CRITICAL CARE NURSES' KNOWLEDGE OF THE CARE AND USE OF CENTRAL VENOUS LINES

Karen L. Henderson

2002

CRITICAL CARE NURSES' KNOWLEDGE OF THE CARE AND USE OF CENTRAL VENOUS LINES

A research project report submitted in
partial fulfilment of the requirements for
the degree of Master of Clinical Nursing

by
Karen L. Henderson

School of Nursing and Health Studies
Faculty of Arts, Health and Sciences
Central Queensland University
July 2002

ABSTRACT

The primary aim of this cross-sectional research project was to evaluate critical care nurses' knowledge of the care and use of central venous lines. A secondary purpose was to determine if their knowledge was related to sociodemographic characteristics.

A true-or-false and multiple-choice questionnaire was developed by the researcher, subjected to review by a panel of experts and pilot-tested. It was examined for reliability, item difficulty and discrimination in order to improve the validity of the instrument prior to the research study. Sociodemographic questions were included to examine the influence of variables such as critical care nursing experience, educational background, job position and location of practice on the nurses' knowledge of the care and use of central venous lines. T-tests and analysis of variance were used to test hypotheses related to differences in mean scores among sociodemographic subgroups and a predetermined score that indicated sufficient knowledge of the participants in the study.

The final 30-item questionnaire was mailed to six hundred members of the Australian College of Critical Care Nurses. A total of 250 nurses (42%) completed the questionnaire. The mean knowledge score of all the participants was 23.4 or 78% items correct, with a standard deviation of 3.41. The range of correct scores was 14 to 30. Significantly low mean scores were found in all subgroups except for nurses in managerial or educational positions, nurses working in a large rural area and nurses with a Master's degree or higher level of education. Nurses who completed a

hospital-based critical care program had significantly higher scores than those who did not. There was a significant difference in scores according to the years of critical care experience with increasing scores as the years of experience increased.

The results suggest that critical care nurses have a general knowledge deficit of central venous lines. Educational programs, hospital-based critical care programs and the use of preceptors are methods that can be used to improve the knowledge base of nurses working in critical care areas. This study may be replicated on a larger scale to improve the validity and reliability of the questionnaire and to validate its findings.

DECLARATION

I certify that the research project entitled, "Nursing Knowledge of Central Venous Lines in the Critical Care Setting" and submitted for the award Master of Clinical Nursing is the result of my own research, except where otherwise acknowledged, and that this research project (or any part of it) has not been submitted for a higher degree to any other institution.

Signature Redacted

Karen L. Henderson
July 2002

ACKNOWLEDGMENTS

The preparation and conduction of this research project would not have been possible without the significant support and guidance from a number of individuals. I would like to acknowledge the following people for their particular guidance and support:

Dr. Sansnee Jirojwong for her assistance and guidance in this investigation.

Ms. Margie Wallin for her dedicated library support to distance students and prompt responses to my many enquiries.

The 'panel of experts' from the Fraser Coast Health Service District, who assisted with the construction of the questionnaire:

Dr. Gerald Meijer, Director of Intensive Care Services

Dr. Ian Cripwell, Staff Specialist Anaesthetist

Ms. Marilyn Jensen, NPC ICU/CCU

Ms. Margaret Cassidy, Critical Care Educator

Ms. Natalie Millen, CN

Ms. Kerrian Phillips, CN

The members of the Australian College of Critical Care Nurses who participated in the research project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF DEFINITIONS

Arterial pressure monitoring – the continuous measurement of systolic, diastolic and mean blood pressures using a short 20 gauge catheter inserted into an artery; allows for arterial blood sampling.

Central venous line (CVL) – an intravenous catheter inserted into a central vein such as the subclavian, internal jugular or femoral; also known as a central venous catheter.

Central venous pressure (CVP) – a reflection of the volume of the blood returning to the heart, which exerts pressure on the walls of the right atrium.

Haemodynamic monitoring – the monitoring of the forces involved in circulating blood around the body; assists in the direction of appropriate therapeutic interventions to optimise cardiovascular function.

Pulmonary Artery (PA) catheter – a multilumen catheter placed centrally with the tip in a pulmonary artery; in addition to calculating cardiac output, it permits continuous direct measurement of right heart pressure and indirect measurement of the left side of the heart.

Total Parenteral Nutrition (TPN) – the provision of all essential nutrients without using the gastrointestinal tract.

CHAPTER 1

INTRODUCTION

Haemodynamic monitoring is an integral part of critical care nursing, providing direction for therapeutic interventions aimed at optimising cardiovascular function. Pulmonary artery (PA) catheters, central venous lines (CVLs) and arterial blood pressure lines are three types of methods currently utilised in the critical care setting.

Over the last five years, PA catheters have been associated with significant risks and increasingly have been replaced with the use of CVLs that measure central venous pressure (CVP) as a simpler method of assessing circulatory volume and cardiac function (Hinds & Watson 1999; Druding 2000). This trend has been more noticeable outside of major metropolitan cities and in the general intensive care units of rural areas where haemodynamic monitoring is used less frequently (Brandstetter *et al.* 1998). Deficiencies of knowledge regarding the insertion, maintenance and interpretation of values may be contributing factors to the increased risks associated with PA catheters. Physicians and nurses practicing in smaller urban hospitals may not use them often enough to maintain adequate skill levels (Brandstetter *et al.* 1998).

A CVL is a flexible catheter, 20 centimetres in length, which is inserted percutaneously under sterile conditions by a physician through a major vein such as

the subclavian vein and terminates in the superior vena cava (Figure 1.1). It allows for monitoring of the CVP, a reflection of the pressure of blood in the vena cava and provides information about intravascular blood volume and right ventricular heart function. The haemodynamic monitoring system consists of the same components used with arterial blood pressure lines and PA catheters.

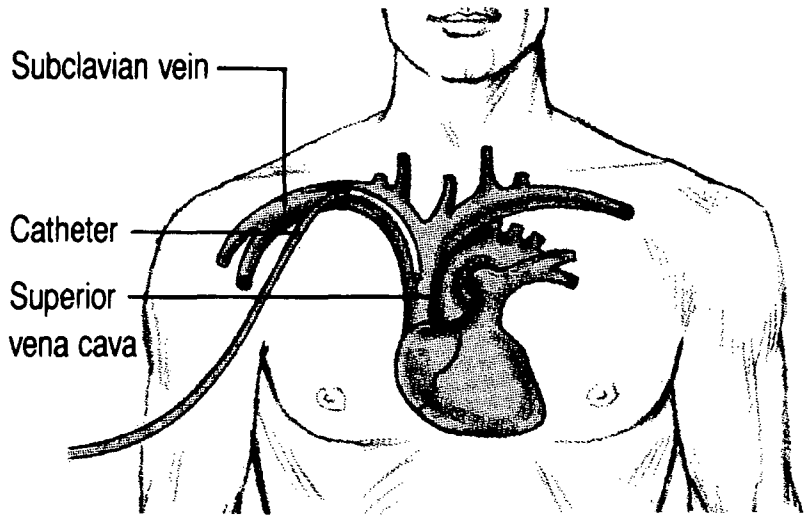


Figure 1.1 Central venous line placement[†]

[†]Source: Krozek, C., Millam, D. & Pelikan, R., 1996, 'Intravascular Therapy', in *Nursing Procedures*, 2nd edn, ed S. Daly, Springhouse, Springhouse, p. 298.

Equipment includes a flush solution administered under pressure, noncompliant pressure tubing, a transducer, an amplifier and a monitor to display the waveform. Pressures are transmitted through the catheter and pressure tubing to the transducer where it is changed to an electrical signal. The monitor then converts and displays this signal in the form of a waveform for a CVP value in millimetres of

mercury (mmHg.). Patient position, transducer position and the patient's breathing pattern may affect the accuracy of the readings (Von Ruedon 1998).

CVLs are used not only for haemodynamic monitoring, but also for fluid resuscitation in emergency situations, the infusion of medications and for the provision of total parenteral nutrition (Henderson 1997). The use of a CVL increases the patient's risks of pneumothorax, infection leading to sepsis, thrombus formation and provides a means for air to enter the circulatory system in the form of an embolus. These complications are life-threatening conditions that patients may develop if nursing care is not properly provided (Drewett 2000). The high standards of practice in hospitals requires that nurses have a comprehensive understanding of the use and maintenance of CVLs to enable the collection of accurate patient information and to prevent complications.

1.1 Statement of the Problem

Lack of knowledge and inadequate care of CVLs by nurses in critical care settings may lead to an increased risk of mortality of patients with a highly compromised health status. There is little published information relating to this issue in Australia, including Queensland. This cross-sectional research project was undertaken to objectively assess the knowledge base of critical care nurses in regards to CVLs using a quantitative approach in the form of a paper and pencil questionnaire. The study population was limited to registered nurses who work in a critical care area. A questionnaire designed by the researcher was distributed through

the mail to nurses using a national database from the Australian College of Critical Care Nurses (ACCCN).

Independent variables included in the study were: nurses' level of education, additional certificates of learning, job position, years of experience as a nurse, years of service in critical care, hospital size and its location. The self-reported data was analysed to determine if the nurses had an acceptable knowledge of CVLs. Statistical procedures were employed to determine if the sociodemographic variables had a relationship with their knowledge.

1.2 Purpose of the Study

The primary aim of this cross-sectional research study was to determine if there was a knowledge deficit in the use and maintenance of CVLs by nurses in a critical care setting. The secondary purpose of this study was to determine if critical care nurses' knowledge of CVLs related to their sociodemographic characteristics. This study based the concept on two previous studies of haemodynamic monitoring involving critical care nurses' knowledge of PA catheters (Burns, Burns & Shively 1996) and arterial blood pressure lines (McGhee & Woods 2001). Both of these studies, conducted in the United States, indicated a general lack of nursing knowledge regarding haemodynamic monitoring and that knowledge varied in relation to sociodemographic characteristics.

1.3 Research Questions

The health care system across Australia includes hospitals in remote, rural, and metropolitan communities. Therefore, a comparison of nursing skills was possible. Questions that were dealt with by this study include:

- Did nurses working in critical care settings have adequate knowledge to use and care for CVLs?
- Did nurses working in rural and remote hospitals report a higher, lower or equal knowledge base compared to nurses working at metropolitan hospitals?
- Did nurses with more nursing experience demonstrate a greater knowledge of CVLs?
- Did nurses demonstrate a greater knowledge if they have furthered their education?

1.4 The Importance of the Study

This project investigated whether more nursing education is indicated regarding CVLs. Indirectly, this project may reduce the risk of inadequate care of patients with CVLs by encouraging nurses to review policies and guidelines regarding the care and maintenance of CVLs. Improvement of nursing knowledge of CVLs may decrease the morbidity and mortality of patients with this invasive piece of equipment in place. The results of this project would be beneficial to nurse practice coordinators, nurse educators, nurse clinicians, and staff nurses of critical

care units by addressing a quality of care issue: Do critical care nurses demonstrate an acceptable level of knowledge of CVLs?

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Haemodynamic monitoring is an important aspect of critical care nursing for planning and evaluating therapy in critically ill patients. PA catheters, CVLs and arterial blood pressure lines are three major methods currently utilised. Over the past five years, controversy over the dangers of PA catheters has resulted in an increased use of CVLs. Measurement of central venous pressure from a CVL is a more simplified method of assessing circulatory volume and myocardial function (Hinds & Watson 1999).

An extensive literature search was undertaken by the researcher to evaluate studies that specifically addressed physician or nursing knowledge of CVLs. Medline, Cinahl, Knowledge Server, Infotrac, ProQuest, WebSPIRS, Ingenta Journals, FirstSearch and Ovid were some of the databases reviewed. Key words used in the search included central venous line, central venous catheter, central venous pressure, haemodynamic and hemodynamic monitoring. The literature related to CVLs is reported in this chapter. For organisational purposes, the literature is presented under the following topics:

- Changes in Haemodynamic Monitoring

- Central Venous Lines
- Monitoring the Central Venous Line
- Summary

2.2 Changes in Haemodynamic Monitoring

The PA catheter has a minimum of four lumens and is 110 cm in length. As a balloon-tipped catheter, it allows for the assessment of right ventricular function, pulmonary vascular status and indirectly, left ventricular function. Insertion involves placing the catheter centrally with the tip in the right atrium of the heart. The balloon is then inflated and the catheter floats through the tricuspid valve into the right ventricle, across the pulmonic valve and into the pulmonary artery where it is allowed to wedge and the balloon deflated (Figure 2.1) (Milford 1996). Complications include pneumothorax, infection leading to sepsis, air embolism, ventricular dysrhythmias, migration of the catheter and pulmonary artery rupture. Nursing care and interpretation of the readings is complex to ensure accurate values and minimise operator error while preventing complications (Milford 1996).

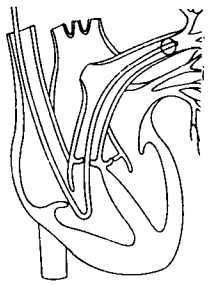


Figure 2.1 Pulmonary artery catheter placement[†]

[†]Source: Milford, C., 1996, 'Cardiovascular Care', in *Nursing Procedures*, 2nd edn, ed S. Daly, Springhouse Corp., Springhouse, p. 369.

PA catheters have been associated with significant risks and disadvantages. In a five-year observational study of 5,735 patients, Connors *et al.* (1996) concluded that PA catheters were associated with increased mortality, length of stay, intensity of care and cost. Patients who were catheterised had a higher 30-day mortality rate, used more resources and stayed in the intensive care unit longer. After adjustment for treatment selection bias and a variety of risk factors, the cause of this lack of benefit remained unclear to the researchers.

Two years later, Brandstetter and colleagues (1998) suggested that a user lack of knowledge regarding management and data interpretation along with infrequent use caused these untoward effects to be related to the use of PA catheters. Jones (2000) agreed with Brandstetter and colleagues and suggested that improved training in its use and interpretation of data was required. A study of physicians' knowledge of the PA catheter conducted in 1990 by Iberti and colleagues in North America provided the basis for these opinions. After administering a 31 item multiple-choice questionnaire to 496 physicians, it was concluded that physician understanding of PA

catheters was extremely variable and may lead to inappropriate therapeutic decisions and increased patient morbidity. The internal reliability coefficient for the study was 0.71. Mean scores varied according to training, frequency of use of the data and frequency of insertion. A need for re-evaluation of accreditation policies for use of PA catheters was called for, using a minimum of five insertions per year to maintain mastery of the device (Iberti *et al.* 1990).

In the United States, Burns, Burns and Shively (1996) assessed 168 critical care nurses' knowledge of the PA catheter using the original questionnaire developed by Iberti and colleagues. Fourteen demographic questions were included to examine variables that might influence knowledge scores. They concluded from the low scores that there was a nursing knowledge deficit and that it was directly related to the frequency of use, nursing experience and education. The internal reliability coefficient for the study was 0.60, lower than Iberti and colleagues' study of physicians' knowledge. The researchers determined that the subsection topics of physiology, waveform analysis, recognition of complications and application of data were not necessarily related to each other and that led to the lower value. Limitations to this study included a nonrandom sampling method and different testing times with various settings. The researchers felt that a revision of the questions to better reflect knowledge specific to critical care nurses would improve the study.

A panel of experts at a workshop conducted by the National Heart, Lung and Blood Institute and the US Food and Drug Administration determined that after consideration of recent published literature there was little evidence that PA catheters improved patient care (Bernard *et al.* 2000). The lack of randomised trials showing

PA catheter effectiveness brought into question the benefit of using this device. Recommendations made included the standardisation and monitoring of physician and nurse education to improve the quality and use of clinical information derived from the PA catheter and the conduction of clinical trials investigating its safety and effectiveness.

For these reasons, it has been suggested that PA catheters be used only in the most critically ill patients or when other assessment skills do not provide adequate information (Druding 2000). These concerns have contributed to the declining use of PA catheters with CVLs taking their place, especially in the general intensive care units outside of major metropolitan or capital cities where physicians and nurses may not use them often enough to maintain adequate skill levels (Brandstetter *et al.* 1998).

