A Learning Programme for Nurses for the Prevention of Ventilator-associated Infections in Adult Patients

Thesis presented in partial fulfilment of the requirements for the degree of

Masters in Higher Education at the

University of Stellenbosch

Juliana van der Merwe

PROF CHRIS KAPP
DR THELMA VAN DER MERWE

December 2005

DECLARATION

I, the undersigned, hereby declare that the work contained in this dissertation is my own, original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature: ..... Date: 15 September 2005

ABSTRACT

Ventilator-associated infections contribute to most of the fatal infections in the intensive care. Considerable intensive care resources are also consumed in the treatment of ventilator-associated infections. Not only economic costs, but also expenditure of staff energies, physical resources, treatment expenses and admission to the intensive care contribute to the complexity of the problem. Despite the large progress in medical treatment over the past decades, the incidence and case fatality rates of health-care-associated ventilator-associated infections remain high. Patients who require mechanical ventilation have a particularly high risk of health-care-associated infections.

Ventilator-associated infections have been a major complication for years, but the researcher has found that no formal attempts, except for inclusion of the concept as part of critical care nursing curricula, have been made to educate nurses with regard to the active prevention of ventilator-associated infections in adult patients. There are also limited data available regarding infection control education-based interventions targeting healthcare systems, e.g. intensive care units.

The research goal was to establish and evaluate a learning programme for nurses caring for adult patients with ventilator-associated infections (Learning Programme). This took place in two Australian hospitals during 2003 and 2004. The objectives of the research were divided into three phases. Evidenced-based literature on the above concepts was utilised by the researcher and deductively implemented and validated by a focus (specialist) group to develop the Learning Programme in Phase One.

In Phase Two, a one group pre-test post-test for nurses regarding ventilator-associated infections was utilised. Nurses were tested before the implementation of the Learning Programme, and the pre-test revealed nurses had inadequate knowledge regarding the prevention of ventilator-associated infections. After implementation of the Learning Programme, the Sign Rank test was utilised to analyse the pre-and post-test data. The nurses' post-test scores regarding the prevention of ventilator-associated infections revealed a significant improvement, and therefore the conclusion could be made that the concepts included in the Learning Programme were conducive to enhance the knowledge base of nurses caring for mechanically ventilated adult patients.

A partially explanatory method was utilised to analyse the questionnaire data for the Learning Programme. Results revealed the need for such a programme for nurses caring for adult patients being mechanically ventilated.

The ultimate purpose of the development and implementation of the Learning Programme was to improve outcomes for patients being mechanically ventilated by improving the knowledge base of nurses. To realise this phase of the research, a process of impact evaluation was utilised. Both hospitals had a statistically significant drop in their ventilator-associated infection rates from the pre-intervention year to the post-intervention period, verifying the need for a Learning Programme.

Recommendations were made according to the four domains in nursing practice: clinical nursing, nursing management, nursing education and future research.

OPSOMMING

Ventilatorverwante infeksies dra by tot die meeste van die dodelike infeksies in die intensiewesorgeenheid. 'n Aansienlike mate van intensiewesorghulpbronne word ook verbruik tydens die behandeling van ventilatorverwante infeksies. Nie slegs die ekonomiese koste nie, maar ook besteding wat betref energie van personeellede, fisiese hulpbronne, uitgawes in verband met die behandeling en toelating tot die intensiewesorgeenheid dra by tot die kompleksiteit van die probleem. Ondanks die groot vordering wat die afgelope paar dekades ten opsigte van mediese behandeling gemaak is, bly die voorkoms en die gevallesterftekoers wat met gesondheidsorg en infeksies weens die gebruik van ventilators verband hou, hoog. Pasiënte wat meganiese ventilering benodig, is aan 'n besonder hoë risiko van infeksies wat met gesondheidsorg verbind word, blootgestel.

Ventilatorverwante infeksies is reeds jare lank 'n ernstige komplikasie, maar die navorser het bevind dat geen formele pogings tot dusver aangewend is om verpleegkundiges op te lei met betrekking tot die aktiewe voorkoming van ventilator-verwante infeksies in die volwasse pasiënt nie, met die uitsondering van die insluiting van die konsep as deel van infeksiebeheer. Daar is ook beperkte data beskikbaar met betrekking tot onderriggebaseerde infeksiebeheer intervensies met spesifieke verwysing na gesondheidsorgstesels soos byvoorbeeld intensiewe sorg eenhede.

