et al (2000), ICU patients are more likely to die when exposed to excessive workload. This association between workload and mortality has been mainly attributed to inadequate supervision of patients, errors committed by staff and overcrowding resulting in nosocomial infections.

A study by Beckmann et al (1998), which involved the analysis of 3,600 incident reports, showed that staff shortages in ICU, resulting in high workload was clearly associated with compromised quality of care, errors, documentation problems, incorrect equipment setup and inadequate supervision of patients.

An Australian study by Morrison et al (2001) looked at the effect of nursing staff inexperience on the occurrence of incidents in the critical care environment. The objective of the study was to identify incidents associated with nursing staff inexperience and estimate their effect on the quality of patient care. Incidents related to nursing staff inexperience were extracted from the Australian Incident Monitoring Study in Intensive Care Units (AIMS-ICU) database and analysed using descriptive methodology. 1,472 incidents were identified as related to nursing staff inexperience. An undesirable major adverse patient outcome was selected in 20% of reports. The study concluded that nursing staff inexperience can have a negative impact on the quality of care delivered to critically ill patients as shown by the occurrence and outcome of incidents related to such inexperience. Errors were found to be more likely to occur when nursing staff

inexperience is combined with nursing staff shortage, inadequate supervision and high unit activity. Morrison et al (2001) recommend that nurse managers and educators consider the special requirements of inexperienced nurses when scheduling or employing staff. Safe patient care requires these issues be included in discussions related to Intensive care nurse resource management.

#### **4.4 Nurse Scheduling in critical care**

Nurse scheduling can be classified by a time horizon in which decisions are made. Nurse scheduling can be described as the short term (usually a few weeks) allocation of nurses to a working time period. (Burke et al 2004)

Most nurse scheduling literature can be found in Cheng et al (2003) and Burke et al (2004) providing nurse scheduling survey papers. They summarized the overview of the nurse scheduling models and the solution methodologies from the 1960's to 2004 and found that the majority of the literature on nurse planning is in fact on scheduling. The models were found to only consider the nurse budgeting and scheduling stages of nurse resource planning; they ignored changes in staff and patient forecasts and they assumed the schedule would be followed as planned. Anecdotal evidence does however suggest that changes to schedules occur frequently and this has an impact on nurse resource planning.

Cartledge (2001) carried out a study to explore the reasons why nurses leave ICU and cited a lack of flexibility in scheduling systems as a dominant factor. She concluded that scheduling systems need to retain flexibility in order to help retain staff.

Self-scheduling is one aspect of allowing for increased flexibility in working for nurses. It appears to be a part of the employment practice that nurses want and that can potentially help with recruitment, retention and improve the quality of patient care.

Bailyn et al (2007) described a pilot project on self-scheduling (self-scheduling) for hospital nurses to assess its potential values and difficulties in implementation. A self-scheduling programme was implemented on one nursing floor for a year. Its effect on nursing perceptions was gauged by an informal questionnaire, and its effect on the nurse manager was gauged by counting change requests and sick calls, as well as her time spent on scheduling and her perceived annoyance in doing it. During the time of the pilot project nurses felt that they had better control of their time and were able to give better patient care, change requests decreased, as did the time spent by the nurse manager and her sense of annoyance. However, since the nurses did not adhere to the rules of the programme, despite repeated efforts by the nurse manager, the attempt floundered. Bailyn concluded that self-scheduling can have positive results for nurses and benefit the nurse manager but if nurses see this as an individual entitlement instead of a balance between individual and unit benefit, everyone loses.

In summary, nurse scheduling is an integral part of nurse resource management. In specifying a systems solution, the nurse scheduling element must balance flexibility for staff with ensuring adequate numbers of suitably qualified nurses to be available for or patient care on each and every shift. A system solution should allow nurses to make roster requests within a rule based framework, this should allow equitable distribution of preferred and non preferred shifts. In addition, the nurse roster component of a system solution should provide a means of ensuring that nurses are aware of their work schedule at least one month in advance of time and should also factor in overtime availability. In short, the system should address the current scheduling issues that have been identified as inefficiencies in the ICU setting.

#### **4.5 Nurse allocation and Nursing Skill Mix/ Match in critical care**

*If staff allocation decisions are based on inadequate information and/or inappropriate consideration of all contributing factors to required nursing skill, then the risk exposure to adverse events and poor outcome is likely to be greater (Rischbieth 2006).*

Nursing skill mix and staffing decisions are widely debated and often hotly contested. Management mandate is to recruit and retain nurses and ensure they are sufficiently trained to provide quality care within their competence (Shuldham, 2004). Nurses want good working conditions, appropriate training, a fair workload and collegial support (Aiken et al, 2002, Australian Health Workforce advisory committee, 2002). Intensive Care Units, nurse numbers, available nursing skills and patient allocation decisions impact directly on care provision and outcomes according to Rischbieth (2006). She argues that staffing decisions that are based on insufficient knowledge which lack consideration of all pertinent factors result in poor skill matching, potential adverse events and poor outcomes and that a critically inextricable link exists between staffing decisions, patient safety and risk in the Intensive care Unit. She recommends the use of a multifactorial skill-matching approach within a dedicated staffing decision-support system.

The Royal College of Nursing in its Guidance for nurse staffing in critical care (2003) suggest that a senior critical care nurse can most accurately identify the nursing resource required by a critically ill patient. Additional issues need to be considered when allocation decisions are being made, according to the RCN (2003) and Ball and McEgliott (2002) these are;

- The knowledge and experience of the nurse caring for the patient
- The aspects of care that require the full attention of the critical care nurse even if the patients dependency needs are minimal, for example, spending time with bereaved families.

- Occasions where more than one nurse is required to provide care, for example, when admitting or transferring a patient, repositioning patients with complex needs.
- Adequate numbers of skilled nurses should be available in critical care areas to respond to the shared and sometimes unpredictable workload.
- In integrating risk management with dependency, for example, patients that are dependent on inotropic drugs or haemofiltration are at risk and need a critical care nurse to detect and prevent possible life threatening complications.

Amanda Rischbieth, has written extensively on staffing in critical care. Indeed the only reference to the term ‘skill matching’ that the author of this literature review has been able to locate is found in her very recent work. She herself describes the idea of skill matching in relation to nurse allocation in critical care as a new and innovative approach to workforce planning and management. Rischbieth has found that no systems to formally assess skill and then match the allocation of nurses to patients in ICU have been described and suggests that current practice is somewhat haphazard. Rischbieth argues that skill matching in ICU is a more innovative approach to ICU workforce planning and requires a comprehensive multifactorial approach rather than using single indicators such as nurse-patient ratios or utilization hours.

The following factors need to be considered in relation to skill matching;

- The nurses’ critical care qualification
- Nurses’ ICU experience
- The nurses’ demonstrated skill level and/ or completion of clinical competence in line with ICU specific evaluation
- The layout of the ICU, physical location of the patients in the unit
- The availability, type of and accessibility/ proximity to, appropriate support staff (educators/ floats/ ancillary staff)
- The nurses’ ability to work with minimal supervision in managing specific therapies
- Peer knowledge of the individuals attributes and critical care knowledge from previously worked shifts in that ICU

- Nurses familiarity with unit specific technologies and operation of equipment
- Knowledge of patient acuity
- Knowledge of required patient therapies/ interventions

In the ICU setting, there is a need for nurse-patient allocation decisions to be made rapidly and judiciously, often with dynamic review required throughout a given shift as demand fluctuates. If staff allocation decisions are based on inadequate information and/or inappropriate consideration of all contributing factors to required nursing skill, then the risk exposure to adverse events and poor outcome is likely to be greater (Rischbieth 2006).

In summary, the information required for the nurse in charge to make appropriate allocation decisions should be easily accessible. This includes patient workload/ dependency scores, the patient plan of care, the available nurse complement and their relevant skills and competencies.

#### **4.6 Nurse Resource Management systems.**

Information systems in the health care industry have evolved from an administrative to a strategic orientation. They are now commonly used, not only to enhance productivity, but also to improve effectiveness and create a competitive edge. Health care organizations have even secured enormous strategic advantages by using Information Technology to radically transform many of their operations (Venkatraman 1996; Porter et al 1986; Clemons, 1986)

Solomon (1998) looked primarily at the automation of patient dependency/ nurse workload scoring systems, but did suggest that there is a clearly recognized need to develop specialized Information Systems for human resource management within hospitals because of:

- The increasing need for accurate patient information which can be provided by the computerization of Patient Dependency Systems on a long-term basis;

- The need for faster methods of continuous re-examination and revision of Health Care Indicators whenever there is a change in the population and/or the nature of patients' treatment;
- The fact that the Time Standards method used can not be generalized from one unit to another and must be determined for each new unit within the same hospital;

Soloman recognized the inefficiency of the manual calculation of daily staffing requirements for each unit. He suggested that, using appropriate systems solutions, these predictions can be made faster and more accurate, in addition, they can broaden the scope of the data collection process which can help to satisfy other organizational needs and help in improving the quality of patient care delivery.

Also, since Information Technology has matured, hospitals can no longer afford not to make use of technology to utilize and control their resources more efficiently. In 1998, Solomon presented a number of factors that could influence the automation of Patient Dependency Systems in hospital settings but central to their effectiveness was the requirement for computations and calculation. This was in recognition of the fact that the majority of scoring tools require quite complex calculations.

Several commercially available nurse resource management systems have been identified during the course of this research. However, few of them appear to holistically address the resource management issues. For example, there are many computerized tools that can provide nurse scheduling functions and automated patient dependency/ nurse workload scores. There are systems that can assist with nurse workforce planning by utilizing retrospective data for forward planning but only the Trendcare® system appears to combine the functions required for efficient nurse resource management.