McGhee and Woods (2001) conducted a survey of 68 critical care nurses regarding their knowledge of arterial pressure monitoring in the United States. Using a questionnaire developed by the researchers, summary statistics and analysis of variance were used to determine if scores differed among sociodemographic subgroups. They found a general knowledge deficit amongst all the participants regarding this form of haemodynamic monitoring. An internal reliability coefficient was not reported in their results. The demographic subgroup of nurses who obtained Advanced Cardiac Life Support certification tended to have higher scores (McGhee & Woods 2001). Weaknesses in this study included the small sample size, low response rate (17.4%), the small number of questionnaire items (18) and that it was

conducted as a pilot study. Further research using this questionnaire has not yet been published.

2.3 Central Venous Lines

PA catheters are used to obtain specific intracardiac data in the diagnosis and evaluation of heart disease, shock states and pulmonary conditions that compromise the cardiovascular status by simultaneously assessing multiple haemodynamic parameters (Milford 1996). In comparison, CVLs provide for monitoring only one parameter, the CVP and are indicated in patients with alterations in fluid volume and to assess diuretic therapy. Unlike the haemodynamic parameters obtained from a PA catheter, the CVP is only an indicator of the function of the right side of the heart. It is a simpler method of assessing cardiac function, blood volume and vascular tone. Additionally, they are commonly used for emergency fluid resuscitation and drug or nutritional therapy that may be harmful to peripheral veins (Henderson 1997).

No studies were found that addressed a health care provider's knowledge of CVLs in a comprehensive manner. While there is an apparent lack of research-based studies involving nurses' knowledge of CVLs, many authors have written about and published studies of individual aspects of CVLs. McDermott (1995) and Henderson (1997) wrote comprehensive articles covering the use, complications and maintenance of CVLs, including measuring and interpreting central venous pressure (CVP). Neither of the articles was research based. Henderson's article (1997) included a twenty-question assessment for continuing education purposes. However,

no statistics were compiled and published at a later date to indicate how nurses performed.

Henderson (1997) recommended the use of the distal port for CVP measurement to avoid inaccurate readings as the other lumens can be near the vessel wall. A study by Scott *et al.* (1998) involved the measurement of CVP readings from different ports of a triple lumen CVL. Their results determined that pressure readings from both the proximal and medial ports varied significantly from the distal port ($p < .001$) with the distal port proving to have the lowest value (Figure 2.2). The differences between the values may be clinically significant and influence the care provided to a critically ill patient (Scott *et al.* 1998). Gourlay (1996) also recommended the use of the distal port for CVP measurement to avoid potential drug and fluid incompatibilities and interactions.

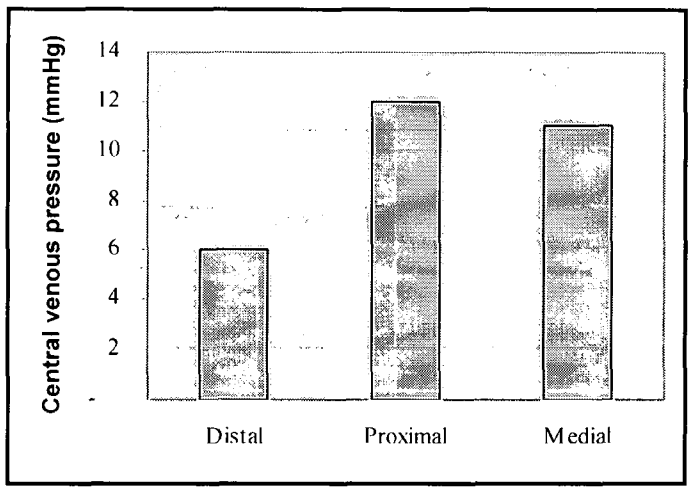


Figure 2.2 Central venous pressures from different ports of a triple-lumen catheter†

†Source: Scott *et al.* 1995, 'Influence of Port Site on Central Venous Pressure Measurements from Triple-Lumen Catheters in Critically Ill Adults', *American Journal of Critical Care*, vol. 7, no. 1, pp. 60-63

Weatherill (1999) attempted to do a study in the United Kingdom to determine the policy for maintaining patency of infrequently used lumens of CVLs. This study could not be completed due to a low response rate, forcing Weatherill to look elsewhere for information. Final recommendations included flushing frequently used lumens with 0.9 per cent sodium chloride and infrequently used lumens with heparin solution in a concentration of 10 units/ml (Weatherill 1999).

A survey of ninety-two persons by Clemence, Walker and Farr (1995) in the United States reported a significant diversity of practice with the use of antiseptics, dressing changes and blood collection methods. An observational study by Roach, Larson and Barlett (1996) also found a wide variety of practices with variation from written protocols in the care of intravascular sites. A total of 116 site care episodes were observed in five critical care units located in Washington, DC. The researchers reported variations of practice within the same institution, as well as between different hospitals. Larwood, Anstey and Dunn (2000) conducted a randomised, prospective study in Queensland to evaluate the method used to change intravenous fluids and lines. While this study indicated it is safe to use aseptic technique, like the other studies, it only addressed problems introducing infection to patients.

Mermel (2000) provided an extensive literature review on the prevention of catheter-related infections and made suggestions of preventive strategies based on prospective and randomised trials. Simple interventions included:

- Use of chlorhexidine antiseptic for cleansing insertion sites,
- The use of povidone-iodine ointment to insertion sites,

- Disinfection of injection hubs prior to access with either alcohol, povidone-iodine or chlorhexidine and
- The use of either gauze or transparent dressings.

A growing trend to provide nutrition early in the course of a critically ill patient's disease has promoted the use of total parenteral nutrition or TPN. Due to the hypertonic nature of TPN, infusion of these solutions must be through a CVL. Two comprehensive articles by Bowers (1999) and Khaodhiar and Bistrian (1999) addressed the need for nutritional support in critical care, types of TPN, the nurse's role and complications that can occur. While informative, neither article was research based. The extensive literature search did not lead to any systematic studies regarding assessment of nursing knowledge of TPN infusion through a CVL.

2.4 Monitoring the Central Venous Line

Aspects such as CVP values, position of the patient, measurement of the CVP, maintenance of the line, infection and complications were considered for this study of critical care nurses' knowledge of the care and use of CVLs. Normal CVP values varied from one author to another author, ranging from 0-6 mmHg (Daily 1996; Von Ruedon 1998) to 2-5 mmHg (Thelan, Urden, Lough & Stacy 1998) and 2-8 mmHg (Cooke & Barrie 1997; Morelli 1999). Furthermore, a normal CVP can be as high as 12 mmHg depending on pre-existing physiological factors (Cooke & Barrie 1997). These authors agreed that the trend of values is more significant as related to the patient's cardiovascular status and response to therapeutic

interventions. The non-uniformity of a specific range of normal CVP values led to the exclusion of this aspect in this proposed study.

When monitoring the CVP, intravascular pressure signals are transmitted through the CVL and tubing to a transducer that converts it to an electrical signal and consequently a waveform on the monitor (Thelan *et al.* 1998). Use of the correct anatomical reference point for placement of the transducer is vital for obtaining accurate measurements. For example, a transducer placed below the reference point will yield falsely elevated readings (Von Ruedon 1998). The phlebostatic axis is recommended for use as the reference point (Daily 1996; Henderson 1997; Thelan *et al.* 1998). Defined, this axis is at the intersection of the midaxillary line and the fourth intercostal space (Henderson 1997).

The central venous pressure waveform actually consists of three separate waves: 1.) The 'a' wave represents atrial contraction 2.) The 'c' wave represents ventricular systole and 3.) The 'v' wave represents filling of the atria (Figure 2.3).

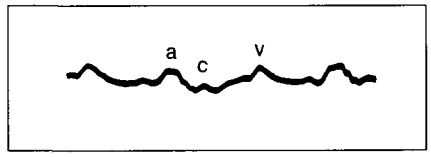


Figure 2.3 Central venous pressure waveform[†]

[†]Source: Gilliam, D. S., 1995, 'Mechanical Complications in Coronary Artery Disease: Heart Failure and Shock', in *Commonsense Approach to Coronary Care*, 6th edn., eds. M. Crawford & M. Spence, Mosby, St. Louis, p. 325.

Cardiac conditions such as atrial fibrillation, tricuspid stenosis, pulmonary hypertension and cardiac tamponade are associated with waveform abnormalities.

These abnormalities may cause the CVP to be elevated when the patient is not hypervolaemic (Cook 1996; Druding 2000; Queensland Health 1999). Critical care nurses should have an understanding of these physiological changes.

A survey of clinicians reported significant variation in the type of dressings, frequency of dressing and line changes, use of antiseptics and ointments, and types of flushes used to maintain line patency (Clemence, Walker & Farr 1995). More recent literature reviews by Larwood (2000) and Mermel (2000) found varying practices continue and suggest that further research is needed. As these particular practices probably vary from hospital to hospital, it was decided not to include questions regarding these topics in this proposed study.

2.5 Summary

CVLs are used for a variety of purposes, including haemodynamic monitoring, emergency fluid resuscitation, drug infusions and providing for nutrition. The increasing use of CVLs has led to the need to assess the critical care nurses' knowledge base for the use and maintenance of this invasive piece of equipment. No research study was found to address nurses' knowledge of CVLs in a comprehensive manner.

Various studies have identified a lack of knowledge among health care providers caring for patients requiring haemodynamic monitoring. Iberti and colleagues (1990) identified wide variations in physicians' knowledge of the use of PA catheters, which could lead to inappropriate therapeutic decisions and increased patient morbidity. The findings of Burns, Burns and Shively (1996) and McGhee and

Woods (2001) that showed a general lack of nursing knowledge of two methods of haemodynamic monitoring, PA catheters and arterial blood pressure, support the need for this study.

CHAPTER 3

METHODOLOGY

One of the major objectives of this study was to assess the knowledge of critical care nurses in regards to CVLs and compare those with adequate knowledge and those with inadequate knowledge relating to their sociodemographic data. This chapter will describe the design of the study, hypotheses and study variables, development of the questionnaire, the population under study and sample size, ethical considerations, data analysis, the conduction of a pilot study, questionnaire revision and a summary.

3.1 Study Design

The design of this study was a cross-sectional study. Data was collected using a questionnaire designed by the researcher. This enabled the researcher to obtain information about the distribution and relationships of the variables by asking questions of a group of people in a defined population at one point in time. The questionnaire was developed by reviewing relevant literature, initial questionnaire design, an assessment of the designed questionnaire by a panel of experts and conducting a pilot study. Incorporation of feedback from the experts and the results

of the pilot study were used to revise the questionnaire, which was then used to collect actual data.

3.2 Hypotheses

Null hypotheses:

All critical care nurses demonstrate an adequate knowledge relating to their use and care of CVLs.

There is no significant relationship between their knowledge of CVLs and demographic information.

Alternative hypotheses:

A proportion of critical care nurses would have inadequate knowledge relating to the use and care of CVLs.

Critical care nurses who worked in larger metropolitan hospitals had a higher level of knowledge of CVLs compared to nurses who worked at rural and remote hospitals.

Critical care nurses who worked in a critical care unit more than five years were more knowledgeable about CVLs than those with less work experience in critical care.

Critical care nurses with additional certificates of learning or post-graduate university education were more knowledgeable about CVLs than those without.

3.3 Variables under Study

Seven sociodemographic questions were included in the study to examine variables that might influence knowledge scores. The independent variables of this study included:

- Nursing role or position
- Location of nurses' main place of employment
- Size of hospital
- Length of time working in a critical care area
- Years of working experience as a nurse
- Highest level of education
- Additional certificates of learning.

Nursing role or job position was defined by three categories:

- Management positions such as Nurse Manager, Nurse Practice Coordinator or Educator
- Clinical Nurse positions that could be described as Clinical Nurse Specialist, Charge Nurse, Shift Coordinator or Senior Nurse
- Staff nurse or Registered Nurse.

Using definitions from a government report, *Workforce Characteristics: Nurses Re-registered in Queensland* (Queensland Health 2000), the location of nurses' main place of employment was categorised according to population:

- Capital city or major metropolitan area – population at least 100,000
- Large rural city – population 25,000 or more
- Small rural city – population 10,000 to 24,999

- Other rural area – population less than 10,000
- Remote area – a designated remote zone

Size of hospital was divided into categories according to the bed capacity set by the Commonwealth Health Department (Queensland Health 2000) as: 25 or less, 26-50, 51-100, 101-200 and 201 or larger. The length of time worked in a critical care area and years of service as a registered nurse were divided into categories of less than 2 years, 2-5 years, 6-10 years and more than 10 years.

The highest level of education or degree completed included diploma, bachelor, post-graduate certificate award, post-graduate diploma award and master degree or higher. Additional certificates of learning were defined as continuing education classes that are acknowledged by a certificate of satisfactory completion but do not result in a university award. These included the completion of a trauma seminar, a hospital-based critical care program and advanced life support courses.

3.4 Instrumentation

This study used a self-completed questionnaire designed by the researcher to collect information. Advantages to using a questionnaire include cost containment, the ability to reach geographically dispersed participants, limitation of interviewer bias and complete anonymity of the participants (Frazer & Lawley 2000). A structured or closed-ended questionnaire takes less time for participants to complete. The construction of the questionnaire involved multiple steps to ensure content validity, reliability and reduce bias.

Preparation of the questionnaire considered the following:

- Question content as determined by the literature review
- Involvement of a panel of experts in the field
- Wording to make the questions appropriate and relevant; eliminate the use of double negatives
- Use of true-or-false and multiple-choice, closed-ended questions with one correct answer, taking care not to 'lead' the respondent
- Structure and layout to gain respondent cooperation and avoid order bias
- More difficult questions were placed later in the questionnaire
- Page layout was such that questions fit the page; two columns per page were utilised so not to appear cramped
- Placement of sociodemographic questions at the end of the questionnaire

The questionnaire content incorporated various aspects including insertion of a CVL, maintenance, haemodynamic monitoring, complications and removal of the line. Specific questions were written to ascertain nursing knowledge of patient position for insertion and obtaining a CVP reading, the correct procedure for removing a CVL and infusion of TPN and drugs. Maintenance included use of correct equipment and maintaining patency of the lumens. Interpretation of central venous waveforms and the CVP value were considered important factors in addition to prevention, recognition and treatment of complications. Complications included arrhythmias, air embolism, catheter related infection and central vein thrombosis. Lack of knowledge in these areas may be detrimental to patient outcomes and may have an affect on the morbidity and mortality rates of patients with a CVL (Thelan *et al.* 1998).

Thirty-eight true-or-false and multiple-choice, closed-ended questions were developed based on review of the literature and given to a panel of seven experts in the critical care field for evaluation. The panel included two intensivist physicians, a nurse practice coordinator, a critical care educator and three clinical nurses. These experts were asked for input in the determination of an acceptable level of nursing knowledge, to suggest questions to be added or removed and to comment on the clarity and representativeness of the questions. This provided content validity of the designed questionnaire.

A percentage of correct answers was used to determine the level of knowledge. Baumgartner and Jackson (1995) stated that this type of evaluation is graded on a pass-fail basis and the standards should be higher in comparison to when a grading scale is applied. Criterion for passing a knowledge test is recommended to be 80-90% correct answers to show mastery or indicate a sufficient level of knowledge of a topic (Baumgartner & Jackson 1995). The researcher and panel of experts considered the importance of nursing care of patients with a CVL and the severity of morbidity and risk of mortality associated with CVLs. As this questionnaire involved knowledge concerning a critical care area, a score of 85% was agreed to be the minimum acceptable score to demonstrate sufficient knowledge.

Comments given by the panel of experts were used to revise the questionnaire. Questions were organised and checked for wording and layout. Instructions to participants were given relating to the study objectives, inclusion criteria and methods used to complete the questionnaire. The questionnaire consisted of thirty-three questions and was later utilised in the pilot study. A cover letter was

provided as an introduction to the survey and to encourage nurses to respond. The length of this was kept to one page and included the name and contact information of the researcher, an explanation of how the respondents were selected, assurance of anonymity and provision of the results upon request. The cover letter closed with a statement of appreciation and the researcher's handwritten signature in blue ink to indicate personalisation. Participants in the pilot study were requested to provide feedback.