#### **4.6.1 Trendcare® system**

The TrendCare® system is a computerized patient nurse dependency and clinical pathway management system. ([www.Trendcare.com](http://www.Trendcare.com)) The functionality of the system includes patient acuity and workload management, clinical resource management and clinical costing. The system also includes other functions such as; discharge analysis, bed management and patient diet ordering. A human resource management (HRM) component is also included to track staff competencies, training, performance reviews and staff utilisation.

Dr Virginia Plummer (2005) of Monash University completed a 3 year doctorate study confirming the accuracy and validity of the Trendcare® system. The study concluded that hospitals currently using mandated nurse-patient ratios as a method of staffing could improve patient care, allocate fairer workloads and save money if they scheduled nurses according to patient needs by using the system. Plummer's study found that the TrendCare® system predicts nursing care requirements with greater accuracy than ratios for all hospital settings and patient conditions in public and private hospitals.

Under the TrendCare® system there is a closer correlation between the needs of a patient and the care provided; if a patient's condition altered, or there is a sudden influx of patients after a major accident or incident, the TrendCare® system can identify the required staffing arrangements.

TrendCare® user sites have reportedly achieved significant improvements in quality care, staff satisfaction and efficiencies by using the system. Efficiencies have reportedly been gained by using TrendCare® data to measure peaks and troughs in clinical workloads due to changes in patient activity and acuity, and re-engineering rosters accordingly. The efficiency reports generated by the system enable nurse managers to explain expenditure (related to resource utilisation) and measure the impact of identified trends and changes in patient activity and acuity over time. The multidisciplinary clinical pathway and clinical outcome options of the system enables clinical staff to define the standard of care required for patients, and the expected patient outcomes. The clinical pathway system

facilitates variance tracking and analysis, and contains automated patient history, risk management assessments and outcome assessments.

### Limitations.

The system is currently limited to sites in Australia and New Zealand. There are no live sites in Europe as yet although implementation in one UK site is planned for mid 2007. The tool used to measure nurse workload and categorise patients is a proprietary system tool which was developed specifically for use with TrendCare®. As such, its validity has not been extensively tested. Aside from the research carried out by Dr. Plummer (2005), the author has failed to identify any other studies relating to the validity of this system tool.

The system is modular, decisions can be made to use or not use particular modules. Anecdotal evidence suggests that this affects the functionality of the system. The reporting tools which appear to be central features of the system are reliant on full use of the system. In addition, despite the claim that the system has interfacing capabilities there do appear to be issues with particular systems, as such, it is possible that duplication of data entry may be required in certain circumstances.

### **4.7 Chapter conclusion**

This chapter has outlined the issues related to nurse resource management in critical care. The literature has revealed that health managers worldwide are now more focused on containing expenditure while ensuring quality and managing risk and as such, staffing levels and skill mix are now being considered as the primary determinants of quality. The key issues of recruitment and retention, education and training, workforce planning and leadership need to be addressed to ensure that a high quality service can be delivered. Information systems are needed to address the complexities of managing workloads and addressing quality issues in an efficient way.

Inadequate staffing levels and staff inexperience have been shown to have an adverse effect on patient care. These issues can be addressed by means of identifying and addressing deficiencies in staff training and ensuring that adequate numbers of suitably qualified staff are scheduled for each shift. This is a complex task and can be best managed by utilizing a system that can provide a means of shift planning based on the needs of the patient population. Nurse scheduling must address the needs of both the staff and the organisation. This must be balanced to allow the staff to have a timely and flexible schedule and the organization to have an appropriate mix of suitably qualified staff available to meet the needs of the patients.

One commercially available nurse resource management system was identified that could potentially provide a system solution, the Trendcare® system has been successfully implemented in sites in Australia and the far east. As yet it has not been used outside of these domains. Although it does appear to offer a means of ensuring that staffing levels meet unit needs by means of prediction and actualizing of workload measurement this system is limited by its interfacing capabilities and the lack of a skill matching/ nurse allocation tool.

An effective system solution will be required to address all elements of nurse resource management. This includes a staff skills and experience database, a staff scheduling tool, interfacing capability to make use of nurse workload scores and patient care plans and a nurse allocation tool to ensure that best match of nurse skills to patients needs is achieved.

## **Chapter 5: The proposed Nurse Resource Management System.**

### **5.1 Overview**

The literature review and the domain analysis related to current practices in nurse resource management have provided sufficient information to move forward with a proposal for a nurse resource management systems solution. Central to this proposal is the provision of a system which can provide users with an efficient means of identifying the appropriate staff member to care for a particular patient at a specific time - thus ensuring the quality of patient care delivery is absolutely maximized.

The domain is well developed in terms of its IT applications and infrastructure. The proposed solution is a computerised clinical information system which can interface with existing systems to utilize the data that is already collected. This includes the patient demographic data which is held within the hospitals PAS system and the data that can potentially be captured by the CareVue® CIS for measuring nursing workload and planning patient care. The system will then be required to combine this information with the data related to staff availability, skills, experience and competencies to provide an allocation tool which will match nurses to patients based on best options available. This chapter will detail the systems requirements specification (SRS) with the UML providing a means of describing the system's elements and functionality.

### **5.2 Introduction to Software Requirements Specification and UML**

The development of an information system is often a lengthy and complex process. Management of such a project requires a modular approach, dividing the development into well defined stages in time. Between each stage of development, there should be checkpoints to ensure the project is on track. (Van Bommel & Musen 1997). The identification of clear, specific objectives prior to design or purchase of any software system is a crucial element in successful implementation. There is an absolute requirement for end user involvement in the system specification in order to realize the

benefits of investing in a system. Involvement from the start of the project will help ensure that the system developed best fits the needs of the users and the organization (Locke, 1996).

The software requirements specification (SRS) is a document that serves as a foundation for hardware engineering, software engineering, database engineering and human engineering. It is developed by a systems analyst in order to provide an in depth description of the functions of the specified computer system and the components that will govern its development. It also describes the information input and output processes. The production of a SRS should help the stakeholders to accurately describe what they want from the development of a computer system and should also assist the software developer to understand the requirements. (Pressman, 1997, IEEE 1994)

### **5.3 UML for the proposed solution**

The UML will be used to describe the system at a high level in terms of user interaction and functionality (Schmuller, 2004). The elements of the UML that will be used are class diagrams and use cases. Class diagrams are an important feature of the UML as they enable analysts to understand the clients' needs and as such provide the representations that the software developer can work from (Schmuller, 2004). The use case is a construct for describing how a system will appear to users. There are two main components to the use case diagram: the actor who initiates the use case and the use case which is the subsequent action of the system. The actor is represented in the model by a stick figure and an ellipse represents the use case. A straight line represents the association between the two. An actor initiates the use case and an actor (may be the same one) may receive something from the use case. The initiating actor is on the left of the use case and the receiving actor is on the right (Schmuller, 2004).

### **5.3.1 The Actors**

The term ‘Actor’ is used in the UML to describe the users and other systems interacting with a system. There are nine actors in the use case diagram for the proposed nurse resource management system. The Actors and the role they will play in relation to the system have been identified as follows:

The Clinical Nurse Manager: The clinical nurse manager will be interacting with the system more than any other member of personnel. As such, the nurse manager plays a key role in the system specification. The nurse manager will be responsible for ensuring that the interfaced and manually entered data is present and valid prior to utilising the data for allocation purposes. The nurse manager will also be responsible for producing the roster for staff nurses.

Staff Nurse: The staff nurse represents any nurse who is being scheduled to work on the nurse scheduler and allocated to care for a patient. The staff nurse will also be responsible for providing the CareVue® CIS with patient bedside data required to send to the system for allocation purposes.

The Nurse Facilitator: The nurse facilitator will interact with the system less frequently but will play an important role in defining the nurse skills and competencies database. Maintenance of the skills and competencies database held within the nurse profile will be the direct responsibility of the nurse facilitator.

Nurse Administrator/ Business Manager: The nurse administrator will retrieve reports from the system and will play a role in defining the content of system reports, the reports will be related to attendance, absenteeism and training and costs. Reports may be automated, i.e. sent at preset intervals, or manual.

Payroll Administrator: The payroll administrator will be able to upload information from the system which will provide the payroll system with attendance and costs data. This interface should upload data automatically and therefore avoid the need for manual duplication of data entry. The payroll administrator will also be able to request and receive attendance and costs reports from the system.

Systems Administrator: The systems administrator will be responsible for ensuring that the system is kept operational and is backed up at preset intervals, not less than 24 hourly. Automated system error reports will be sent from the system to the system administrator. This actor will also be responsible for system configuration and troubleshooting.

The CareVue® CIS: The CareVue® CIS will be represented as an actor as it will be interfaced to the system, sending validated patient data (TISS-28 scores and care plans) at preset intervals.

The PAS System: The PAS system will be represented as an actor as it will be interfaced, sending patients' demographic data to the system.

### **5.3.2 Description of the Use Case Diagram (Figure 5.1)**

#### Use Cases for all users:

All users will be permitted to log on to the system on entry of a preset alphanumeric password. Password control will be administered by the system administrator, additional password controllers will also be permitted to administer passwords. In order to log on to the system, users will be required to click on an icon on one of the desktop PC's or workstations in ICU.

#### System administrator use cases:

The systems administrator (SA) has overall control of the system administration and configuration. The SA password will allow the highest level of access to the system

SA will ensure that the system is available for use at all times and will provide the contingency plan for any downtime. The SA will also ensure that interfaces to foreign systems are functioning correctly. System backup, disaster recovery, contingency plans and system security will be the responsibility of the SA. The SA will also be responsible for overall password control and access level determination for end users. System configuration and management functions will also be performed by the SA. The SA will be responsible for creating report templates and also for training key users in report creation.

Clinical Nurse Manager (CNM) use cases:

The CNM password will have full access to the system with the exception of the systems administrator functions. The CNM will enter data related to staff/ patients into the system. The CNM will be able to produce and modify a nurse schedule. The CNM will be able to upload/ modify patient demographics from the PAS interface. The CNM will be able to upload/ modify patient TISS-28 scores and patient care plans from the CareVue® interface. The CNM will be able to view/ modify all staff profiles this will include training/ education and attendance profiles. The CNM will be able to create and print system reports. The CNM will be able to produce and modify a shift allocation. The CNM will be able to validate staff attendance data for export to the payroll system. The CNM will be able to generate and view system messages/alerts.

Nurse Facilitator (NF) use cases:

The NF will be able to enter data related to staff training/ competencies into the system. The NF will be able to view/ modify all staff profiles this will include training/ education and attendance profiles. The NF will be able to create and print system reports. The NF will be able to generate and view system messages/ alerts.

Staff Nurse (SN) use cases:

The SN will be able to enter roster requests into the system. The SN will also be able to enter their overtime availability into the system. The SN will be able to request study day/ conference and course leave into the system. The SN will be able to view their individual

profiles and messages. The SN will be able to view their individual skills and training profile. The SN will be able to view their attendance profile. The SN will be able to view generic system messages. The SN will be able to view their personnel messages.

Nurse Administration (NA)/ Business manager (BM) use cases:

Both NA and BM will be able to request system reports. Both NA and BM will be able to view and print system reports.

Salaries/ Payroll use cases:

The Payroll system will be able to upload staff attendance data for use in the payroll system. The upload of data onto the payroll system will be automated and will occur at predetermined intervals. The Payroll manager will be able to send attendance query messages to the CNM. Messages sent from the payroll manager should be flagged by the system as high priority; the CNM should receive a notification that a message from payroll manager has been received. The Payroll Manager will be able to request system reports.

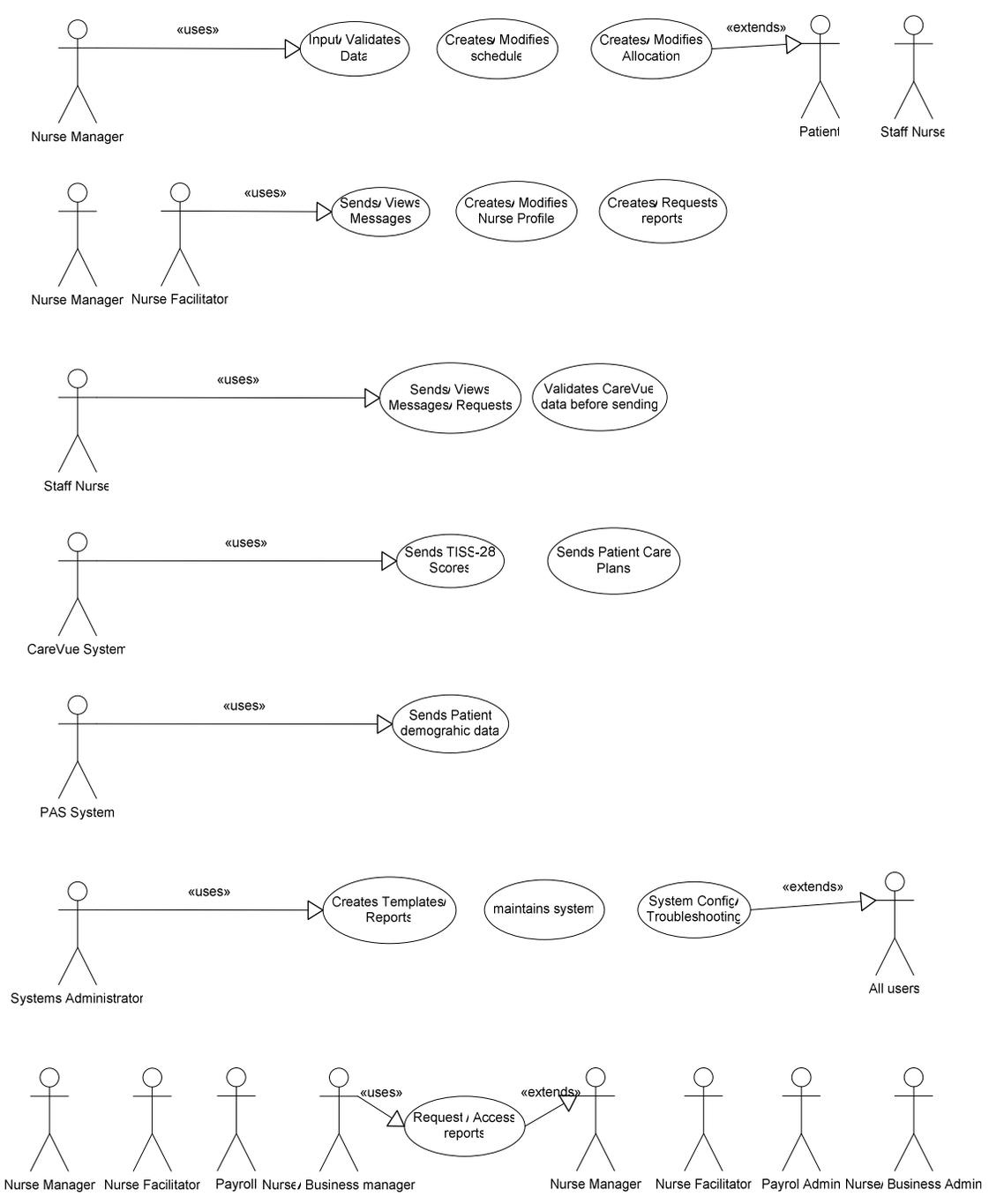
The Payroll manager will be able to print system reports.

PAS system use cases:

The PAS system will be able to send patient demographic data to the system at preset intervals and on request by authorised user.

CareVue® system use cases:

The CareVue® system will be able to send patient TISS-28 scores and care plans to the system on request by authorised user(s). The CareVue® system will be configured to display a system message to notify staff of the requirement to send updated scores and care plans to the resource management system.



**Figure 5.1 : Use Case Diagram**

### **5.3.3 Classes**

A UML class is a category or group of objects that have similar attributes and common behaviours. An object is any person, place, thing, concept, event, screen, or report applicable to a system. Objects both know things (they have attributes) and they do things (they have methods). A class is a representation of an object, it is simply a template from which objects are created. Classes form the main building blocks of an object-oriented application. (Schmuller 2004)

Twenty UML system classes have been identified as follows; (depicted in figure 5.2)

Systems Administrator: This class has a multiplicity of one. The systems administrator class is associated with many of the other system classes. It will be associated with creating, adding and modifying system configuration, report templates and rules related to other system classes.

Clinical Nurse Manager: This class has a multiplicity of one. The nurse administrator class is associated with many other classes and activates many of the system functions. The nurse manager class activates the schedule and allocation classes. It also sends and views messages and creates, view and modifies profiles and reports.

Nurse Facilitator: This class has a multiplicity of one. The nurse facilitator class sends and views system messages and creates and modifies nurse profiles. This class can also create, view and print system reports.

Staff Nurse: This class has a multiplicity of one. The staff nurses attributes include sending and viewing schedule messages and viewing nurse profile.

Nurse Administrator: This class has a multiplicity of one. The nurse administrator attributes include sending and viewing messages and requesting, accessing and printing system reports.

Business Administrator: This class has a multiplicity of one. Attributes include sending and viewing messages and requesting, accessing and printing reports.

Payroll Administrator: This class has a multiplicity of one. Payroll administrator class attributes include sending and viewing messages and requesting, accessing and printing reports.

CareVue® System: The CareVue® system class has a multiplicity of one. This class sends patient TISS-28 scores and care plan data to the Patient data manager class.

PAS System: The PAS system class has a multiplicity of one. This class manages interfaced patient demographic data sent from the PMI to the patient data manager class.

Report Manager: The report manager has a multiplicity of zero or more. The report manager class manages all report requests both automated and manual. This class accepts requests and provides reports in preconfigured formats either as email attachments or printed material.

Report Builder: The report builder has a multiplicity of zero or more. The report builder class is attributed to providing report templates for the report manager to use to produce system reports to authorized users and systems.

Query Manager: This class has a multiplicity of zero or more, it manages report queries related to existing reports and allows authorized users to create new report queries.

Nurse Profile: The nurse profile has a multiplicity of one. This class manages all elements of individual nurse profiles. Attributes include nurse grade, competencies and attendance records. The nurse profile can be created, modified and viewed dependant on the user level of access.

Message Manager: The message manager class has a multiplicity of zero or more, this class manages the creation, sending and receipt of messages between staff members. The message manager class also interfaces with the schedule rule manager and provides automated messages based on requests received.

Nurse scheduler: The nurse scheduler class has a multiplicity of one. The nurse scheduler is the automated finalized schedule which has been validated by the nurse manager. The nurse manager is required to activate the creation of the nurse schedule. The class can be viewed by all but creation/ modification is limited to authorized users.

Schedule rule manager: This class has a multiplicity of one or more. The schedule rule manager class provides the system with a rule management tool to allow staff to make schedule requests via the message manager. The rule manager will utilize logical decision support statements to determine if request can be accepted. Accepted requests can form part of a future nurse schedule. This class sends a return message to the message manager; in addition it updates the schedule builder class with successful requests.

Schedule builder: The schedule builder class has a multiplicity of one or more. This class accepts schedule requests sent via message manager if the schedule rule manager conditions are met. The schedule builder also interfaces with the nurse profile class to build a schedule which provides the required mix of nurse grades and skills on each shift.

Allocation Rule Manager: This class has a multiplicity of one or more. It is the class that determines which available nurse is allocated to each patient. It receives data from the patient data manger, the nurse profile and the nurse schedule. Allocation rule manager will use logical decision support statements to provide optimal nurse patient allocation.