Critical care nurses working in the Fraser Coast Health Service District in Queensland comprised the population for the pilot study. The district is comprised of two public hospitals, one servicing a large rural city and the other a small rural city. Members from the panel of experts were excluded from the pilot study. Further revision to the questionnaire was made based on the results of the pilot study. The final questionnaire contained thirty question items. This was later distributed to the study population (Appendix 1).

3.5 Population under Study

The study population was all registered nurses who work in a critical care area in Australian public and private hospitals. They were members of the Australian College of Critical Care Nurses (ACCCN) willing to take part in a research project endorsed or approved by the association. This professional organisation supports nursing research by making available a national database of 1,521 out of 2,400 members (63.4%) who have indicated their willingness to participate in nursing

related studies. The researcher did not use a list of members of each state's Nursing Council for a study population, as it did not ensure a good representation of critical care nurses.

Using a table of random numbers, a sample size of six hundred nurses was chosen from the database supplied by ACCCN to answer the research questions and test the hypotheses. Nurses who were members of the panel of experts or who participated in the pilot study were excluded from the sampling frame. The questionnaire was distributed through the mail by the researcher to these nurses in a single stage sampling method. Participants were asked to return the questionnaire in the provided postage-paid envelope within two weeks. Data was collected during a four-week period. No follow-up was made with those who did not return the completed questionnaire.

3.6 Ethical Consideration

All forms of research involving or having an impact on humans must conform to high standards of academic integrity and ethical practice. As this research project was a survey that did not involve healthcare clients, the researcher obtained ethical approval from the Ethical Research Review Committee of the School of Nursing and Health Studies at Central Queensland University (Appendix 2). Permission to conduct the pilot study was obtained from the Nurse Practice Coordinator of both participating critical care units (Appendix 3). After ethical

approval was received, ACCCN provided the database of potential participants to the researcher.

An introduction letter that explained the nature of the study accompanied each questionnaire (Appendices 4 and 5). Participants' names were not gathered to assure anonymity. The questionnaire was mailed to the participant's home address and completion did not have an effect on his or her work. Participation in the study was voluntary. The return of the completed questionnaire reflected the nurse's consent to participate. Data has been and will continue to be stored securely in the researcher's home office for a period of five years. Only the researcher and her study supervisor could gain access to the data.

3.7 Data Analysis

All data entry, editing and analysing were conducted by the researcher. Responses from the returned questionnaires were entered into a computer using the Statistical Package for the Social Sciences (SPSS) Student Version 6.1 (1996). Inconsistency of answers of selected questions was checked. If needed, responses were discarded from question items.

In order to compute a knowledge score of each participant, a score of one was given for a correct answer and a zero score was given for an incorrect response (Appendix 6). The possible score ranged from zero to 30. Baumgartner and Jackson (1995) suggest that 80-90% questions be answered correctly for a sufficient level of knowledge of a topic. The researcher and panel of experts considered the importance

of care of patients with a CVL and the severity of morbidity and risk of mortality associated with CVLs to decide that 85% of correct answers would demonstrate an acceptable level of knowledge for critical care nurses. Therefore, the minimum score used in this study, to indicate the acceptable nurses' knowledge relating to the use and care of patients with a CVL, was 25.

The internal reliability of the designed questionnaire was tested using the Kuder-Richardson 20 formula (Appendix 7). This formula was selected as the question items had either correct or incorrect responses and would give a reliability coefficiency of the knowledge measurement instrument (Polit & Hungler 1999). The internal reliability is used as a measure of how similar the items are to each other or the internal consistency of the questionnaire (Jackson & Furnham 2000).

The coefficiency alpha can range between 0.00 and 1.00. The higher the coefficiency alpha, the more valid the internal consistency of question items. The minimum alpha value of 0.70 may be sufficient (Polit & Hungler 1999). This implies that 70% of the measured variance of the scores is reliable and 30% is owing to random error or fluctuations (Bowling 1997). A lower alpha indicates that the question items have little similarity with each other. However, an alpha higher than 0.85 may indicate tautology because of redundant items being included in the scale (Jackson & Furnham 2000).

Descriptive statistical analysis was used for organising and summarising the data obtained from the sample. Descriptive data was analysed and presented in numbers and percentages. A frequency distribution was utilised to systematically arrange scores from the lowest value to the highest value. A frequency distribution

was used to summarise sociodemographic data. Three indices of central tendency were calculated: mode, median and mean. Other values calculated to present data distribution were range, variance and standard deviation. Data was presented in tables and figures.

A one sample t-test is used in a measurement situation where the mean performance of a group is being compared to an expected mean of a specified value or a standard expressed as a mean (Baumgartner & Jackson 1995). It determines the probability of difference as real opposed to chance. One sample t-tests were used to compare the mean score obtained by sociodemographic groups of participants with the minimum score of 25. The minimum level of statistical significance was 0.05.

The t-test for two independent groups was used to compare the mean scores of two different groups of the sample. Nurses were categorised to two groups according to their additional learning certificates. A statistical significance level (α) of 0.05 was chosen to reject a null hypothesis ($p < 0.05$).

One-way analysis of variance (ANOVA) was used to compare the mean scores of more than two groups of nurses according to their sociodemographic characteristics. For example, it was used to determine if there were significant differences between mean knowledge scores of nurses grouped according to their main nursing role or position. One-way ANOVA permits three or more groups to be compared but is limited to assessing the effects of only one independent variable at a time. It is used to test the null hypothesis that the populations represented by the groups are equal in mean performance (Baumgartner & Strong 1998). Levene's test

for Homogeneity of Variances was used to ensure that the homogeneity assumption was not violated. The F probability value was set at 0.05.

3.8 Pilot Study

A purposive selected sample of twenty-seven critical care nurses working in the Fraser Coast Health Service District participated in the pilot study. Permission to conduct the pilot study was obtained from the Nurse Practice Coordinator of the two participating critical care units. A 33-item questionnaire containing true-or-false and multiple-choice questions, in addition to sociodemographic questions, was mailed to participants. A postage-paid envelope was provided for return of the questionnaire. Participants were invited to comment on the clarity of questions and make suggestions for improvement of the questionnaire.

Nineteen questionnaires were returned with a response rate of 70%. One participant did not complete the sociodemographic data subsequently this questionnaire was not included in the data analysis. The majority of the respondents were registered nurses (n = 14, 77.8%) with a Bachelor degree of education, worked in a large rural city (n = 10, 55.56%) and had more than ten years of nursing experience (n = 11, 61.11%). The majority of respondents also had advanced life support certification (n = 11, 61.11%) (Table 3.1). Both hospitals had a capacity of 51-100 beds. Only one participant had less than two years nursing experience and no participant had between 2-5 years nursing experience.

Table 3.1 Sociodemographic data of the participants of the pilot study

Sociodemographic Factors	Number	Per cent
Nursing Position		
Clinical Nurse	4	22.22
Registered Nurse	14	77.78
Job Location		
Large Rural	10	55.56
Small Rural	8	44.44
Years Critical Care Experience		
Less than 2 years	5	27.78
2-5 years	5	27.78
6-10 years	5	27.78
More than 10 years	3	16.67
Years Nursing Experience		
Less than 10 years	7	38.89
More than 10 years	11	61.11
Highest Level of Education		
Diploma	3	16.67
Bachelor Degree	7	38.89
Post-Graduate Certificate	6	33.33
Post-Graduate Diploma	2	11.11
Additional Learning Certificates		
Trauma	4	22.22
Hospital-based Program	8	44.44
Advanced Life Support	11	61.11

The range of correct items or knowledge score was 18 to 32. The mean knowledge score of the questionnaire was 25.2 or 76% items correctly answered, with a standard deviation of 3.75 (Figure 3.1). Of the knowledge scores, 72% (n = 13) of the participants had a score less than the minimum passing score of 28 indicating an inadequate level of knowledge in caring for patients with a CVL. The

Kuder-Richardson 20 coefficient, an indication of internal reliability, was 0.70 and considered an acceptable level (Polit & Hungler 1999).

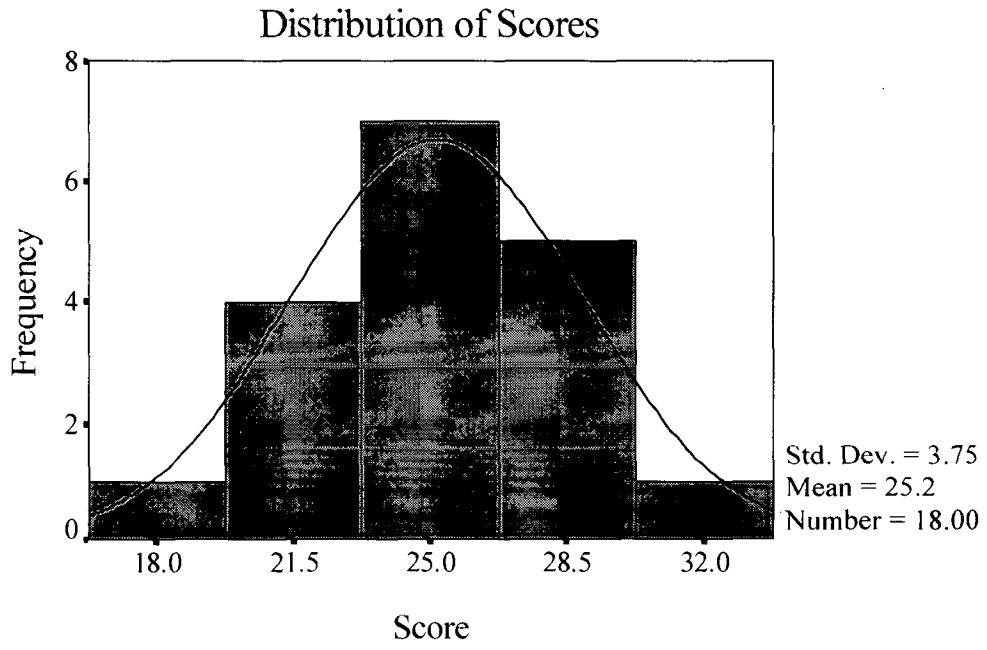


Figure 3.1 Distribution of knowledge scores of participants in the pilot study

A series of one-sample t-tests were obtained to compare the mean knowledge scores of the participants with the minimum passing score of 28 (85%) necessary to demonstrate adequacy of knowledge to care for patients with a CVL (Table 3.2). The mean knowledge score of all critical care nurses participating in the pilot study was found to be significantly lower than the minimum passing score (p = 0.005). The following groups of participants had an average knowledge score lower than the passing score: Registered nurses, nurses working in a small rural area, nurses with 2-5 years critical care experience, nurses with less than 10 years nursing experience

and nurses with a Bachelor degree or a Post-Graduate Certificate (see details in Table 3.2).

Table 3.2 Test of relationship between the participants' mean knowledge score and the minimum passing score of pilot study

Factors	Number	Mean Score (Standard Deviation)	t (df)	*p*
All Participants	18	25.17 (3.75)	-3.21 (17)	0.005*
Nursing Position				
Clinical Nurse	4	29.00 (2.58)	0.77 (3)	0.495
Registered Nurse	14	24.07 (3.32)	-4.43 (13)	0.001*
Job Location				
Large Rural	10	26.70 (3.09)	-1.33 (9)	0.217
Small Rural	8	23.25 (3.77)	-3.56 (7)	0.009*
Years Critical Care Experience				
Less than 2 years	5	23.00 (4.18)	-2.67 (4)	0.056
2-5 years	5	24.40 (2.70)	-2.98 (4)	0.041*
6-10 years	5	26.20 (3.90)	-1.03 (4)	0.360
More than 10 years	3	28.33 (2.89)	0.20 (2)	0.860
Years Nursing Experience				
Less than 10 years	7	23.71 (3.15)	-3.60 (6)	0.011*
More than 10 years	11	26.09 (3.94)	-1.61 (10)	0.139
Highest Level of Education				
Diploma	3	28.33 (1.53)	0.38 (2)	0.742
Bachelor Degree	7	23.00 (3.65)	-3.62 (6)	0.011*
Post-Graduate Certificate	6	24.83 (2.93)	-2.65 (5)	0.045*
Post-Graduate Diploma	2	29.00 (4.24)	0.33 (1)	0.795
Additional Learning Certificates				
Trauma	4	27.25 (4.57)	-0.33 (3)	0.764
Hospital-based Program	8	27.12 (3.91)	-0.63 (7)	0.547
Advanced Life Support	11	26.00 (4.05)	-1.64 (10)	0.132

*$p < 0.05$

The average knowledge scores of nurses who completed a trauma educational program, a hospital-based critical care program or an advanced life support program were compared with nurses who did not complete each training program. Results showed that nurses who completed a hospital-based critical care program had a significantly higher average knowledge score than those who did not. Nurses who completed a trauma educational program or an advanced life support program had a similar average knowledge score to those who did not (Table 3.3).

Table 3.3 Test of the difference of an average knowledge score between nurses who completed different educational programs and those who did not in pilot study

Additional Education Program	Number	Mean (standard deviation)	*t* (df)	*p*
Completed trauma education				
Yes	4	27.25 (4.57)	-1.29 (16)	0.217
No	14	24.57 (3.43)		
Completed a hospital-based critical care program				
Yes	8	27.12 (3.91)	-2.20 (16)	0.043*
No	10	23.60 (2.91)		
Completed an advanced life support program				
Yes	11	26.00 (4.05)	-1.20 (16)	0.248
No	7	23.86 (3.02)		

*$p < 0.05$

The difference of an average of knowledge score between nurses with different characteristics was compared using a student t-test for two groups or ANOVA for three groups (Tables 3.4 and 3.5). Results showed that clinical nurses

had a significantly higher average knowledge score than registered nurses. Nurses who worked in a large rural area had a significantly higher average knowledge score than the score obtained by nurses who worked in a small rural area. The average knowledge scores of nurses categorised by their period of working experience in critical care settings, period of working as professional nurses and the highest level of education were not statistically different.

Table 3.4 Independent sample t-tests of the different groups of participants' mean knowledge scores of pilot study

Group Factor	Number	Mean Score (standard deviation)	t (df)	*p*
Nursing Position				
Clinical Nurse	4	29.00 (2.58)	2.72 (16)	0.015*
Registered Nurse	14	24.07 (3.32)		
Job Location				
Large Rural	10	26.70 (3.09)	2.14 (16)	0.049*
Small Rural	8	23.25 (3.77)		
Years Nursing Experience				
Less than 10 years	7	23.71 (3.15)	-1.34 (16)	0.198
More than 10 years	11	26.09 (3.94)		

*$p < 0.05$

Table 3.5 One-way Analysis of Variance of the different groups of participants' mean knowledge scores of pilot study

Group Factor	df	SS*	*F*-Ratio	*p*
Years Critical Care Experience				
Between Groups	3	61.833	1.633	0.227
Within Groups	14	176.667		
Total	17	238.500		
Highest Level of Education				
Between Groups	3	93.000	2.983	0.067
Within Groups	14	145.500		
Total	17	238.500		

*Where SS = sum of squares

Of the questionnaires completed, 72% of nurses participating in the pilot study had a knowledge score less than the minimum passing score of 28. Clinical nurses and nurses with more than 10 years of critical care experience had a mean knowledge score higher than the minimum passing score. Registered nurses and less experienced nurses in critical care had significantly lower mean scores than the passing score. This indicated a need for mentoring or a responsibility for teaching less experienced nursing staff in the critical care area to care for patients with a CVL.

The mean knowledge score of nurses with a diploma was less than 28 but this was a nonsignificant difference. The group was small (n = 3) and this result might have been due to sample errors. Nurses with a Bachelor Degree, post-graduate certification and those working in a small rural city had mean knowledge scores significantly lower than the minimum passing score. There was a need for education that could be in-service or workshop sessions to improve the skill level of these nurses in caring for patients with CVLs.

It will be of interest to the critical care educator that nurses who completed a hospital-based critical care program had mean knowledge scores significantly higher than the other nurses who participated in the pilot study (see Table 3.3). Nonsignificant results were found in nurses who obtained other additional learning certificates.