Nurse Allocation: This class has a multiplicity of one. It is activated by the nurse manager and creates a nurse allocation which matches nurse to patients based on data collection from several other classes.

Patient Data Manager: The patient data manager class has a multiplicity of one or more. This class receives patient data from the CareVue® and PAS systems, the patient data manager then forwards patient data to the nurse allocation manager.

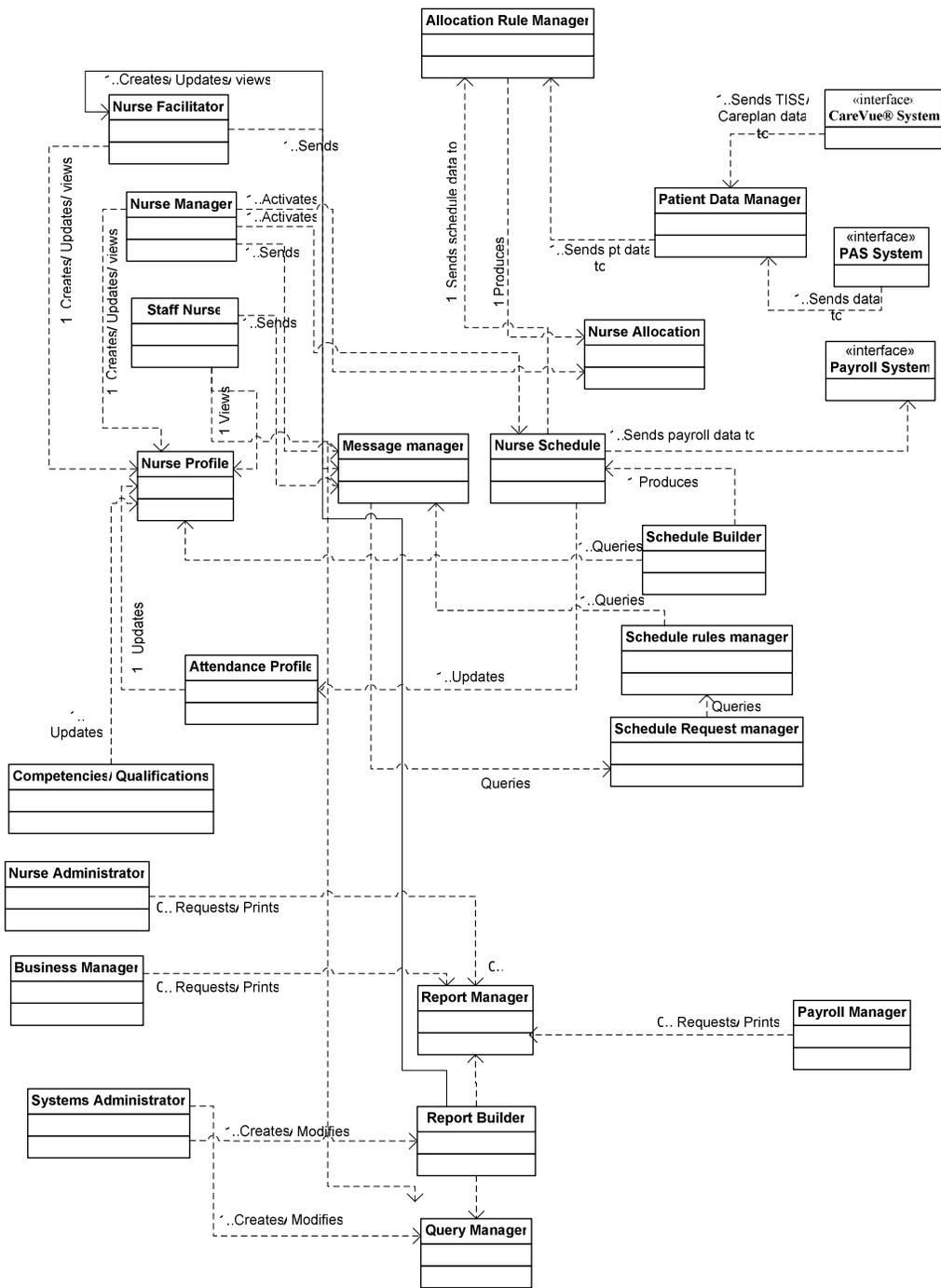


Figure 5.2 Class Diagram

## **5.4 Functional Requirements of Nurse Resource Management system**

The functional requirements of the system will now be outlined. These will provide a more detailed description of the various system functions and the actors that will perform these functions. The functions are described in the modules and interfaces that make up the resource management system.

### **5.4.1 The Application, General functional and performance requirements**

The application will be installed on an application server in the hospital's IT department. The application will be accessible on computer workstations in the ICU. (Currently these are located at all patient bedsides, unit offices and nurses' stations).

The User Interface for the system shall be a Graphical User Interface (GUI).

The application shall be activated by a keyboard and mouse.

The system shall use full screen and will promote a uniform format.

Each workstation shall be linked to laser printer.

Each workstation shall be linked to the hospital network.

Each workstation shall have a user manual available in both hard and soft copy.

Information shall be imported from other applications to avoid duplication of data.

Information can be exported to Microsoft® Excel/ Access and statistical applications for reporting purposes.

Information will be presented in a structured, intuitive format.

The users of the system will primarily be the clinical nurse managers but will also include administration staff and nursing staff. The training required will be dependent on the user, but should be minimal.

Password should provide appropriate level of user access. Clinical Nurse Managers' will be assigned password control.

Policies and Guidelines for use of nurse resource management system will be devised.

End users shall be notified of planned system downtime.

In the event of a systems error occurring, end users shall be given a notification message which should direct them as to correct course of action to take, i.e. log off/ shut down and restart application.

The system shall provide an email message to the systems administrator to inform them of system errors or faults.

The system shall be available to end users at all times. Any interruption in system availability should be scheduled. System faults shall be prioritised as urgent. System downtime shall not be for any more than four hours.

Guidelines and contingency plans shall be in place in the event of an unplanned system interruption.

The systems administrator shall be alerted to any system security violations.

#### **5.4.2 Login**

The system shall allocate each user with a unique username and password. The password shall dictate the users' level of access.

The system shall require that the password be changed periodically.

The system shall provide users with a prompt when the password has expired, this will allow the user to change their password.

The system shall prompt the user to enter their username and password when they open the application.

The system shall allow users to change their passwords at their own discretion.

The system shall prompt the user to log off when data entry is completed.

The system shall log out any user who has been logged on for longer than ten minutes without interaction with the system.

The system shall provide users with system messages on log on, these will include generic and personal messages.

### **5.4.3 THE PAS INTERFACE**

#### **Retrieving Patient Demographic data.**

The system shall require that all patients entered onto the system have a unique hospital MRN.

The system shall commence a search on the Patient Master Index (PMI) on the PAS when the patients' MRN is entered on the patient demographic screen on the system. The patient demographic data will download from the PAS system through the interface with PAS.

The system shall require the user to confirm that the patient data is correct prior to finalising the downloaded data.

In the event that the user does not have access to a MRN for the patient they will have the option of manually entering the patients' demographic data. This will provide a short term system solution to allow the user to bypass the MRN; the system shall however require a valid MRN in order to allow for interfaced data to enter into the patient profile. The user is required to update the MRN data as soon as it is available, otherwise only manual data can be entered onto the patient profile.

Patients with previous episodes on the system shall have their prior record recalled to avoid duplication and facilitate efficient record management.

### **5.4.4 THE CAREVUE INTERFACE**

#### **5.4.4.1 Nurse workload / dependency scoring tool user requirements:**

The data required for nurse workload scoring is collected on the CareVue® system and so therefore the system shall accept this data from the CareVue® system. The tool selected for use with the system is the TISS-28 workload scoring tool.

The system shall only accept scores that have been validated by the bedside nurse prior to being exported to the nurse resource management system.

The system shall display validated scores accompanied by a flag indicating validation, the system flag will be automatically attached on password entry by the bedside nurse.

The system shall allow system users to check the identity of the validating nurse.

The system shall display the details of the validating nurse; this entry will be time stamped and will include an audit trail to capture modifications which may have been made.

The system shall allow non validated scores to be entered, i.e. those that have not been password validated by the bedside nurse. Non validated scores, although permitted, will be clearly identified so they will be easily recognisable as non validated scores. The system will display these entries but will not accept them as part of the patient score record until they are validated by an authorised user.

The system shall allow nurse workload scores sent to the system via CareVue® to be overwritten by authorised users if required. Scores modified following entry onto the system will be clearly identified by the system as modified scores.

The system shall require that a validated TISS-28 score is available for a patient for automated nurse allocation to be completed.

The system shall allow authorised users to override the requirement for validated nurse workload scores in the event that a TISS-28 score is unavailable or the interface is unavailable. In this event, the system shall allow a manual nurse- patient allocation to be made.

The system shall utilise the TISS-28 score to determine the minimum grade of the nurse required to care for each patient. This will provide a very basic allocation tool.

The system shall require validated TISS-28 score to be sent via CareVue® at preset intervals, 3 times in each 24 hour period at 0600, 1200 and 2000.

#### **5.4.4.2 The Patient Care Plan**

Patient care plan data is also collected on the CareVue® system and so therefore the system shall accept this data from the CareVue® system. The patient plan of care on CareVue® is currently entered into the notes section of the application as structured text.

It is not possible to interface CareVue® structured text, only CareVue® flow sheet rows

can be interfaced. As such, the CareVue® care plan will require reconfiguration to include a structured patient care plan created using preconfigured pick lists. CareVue® reconfiguration would be a relatively simple process which could be performed by a CareVue® system administrator, it will involve the care plan appearing on the main patient care flow sheet in a section called 'Care Plan'. Each care item will be configured into a pick list menu, this will then be used by the bedside nurse to complete the care plan, up to ten pick list menu items may be selected to create the care plan. The care plan for each patient shall be completed by the bedside nurse at the beginning of each shift. The care plan shall be updated at the end of each shift.