Limitations to the pilot study included a single study setting, a small sample size (n = 18) and nonrandom sampling. The high response rate could have been influenced by the participants' awareness that their colleague in the same health care district conducted this project. Support from senior managers from the health service district might have encouraged eligible nurses to respond to the questionnaire.

3.9 Questionnaire Revision

The participants' response to each item of the questionnaire was used to analyse its level of difficulty and the discrimination index. Baumgartner and Jackson (1995) indicated that each question item used to evaluate an individual's knowledge should not be too difficult or too easy to answer. The item should also be able to differentiate an individual who has a good knowledge of the assessed aspect from an individual who has a poor knowledge. The former characteristic is called "the level of difficulty" of a question and the later characteristic is called "the discrimination index" of a question item. The following steps were used to assess the level of difficulty and the discrimination index (Baumgartner & Jackson 1995).

The first step in the item analysis was to assign the participant's level of knowledge, based on his or her total knowledge score, into one of three groups: those who had a high level of knowledge, a moderate level of knowledge or a low level of knowledge. A total knowledge score that each participant (n = 18) obtained was computed. A range of the knowledge scores of all participants (range 18-32) and a mean score (25.17) were computed. Based on the frequency distribution of the participants' obtained scores, approximately 39% of the lower scores (a knowledge score less than 25) were calculated and this group of seven participants was used to indicate a low level of knowledge. Approximately 39% of the higher scores (a knowledge score more than 25) were calculated and this group of seven participants indicated a higher level of knowledge. Four participants (22%) scored 25 indicating a moderate level of knowledge and were not used in the item analysis.

The second step was to make a record of the answer that each participant in the top and bottom groups chose for each item (Appendix 8). From this data the number and percentage of the participants in the top and bottom scoring groups who answered correctly was computed for each question item. Each item was classified to one of three difficulty levels: low, moderate or high level of difficulty, based on its correctly answered percentage. A low level of difficulty question item was an item that more than 85% of the participants in both groups answered correctly. A moderate level of difficulty question item was an item that between 50% and 85% of the participants answered correctly. A high level of difficulty question item was an item that less than 50% of the participants answered correctly. Appendix 9 gives the percentage of the participants who answered each question item correctly and its

level of difficulty. Of the thirty-three question items, seventeen were found to have a low level of difficulty or "easy" questions, twelve had a moderate level of difficulty and four had a high level of difficulty or "hard" questions.

The discrimination index was also computed using the top and bottom scoring groups of participants (Appendix 9). The value ranges from –1.0 to +1.0. If a higher percentage of the participants in the bottom group answered an item correctly than the top group, the item discriminated negatively and was revised or rejected from the questionnaire. Negative values indicated an item's lack of discriminating characteristics. A zero value occurred when the same number of participants in both groups answered correctly. If a higher percentage of the participants in the top group answered an item correctly than the bottom group, the item discriminated positively. Values closer to +1 had a high level of discrimination of nurses with good knowledge in relation to caring for patients with a CVL from nurses with poor knowledge.

The assessment of the level of difficulty and the discrimination index of each question item was used to revise the wording of two question items with a negative discrimination index value (questions #26 and #29), remove two question items with a low level of difficulty (questions #2 and #19) and remove one question item due to the ambiguity of the evidence based answer (question #30). Sequence of some question items was rearranged. The thirty question items subsequently would be used to assess the knowledge relating to care of patients with a CVL during the data collection steps. The Kuder-Richardson 20 coefficient value of the revised questionnaire was recalculated and remained at 0.70.

3.10 Summary

The methodology for this research project has been described in this chapter. A questionnaire was developed to assess critical care nurses' knowledge relating to caring for patients with central venous lines. The self-report questionnaire consisted of true-or-false and multiple-choice questions with only one correct answer for each question.

A pilot study was conducted among twenty-seven critical care nurses in the Fraser Coast Health Service District before distributing the questionnaire to a sample of six hundred critical care nurses. Data from the pilot study was analysed descriptively and analytically in this chapter. The questionnaire was revised based on the assessment of its internal reliability, the level of difficulty and the discrimination index of each question item. The final questionnaire consisted of thirty items used to assess nurses' knowledge relating to care for patients with a CVL and seven other questions used to assess their sociodemographic characteristics.

The sample size and its sampling frame were also described in this chapter. The following chapter, chapter four, will present the results based on the study sample that completed and returned the questionnaire.

CHAPTER 4

RESULTS

In this chapter the findings of the study will be presented. It will cover four main topics: the sociodemographics of the sample, question items answered correctly, distribution of knowledge scores of the sample and how the knowledge scores related to their sociodemographic characteristics.

4.1 Sociodemographics of the Sample

Six hundred critical care nurses who are members of ACCCN were randomly selected and invited to participate in the study. A questionnaire consisting of thirty true-or-false and multiple-choice questions assessing knowledge relating to the care of patients with a CVL and seven sociodemographic questions was mailed to the sample population by the researcher. A postage-paid envelope was provided for return of the completed questionnaire. Data was collected during a period of four weeks.

Two hundred and fifty questionnaires were returned with a response rate of 42%. Three participants (1.2%) indicated that their main nursing role was 'research' and subsequently they were included in the Manager category. Only one nurse (0.4%) from a 'remote' area and four (1.6%) from 'other rural' areas completed the

questionnaire. These participants were consequently categorised with participants from a 'small rural' area. Hospital size was categorised to three groups: hospitals with less than 100 beds, 101-200 beds and more than 200 beds. Six participants (2.4%) were educators that worked outside of a hospital setting and were included in the Manager category.

The majority of the participants were clinical nurses (n = 106, 42.4%), worked in a major metropolitan area (n = 182, 72.80%) and worked in a hospital with more than 200 beds (n = 162, 66.39%). The majority of the participants also had more than 10 years of critical care experience (n = 108, 43.2%) and more than 10 years of nursing experience (n = 174, 69.6%). One hundred and ninety-three participants (77.2%) completed post-graduate education: Certificate (n = 80, 32.0%), Diploma (n = 73, 29.2%) and Master Degree or higher (n = 40, 16.0%) (Table 4.1).

Table 4.1 Sociodemographic characteristics of the participants

Sociodemographic Factors	Number	Per cent
Nursing Position		
Manager	48	19.20
Clinical Nurse	106	42.40
Registered Nurse	96	38.40
Job Location		
Major Metropolitan Area	182	72.80
Large Rural City	42	16.80
Small, Other Rural and Remote Areas	26	10.40
Size of Hospital*		
100 beds or less	26	10.66
101-200 beds	56	22.95
201 beds or more	162	66.39
Years Critical Care Experience		
Less than 5 years	65	26.00
6-10 years	77	30.80
More than 10 years	108	43.20
Years Nursing Experience		
2-5 years	11	4.40
6-10 years	65	26.00
More than 10 years	174	69.60
Highest Level of Education		
Diploma	13	5.20
Bachelor Degree	44	17.60
Post-Graduate Certificate	80	32.00
Post-Graduate Diploma	73	29.20
Master Degree or higher	40	16.00
Additional Learning Certificates**		
Trauma	29	11.60
Advanced Life Support	136	54.40
Hospital-based Program	137	54.80

*Total n is not equal to 250 due to missing data

**Total n is more than 250. One participant might complete more than one learning certificate

4.2 Question Items Answered Correctly

Question items covered six areas of knowledge necessary to adequately care for a patient with a CVL: 1.) insertion, 2.) management, 3.) complications of CVLs, 4.) analysis of the CVP waveform, 5.) measurement of the CVP and 6.) interpretation of the CVP. The number and percentage of the sample that answered each question item correctly is presented in the following tables. More than 84% of the participants answered questions correctly that related to the insertion of a CVL (item 1, 94%; item 2, 86%; and item 7, 96%) and management of the CVL (item 5, 84%; item 8, 88%; item 9, 98%; item 11, 92%; and item 30, 95%) (Table 4.2).

Table 4.2 Number and percentage of the participants who answered question items correctly in the areas of insertion and management of a CVL

Question Item	Number (per cent) answered correctly
1. When preparing to insert a CVL, the patient should be placed *in a 10-15° head down position.*	235 (94)
2. Following insertion of a CVL, the catheter tip should be situated *just above the right atrium.*	215 (86)
5. Which lumen should be used for the infusion of total parenteral nutrition? *A dedicated port*	209 (84)
7. The pressure of the flush bag should be maintained at *300 mm Hg.*	240 (96)
8. When the appropriate pressure of the flush bag is maintained, approximately how much fluid is delivered each hour to maintain line patency? *3 ml per hour*	219 (88)
9. The CVP is an indicator of *preload of the right side of the heart.*	245 (98)
11. Reasons for measuring CVP include: *To provide an estimation of hydration status and blood volume deficit*	231 (92)
30. Inotropic drugs can safely be infused in the port that is also being used for CVP readings. *False*	238 (95)

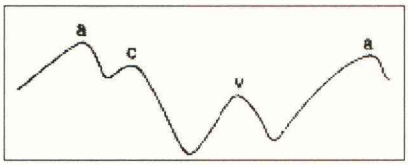
Ninety-one per cent of the participants recognised hand-washing technique as the most important measure to prevent infection associated with CVLs (item 18) but only 78% recognised infection as the most common complication for patients with a CVL in situ (item 16). Ninety-eight per cent of the participants correctly identified the use of threaded luer lock connections to prevent air embolism from occurring (item 14) while 68% identified how to position the patient with a suspected air embolism (item 15) and 72% identified the correct procedure to prevent an air embolism occurring on removal of the CVL (item 19). The remaining two question items regarding complications (items 6 and 17) were answered correctly by 96% and 92% of the participants respectively (Table 4.3).

Table 4.3 Number and percentage of the participants who answered question items correctly in the area of complications of CVLs

Question Item	Number (per cent) answered correctly
6. After the insertion of a CVL, your patient develops an irregular heartbeat. What is the likely cause in relation to the CVL? *The catheter has advanced into the right atrium*	243 (97)
14. To prevent air embolism from occurring, one should *use threaded luer lock connections*	246 (98)
15. You suspect your patient has an air embolism. How should you position the patient? *Left-side, head down*	169 (68)
16. The most common complication of CVLs is *catheter related infections.*	196 (78)
17. Your patient complains of pain and tingling in the right arm. On inspection, you find the arm oedematous. You suspect *central vein thrombosis.*	230 (92)
18. The single most important measure to prevent infection associated with CVLs is *proper hand washing in between every patient contact.*	228 (91)
19. When a patient cannot lie down, how can intrathoracic pressure be increased to prevent air embolism during removal of the catheter? *Ask the patient to perform the Valsalva manoeuvre*	181 (72)

Three questions dealt with the components of the CVP waveform (items 21, 22, and 23). Fifty-eight per cent of the participants identified atrial contraction, 41% atrial filling and 35% ventricular contraction in the CVP waveform provided. Eighty-seven per cent of the participants recognised that the CVP waveform may be affected by long tubing and air bubbles. Ninety-six per cent of the participants correctly identified patient position and the reference point (item 3) for obtaining a CVP reading while 72% identified the correct method for getting an accurate reading from the monitor (item 20). The correct lumen for CVP measurements was identified by 69% of participants (item 4). Less than half of the participants (42%) correctly identified how to convert a CVP reading in cmH_20 to its equivalent in mmHg. (item 27) (Table 4.4).

Table 4.4 Number and percentage of the participants who answered question items correctly in the areas of CVP waveform analysis and measurement

Question Item	Number (per cent) answered correctly
3. At what reference point should the transducer be levelled for central venous pressure (CVP) monitoring? *Supine position – midaxillary line, 4th intercostal space*	239 (96)
4. Which lumen should ideally be used for central venous pressure measurements? *The distal port*	173 (69)
10. The CVP waveform may be damped by *long tubing and air bubbles.*	218 (87)
20. CVP readings of a correctly levelled and zeroed system are most appropriately recorded from *a freeze frame picture of the waveform at the end of expiration.*	180 (72)
 The above tracing of CVP waveforms was used for the following three questions: 21. The a wave represents *atrial contraction.*	146 (58)
22. The c wave represents *ventricular contraction.*	88 (35)
23. The v wave represent *atrial filling.*	103 (41)
27. To convert a CVP reading in cmH_20 to its equivalent in mmHg., the CVP measurement is *divided by 1.36.*	104 (42)

Seven questions dealt with interpretation of the CVP reading. Observing for trends in the CVP reading was identified by 67% of the participants how to best determine patient response to treatment (item 24). Factors that may elevate the reading were covered in items 12 (79% correct), 25 (75% correct), 26 (54% correct) and 29 (78% correct). Items 13 and 28 dealt with factors that lower the CVP, which 88% and 70% of the participants answered correctly (Table 4.5).

Table 4.5 Number and percentage of the participants who answered question items correctly in the area of interpretation of the CVP

Question Item	Number (per cent) answered correctly
12. An elevated CVP reading may be caused by *pulmonary hypertension*	197 (79)
13. A low CVP reading may be found with *the administration of vasodilatory drugs*	221 (88)
24. Pre-existing physiological factors can have an affect on the CVP reading. How can you best determine patient response to treatment? *Observe for trends in the CVP reading*	167 (67)
25. How does an increase in intrathoracic pressure, such as in the positively pressure ventilated patient, affect the CVP? *It raises the CVP reading*	188 (75)
26. Physiological factors that may cause the CVP to be elevated when the patient is not hypervolaemic include *atrial fibrillation, cardiac tamponade, tricuspid stenosis.*	136 (54)
29. High intrathoracic pressures, which can occur with mechanical ventilation, raise the CVP reading and may mask the signs of hypovolaemia. *True*	195 (78)

Questions that the higher percentage of participants answered correctly addressed insertion and management of a CVL. Lower scores were related to waveform analysis, measurement of the CVP and interpretation of the CVP value.

4.3 Distribution of Knowledge Scores

The range of knowledge score was between 14 and 30. The mean knowledge score of the questionnaire was 23.4 or 78% items correctly answered, with a standard deviation of 3.41. Figure 4.1 shows the distribution of knowledge score of all participants.

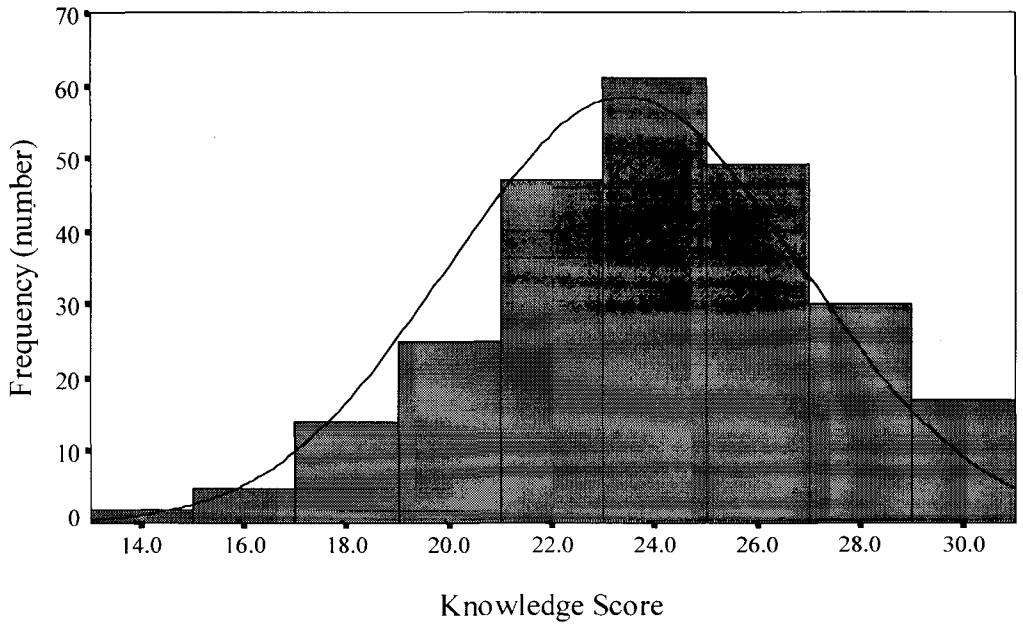


Figure 4.1 Distribution of knowledge scores of the participants

Cumulative frequency indicated that of the knowledge scores, 61.6% of the participants had a score less than the minimum passing score of 25 necessary to demonstrate adequacy of knowledge to care for patients with a CVL (Figure 4.2). The Kuder-Richardson 20 coefficient was 0.66, slightly lower than the desired 0.70.