The patient care plan on CareVue® shall consist of a preconfigured pick list of care needs of the ICU patient. This pick list will correspond to the nurse competencies and skills list within the nurse profiler part of the system.

The bedside nurse will be required to use the pick list on CareVue® to generate a care plan for the patient. This list will consist of a minimum of 3 and a maximum up to 10 care interventions planned for the forthcoming shift.

The system shall only allow preconfigured care items to be entered onto the care plan. Additional care plan items can be added by systems administrator on request; any newly configured care plan items must have a corresponding skill or competency within the system.

The system shall require that the completed care plan be password validated by the bedside nurse, as with the TISS-28 score, the system shall only accept validated care plans.

The system shall require that a validated care plan is available for each patient on each shift. Each care plan will be accompanied by a flag indicating validation, the system flag will be automatically attached on password entry by the bedside nurse.

The system shall allow authorised users to view the care plan, details of validating nurse and associated audit trail.

The system shall allow care plans sent to the system via CareVue® to be modified by authorised users if required. Care plans modified following entry onto the system will be clearly identified and must be accompanied by a user comment to denote reason for modification.

The system shall require that a validated care plan is available for each patient for the automated nurse allocation to be completed.

The system shall allow a manual allocation to take place in the event that the CareVue® system, and therefore patient care plan, is temporarily unavailable.

The system shall utilise the care plan to determine the skills and competencies of the nurse required to care for each patient.

The care plan pick list menu will be linked with the competencies pick list menu contained in the nurses profile. Both will have associated keywords, the allocation rule manager will be used to compute the optimal nurse-patient match, for example, the care plan for a patient on mechanical ventilation and renal dialysis will list both 'Mechanical Ventilation' and 'CRRT'. The nurse profile must include a full competency in, 'Care of ventilated patient' and 'CRRT' for this nurse-patient allocation to be made.

The system shall require validated care plans to be sent via CareVue® at preset intervals, 3 times in each 24 hour period at 0600, 1200 and 2000.

The system shall allow authorised users to create, email and print out system reports, this will be further outlined in the 'Reports' section later in this chapter.

#### **5.4.5 The Nurse Schedule**

The following functions are essential in specifying the requirements of the scheduling module of the system;

The system shall have all possible shifts and associated rules and parameters preconfigured.

Shift times, rules and parameters for schedule requests will be decided on by the nurse manager.

The system shall require that all staff members have a profile on the system. A staff profile will include their contract details, hours of work, annual leave/ study leave and other leave entitlements, the profile will also include their qualifications, skills, competencies and any other information relevant to the scheduling process.

The system shall allow users to enter schedule requests. The system shall process all schedule requests via the schedule rule manager. The schedule rule manager will

contain sets of rules for all staff based on their grade, hours of work and leave entitlements. Each staff member will have rules applied to their individual profile. For example, a nurse that works only weekends on a part time basis will have rules applied that permit only weekend scheduling, this will prevent the CNM from inadvertently scheduling this nurse from week day duties. The rules can be updated/ modified by the clinical nurse manager.

The nurse schedule shall primarily be automated and available one month in advance. The system shall require that any request received after the monthly deadline is entered manually by nurse in charge.

The system shall allow the clinical nurse manager to make manual entries and changes to the schedule.

The system shall provide staff with an immediate automated response to their schedule request to inform them if their request was submitted successfully.

The system shall have a preconfigured list of reasons for unsuccessful schedule requests; the relevant reason for request rejection should be displayed in order to provide the user with a valid reason for non acceptance of their request.

The system shall allow schedules to be converted into HTML documents which can be posted on the Internet. Posting schedules in this way allows employees to view schedules when they're not at work.

#### **5.4.6 Nurses Profile**

The system requires that an up to date profile of each staff member is completed and stored on the system. The profile will include details related to the nurses' contract, terms of employment, leave entitlements, attendance record, qualifications, relevant experience, skills and competencies. Pick list menus for each of these shall allow a profile for each nurse to be easily created. In addition, the system shall allow templates of nurse categories to be created by authorized users. Each category shall have a number of subcategories, the subcategories shall be the same for each group but the overall category shall be based on the nurses' qualifications and level of experience. For example, on first entering a new nurse onto the system, the CNM will complete a primary category form,

this will consist of pick list menus related to nurses' qualifications and experience. When completed, based on entries, each nurse will be automatically allocated to a primary category. Subcategories will be related to contracted hours of work, leave entitlements, attendance and further training. Each nurses profile details will be entered on the system and stored, from thereon in, profiles can be updated when required.

The profile will serve as a tool to ensure that the system is serving its primary purpose of matching nurses' skills to patients care needs but will also fulfill a number of other functions. For example, it will be a resource that can be queried by the nurse facilitators, managers and administrators for unit needs analysis and forward planning.

The system shall require that all staff have a system profile. The system shall allow the nurse manager or nurse facilitator to create, add and modify staff profiles.

The system shall allow all staff to view their personal profile.

The system shall allow all staff to request a profile update. This can be done via the messaging system.

#### **5.4.7 Nurse Allocation**

The nurse allocation module is the piece of the system that brings together all the data which has been entered and validated to perform the function of matching the nurses available to the patients requiring care.

The system shall require that all patient census data, staff schedule and staff profile data is present and correct for its full functionality to be realized. The system shall allow authorized users to enter the nurse-patient allocation menu. The users' level of access will be determined by their password, all users, nurse managers and staff nurses that manage shifts should be able to access the nurse-patient allocation part of the system.

The system shall display all patient census details to include the patient's name, MRN, age and consultant, latest TISS-28 score and care plan status.

The system shall also show the patient's infection status by means of a symbol beside the patient's name; this will be as per the current symbolic convention in use in the domain.

The system shall list the patients in order 1 – 15 dependant on their bed location in the unit.

The system shall allow the nurse manager activating the nurse allocation to review individual patients full care plan from this screen.

The system shall also display all the details of the staff on duty on the same screen as the patient census screen. This will include the nurses' name and grade. The system shall allow the nurse manager to access the full profile of all nurses from this screen.

The system shall provide the CNM with details of any missing data.

The system shall not allow a nurse-patient allocation to be activated until all required data is entered.

When all data is complete, the system shall allow the CNM to proceed with activating the nurse-patient allocation.

The system shall display the completed allocation in order of patient bed number. (Figure 5.3)

The system shall flag any allocation of nurse to patient that does not achieve a 100% skill match. This will occur where the nurse allocated is in a lower skill grade group than required or does not have all the required competencies completed. In this case, the percentage skill match achieved will be displayed.

The system shall allow the nurse manager to identify the reason for reduced skill match.

The nurse manager may, if required, override an automated allocation.

The system shall, where required, allocate a NF to assist lower grade staff.

The system shall allocate each nurse with an assistant, based on workload and on geographical location of nurses and patients in the unit.

The system shall limit the movement of staff in isolation areas in line with infection control policies. The system shall not allow assistants in the isolation areas to be allocated to assist in non isolation area.

Nurse Allocation screen										
Bed Number	MRN	Surname	First name	Infection status	TISS-28 Score	Care Plan status	Nurse Name	Grade	Assistant	Skill match achieved
1	100000	McNamara	Maurice	#	40	+	Gearty, Annette	4	FI Janice Moore	100%
2	111	Smith	Alfred		35	+	Hughes, Aine	1	Jane Dunne	100%
3	11111	Hackett	Scott	#	35	+	Hamid, Ahmed	3	FI Janice Moore	100%
4	12222	Auden	Sean	\$	45	+	John, Princee	2	FI Lui Tan	70%*
5	13333	McDermott	Deirdre	#	40	+	Byrne, Francis	3	FI Janice Moore	100%
6	14444	O'Carroll	Thomas	#	50	+	O'Brien, Keith	3	FI Lui Tan	100%
7	15555	Hynes	Molly	\$#	45	+	Behan, Hannah	3	FI Lui Tan	100%
8	222	Kelly	Jennifer		40	+	Dunne, Jane	1	NF Kim Graham	80%
9	333	Byrne	Catherine		50*	+*	O'Brien, Mary	2	NF Kim Graham	80%
10	444	McGrath	Mary		45	+	Lynch, Sarah	3	Nadia Aziz	100%
11	555	Brennan	Frank		30	Pending	Aziz, Nadia	3	Sarah Lynch	100%
12	666	Brown	James		35	+	Matthew, Joseph	3	Mary Kennedy	100%
13	777	Keogh	Ciaran		30	+	O'Reilly, Janet	2	NF Una James	80%
14	888	Fahy	Phillip		45	+	Kennedy, Mary	4	Joseph Matthew	100%
15	999	Rodgers	Grace		40	+	Gallaher, Louise	3	NF Una James	100%

**Figure 5.3 Sample Nurse Allocation screen**

## **5.4.8 System reports**

### **5.4.8.1 Patient reports:**

This refers to the number of patients in the unit and how much care each patient requires.

The system shall provide TISS 28 scoring data reports at predetermined intervals. Scoring data reports shall be in spreadsheet format and shall be exportable to other applications for analysis.

Care plan reports shall also be automatically sent to relevant users at predetermined intervals.

These reports shall be automatically sent, via email, to nurse managers and medical staff.

### **5.4.8.2 Nurse Profile reports:**

The system shall produce staff reports relating to competencies, training attendance and workload at predetermined intervals. Where possible, reports will be automated and printed or sent via email as required. Authorised staff with appropriate training shall be permitted to manually produce nurse profile reports. For confidentiality to be maintained, the system shall require reports to be configured to print to named printers only.

### **5.4.8.3 Costs and budget reports**

The system shall produce staffing budget reports in relation to scheduled staff costs, overtime staff costs, agency staff costs, absentee staff costs and training staff costs. Employees' accumulated hours reports shall be provided to help ensure that overtime costs don't exceed the limitations of the staffing budget. The system shall produce accumulated hours reports to ensure that EU work time directives are being adhered to. Costs and budget reports shall be available to managers, nurse administrators and payroll managers. Costs reports shall be broken by pay or fiscal periods or by cost type i.e.

scheduled staff, overtime staff, agency staff, premium payments, staff training etc. as required.

System reports shall be provided to authorized users as required. Reports shall be automated where required but shall also be available on request by authorized personnel. Reports shall be produced in a standardized format and shall be available as email attachments or in printed form. The systems administrator shall be responsible for ensuring that system reporting functionality is maintained and that key staff receive training in report creation and modification.

### **5.5 Chapter conclusion**

This chapter has provided an overview of the proposed nurse resource management system in relation to its uses and functions. The process of systems requirements specification is an iterative one, as such, this proposal is merely the starting point from which a system providing the required functionality should emerge. It is anticipated that the system will be modular and encompass all aspects of nurse resource management to include nurse workload measurement, the patient care plan, the nurse schedule, the nurses' profile and the nurse-patient allocation. The system should also provide a reporting tool which will allow for efficient audit and review of nursing staff deployment, training and costs. The addition of a nurse resource management application should improve efficiency and promote quality of patient care delivery by means of providing a skill matching tool. It is also envisaged that the system could be applied to any critical care setting and indeed be adapted for use in other hospital departments.

## **Chapter 6: Evaluation/ Conclusion**

The purpose of this dissertation was to analyse the requirements for a nurse resource management system for specific use in the critical care setting. The main objective of the system being to provide an efficient method of ensuring that the nurse resources available are utilized in the best possible way, ensuring that patients receive the highest possible standards of nursing care based on their individual needs. It became clear from the outset that the best possible systems solution would require the merging of several, currently unrelated, elements of nurse resource management, any attempt to look at these elements in isolation would not improve efficiency or enhance the quality of care delivery.

The domain analysis revealed that the current manually recorded nurse resource management processes in use are inefficient, fragmented, and costly. Each of these processes; the patient dependency score, the nurse schedule and the nurse allocation are isolated processes that are in no way linked. In addition, processes such as staff training and development are recorded in an ad hoc fashion. The result is that there is no efficient means of ensuring that the skills of nurses match the needs of the patient population.

The literature review revealed that there are many means of identifying the acuity of patients and the workload of nurses but none of these systems are perfect, the way forward is to look at systems that address the daily needs of patients and provide a means of forward planning. Utilization of the scoring tools available in the context of a combined approach within a nurse resource management system may prove to enhance their validity.

The literature review also found that nurse scheduling means weighing a host of factors, it must take into account patients' needs, nurses' shift preferences and areas of expertise, annual leave, overtime, the units' budget, and other considerations. By establishing scheduling procedures, the claims that patients and staff make on the scheduling process can be balanced to some degree. The goal of scheduling is to deploy the right combination of nurses for each shift and to utilise them in such a way that staff resources are not overextended or wasted. A system which addresses nurse scheduling must take

account of a variety of factors that influence the scheduling process. Factors which are important to staff such as flexible working hours, shift times, days and hours of work, time off and overtime request. The system must also account for the needs of the organization to ensure that sufficient numbers of suitably qualified staff are available for duty on each shift.

Key to the system proposal is the integration of existing systems and the provision of a solution which addresses all aspects of nurse resource management. The main requirements are evaluated in the context of how the proposed system addresses them;

Requirement for the provision of a patient dependency/ nurse workload scoring tool:

The research showed that currently nurses in ICU use systems to categorize patients that are imprecise, and which do not accurately gauge the level of nursing input to patient care. If the needs of patients in ICU are to be met a more reliable way of determining the number and skill level of nurses will have to be developed. The literature on patient dependency/ nurse workload scoring tools suitable for use in the critical care setting, showed the TISS-28 score to be the most well validated tool available, the CareVue® system is capable of providing an automated TISS-28 score for each patient. The proposed system would import TISS-28 scores which could then be utilised for nurse workload measurement. Replacement of the current dependency score and automating data collection processes would improve efficiency. In addition, the provision of a reporting tool, looking at data trends in terms of nursing workload over specified time frames will allow for shift planning based on patients needs.

Requirement for the provision of an automated nurse scheduling system:

In specifying a systems solution, the nurse scheduling element must balance flexibility for staff with ensuring adequate numbers of suitably qualified nurses to be available for or patient care on each and every shift. The system solution would allow nurses to make roster requests within a rule based framework, this would allow equitable distribution of preferred and non preferred shifts. In addition, the nurse roster component of the system would provide a means of ensuring that nurses are aware of their work schedule at least

one month in advance of time and would also factor in overtime availability. In short, the system proposed would address the current scheduling issues that have been identified as inefficiencies in the ICU setting. TISS-28 score reports could also be utilized when devising the nurse roster to reflect on nurse resource requirements for the previous roster period. These reports could provide a form of predicting the staffing needs of the unit. The system could also export data to the payroll system thereby eliminating the need for duplication of payroll data and also reducing the margin for errors in staff payments.

Requirement for the provision of a nurse-patient allocation system:

The proposed solution is a system which integrates the existing tools in use to ensure that nurse-patient allocation is optimized. To do this, the system will be required to analyse data related to patients and nursing staff. The benefits of combining the information related to staff and patients' is the provision of the skill matching tool. Nurse staffing and skills requirements could be more accurately identified by utilizing the TISS-28 scoring tool and the patient care plan. The TISS-28 will determine the number and skill level of staff required while the care plan will determine the additional competencies required for nurse-patient allocation. The system would allow patient care plan and TISS-28 score data to provide a basis for discerning the needs of the patient while the nurses' critical care qualifications, ICU experience and clinical competencies would also be automatically considered when nurse-patient allocations are made. Other allocation decisions which the system will support will be the physical location of the patients in the unit, the availability, type of and accessibility/ proximity to, appropriate support staff (educators/ floats/ ancillary staff), the nurses' ability to work with minimal supervision in managing specific therapies. In addition, nurse competencies could also be audited using system reports by retrospectively comparing the patient care plan with the competencies of staff allocated. This retrospective data could allow the nurse facilitators to identify training issues that need to be addressed; they can then prioritise staff training and provide the appropriate education to the relevant staff. Training can then be scheduled as part of the nurse schedule. Mandatory training can also be flagged when updates are required. Reporting the percentage of skill matching achieved and identification of the

reasons for reduced skill matching will also provide a basis for ensuring that staff training needs are identified and efficiently managed. Skill matching and nurse to patient ratios reports will provide a measurement of the units' performance in relation to providing patients with a high standard of nursing care.

## **Conclusion**

The research domain is particularly interesting in relation to healthcare informatics. On one hand we are presented with a high tech, busy clinical setting with a well established IT infrastructure, an existing clinical information system at the patient bedside and a complement of highly trained IT literate staff. On the other hand we have ineffective paper trails and less than efficient human resource management. The system proposed in this research could bridge the clinical/ administrative gap and, in doing so, help realise the full value of data which is already collected. The system solution should encompass all aspects of nurse resource management; this includes nurse scheduling, nurse workload measurement and nurse allocation. The system must account for the needs of the organization to ensure that sufficient numbers of suitably qualified staff are available for duty on each shift. A fully integrated system has the potential to significantly reducing costs, improve staff retention, enhance nurses' job satisfaction and ultimately, help improve the overall quality of patient care delivery in the critical care setting.

The ability to provide quality health services depends on the availability of a workforce by practitioners who are qualified and safe and competent to practice. The HSE is the largest employer of health professionals in Ireland and is competing in a global market for the health workforce amid growing shortages across the medical and nursing professions. In this context, it is important that workforce management systems support clinical staff to deliver services and assist in attracting and retaining highly skilled staff. In the critical care area there is a need to move beyond measures of survival and mortality and to be concerned about longer term outcomes for patients and their care givers. There is also a need to develop interdisciplinary approaches to new ways of working, to this end, a nurse resource management system, which assists with skill matching, should help support, value and nurture staff and patients alike.

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## **Appendix B: Patient Dependency Classification**

The patient dependency classification is based on the nurse's assessment of the patient's needs for the previous 6 hours. The data is entered on an approved dependency rating scale form.

A score should always be given in the first three determiners for Respiratory, Haemodynamic and Neurological needs.

A score should be given to the final three determiners if required – Special procedures, Drainage and elimination, Care of relatives. In addition a 'tick' (representing a 'C' score) is given where a patient is on Continuous Renal Replacement Therapy (CRRT).

### **Intensive Care Determiners:**

#### Respiratory:

- A. Patients in this category will be breathing spontaneously, with or without O<sub>2</sub> therapy. Blood gases are within normal limits.
- B. 1. Patient breathing spontaneously with or without O<sub>2</sub> but:
  - May have a tracheostomy/ mini-trach insitu
  - Requires additional chest physiotherapy and 1 – 2 hourly endotracheal suction to remove chest secretions.
  - Patient recently weaned off ventilator (within last 6-12 hours) and requires regular surveillance of respiratory status in this initial period, > hourly observations
  - Blood gases are outside of acceptable range.

2. Patient ventilated and:

- Blood gases within acceptable limits with minimal adjustment to ventilator settings.
- Patient requires 1 – 2 hourly endotracheal suction.
- Patient requires hourly observations of respiratory status and ventilation.
- Patient breathing on 'spontaneous mode' on ventilator, with or without inspiratory support. Patients in this category should be well established on this mode and blood gases should be within acceptable range.

C. 1. Patient being actively weaned off ventilation using any of the following:

- Intermittent Continuous Positive Airway Pressure (CPAP)
- Continuous CPAP.
- Pressure support
- T-Piece and requiring constant surveillance of respiratory status, i.e. > 1 hourly.
- Blood gases outside of acceptable range.