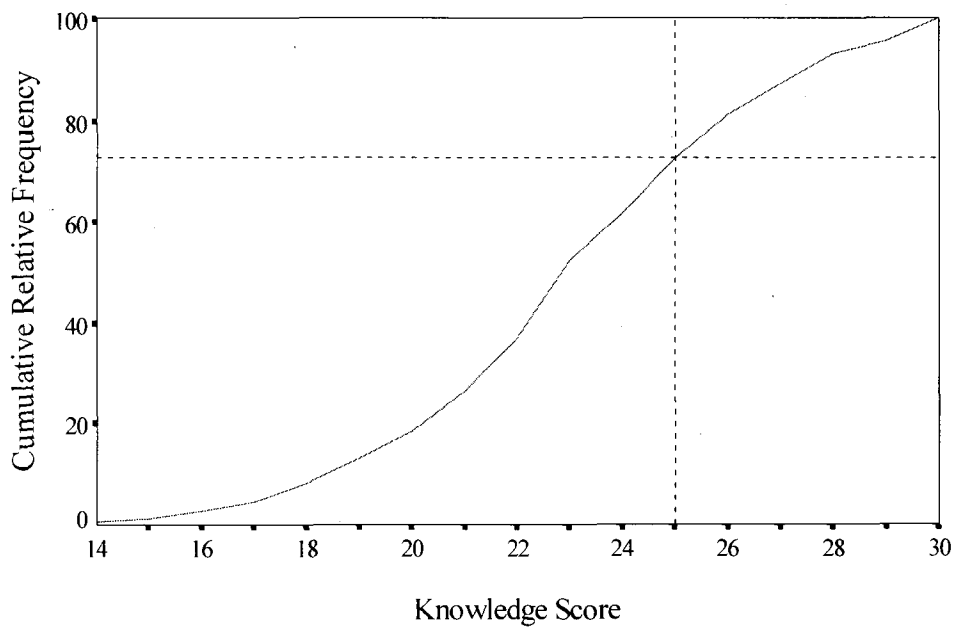


Figure 4.2 Cumulative per cent of the participants' scores

4.4 Relationship between the Participants' Sociodemographic Characteristics and the Knowledge Score

A series of one-sample t-tests were used to compare the mean scores of the participants' sociodemographic characteristics with the minimum passing score of 25 (85%) to demonstrate adequacy of knowledge to care for patients with a CVL (Table 4.6). A significance level α of 0.05 was used to indicate the statistical difference ($p < 0.05$). The average knowledge score of all participants was significantly lower than the passing score ($p = 0.000$). The mean knowledge score of the different groups of participants was significantly lower than the passing score in all of the groups except for participants in a management position, participants working in a large rural city, participants with a Diploma and participants with a Master Degree or higher level of education.

Table 4.6 Test of relationship between the participants' mean knowledge score and the minimum passing score

Factors	Number	Mean Score (Standard Deviation)	t (df)	*p*
All Participants	250	23.42 (3.41)	-7.31 (249)	0.000*
Nursing Position				
Manager	48	24.19 (3.67)	-1.53 (47)	0.132
Clinical Nurse	106	23.57 (3.06)	-4.83 (105)	0.000*
Registered Nurse	96	22.89 (3.58)	-5.79 (95)	0.000*
Job Location				
Major Metropolitan Area	182	23.36 (3.14)	-7.06 (181)	0.000*
Large Rural City	42	24.10 (3.49)	-1.68 (41)	0.101
Small, Other Rural and Remote Areas	26	22.81 (4.81)	-2.32 (25)	0.028*
Size of Hospital				
Less than 100 beds	26	22.73 (4.76)	-2.43 (25)	0.023*
101-200 beds	56	23.82 (3.03)	-2.91 (55)	0.005*
201 beds or more	162	23.35 (3.28)	-6.42 (161)	0.000*
Years Critical Care Experience				
Less than 5 years	65	22.28 (3.56)	-6.16 (64)	0.000*
6-10 years	77	23.78 (3.55)	-3.02 (76)	0.003*
More than 10 years	108	23.86 (3.06)	-3.87 (107)	0.000*
Years Nursing Experience				
2-5 years	11	21.27 (4.36)	-2.83 (10)	0.018*
6-10 years	65	22.88 (3.54)	-4.83 (64)	0.000*
More than 10 years	174	23.76 (3.23)	-5.04 (173)	0.000*
Highest Level of Education				
Diploma	13	23.38 (3.86)	-1.51 (12)	0.157
Bachelor Degree	44	23.59 (3.67)	-2.55 (43)	0.014*
Post-Graduate Certificate	80	22.80 (3.36)	-5.85 (79)	0.000*
Post-Graduate Diploma	73	23.45 (3.28)	-4.03 (72)	0.000*
Master Degree or higher	40	24.45 (3.16)	-1.10 (39)	0.278
Additional Learning Certificates				
Trauma	29	23.10 (4.39)	-2.33 (28)	0.027*
Advanced Life Support	136	23.26 (3.40)	-5.95 (135)	0.000*
Hospital-Based Program	137	23.87 (3.41)	-3.88 (136)	0.000*

*$p < 0.05$

The t-test for two independent groups was carried out to compare the average knowledge scores of participants who completed a trauma educational program, a

hospital-based critical care program or an advanced life support program with participants who did not complete each training program. The participants who completed a hospital-based critical care program had a significant average knowledge score higher than those who did not complete the program ($p = 0.023$). Participants who completed a trauma educational program or an advanced life support program had a similar average knowledge score to those who did not (Table 4.7).

Table 4.7 Test of the difference of an average knowledge score between nurses who completed different educational programs and those who did not

Additional Education Program	Number	Mean (Standard Deviation)	*t* (df)	*p*
Completed trauma education				
Yes	29	23.10 (4.39)	0.43 (248)	0.670
No	221	23.47 (3.27)		
Completed an advanced life support program				
Yes	136	23.26 (3.40)	0.20 (248)	0.421
No	114	23.61 (3.42)		
Completed a hospital-based critical care program				
Yes	137	23.87 (3.41)	-2.29 (248)	0.023*
No	113	22.88 (3.34)		

*$p < 0.05$

The difference of an average of knowledge score between nurses with different characteristics was compared using ANOVA (Table 4.8). Results showed there were significant differences in the mean knowledge scores of participants in the groups distinguished by years of critical care experience ($F = 5.157$, $p = 0.006$) and

years of nursing service ($F = 3.992$, $p = 0.020$). At a significance level of 0.05, the modified Least-Significant Difference or Bonferroni post hoc test showed the mean knowledge score of nurses increased as the years of critical care experience increased. Among the groups of nurses divided according to years of nursing experience, none differed significantly at the 0.05 level. This eliminated a possible Type I error. Type I errors occur when it is concluded that a relationship exists when in fact it does not (Coakes & Steed 1997).

Table 4.8 One-way Analysis of Variance of the different groups of participants' mean knowledge scores

Group Factor	df	SS	*F*-Ratio	*p*
Nursing Position				
Between Groups	2	57.966	2.526	0.082
Within Groups	247	2833.090		
Total	249	2891.056		
Job Location				
Between Groups	2	29.613	1.278	0.280
Within Groups	247	2861.443		
Total	249	2891.056		
Hospital Size				
Between Groups	2	22.041	0.948	0.389
Within Groups	241	2801.972		
Total	243	2824.012		
Years Critical Care Experience				
Between Groups	2	115.877	5.157	0.006*
Within Groups	247	2775.179		
Total	249	2891.056		
Years Nursing Experience				
Between Groups	2	90.520	3.992	0.020*
Within Groups	247	2800.536		
Total	249	2891.056		
Highest Level of Education				
Between Groups	4	74.560	1.621	0.169
Within Groups	245	2816.495		
Total	249	2891.056		

* $p < 0.05$

4.5 Summary

The majority of the participants in the study were clinical nurses, worked in a major metropolitan area and worked in a hospital with more than 200 beds. The majority of participants also had more than 10 years of critical care experience and more than 10 years of nursing experience. Most of the participants completed a form of post-graduate education and more than half of the participants obtained an additional learning certificate such as advanced life support or a hospital-based critical care program.

The average knowledge score of all participants was significantly lower than the passing score of 25 necessary to demonstrate adequacy of knowledge to care for patients with a CVL. The mean knowledge score of the different groups of participants was significantly lower than the passing score in all of the groups except for participants in a management position, participants working in a large rural city, participants with a Diploma and participants with a Master degree or higher level of education. The participants who completed a hospital-based critical care program had a significant average knowledge score higher than those who did not complete the program. Participants who completed a trauma educational program or an advanced life support program had a similar average knowledge score to those who did not. There were significant differences in the mean knowledge scores of participants in the groups distinguished by years of critical care experience. The mean knowledge score of participants increased as the years of critical care experience increased.

CHAPTER 5

DISCUSSION

This final chapter will discuss the findings and compare them to other studies. The representativeness of the participants with the general population of critical care nurses will be discussed in addition to the characteristics of participants with an adequate knowledge of caring for patients with a central venous line. Implications of the findings, study limitations, recommendations and a summary will also be included in this chapter.

5.1 Representativeness of the Participants

According to statistics compiled by the Australian Institute of Health and Welfare (AIHW, 2001), there were 162,900 registered nurses employed in Australia in 1997. Of these nurses, 5.7% indicated their area of clinical nursing was critical care. The Australian College of Critical Care Nurses (ACCCN) represents approximately 25% of these nurses with a membership of 2,400. Of these members, 25% were invited to participate in the study with a response rate of 41.6%.

Of the total number of employed nurses in Australia, 84.8% indicated they worked in a clinician role and 6.2% in a manager, education or research position with the remaining 10% classified as 'other' (AIHW, 2001). The clinical role was not further subdivided by AIHW into the positions of clinical nurse and registered nurse

nor was it given for critical care nurses. Of the participants in the study, 80.8% indicated their position as either a clinical nurse or registered nurse and 19.2% as a manager, educator or researcher.

In 1997, 84.9% of all Australian nurses employed in a critical care setting indicated they worked in a capital city or major metropolitan centre, 7.8% in a large rural centre and 7.4% in a small, other rural or remote area (AIHW, 2001). Queensland statistics for the same year differed in that 60.7% of the nurses were employed in a capital city or major metropolitan centre, 19.3% in a large rural centre, 14.3 in a small, other rural or remote area and 5.7% of nurses not stated (Queensland Health, 2000). The study participants followed the Queensland pattern more closely in that 72.8% indicated they worked in a capital city or major metropolitan centre, 16.8% in a large rural centre and 10.4% in a small, other rural or remote area. Table 5.1 presents the comparison of the geographic location of main jobs.

Table 5.1 A comparison of the geographical locations of critical care nurses' main place of employment

Geographic location of main job	Australia nurses* (per cent)	Queensland nurses† (per cent)	Study participants (per cent)
Capital city/metropolitan centre	84.9	60.7	72.8
Large rural centre	7.8	19.3	16.8
Small, other rural and remote centres	7.4	14.3	10.4
Not stated	–	5.7	–

*Source: Australian Institute of Health and Welfare (AIHW), 2001, *Nursing labour force 1999*, AIHW cat. no. HWL 20, AIHW (National Health Labour Force Series no. 20), Canberra.

†Source: Queensland Health, 2000, *Workforce characteristics: Nurses re- registered in Queensland, 1996, 1997 and 1999*, URL: http://www.health.qld.gov.au.

Statistics indicating the level of education completed by nurses who work in the critical care area were not available. In 1997, 9,356 Australian nurses completed a nursing related education program (AIHW, 2001). The majority of nurses completed a bachelor program (75.5%) while 17.3% received a post-graduate diploma, 3.5% a post-graduate certificate, 3.2% a master degree or higher and 0.1% a diploma. Percentages of nurses completing a program followed the same pattern for the previous five years with the exception of a declining number of diploma degrees as the program was phased out of existence. The majority of the study participants (77%) had completed a post-graduate level of education.

Statistical information about the size of hospital, years of critical care experience, years of nursing experience and additional learning certificates were not available. Demographic data of the ACCCN membership is not available to the

public, making comparison of the study participants to all ACCCN members impossible.

The prevailing consideration in assessing a sample is its representativeness or the extent to which the sample has characteristics of the general population, in this case, all critical care nurses in Australia (Polit & Hungler 1993). Utilising the database from ACCCN provided for a variety of critical care nurses from across Australia to be surveyed. The survey sample was similar to the general population of critical care nurses in that the majority of participants were either clinical or registered nurses and worked in a capital city or metropolitan centre. The number of participants decreased as the population of the geographic locations decreased. Data was not available to compare the remaining sociodemographic characteristics to the general population or to any of the characteristics of the members of ACCCN.

5.2 Measurement of the Knowledge Relating to the Care of Patients with a Central Venous Line

The construction of the questionnaire involved multiple steps to ensure content validity, reliability and to reduce bias. Preparation of the questionnaire for the study included question content as determined by the literature review, the use of true-or-false and multiple-choice, closed-ended questions with one correct answer, assessment of items by a panel of six experts in the critical care field and the conduction of a pilot study. After the pilot study, an analysis of the level of difficulty and the discrimination index of each item was used to revise the questionnaire.

The Kuder-Richardson 20 coefficient was 0.66 and lower than the desired 0.70. When compared to the results of the pilot study, the standard deviation, an index of the variability of the data, was lower. This indicated a more homogeneous distribution of scores in the larger study group in contrast to the higher standard deviation of the pilot study (Jackson & Furnham 2000). A larger standard deviation would have resulted in a higher reliability coefficient (Baumgartner & Jackson 1995).

From the literature search, four questionnaires were found to deal with the different forms of haemodynamic monitoring. The questionnaire used by Clemence, Walker and Farr (1995) asked fifteen questions related to CVLs regarding infection, patency and obtaining blood specimens. The study was done in a survey format looking at diversity of practice and did not test the participants' level of knowledge.

Iberti and colleagues' questionnaire used in the study of physicians' knowledge of the pulmonary artery (PA) catheter (1990) was administered to 121 physicians in the pilot study. The Kuder-Richardson 20 coefficient was 0.71 and after item analysis, minor changes were made in four response options involving three of the thirty-one question items. The revised version of the questionnaire was administered to 375 physicians in an unannounced manner during scheduled meetings. The published paper combined the results of all 496 participants and did not include a reliability coefficient for the revised version of the questionnaire.

Burns, Burns and Shively (1996) used Iberti and colleagues' questionnaire to test the knowledge of 168 critical care nurses in southern California metropolitan areas. The internal reliability coefficient in this study was 0.60. They determined that

'the areas of knowledge assessed, including physiology, waveform analysis, recognition of complications and application of data, were not necessarily related to each other' and that led to the lower value (Burns, Burns & Shively 1996).

McGhee and Woods (2001) constructed an 18-item questionnaire to test critical care nurses' knowledge of arterial pressure monitoring in a pilot test of 68 participants. A pre-pilot study was conducted using fourteen nurses to evaluate the initial questionnaire. No internal reliability coefficient was reported for either the pre-pilot or pilot study. Further data in the form of a study of arterial pressure monitoring has not been published.

The demonstration of mastery on a topic includes items that test knowledge, comprehension and application of the subject. This formative type of evaluation is graded on a pass-fail basis and the standards should be higher in comparison to when a grading scale is applied (Baumgartner & Jackson 1995). When determining the passing score of the questionnaire, the researcher and panel of experts considered the importance of nursing care of patients with a CVL and the severity of morbidity and risk of mortality associated with CVLs. Baumgartner and Jackson (1995) suggested that 80-90% questions be answered correctly to indicate a sufficient level of knowledge of a topic.