2. Patient ventilated but:

- Requiring high concentrations of O<sub>2</sub> and the use of PEEP valve or high frequency ventilation to maintain adequate blood gases.
- Requires > 1 hourly endotracheal suctioning.
- Requires > 1 hourly observations of respiratory status.

3. Patient needing active medical and nursing intervention to maintain airway and respiratory status. For example, planned or emergency intubation and ventilation due to acute respiratory distress, airway obstruction or respiratory arrest.

## Haemodynamic

Note: Cardiac monitoring will be in situ for all patients whilst in the Intensive Care Unit.

- A. This category will generally be applied to patients who are either ready for transfer back to the ward or long term patients whose problems are not haemodynamic in nature.
1. Heart rate and blood pressure stable. Observations of heart rate and blood pressure recorded 2 – 4 hourly. Good urine output.
- B. This category will apply to the majority of ICU patients. The haemodynamic status of these patients will generally be stable but with a potential for sudden change which therefore demands constant surveillance.
1. Patient requires 1 hourly observations of heart rate, blood pressure and/ or 1 – 2 hourly recordings of CVP. Urine output may be variable and the patient may require diuretic therapy.
- C. Haemodynamic status is very poor with periods during which observations are recorded more frequently than hourly and/ or the patient requires one of the following:
- Inotropic therapy to maintain haemodynamic status.
  - Transfusions of blood, colloids or crystalloids to maintain blood pressure and CVP \*
  - Continuous Intravenous infusion OR anti-arrhythmic drugs to control cardiac arrhythmias requiring constant surveillance.
  - Patients undergoing exchange blood transfusions.
  - Patients undergoing peritoneal dialysis.
  - Patients requiring Pulmonary Artery Catheter pressure monitoring.
  - Patients requiring active nursing and medical cardio-pulmonary resuscitation to maintain life.
  - Patients that are brain-stem dead whose organs are to be used for transplantation and therefore require surveillance of haemodynamic status to ensure organs are viable for transplantation.

\*The majority of patients in ICU require intravenous fluid therapy. To qualify for this category, patients must require these transfusions in order to maintain adequate blood pressure and CVP. Patients receiving transfusions to improve Hb do not qualify.

Neurological.

- A. Patient is awake, alert and orientated requiring normal psychological support.
  
- B.
  - 1. Patient is awake, alert and orientated but appears withdrawn, anxious or depressed and requires more than normal active psychological support.
  
  - 2. The patient is well sedated on a ventilator with the aid of routine sedation and/ or paralyzing agents. The patient may require occasional additional bolus doses of sedative drugs.
  
- C.
  - 1. Patient ventilated and receiving routine sedation but resisting ventilation, unsettled and requiring regular bolus doses of sedative drugs in addition to routine sedation.
  
  - 2. Patient not ventilated but is confused/ agitated/ disorientated/ aggressive, requiring bolus doses of sedative drugs to calm. Close surveillance required to maintain a safe environment.
  
  - 3. Patient unconscious for reasons other than sedation e.g.
    - Head Injury
    - Drug Overdose
    - Diabetic Coma

### Special Procedures:

This category requires broad interpretation and should be used to cover patients needs that have not been covered in previous categories.

C.

1. Patients being admitted or transferred out.
2. Patients going to theatre.
3. Patients requiring a nurse escort to remain with them to and from a particular point e.g. CT scan.
4. Patients requiring nurse escort to other hospitals or transfer to ward.
5. Patients with dressings requiring daily or more frequent renewal, e.g. burns dressings, extensive pressure sores, wound dehiscence.
6. Patients being barrier nursed.
7. Patients requiring 3 or more nurses to lift and provide pressure area care e.g. due to spinal injury or obesity.
8. Radiological Investigations (multiple)

### Drainage and Excretion

C.

This category should be used for patient who have lost control over excretion of bodily waste and fluids due to:

- Drug induced paralysis and sedation.
- Unconsciousness due to reasons other than the above.
- Surgery.
- Confused mental state.
- Pathological condition.
- Spinal Injury.

These patients require frequent nursing intervention for extra hygiene care/ general drain care.

1. Patients with faecal or urinary incontinence.

2. Uncontrolled or newly established colostomies/ ileostomies.
3. Persistent vomiting.
4. Haemorrhage.
5. Copious drainage into drainage receptacles.
6. Regurgitation.

### Care of Relatives

- B. It is expected that all relatives of patients in ICU will require a degree of support and information. This determiner is to be used only where relative support above the norm is required.
1. An admission to the unit when it has not been possible to prepare the relatives in advance or when admission was unexpected and relatives require extensive explanation and reassurance. E.g. admission post RTA.
  2. A patient's condition deteriorates rapidly or unexpectedly and relatives require extra support or explanation
  3. A patient is to undergo investigations or procedures of a very significant nature. E.g. CT scan, return to theatre, brain stem tests.
  4. A patient has died and the family require bereavement support.
  5. Relatives are extremely anxious or demanding of the nurse's time for another reason and require extra explanations and support.

## **Appendix C: Nursing Interventions Classification (NIC)**

The Nursing Interventions Classification (NIC) is a comprehensive, research-based, standardized classification of interventions that nurses perform. It is useful for clinical documentation, communication of care across settings, integration of data across systems and settings, effectiveness research, productivity measurement, competency evaluation, reimbursement, and curricular design. The Classification includes the interventions that nurses do on behalf of patients, both independent and collaborative interventions, both direct and indirect care. An intervention is defined as "any treatment, based upon clinical judgment and knowledge, that a nurse performs to enhance patient/client outcomes."

While an individual nurse will have expertise in only a limited number of interventions reflecting on her or his specialty, the entire classification captures the expertise of all nurses. NIC can be used in all settings (from acute care intensive care units, to home care, to hospice, to primary care) and all specialties (from critical care to ambulatory care and long term care). While the entire classification describes the domain of nursing, some of the interventions in the classification are also done by other providers. NIC can be used by other non-physician providers to describe their treatments.

NIC interventions include both the physiological (e.g. Acid-Base Management) and the psychosocial (e.g. Anxiety Reduction). Interventions are included for illness treatment (e.g. Hyperglycemia Management), illness prevention (e.g. Fall Prevention), and health promotion (e.g. Exercise Promotion). Most of the interventions are for use with individuals but many are for use with families (e.g. Family Integrity Promotion), and some are for use with entire communities (e.g. Environmental Management: Community). Indirect care interventions (e.g. Supply Management) are also included. Each intervention as it appears in the classification is listed with a label name, a definition, a set of activities to carry out the intervention, and background readings.

The 514 interventions in NIC (4th ed.) are grouped into thirty classes and seven domains for ease of use. The 7 domains are: Physiological: Basic, Physiological: Complex, Behavioral, Safety, Family, Health System, and Community. Each intervention has a

unique number (code). NIC interventions have been linked with NANDA nursing diagnoses, Omaha System problems, and NOC outcomes. The classification is continually updated with an ongoing process for feedback and review. In the back of the book, there are instructions for how users can submit suggestions for modifications to existing interventions or propose a new intervention. All contributors whose changes are included in the next edition are acknowledged in the book. New editions of the classification are planned for approximately every 4 years. The classification was first published in 1992, the second edition in 1996, the third edition in 2000, and the fourth edition in 2004. Work that is done between editions and other relevant publications that enhance the use of the classification are available from the Center for Nursing Classification & Clinical Effectiveness at the College of Nursing, The University of Iowa.

NIC is recognized by the American Nurses' Association (ANA) and is included as one data set that will meet the uniform guidelines for information system vendors in the ANA's Nursing Information and Data Set Evaluation Center (NIDSEC). NIC is included in the National Library of Medicine's Metathesaurus for a Unified Medical Language and the cumulative index of nursing Literature (CINAHL). NIC is also included in the Joint Commission on Accreditation for Health Care Organization's (JCAHO) as one nursing classification system that can be used to meet the standard on uniform data. The National League for Nursing has made a 40-minute video about NIC to facilitate teaching of NIC to nursing students and practicing nurses. Alternative Link has included NIC in its ABC codes used for reimbursement for alternative providers. NIC is registered in HL7 and is mapped into SNOMED (Systemized Nomenclature of Medicine).

Hundreds of health care agencies have adopted NIC for use in standards, care plans, competency evaluation, and nursing information systems; nursing education programs are using NIC to structure curriculum and identify competencies of graduating nurses; authors of major texts are using NIC to discuss nursing treatments; and researchers are using NIC to study the effectiveness of nursing care. Interest in NIC has been demonstrated in several other countries, notably Brazil, Canada, Denmark, England,

France, Germany, Iceland, Japan, Korea, Spain, Switzerland, and The Netherlands. NIC has been translated into Chinese, Dutch, French, German, Japanese, Korean, and Spanish; other translations are in progress.

## **Appendix D: APACHE II Score**

**APACHE II** ("Acute Physiology and Chronic Health Evaluation II") is a severity of disease classification system (Knaus et al., 1985), one of several ICU scoring systems. After admission of a patient to an intensive care unit, an integer score from 0 to 71 is computed based on several measurements; higher scores imply a more severe disease and a higher risk of death.

APACHE II was designed to measure the severity of disease for adult patients admitted to Intensive care units. The lower age is not specified in the original article, but a good limit is to use Apache II only for patients age 15 or older.

This scoring systems is used in many ways:

- Some procedures and medication is only given to patients with certain APACHE II scores.
- APACHE II score can be used to describe the morbidity of a patient when comparing the outcome with other patients.
- Predicted mortalities are averaged for groups of patients in order to specify the group's morbidity.

Even though newer scoring systems, like SAPS II have replaced APACHE II in many places, APACHE II continues to be used extensively because so much documentation is based on it.