In this study, it was determined that 85% of correct answers on the questionnaire would demonstrate an acceptable level of knowledge for critical care nurses. The minimum score to indicate the acceptable nurses' knowledge relating to care of patients with a CVL was 28 correct answers in the pilot study and 25 correct answers in the study where the revised questionnaire was used. A passing score was

not designated in the two studies regarding knowledge of PA catheters (Iberti *et al.* 1990; Burns, Burns & Shively 1996). McGhee and Woods (2001) set a passing score at 66% correct answers and none of the participants achieved a passing score.

The study of physicians' knowledge of PA catheters involved item analysis on the pilot study results however details of the analysis were not published (Iberti *et al.* 1990). Item analysis was not done in the study of nursing knowledge of PA catheters despite the low reliability coefficient of 0.60 (Burns, Burns & Shively 1996). McGhee and Woods (2001) found in their analysis of the questionnaire testing nursing knowledge of arterial pressure that the majority of questions had an item difficulty of 'hard' and proved to have a moderate amount of item discrimination.

Analysis of item difficulty on the questionnaire used in the pilot study of nursing knowledge of CVLs revealed that 29 of 33 items had a low to moderate level of difficulty. Over half of the question items or 51.5% had a low level of difficulty and 36% a moderate level of difficulty. In comparison, the majority of question items in the questionnaire used by McGhee and Woods (2001) had a high level of item difficulty and a moderate amount of item discrimination. The internal reliability coefficient in the study was lower than the study by Iberti and colleagues but higher than the questionnaire used by Burns, Burns and Shively to test the knowledge of critical care nurses.

The standing of the questionnaire used in this study is good compared to the other studies with some need for improvement. In order to improve the internal reliability of the questionnaire, the difficulty and discrimination index of the items should be increased to improve the test sensitivity or the ability to discriminate

among individuals. Lowering the passing score to 80% correct items should be considered.

5.3 Characteristics of the Participants' Knowledge in Relation to the Care of Patients with a Central Venous Line

The participants' mean test score of 23.4 or 78% items correct was lower than expected and fell significantly below the desired 85% to demonstrate sufficient nursing knowledge in relation to the care of patients with a CVL. This finding was an improvement compared with previous studies of health care providers' knowledge of haemodynamic monitoring. The mean test score of physicians' knowledge of PA catheters was 67% items correct (Iberti *et al.* 1990) while the nursing knowledge was 56.8% items correct (Burns, Burns & Shively 1996). Nurses participating in the study of arterial pressure monitoring proved to have an average of 36.7% items correct (McGhee & Woods 2001).

Question items that a higher percentage of participants answered correctly addressed insertion and management of a CVL. Lower scores were related to waveform analysis, measurement of the CVP, interpretation of the CVP value and complications that can occur when a CVL is in situ. An average of 45% of the participants correctly interpreted the three components of the CVP waveform. Iberti and colleagues (1990) found that 47% of the participants interpreted PA waveforms correctly while questions regarding arterial pressure waveforms had less than 35% correct answers (McGhee & Woods 2001).

A high percentage of participants (96%) identified the correct reference point used to monitor CVP but a lower percentage identified what port to use (69%) and the method to obtain an accurate pressure reading (72%). Other participants (28%) were willing to accept CVP values as calculated and displayed by the monitor or from a clear and large waveform, not taking fluctuations from the respiratory pattern into consideration. In comparison, 53% of physicians (Iberti *et al.* 1990) and 61% of nurses (Burns, Burns & Shively 1996) determined PA pressure correctly.

While 98% of the participants of this study identified methods to prevent air embolism from occurring in a patient with a CVL in place, 68% knew how to position a patient suspected of having this life threatening complication and 72% indicated the correct procedure for removing a CVL to prevent an air embolism. Only 78% of the participants recognised infection as the most common complication of a CVL. Iberti and colleagues (1990) found less than 70% participants answered these types of question items correctly. This indicated a higher level of knowledge in basic question items and a lower level in the application of knowledge.

Several relationships between the critical care nurses' knowledge of CVLs and their sociodemographic information were found to be significant. Nurses working in a major metropolitan or capital city and those working in hospitals with more than 201 beds had significantly lower mean scores. This is surprising in that educational services should be more than adequate at larger facilities. Knowledge scores of nurses with a Diploma or a Master/PhD level of education were nonsignificant however the 'Diploma group' was small (n = 13) and this may have been due to a Type I error. The small group size may have been due to education at

the Diploma level has been phased out in preference to a Bachelor level of education and the tendency of nurses working in critical care to further their education.

While nurses who completed a hospital-based critical care program had mean knowledge scores significantly different than those who did not (23.87 compared to 22.88), the scores were still significantly lower than the desired 85% correct items. Nurses who have worked in a critical care area for more than five years were more knowledgeable about CVLs than those with less work experience in critical care. There was a significant increase in mean knowledge scores as the years of critical care experience increased. Iberti and colleagues (1990) and Burns, Burns and Shively (1996) found improved scores associated with the level of education, additional certification or education and the years of experience in critical care. McGhee and Woods (2001) found that only one demographic characteristic, advanced life support training, was shown to have a relationship with the test scores of arterial pressure monitoring.

These findings suggested that the use and management of CVLs has not been addressed sufficiently at lower levels of nursing education. Critical care educators and nurse managers should determine the requirements of their staff related to CVL education. Knowledge criteria should be established and evaluated on an annual basis. Conducting continuing education courses and encouraging attendance at a hospital-based critical care program or a university post-graduate program could correct deficiencies. Improved levels of critical thinking in the application of knowledge and clinical decision-making have been associated with the higher levels of education (DEST 2001). Consistent with the pilot study, a need for mentoring or a

responsibility for teaching less experienced nursing staff in the critical care area was indicated.

5.4 Implications of the Findings of the Study

The results of this study indicated a knowledge deficit of critical care nurses in regards to the care of patients with a CVL. Areas that need to be addressed include waveform analysis, measurement of the CVP, interpretation of the CVP value and complications that can occur with a CVL in situ. Lack of knowledge in these areas could lead to improper treatment of the patient and an increased probability of complications occurring, all of which could increase patient morbidity and mortality.

There is a need to look at the methods of education and training of nurses who take care of patients with CVLs in situ. Post-graduate certification and diploma programs with a speciality in critical care need to ensure minimal competency and skill in this area. Nurse educators need to review their in-service programs and include annual skill checks to see that the critical care nurses demonstrated an acceptable level of knowledge of CVLs. Procedure manuals need to be updated to include accurate information on the insertion, monitoring and removal of CVLs. For example, each institution's policy and procedure manual should include a document for obtaining an accurate CVP reading with details for the equipment appropriate for that institution.

Nurse practice coordinators should recognise that less experienced staff need mentoring and use more knowledgeable staff as resource people. Opportunities such

as Internet teleconference links with groups of critical care nurses at various facilities can be used to provide a range of educational in-services. In this manner, for example, nurses working in large rural cities with a relatively acceptable level of knowledge could share their knowledge with nurses in both large metropolitan and small rural areas.

5.5 Limitation of the Study

The response rate for this study was 41.6%. A follow-up or reminder note might have increased the response rate, however, cost and time limited the use of this strategy. In comparison, the study of nurses' knowledge of arterial pressure monitoring reported a 17% response rate (McGhee & Woods 2001). The questionnaires in both studies of knowledge of the pulmonary artery catheter were offered to volunteers at meetings or conferences and the response rates were not recorded (Iberti *et al.* 1990; Burns, Burns & Shively 1996).

Utilising the database from ACCCN provided for a variety of critical care nurses from across Australia to be surveyed however it also resulted in several biases. The major limitations of this study were the sampling method and that the participants were volunteers. The generalisability of this study is limited due to lack of demographic data from ACCCN to compare the study population with its members. The study population was similar to the general population of critical care nurses in that the majority worked in a metropolitan centre and the number of participants decreased as the geographical population decreased. The study

population differed significantly from the general population in that the majority of participants furthered their education. Statistical information about the remaining demographic statistics was not available.

Volunteers could have possessed certain characteristics that were different to non-volunteers and encouraged them to participate in the study. Nurses who were members of a professional organisation and indicated a willingness to partake in research studies may have responded differently from other nurses. Characteristics such as these may have biased the sample in what may have increased the level of knowledge. Non-participants may have had a lower level of knowledge.

Members of ACCCN may have more experience in critical care and be more knowledgeable than other critical care nurses. Nurses who felt they were more knowledgeable about CVLs may have had a higher response rate. The survey was distributed by mail and completion unsupervised. As a consequence, participants may not have relied on their own knowledge and conferred with colleagues or consulted textbooks. Total years of nursing experience may have been a confounding variable with years of critical care experience.

Content validity may have been a threat to the study. The questions used to assess the nurses' knowledge must be representative of all the questions that could be asked regarding care of the patient with a CVL. Five participants queried the use of the midaxillary line as a reference point as opposed to the midthorax or one half of the anterior/posterior chest wall diameter. Four participants felt that the 'c' wave represented tricuspid valve closure during ventricular systole as opposed to ventricular contraction. One participant stated, 'any of the (CVL) ports can be used

for measurement of the CVP. According to the research, the key issue is being consistant (sic) about the chosen port.' Further literature review will be needed to document these particular points.

The high cut-off knowledge score of 85% correct answers was another limitation that affected the results in that many failed to achieve a passing score. However this cannot discriminate well of those who require further education and those who do not. Future studies will need to revise the cut-off point or passing score.

5.6 Recommendations

Although the generalisability of this study is limited, it is of concern that the participants' mean knowledge score was significantly lower than 85% correct items. Educational programs, hospital-based critical care programs and the use of preceptors can be used to improve the knowledge base of nurses working in critical care areas. Further research, after revision of the questionnaire, is indicated on a larger scale to ascertain critical care nurses' knowledge of caring for patients with a CVL.

Nurse practice coordinators and critical care educators should establish the knowledge requirements of their nursing staff and convey pertinent education while evaluating their knowledge on an annual basis. Designating a person or small group in each unit to review literature and disseminate information will encourage the use of research findings and lead to a research-based practice. This focus on the quality

of care will enhance the professional growth of critical care nurses and optimise patient outcomes.

The variety of answers from participants suggested that nursing care of patients with a CVL might not be uniform. From the literature review, wide variations in practice were found with procedures such as types of dressings, fluid and line changes and types of flushes used to maintain line patency. This indicates a need for national research-based standards of practice that can be applied in every critical care unit.

Additional research on critical care nurses' knowledge of CVLs is indicated. Replication of this study on a larger scale is needed to validate its findings. Despite careful development of the questionnaire that included review of the literature, input from a panel of experts and a pilot study, the reliability coefficient was less than desirable. Further analysis and revision of the research tool is needed before it can be used again.

5.7 Summary

A discussion of the results of this research project has been presented in this chapter. The average knowledge score of all participants was significantly lower than the passing score necessary to demonstrate adequacy of knowledge to care for a patient with a CVL. Findings in this study supported the study conducted by McGhee & Woods (2001) who mentioned that critical care nurses did not have sufficient knowledge to monitor haemodynamic parameters at a satisfactory level.

The groups of participants in a management position, those working in large rural cities and those with a Master degree or higher obtained passing mean knowledge scores. The mean knowledge score of participants increased as the years of critical care experience increased. Participants who completed a hospital-based critical care program had mean knowledge scores significantly higher than those who did not complete the program.

Nurse practice coordinators and critical care educators should establish the knowledge requirements of their nursing staff and assess their skill level annually. Experienced staff need to be nominated as resource people to mentor the less experienced. Procedure manuals need to be updated to include accurate information on the insertion, monitoring and removal of CVLs. Educational in-services need to be utilised to share information between hospitals and nurses.

Additional research on critical care nurses' knowledge of care of the patient with a CVL is indicated. Further analysis and revision of the research tool is needed prior to being used again. The difficulty and discrimination index of the question items need to be increased to improve the internal reliability coefficient. Future studies need to revise the cut-off point of passing score of the questionnaire.

REFERENCES

Australian Institute of Health and Welfare (AIHW), 2001, *Nursing labour force 1999*, AIHW cat. no. HWL 20, AIHW (National Health Labour Force Series no. 20), Canberra.

Baumgartner, T. A. & Jackson, A. S., 1995, *Measurement for evaluation*, 5th edn, Brown & Benchmark, Madison.

Baumgartner, T. A. & Strong, C. H., 1998, *Conducting and reading research in health and human performance*, 2nd edn, McGraw-Hill, Boston.

Bernard, G. R., Sopko, G., Cerra, F., Demling, R., Edmunds, H., Kaplan, S., Kessler, L., Masur, H., Parsons, P., Shure, D., Webb, C., Weidemann, H., Weinmann, G. & Williams, D., 2000, 'Pulmonary artery catheterization and outcomes: National Heart, Lung and Blood Institute and Food and Drug Administration Workshop Report', *The Journal of the American Medical Association*, vol. 283, no. 19, pp. 2568-2572.

Bowers, S., 1999, 'Nutrition support for malnourished, acutely ill adults', *MedSurg Nursing*, vol. 8, no. 3, pp. 145-166.

Bowling, A., 1997, *Research methods in health: Investigating health and health Services*, Open University Press, Buckingham.

Brandstetter, R. D., Grant, G. R., Estilo, M., Rahim, F., Sing, K. & Gitler, B., 1998, 'Swan-Ganz Catheter: Misconceptions, pitfalls and incomplete user knowledge - an identified trilogy in need of correction', *Heart & Lung: The Journal of Acute and Critical Care*, vol. 27, no. 4, pp. 218-222.

Burns, D., Burns D. & Shively, M., 1996, 'Critical care nurses' knowledge of pulmonary artery catheters', *American Journal of Critical Care*, vol. 5, no. 1, pp. 49-54.

Clemence, M., Walker, D. & Farr, B., 1995, 'Central venous catheter practices: Results of a survey', *American Journal of Infection Control*, vol. 23, no. 1, pp. 5-12.

Coakes, S. J. & Steed, L. G., 1997, *SPSS: Analysis without anguish*, Wiley & Sons, Brisbane.

Connors, A. F., Speroff, T., Dawson, N. V., Thomas, C., Harrell, F. E., Wagner, D., Desbiens, N., Goldman, L., Wu, A. W., Califf, R. M., Fulkerson, W. J., Vidaillet, H., Broste, S., Bellamy, P., Lynn, J. & Knaus, W. A., 1996, 'The effectiveness of right heart catheterisation in the initial care of critically ill patients', *The Journal of the American Medical Association*, vol. 276, no. 1, pp. 889-897.

Cook, D. J., 1996, 'Does this patient have abnormal central venous pressure?', *JAMA*, vol. 275, no. 8, pp. 630-634.

Cooke, P. A. & Barrie, L. J., 1997, 'Haemodynamic monitoring', in *Coronary Care Manual*, ed. P. L. Thompson, Churchill Livingstone, New York, pp. 199-209.

Daily, E. K., 1996, 'Hemodynamic monitoring' in *Dolan's Critical Care Nursing*, 2nd edn, eds S. D. Ruppert, J. G. Kernicki & J. T. Dolan, Davis, Philadelphia, pp. 213-240.

Department of Education, Science and Training (DEST), 2001, *Model of nursing education and training: A systematic review of the literature*, DEST no. 6769.HERC01A, Canberra.

Drewett, S. R., 2000, 'Complications of central venous catheters: Nursing care', *British Journal of Nursing*, vol. 9, no. 8, pp. 466-478.

Druding, M. C., 2000, 'Integrating hemodynamic monitoring and physical assessment', *Dimensions of Critical Care Nursing*, vol. 19, no. 4, pp. 25-30.

Frazer, L. & Lawley, M., 2000, *Questionnaire design & administration: A practical guide*, Wiley & Sons, Brisbane.

Gourlay, D. A., 1996, 'Central venous cannulation', *British Journal of Nursing*, vol. 5, no. 1, pp. 8-15.

Henderson, N., 1997, 'Central venous lines', *Nursing Standard*, vol. 11, no. 42, pp. 49-56.

Hinds, C. J., & Watson, D., 1999, 'ABC of intensive care: Circulatory support', *British Medical Journal*, vol. 318, pp. 1749-1752.

Iberti, T. J., Leibowitz, A. B., Panacek, E. A., Silverstein, J. H., Albertson, T. E. & Fischer, E. P., 1990, 'A multicenter study of physicians' knowledge of the pulmonary artery catheter', *The Journal of the American Medical Association*, vol. 264, no. 22, pp. 2928-2932.

Jackson, C. J. & Furnham, A., 2000, *Designing and analysing questionnaires and surveys: A manual for health professionals and administrators*, Whurr, London.

Jones, A. L., 2000, 'Invasive haemodynamic monitoring and the management of shock – a step too far for the poisoned patient?', *Journal of Toxicology: Clinical Toxicology*, vol. 38, no. 2, pp. 164-165.

Khaodhiar, L. & Bistrian, B. R., 1999, 'Avoidance and management of complications of total parenteral nutrition', *Nutrition in Clinical Care*, vol. 2, no. 4, pp. 239-249.

Krozek, C., Millam, D. & Pelikan, R., 1996, 'Intravascular therapy', in *Nursing Procedures*, 2nd edn, ed. S. Daly, Springhouse Corp., Springhouse.

Larwood, K. A., 2000, 'Reducing central venous catheter infections', *Australian Critical Care*, vol. 13, no. 3, pp. 107-112.

Larwood, K. A., Anstey, C. M. & Dunn, S. V., 2000, 'Managing central venous catheters: A prospective randomised trial of two methods', *Australian Critical Care*, vol. 13, no. 2, pp. 44-50.

McDermott, M., 1995, 'Central venous pressure', *Nursing Standard*, vol. 9, no. 35, p. 54.

McGhee, B. H. & Woods, S. L., 2001, 'Critical care nurses' knowledge of arterial pressure monitoring', *American Journal of Critical Care*, vol. 10, no. 1, pp. 43-51.

Mermel, L. A., 2000, 'Prevention of intravascular catheter-related infections', *Annals of Internal Medicine*, vol. 132, no. 5, pp. 391-402.

Metheny, N. M., 1996, *Fluid and electrolyte balance: Nursing considerations*, 3rd edn, Lippincott, Philadelphia.

Milford, C., 1996, 'Cardiovascular care', in *Nursing Procedures*, 2nd edn, ed. S. Daly, Springhouse Corp., Springhouse.

Morelli, P., 1999, 'Cardiovascular anatomy and physiology', in *Critical Care Nursing*, eds. L. Bucher & S. Melander, W. B. Saunders, Philadelphia, pp. 109-141.

Polit, D. F. & Hungler, B. P., 1993, *Essentials of nursing research: Methods, appraisal, and utilization*, 3rd edn, Lippincott, Philadelphia.

Polit, D. F. & Hungler, B. P., 1999, *Nursing research: Principles and methods*, 6th edn, Lippincott, Philadelphia.

Queensland Health, 1999, 'Cardiovascular haemodynamic monitoring learning guide', *Transition to intensive care nurse education program*, Queensland, Brisbane.

Queensland Health, 2000, *Workforce characteristics: Nurses re-registered in Queensland, 1996, 1997 and 1999*, URL: http://www.health.qld.gov.au, (accessed 15 July 2001).

Roach, H., Larson, E. & Bartlett, B., 1996, 'Intravascular site care: Are critical care nurses practicing according to written protocols?', *Heart & Lung: The Journal of Acute & Critical Care*, vol. 25, no. 5, pp. 401-408.

Scott, S. S., Giuliano, K. K., Pysznik, E., Elliott, S., Welsh, K. & Delbuono, N., 1998, 'Influence of port site on central venous pressure measurements from triple-lumen catheters in critically ill adults', *American Journal of Critical Care*, vol. 7, no. 1, pp. 60-63.

Thelan, L. A., Urden, L. D., Lough, M. E. & Stacy, K. M., 1998, 'Cardiovascular diagnostic procedures', in *Critical care nursing: Diagnosis and management*, 3rd edn, Mosby, St. Louis, pp. 377-482.

Von Ruedon, K. T., 1998, 'Hemodynamic monitoring', in *Critical care nursing: A holistic approach*, 7th edn, eds C.M. Hudak, B.M. Gallo & P.G. Morton, Lippincott, Philadelphia, pp. 226-245.

Weatherill, K., 1999, 'Keeping the lines open', *Nursing Standard*, vol. 13, no. 52, pp. 41-42.

Appendix 1: Questionnaire

Nursing knowledge of central venous lines in the critical care setting

Please tick the box next to your answer. All questions pertain to an adult patient with a central venous line (CVL) being placed or in situ. Please choose only one, as there is only one correct answer for each question.

1. **When preparing to insert a CVL, the patient should be placed:**

- ❑ a. In a 10-15° head up position
- ❑ b. In a 10-15° head down position
- ❑ c. With the head of the bed elevated 30 degrees
- ❑ d. In a left lateral position

2. **Following insertion of a CVL, where should the catheter tip be situated?**

- ❑ a. The right atrium
- ❑ b. The subclavian vein
- ❑ c. The aorta
- ❑ d. Just above the right atrium

3. **At what reference point should the transducer be levelled for central venous pressure monitoring?**

- ❑ a. Supine position – midaxillary line, 4th intercostal space
- ❑ b. Lateral position – midaxillary line, 5th intercostal space
- ❑ c. Supine, 3 cm beneath the insertion site
- ❑ d. Supine, 5 cm beneath the insertion site

4. **Which lumen should ideally be used for central venous pressure (CVP) measurements?**

- ❑ a. The proximal port
- ❑ b. The medial port
- ❑ c. The distal port
- ❑ d. Any of the ports

5. **Which lumen should be used for the infusion of total parenteral nutrition (TPN)?**

- ❑ a. The proximal port
- ❑ b. The medial port
- ❑ c. The distal port
- ❑ d. A dedicated port exclusively for TPN

6. **After the insertion of a CVL, your patient develops an irregular heartbeat. What is a likely cause in relation to the central venous catheter?**

- ❑ a. The catheter is touching the vein wall
- ❑ b. The catheter is out of the vein
- ❑ c. The catheter has become kinked
- ❑ d. The catheter has advanced into the right atrium

7. **The pressure of the flush bag should be maintained at:**

- ❑ a. 100 mm Hg.
- ❑ b. 150 mm Hg.
- ❑ c. 300 mm Hg.
- ❑ d. 400 mm Hg.

8. **When the appropriate pressure of the flush bag is maintained, approximately how much fluid is delivered each hour to maintain line patency in the adult patient?**

- ❑ a. 2 ml per hour
- ❑ b. 3 ml per hour
- ❑ c. 4 ml per hour
- ❑ d. 5 ml per hour

9. **The CVP is an indicator of:**

- ❑ a. Preload of the right side of the heart
- ❑ b. Afterload of the heart
- ❑ c. Contractility of the heart
- ❑ d. Preload of the left side of the heart

10. **The CVP waveform may be damped by:**

- ❑ a. Tightly secured connections
- ❑ b. Short and stiff, high-pressure tubing
- ❑ c. Long tubing and air bubbles
- ❑ d. The position of the transducer

Answer key: Question 1-b; 2-d; 3-a; 4-c; 5-d; 6-d; 7-c; 8-b; 9-a; 10-c

11. Reasons for measuring CVP include:

- ❑ a. To assess left ventricular function
- ❑ b. To provide a reliable picture of circulatory function
- ❑ c. To optimise cardiac output while minimising the risk of pulmonary oedema
- ❑ d. To provide an estimation of hydration status and blood volume deficit

12. An elevated CVP reading may be caused by:

- ❑ a. Placement of the transducer above the reference point
- ❑ b. Pulmonary hypertension
- ❑ c. Low blood volume
- ❑ d. Hypotension

13. A low CVP reading may be found with:

- ❑ a. Tricuspid valve incompetence
- ❑ b. Pulmonary hypertension
- ❑ c. The administration of vasodilatory drugs
- ❑ d. Right ventricular failure

14. To prevent air embolism from occurring, one should use:

- ❑ a. Tape on all connections
- ❑ b. Threaded luer lock connections
- ❑ c. Push in connectors
- ❑ d. Clear dressings on the insertion site

15. You suspect your patient has an air embolism. How should you position the patient?

- ❑ a. Left-side, head down
- ❑ b. Right-side, head down
- ❑ c. Left-side, head up
- ❑ d. Right-side, head up

16. What is the most common complication of CVLs?

- ❑ a. Catheter related infections
- ❑ b. Pneumothorax
- ❑ c. Arrhythmias
- ❑ d. Haemothorax

17. Your patient complains of pain and tingling in the right arm. On inspection, you find the arm oedematous. You suspect:

- ❑ a. Phlebitis from a previous IV site
- ❑ b. Occlusion of the CVL
- ❑ c. Allergic reaction to a medication
- ❑ d. Central vein thrombosis

18. The single most important measure to prevent infection associated with CVLs is:

- ❑ a. Daily dressing changes using gauze to cover the insertion site
- ❑ b. Daily tubing changes
- ❑ c. Proper hand washing in between every patient contact
- ❑ d. Daily dressing changes using a transparent adhesive film

19. When a patient cannot lie down, how can intrathoracic pressure be increased to prevent air embolism during removal of the catheter?

- ❑ a. Request that the patient perform deep breathing
- ❑ b. Ask the patient to inhale while removing the catheter
- ❑ c. Ask the patient to turn their head
- ❑ d. Ask the patient to perform the Valsalva manoeuvre

20. Central venous pressure readings of a correctly levelled and zeroed system are most accurately recorded from:

- ❑ a. A freeze frame picture of the waveform on the monitor at the end of expiration
- ❑ b. The values calculated and displayed digitally by the monitor
- ❑ c. A printed strip printed from the monitor
- ❑ d. A clear and large waveform

Answer key: Question 11-d; 12-b; 13-c; 14-b; 15-a; 16-a; 17-d; 18-c; 19-d; 20-a

Using the above tracing of CVP waveforms, answer the following:

21. The a wave represents:

- ❑ a. Atrial filling
- ❑ b. Atrial contraction
- ❑ c. Ventricular contraction
- ❑ d. A rise in pressure as the mitral valve opens

22. The c wave represents:

- ❑ a. Atrial filling
- ❑ b. Atrial contraction
- ❑ c. Ventricular contraction
- ❑ d. A rise in pressure as the mitral valve opens

23. The v wave represents:

- ❑ a. Atrial filling
- ❑ b. Atrial contraction
- ❑ c. Ventricular contraction
- ❑ d. A rise in pressure as the mitral valve opens

24. Pre-existing physiological factors can have an affect on the CVP reading. How can you best determine patient response to treatment?

- ❑ a. Obtain a reading every two hours
- ❑ b. Observe for trends in the CVP reading
- ❑ c. Ensure measurement is carried out in the same position
- ❑ d. Obtain a reading every shift

25. How does an increase in intrathoracic pressure, such as in the positively pressure ventilated patient, affect the CVP?

- ❑ a. It raises the CVP reading
- ❑ b. It lowers the CVP reading
- ❑ c. It has no effect on the CVP reading

26. Physiological factors that may cause the CVP to be elevated when the patient is not hypervolaemic include:

- ❑ a. Atrial fibrillation, mitral regurgitation, cardiac tamponade
- ❑ b. Aortic stenosis, mitral regurgitation, cardiac tamponade
- ❑ c. Atrial fibrillation, cardiac tamponade, tricuspid stenosis

27. Using an amplifier/transducer system, CVP readings are recorded in mmHg. Readings can also be obtained in cmH_20 using a manometer set on an infusion stand. To convert a reading in cmH_20 to its equivalent in mmHg., the CVP measurement is:

- ❑ a. Multiplied by 1.36
- ❑ b. Divided by 1.36
- ❑ c. Multiplied by 1.63
- ❑ d. Divided by 1.63

Please indicate whether each statement of the following items is true or false.

28. If the patient is slowly becoming hypovolaemic, the CVP measurements will begin to lower before a compensatory tachycardia or change in blood pressure occurs.

- ❑ a. True
- ❑ b. False

29. High intrathoracic pressures raise the CVP reading and may initially mask the signs of hypovolaemia.

- ❑ a. True
- ❑ b. False

30. Inotropic drugs can safely be infused in the port that is also being used to obtain CVP readings.

- ❑ a. True
- ❑ b. False

Answer key: Question 21-b; 22-c; 23-a; 24-b; 25-a; 26-c; 27-b; 28-a; 29-a; 30-b

Demographic information

Finally we would like to know a little bit about your background so we can see how different nurses respond to the questions you've just answered. Please tick only one box next to your answer.

1. What is your main nursing role or position?

- ❑ a. Manager (Nurse Manager, Nurse Practice Coordinator, Educator)
- ❑ b. Clinical Nurse (Charge Nurse, Shift Coordinator, Senior Nurse)
- ❑ c. Staff Nurse/Registered Nurse
- ❑ d. Other (please specify)

_____

2. Where do you work?

- ❑ a. Capital city or major metropolitan area (population at least 100,000)
- ❑ b. Large rural city (population 25,000 or more)
- ❑ c. Small rural city (population 10,000 – 24,999)
- ❑ d. Other rural area (population less than 10,000)
- ❑ e. Remote area (designated remote zone)

3. What is the size of your hospital?

- ❑ a. 25 beds or less
- ❑ b. 26-50 beds
- ❑ c. 51-100 beds
- ❑ d. 101-200 beds
- ❑ e. 201 beds or more

4. How long have you worked in a critical care area?

- ❑ a. Less than 2 years
- ❑ b. 2-5 years
- ❑ c. 6-10 years
- ❑ d. More than 10 years

5. How long have you worked as a Registered Nurse?

- ❑ a. Less than 2 years
- ❑ b. 2-5 years
- ❑ c. 6-10 years
- ❑ d. More than 10 years

6. What is your highest level of education or degree?

- ❑ a. Diploma
- ❑ b. Bachelor Degree
- ❑ c. Post-graduate Certificate
- ❑ d. Post-graduate Diploma
- ❑ e. Master of Nursing

7. What additional certificates of learning have you obtained?

- ❑ a. Hospital based critical care program
- ❑ b. Advanced Life Support
- ❑ c. Trauma
- ❑ d. Other (please specify)

_____

Your contribution to this survey is greatly appreciated.
Please write any comments or suggestions you wish to make on the back of this page. Please return your completed questionnaire in the postage-paid envelope provided. If the envelope has been mislaid, please forward to:

Attention: Karen Henderson
c/o School of Nursing & Health Studies
Building 18
Central Queensland University
Reply Paid 65293
Rockhampton, Qld 4700

Appendix 2: Ethical Approval

Central Queensland
UNIVERSITY
Where Students Come First.

School of Nursing and Health Studies
Faculty of Arts, Health and Sciences
Central Queensland University
Rockhampton QLD 4701
Direct Ph (07) 4930 9703
Fax (07) 4930 9871
e-mail: d.hay@cqu.edu.au

30th August 2001

Ms Karen Henderson
P.O. Box 4047
Tinana QLD 4650

Re: Ethical clearance application, "Nursing knowledge of central venous lines in the critical care setting"

Dear Ms Henderson

The Ethical Research Review Committee of the School of Nursing and Health Studies has assessed your ethical application to conduct the above research project. The Committee has approved your application, provided you contact your supervisor and clarify the following issues:

- How would you be able to identify whether participants are working at hospitals in rural or remote areas?
- Please indicate the location where data will be stored for five years. Only the researchers or her supervisor will gain access to the original data.

I wish you success in your study.

Yours sincerely,
Signature Redacted

Ms Dawn HAY
Acting Head of the School, School of Nursing and Health Studies

C.C. Dr Sansnee Jirojwong

X-Sender: jirojwos@raven.cqu.edu.au
Date: Fri, 7 Sep 2001 14:01:46 +1000
To: Karen Henderson <patience@optusnet.com.au>
From: Sansnee Jirojwong <s.jirojwong@cqu.edu.au>
Subject: Re: Ethical application

Dear Karen

That is satisfactory.

Can you forward me your questionnaire to have me looked at.