### **Calculation**

The point score is calculated from 12 routine physiological measurements (such as blood pressure, body temperature, heart rate etc.) during the first 24 hours after admission, information about previous health status and some information obtained at admission (such as age). The calculation method is optimized for paper schemas. The resulting point score should always be interpreted in relation to the illness of the patient.

After the initial score has been determined within 24 hours of admission, no new score can be calculated during the hospital stay. If a patient is discharged from the ICU and readmitted, a new APACHE II score can be calculated.

The appendix of the document that originally described the APACHE II score, makes an attempt to describe how to calculate a predicted death rate for a patient. In order to make this calculation of predicted mortality precise, the principal diagnosis leading to ICU admission was added as a category weight: the predicted mortality is computed based on the patient's APACHE II score and their principal diagnosis at admission.

## **Appendix E: Simplified Acute Physiology Score II (SAPS II)**

**SAPS II** is a severity of disease classification system (Le Gall, Lemeshow, Saulnier, 1993). Its name stands for "Simplified Acute Physiology Score", and is one of several ICU scoring systems.

SAPS II was designed to measure the severity of disease for:

- patients
- admitted to Intensive care units
- aged 15 or more

24 hours after admission to the ICU, the measurement has been completed and resulted in an integer point score between 0 and 163 and a predicted mortality between 0% and 100%. No new score can be calculated during the stay. If a patient is discharged from the ICU and readmitted, a new SAPS II score can be calculated.

This scoring systems is mostly used to:

- describe the morbidity of a patient when comparing the outcome with other patients.
- describe the morbidity of a group of patients when comparing the outcome with another group of patients

### **Calculation**

The point score is calculated from 12 routine physiological measurements during the first 24 hours, information about previous health status and some information obtained at admission. The calculation method is optimized for paper schemas. In contrast to APACHE II, the resulting value is much better at comparing patients with different diseases.

The calculation method results in a predicted mortality, that is pure statistics. It does not tell the individual patient's chance of survival. The main purpose of this calculation is to

provide a value that can be averaged for a group of patients, since it gives very unprecise values to calculate an average of the scores of a group of patients.

## **Appendix F: TISS Score**

**4 Point Interventions:** a) Point score for 2 days after more recent cardiac arrest. b) This does not mean intermittent mandatory ventilation which is a 3-point intervention. It does mean that regardless of the internal plumbing of the ventilator, the patient's full mandatory needs are being supplied by the machine. Whether or not the patient is ineffectively breathing around the ventilator is irrelevant as long as the ventilator is providing the entire patient's required minute ventilation. d) Use Sengstaken-Blakemore or Linton tube for esophageal or gastric bleeding. e) Pitressin infusion via IMA, SMA, gastric artery catheters for control of gastrointestinal bleeding, or other intra-arterial infusion. This does not include standard 3 ml/h heparin flush to maintain catheter patency. g) Active pacing even if a chronic pacemaker. h) Include first 2 runs of an acute dialysis. Include chronic dialysis in patient whose medical situation now renders dialysis instable. j) Continuous or intermittent cooling to achieve body temperature less than 33°C. k) Use of a blood pump or manual pumping of blood in the patient who requires rapid blood replacement. p) May even be the initial emergency operative procedure - precludes diagnostics tests, i.e. angiography, CT scan.

**3 Point Interventions:** d) The patient is supplying some of his own ventilatory needs. g) Not a daily point score. Patient must have been intubated in the ICU (elective or emergency) within previous 24 h. i) Measurement of intake/output above and beyond the normal 24 h routine. Frequent adjustment of intake according to total output. x) Includes Rheomacrodex. bb) For example, Stryker frame, CircOlectric.

**2 Point Interventions:** g) Replacement of clear fluids over and above the ordered maintenance level.

**1 Point Interventions :** k) Must have a decubitus ulcer. Does not include preventive therapy.

### **General guidelines for use of TISS**

- 1) Data should be collected at the same time each day/ shift.
- 2) A TISS item should be checked if it was performed at any time during the previous 24

hours.

3) When the patient is discharged from the ICU, a discharge TISS reflecting the previous shift, or 8 hour period, should be completed.

4) Total TISS points should decrease as the patient improves. Conversely, one can safely assume that if TISS points increase, more interventions or more intensive care is being delivered to the patient indicating deterioration of the patient's condition. Therefore, if the TISS points are rising while the patient is, in fact, improving or vice versa, check for errors as interventions may have been added inappropriately.

5) Many interventions are interrelated and can be automatically eliminated from consideration. For example, if the patient was extubated for previous 24 hours, any intervention related to an intubated patient such as controlled ventilation will not apply.

6) When several related intervention are applied within the same 24 h, only award 1 set of points for the maximum intervention. For example, if a patient was on controlled ventilation (4 points), then paced on IMV (3 points), to CPAP (3 points), to T-piece (2 points), and then extubated all within the same 24 h period, assign only 4 points (for controlled ventilation), the maximum intervention offered.

7) Though not essential, TISS data collectors should have a critical care nursing background. Training in the use of the tool should be provided so all nursing staff can easily identify the interventions and make the appropriate associations within and between categories. Collection time is minimized and results are reproducible.

### **TISS Classification**

Class IV :  $\geq 40$  points

Class III : 20 - 39 points

Class II : 10 -19 points

Class I :  $< 10$  points

The classification of patients as per their TISS score can be directly mapped to the grade of nurse caring for the patient. For example, A patient with a TISS score of  $> 40$  points ideally requires an experienced and qualified ICU nurse. A Class 1 patient with a low TISS score may be cared for by a more junior ICU nurse.

**Appendix G: The Nine Equivalents of Nursing Manpower Score (NEMS)**

The NEMS Score	Item Points
1. Basic monitoring; hourly vital signals, regular recording and calculation of fluid balance	<b>9</b>
2. IV medication; bolus or continuously, not including vasoactive drugs	<b>6</b>
3. Mechanical ventilatory support; any form of mechanical/assisted ventilation, with or without PEEP ( <i>eg</i> , CPAP), with or without muscle relaxants	<b>12</b>
4. Supplementary ventilatory care; breathing spontaneously through endotracheal tube; supplementary oxygen, any methods	<b>3</b>
5. Single vasoactive medication; any vasoactive drug	<b>7</b>
6. Multiple vasoactive medication; more than one vasoactive drug, disregarding type and dose	<b>12</b>
7. Dialysis techniques;	<b>6</b>
8. Specific interventions in the ICU, such as tracheal intubation, introduction of pacemaker, cardioversion, endoscopy, emergency operation in the past 24-h, gastric lavage; routine interventions, such as radiographs, echocardiography, ECG, dressings, or introduction of venous or arterial lines, are not included	<b>5</b>
9. Specific interventions outside the ICU, such as surgical intervention or diagnostic procedure; the intervention/procedure is related to the severity of illness of the patient and makes an extra demand on manpower efforts in the ICU	<b>6</b>

## **Appendix H: System of patient related activities score (SoPRA Score)**

### Timings:

SoPRA is a 24 hour score, integrating activities over the day. Data collection should start at midnight (00:00), be updated at the end of each following shift, and then finally at 23:59.

A calendar day is defined as any complete calendar day (00:00 – 23:59) or part thereof. For example, a patient admitted on January 1<sup>st</sup> 2005 at 23:45 and discharged on January 3<sup>rd</sup> at 00:10 would be recorded as having received 3 calendar days of care, for which each calendar day would accrue a SoPRA score.

### Weightings:

The weighting for each activity was agreed by consensus amongst the working group. Subjectivity in SoPRA scoring has been minimized by including definitions with examples.

To maintain simplicity of scoring, a number of rules have been introduced.

### Individual weightings:

All activities that occur during a calendar day (00:00 – 23:59) weight once only, even if repeated. For example, ‘Chest Drain’ only scores once, even if a second drain is inserted later in the same calendar day, and will continue to score each day until removed.

### Where weightings are summed:

If both ‘Core Activities (basic)’ and ‘Core Activities (Intermediate)’ occur during the same calendar day, then the weightings are summed and incorporated into the SoPRA

score. The maximum weighting incorporated into the SoPRA score for a given day is the sum of two variables.

‘Core activities (basic)’ have been chosen to reflect the care that a patient could reasonably expect to receive on a general ward.

‘Core activities (Intermediate)’ have been chosen to reflect the care that a patient could reasonably expect to receive on a HDU; Specifically care related to monitoring.

The number of drug infusions are weighted by counting the number of different drugs infused over 60 minutes during the calendar day. This number is incorporated into the SoPRA score for a given day. Such data should be easily extracted from the prescription chart.

If both ‘Procedure on your Unit (Simple)’ and ‘Procedure on your unit (complex)’ occur during the same calendar day, the weightings are summed and incorporated into the SoPRA score. The maximum weighting given is the sum of two variables.

If ‘Transfer (within your unit)’, ‘Transfer (within hospital)’ and ‘Transfer (other hospital)’ all occur during the same calendar day, the weightings are summed and incorporated into the SoPRA score. The maximum weighting in the case is the sum of three variables.

If ‘Ventilation (Non invasive)’, ‘Ventilation (CPAP)’ and ‘Ventilation (Invasive)’ all occur during the same calendar day the weightings are summed and incorporated into the SoPRA score. The maximum weighting is the sum of three variables.

Where the higher weighting is selected:

If both ‘Psychological support (intermediate)’ and ‘Psychological support (complex)’ occur during the same calendar day, the weighting for ‘Psychological support (complex)’ only is incorporated into the SoPRA score.

If both 'Relatives (intermediate)' and 'Relatives (complex)' occur during the same calendar day, the weighting for 'Relatives (complex)' only is incorporated into the SoPRA score.

If both 'Blood Purification' and 'Blood Purification (complex)' occur during the same calendar day, the weighting for 'Psychological support (complex)' only is incorporated into the SoPRA score.