Sansnee

> Dear Sansnee,
>
> As per the Ethical Research Review Committee of the School of Nursing, I
>need to clarify the following issues with you:
>
> How would you be able to identify whether participants are working at
>hospitals in rural or remote areas?
> The participants in the project will be asked several demographic
>questions, one of which is, 'Where do you work?' The choice of answers
>are as follows:
> a.) Capital city or major metropolitan area
> b.) Large rural area (population 25,000 or more)
> c.) Small rural area (population 10,000-24,999)
> d.) Other rural area (population less than 10,000)
> e.) Remote area (designated remote zone)
>
> Please indicate the location where data will be stored for five years.
>Only the researchers or her supervisor will gain access to the original
>data.
> The original data of this research project will be kept in a locked
>filing cabinet at my (the researcher) home for a period of five years.
>
> Let me know if this is satisfactory. I will attach your reply along with
>the Committee's approval for ethical clearance to my application to the
>Australian College of Critical Care Nurses (ACCCN) for access to their
>national database of members.
>
> Regards,
> Karen Henderson

Dr. Sansnee Jirojwong
Senior Lecturer
Program Coordinator, Master of Family and Community Health
School of Nursing and Health Studies
Faculty of Arts, Health and Sciences
Central Queensland University
Rockhampton QLD 4702
Australia

Direct Ph (07) 4930 6317
Fax (07) 4930 9871
e-mail s.jirojwong@cqu.edu.au
Int'l Ph 61+ 7+ 4930 6317
Int'l Fax 61+ 7+ 4930 9871

Appendix 3: Letter of Approval

Queensland Government

Queensland Health

Intensive Care/Coronary Care

Enquiries to: Marilyn Jensen
NPC IC/CCU
Telephone: (07) 41206985
Facsimile: (07) 41206799
Email: marilynj jensen@health.qld.gov.au

6 August 2001

Karen Henderson
Registered Nurse
Intensive Care/Coronary Care Unit
Maryborough Hospital

Dear Karen

Re: Your project "Nursing knowledge of CVL in the Critical Care setting"

Approval is given for you to approach Registered Nurses who are not members of ACCCN to participate in the pilot study of your project. This approval extends to the Registered Nurses of the ICU/CCUs of both Hervey Bay and Maryborough Hospital.

Yours sincerely

Signature Redacted

Marilyn Jensen
NPC IC/CCU

Office
Hervey Bay Hospital
Cnr Nissen St and Urraween Rd
HERVEY BAY Q 4655

Postal
PO Box 592
HERVEY BAY Q 4655

Phone
(07) 41206666

Fax
(07) 41206799

Appendix 4: Information Letter to Pilot Study Participants

Karen Henderson, CN
PO Box xxxx
Tinana, Qld 4650
Telephone: (07) 41xx xxxx
E-mail: patience@optusnet.com.au

Dr. Sansnee Jirojwong, Study Supervisor
School of Nursing and Health Studies
Faculty of Arts, Health and Science
Central Queensland University
Rockhampton, Qld 4702
Telephone: (07) 4930 6317
Fax: (07) 4930 9871

September 20, 2001

'Nursing knowledge of central venous lines in the critical care setting'

Dear Registered Nurse,

Central venous lines (CVLs) are frequently used in the care of critically ill patients. I am conducting a research project to objectively assess the knowledge base of critical care nurses in regards to the use and management of CVLs by using a paper and pencil questionnaire.

Information from this study will be used to determine if critical care nurses show a need for additional education about CVLs and the focus of the continuing education if indicated. The enclosed questionnaire has been put together with the assistance of a panel of six experts in the critical care field. I would like to invite you to participate in this pilot study to answer the questions, provide input on their content and validity and make suggestions for any changes or additional questions.

The final version of this multiple-choice questionnaire will be distributed through the Australian College of Critical Care Nurses (ACCCN) to nurses who have indicated a willingness to participate in nursing related studies. If you are a member of ACCCN and willing to participate in research, please disregard this pilot study.

This research study has received ethical approval from Central Queensland University, School of Nursing and Health Studies, in accordance to the guidelines of the National Health and Medical Research Council of Australia. Please do not identify yourself on the questionnaire in order to ensure anonymity. Participation in this study is voluntary and the return of the completed questionnaire will reflect your voluntary consent.

Please return the completed questionnaire in the envelope provided within the next week. If you have any questions or wish to obtain a summary of the final results of the study, please contact me using the above address, telephone number or e-mail.

Thank you for your participation.

Sincerely,

Signature Redacted

Karen Henderson, CN

Appendix 5: Information Letter to Study Participants

Karen Henderson, CN
PO Box xxxx
Tinana, Qld 4650
Telephone: (07) 41xx xxxx
E-mail: patience@optusnet.com.au

Dr. Sansnee Jirojwong, Study Supervisor
School of Nursing and Health Studies
Faculty of Arts, Health and Science
Central Queensland University
Rockhampton, Qld 4702
Telephone: (07) 4930 6317
Fax: (07) 4930 9871

October 29, 2001

'Nursing knowledge of central venous lines in the critical care setting'

Dear Registered Nurse,

Central venous lines (CVLs) are frequently used in the care of critically ill patients. I am conducting a research project to objectively assess the knowledge base of critical care nurses in regards to the use and management of CVLs by using a paper and pencil questionnaire.

This multiple-choice questionnaire is being distributed through the Australian College of Critical Care Nurses to nurses who have indicated a willingness to participate in nursing related studies. I would like to invite you to participate in this research project.

The questionnaire has been put together with the assistance of a panel of six experts in the critical care field. Specific demographic questions have been included to determine if they have a relationship with nursing knowledge. Information from this study will be used to determine if critical care nurses show a need for additional education about CVLs and the focus of the continuing education if indicated.

This research study has received ethical approval from Central Queensland University, School of Nursing and Health Studies, in accordance to the guidelines of the National Health and Medical Research Council of Australia. Please do not identify yourself on the questionnaire in order to ensure anonymity. Participation in this study is voluntary and the return of the completed questionnaire will reflect your voluntary consent.

Please return the completed questionnaire in the envelope provided within the next two weeks. If you have any questions or wish to obtain a summary of the final results of the study, please contact me using the above address, telephone number or e-mail. It is anticipated that the research findings will be submitted for publication in a nursing journal aimed at critical care nursing.

Thank you for your participation.

Sincerely,
Signature Redacted

Karen Henderson, CN

Appendix 6: Variable Coding for SPSS

Variable Label	Value	Value Label
Respondent identification number	1 to 250	
Score	0	Incorrect response
	1	Correct response
Total score	0 to 30	Number of correct responses
Main nursing role	1	Management position
	2	Clinical Nurse position
	3	Staff Nurse or Registered Nurse
	4	Other
Location of employment	1	Major metropolitan area
	2	Large rural city
	3	Small rural city
	4	Other rural area
	5	Designated remote zone
Size of hospital	1	25 beds or less
	2	26-50 beds
	3	51-100 beds
	4	101-200 beds
	5	201 beds or more
Years of critical care experience	1	Less than 2 years
	2	2-5 years
	3	6-10 years
	4	More than 10 years
Years nursing experience	1	Less than 2 years
	2	2-5 years
	3	6-10 years
	4	More than 10 years
Highest level of education	1	Diploma
	2	Bachelor degree
	3	Post-graduate certificate award
	4	Post-graduate diploma award
	5	Master degree or higher
Completion of the following:		
Hospital-based critical care program	0	No
	1	Yes
Advanced Life Support course	0	No
	1	Yes
Trauma seminar	0	No
	1	Yes

Appendix 7: The Kuder-Richardson 20 Formula

The Kuder-Richardson 20 formula (KR-20) is a method of calculating an internal consistency reliability coefficient with items that have correct answers. It is preferable to the split-half procedure because it gives an estimate of the split-half correlation for all possible ways of dividing the measure into two halves. The KR-20 can be used when the variance, number of items on the test and the number of participants getting each item correct is known (Polit & Hungler 1999). The formula is as follows:

$$KR\text{-}20 = \left(\frac{K}{K-1}\right)\left(1 - \frac{\Sigma pq}{V_{total}}\right)$$

where K = number of items on questionnaire
V_{total} = variance of the test
p = the number of participants answering an item correctly divided by
$q = 1 - p$
Σpq = the sum of p times q for each item

$$KR\text{-}20 \text{ of Pilot Study} = \left(\frac{33}{33-1}\right)\left(1 - \frac{4.57}{14.03}\right)$$

$$KR\text{-}20 = (1.031)(1 - .3257)$$
$$= 0.70$$

where 33 = the number of items on questionnaire
Variance = 14.03
Σpq = 4.57

$$KR\text{-}20 \text{ of the Study} = \left(\frac{30}{30-1}\right)\left(1 - \frac{4.21}{11.61}\right)$$

$$KR\text{-}20 = (1.034)(1 - .3626)$$
$$= .66$$

where 30 = the number of items on questionnaire
Variance = 11.61
Σpq = 4.21

Appendix 8: Chart showing answers selected by the top and bottom scoring groups of the participants in the pilot study

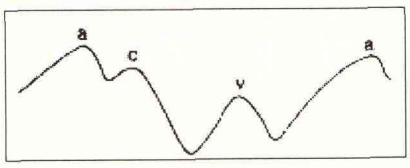
Item	Correct Answer	Group	Response a	b	c	d
1	b	top	3	**4**		
		bottom	3	**2**	2	
2	d	top		1		**6**
		bottom	1			**6**
3	d	top				**7**
		bottom		2		**5**
4	a	top	**7**			
		bottom	**6**	1		
5	c	top			**7**	
		bottom	2	2	**2**	1
6	d	top		1		**6**
		bottom			1	**6**
7	d	top				**7**
		bottom				**7**
8	c	top			**7**	
		bottom			**7**	
9	b	top		**7**		
		bottom		**7**		
10	a	top	**7**			
		bottom	**6**			1
11	d	top				**7**
		bottom			1	**6**
12	b	top		**7**		
		bottom	2	**5**		
13	c	top			**7**	
		bottom	2		**5**	
14	b	top		**7**		
		bottom		**6**	1	
15	a	top	**7**			
		bottom	**3**	3		1
16	b	top	2	**5**		
		bottom	1	**4**		2
17	b	top		**7**		
		bottom		**6**		1
18	d	top		1		**6**
		bottom	2	2		**3**
19	b	top		**7**		
		bottom		**7**		
20	c	top			**7**	
		bottom			**5**	2
21	b	top		**7**		
		bottom	4	**2**		1
22	c	top	1		**5**	1
		bottom	2	3	**1**	1
23	a	top	**5**			2
		bottom		1	5	1
24	a	top	**5**	2		
		bottom	**3**	3	1	
25	a	top	**7**			
		bottom	**4**	3		
26	b	top		**3**	4	
		bottom		**4**	2	1
27	b	top	2	**2**	3	
		bottom	3	**1**	3	
28	b	top	1	**6**		
		bottom	1	**4**	1	1
29	a	top	**6**	1		
		bottom	7			
30	c	top	1		**6**	
		bottom		4	**3**	
31	a	top	**7**			
		bottom	**6**	1		
32	a	top	**6**	1		
		bottom	**5**	2		
33	b	top	1	**6**		
		bottom	3	**4**		

Appendix 9: Summary of the assessment of the level of difficulty and the discrimination index of each question item included in the questionnaire during the pilot study

Level of difficulty = $\frac{\text{number right in top group + number right in bottom group}}{\text{number in top group + number in bottom group}}$

Discrimination index = $\frac{\text{number right in top group – number right in bottom group}}{\text{number in each group}}$

Question item	Number and percentage of the participants that answered correctly	Level of difficulty	Discrimination index
1. When preparing to insert a CVL, the patient should be placed in a *Trendelenburg position.*	6 (43)	High	+0.29
2. The first action taken following the insertion of a CVL is to *order a chest x-ray.*	12 (86)	Low	0.00
3. Following insertion of a CVL, the catheter tip should be situated *just above the right atrium.*	12 (86)	Low	0.00
4. At what reference point should the transducer be levelled for central venous pressure (CVP) monitoring? *Supine position – midaxillary line, 4th intercostal space*	13 (93)	Low	+0.14
5. Which lumen should ideally be used for central venous pressure measurements? *The distal port*	9 (64)	Medium	+0.71
6. Which lumen should be used for the infusion of total parenteral nutrition? *A dedicated port*	12 (86)	Low	0.00
7. After the insertion of a CVL, your patient develops an irregular heartbeat. What is the likely cause in relation to the CVL? *The catheter has advanced into the right atrium*	14 (100)	Low	0.00
8. The pressure of the flush bag should be maintained at *300 mm Hg.*	14 (100)	Low	0.00
9. When the appropriate pressure of the flush bag is maintained, approximately how much fluid is delivered each hour to maintain line patency? *3 ml per hour*	14 (100)	Low	0.00
10. The CVP is an indicator of *the preload of the right side of the heart.*	13 (93)	Low	0.00

Question item	Number and percentage of the participants that answered correctly	Level of difficulty	Discrimination index
11. Reasons for measuring CVP include: *To provide an estimation of hydration status and blood volume deficit*	13 (93)	Low	+0.14
12. An elevated CVP reading may be caused by *pulmonary hypertension*	12 (86)	Low	+0.29
13. A low CVP reading may be found with *the administration of vasodilatory drugs*	12 (86)	Low	+0.29
14. To prevent air embolism from occurring, one should *use threaded luer lock connections*	13 (93)	Low	+0.14
15. You suspect your patient has an air embolism. How should you position the patient? *Left-side, head down*	10 (71)	Medium	+0.57
16. Your patient complains of pain and tingling in the right arm. On inspection, you find the arm oedematous and suspect *a central vein thrombosis.*	9 (64)	Medium	+0.14
17. The single most important measure to prevent infection associated with CVLs is *proper hand washing in between every patient contact.*	13 (93)	Low	+0.14
18. When a patient cannot lie down, how can intrathoracic pressure be increased to prevent air embolism during removal of the catheter? *Ask the patient to perform the Valsalva manoeuvre*	9 (64)	Medium	+0.43
19. Following the removal of the CVL, the nurse may be required *to send the catheter tip for culture and microscopy.*	14 (100)	Low	0.00
20. The CVP waveform may be damped by *long tubing and air bubbles.*	12 (86)	Low	+0.29
 The above tracing of CVP waveforms was used for the following three questions:			
21. The a wave represents *atrial contraction.*	9 (64)	Medium	+0.71

Question item	Number and percentage of the participants that answered correctly	Level of difficulty	Discrimination index
22. The c wave represents *ventricular contraction.*	6 (43)	High	+0.57
23. The v wave represent *atrial filling.*	5 (36)	High	+0.71
24. CVP readings of a correctly levelled and zeroed system are most appropriately recorded from *a freeze frame picture of the waveform at the end of expiration.*	8 (57)	Medium	+0.29
25. What is the most common complication of CVLs? *Catheter related infections*	11 (79)	Medium	+0.43
26. Despite the cause of a low or high CVP, pre-existing physiological factors can have an affect on the reading. How can you best determine patient response to treatment? *Observe for trends in the CVP reading*	7 (50)	Medium	-0.14
27. Physiological factors that may cause the CVP to be elevated when the patient is not hypervolaemic include *atrial fibrillation, cardiac tamponade, tricuspid stenosis.*	3 (21)	High	+0.14
28. To convert a CVP reading in cmH_20 to its equivalent in mmHg., the CVP measurement is *divided by 1.36.*	10 (71)	Medium	+0.29
29. How does an increase in intrathoracic pressure effect the CVP? *It raises the CVP reading*	13 (93)	Low	-0.14
30. When should zero balancing the amplifier/transducer system be done? *After changes in bed or patient position, patient transport or every eight hours*	9 (64)	Medium	+0.43
The following questions were true or false:			
31. If the patient is slowly becoming hypovolaemic, the CVP measurements will begin to lower before a compensatory tachycardia or change in blood pressure occurs. *True*	13 (93)	Low	+0.14
32. High intrathoracic pressures, which can occur with mechanical ventilation, raise the CVP reading and may mask the signs of hypovolaemia. *True*	11 (79)	Medium	+0.14
33. Inotropic drugs can be infused in the port that is also used for CVP readings. *False*	10 (71)	Medium	+0.29