Die navorsingsdoel was om 'n leerprogram vir verpleegkundiges wat na volwasse pasiënte met ventilator-verwante infeksies omsien, te implementeer en te evalueer. Die oogmerke van die navorsing is in drie fases onderverdeel. Die navorser het van bewysgebaseerde literatuur oor die bostaande konsepte gebruik gemaak en konsepte met betrekking tot voorsorgmaatreëls ten opsigte van infeksiebeheer is deduktief deur 'n fokus- (spesialis) groep in die Leerprogram geïmplementeer en gestaaf ten einde die Leerprogram in fase een te gebruik. Die navorsing is gedurende 2003 en 2004 in twee Australiese hospitale gedoen.

In fase twee is die een-groep-voortoets/natoets-strategie vir verpleegkundiges rakende ventilator-verwante infeksies gebruik. Verpleegkundiges is voor die implementering van die Leerprogram getoets. Die voortoets het aangedui dat verpleegkundiges onvoldoende kennis

gehad het ten opsigte van die voorkoming van ventilator-verwante infeksies. Ná implementering van die Leerprogram is die betekende-rangtoets (*Signed Rank test*) gebruik om die data van die voor- en natoets te analiseer. Ná die het verpleegkundiges se tellings ten opsigte van die voorkoming van ventilator-verwante infeksies ’n beduidende verbetering aangetoon. Die gevolgtrekking kan dus gemaak word dat die konsepte wat in die Leerprogram ingesluit is, bevorderlik is vir die verbetering van die kennisbasis van verpleegkundiges wat sorg vir meganies geventileerde volwasse pasiënte.

’n Gedeeltelik verklarende metode is gebruik om die data verkry uit die vraelys vir die Leerprogram te analiseer. Die resultate het die behoefte vir sodanige programme vir verpleegkundiges wat sorg vir volwasse pasiënte wat meganies geventileer word, aangedui.

Die uiteindelike doel van die ontwikkeling en implementering van die Leerprogram was om uitkomste vir volwasse pasiënte wat meganies geventileer word te verbeter deur verbetering van die verpleegkundiges se kennisbasis. Om uitvoering te gee aan hierdie fase van die navorsing, is daar gebruik gemaak van ‘n proses om die impak van ‘n intervensie te evalueer. Albei hospitale het ’n statisties beduidende vermindering in hulle ventilator-verwante infeksiekoerse getoon van die voor-intervensiejaar tot die ná-intervensietydperk wat dus die behoefte aan ’n Leerprogram bevestig.

Aanbevelings is gemaak in ooreenstemming met die vier areas in verpleegpraktyk: kliniese verpleging, verplegingsbestuur, verpleegopleiding en toekomstige navorsing.

DEDICATION

This thesis is dedicated to my mentor,
my role model, my adviser, my friend,

Dr Thelma van der Merwe

This is as much yours than it is mine.....

ACKNOWLEDGEMENTS

I wish to thank God, Almighty for affording me good health, the strength, wisdom and courage to carry out this study.

In addition, I would like to thank the following people:

My parents for their endless love, support and encouragement. Without you this wouldn't have been possible.

In Australia:

A special thanks to the members of the focus group for your guidance, support and hard work carrying out this research.
The management of both hospitals who granted me permission to carry out the research.
The Infectious Diseases Units for gathering the extra data over and above the normal daily workload.
Michael Bailey for doing my statistical analyses for me on short notice.
Each and every dedicated staff member who helped me finish this enormous amount of work.

In Saudi:

Dr Thelma van der Merwe for all the sleepless nights I've caused her.
Mollie Butler who became family over the past year, although we haven't even met.
Mark Fielding for all his input on VAI and WHO, as well as his recommendations.
Irene Barron for reading and editing Chapter two on infection control literature.
Maricris Villaneuva for technical support and typing.

In South Africa:

Prof Kapp for allowing me to make my contribution to nursing education and for putting together the final copy of my thesis.
Jackie Viljoen for doing my language editing and for "cleaning up" my thesis.

TABLE OF CONTENT

LIST OF TABLES AND FIGURES

TABLES

FIGURES

ABBREVIATIONS

ACCCN - The Australian College of Critical Care Nurses

AJIC - American Journal of Infection Control

APIC - Association for Professionals in Infection Control

ATS - American Thoracic Society

CDC - Centre for Disease Control and Prevention

COPD - Chronic Obstructive Pulmonary Disease

FDA - Food and Drug Administration

HEI - Higher Education Institutions

HME - Heat Moisture Exchangers

ICU - Intensive Care Unit

JAMA - Journal of the American Medical Association

MMWR - Morbidity and Mortality Weekly Report

NHS - National Health Service

NIV - Non-invasive Ventilation

NNIS - National Health care related Infections Surveillance

SANC - South African Nursing Council

SDD - Selective Decontamination of the Digestive tract

SHEA - Society for Hospital Epidemiology of America

TB - Tuberculosis

UKCC - United Kingdom Central Council for Nursing, Midwifery and Health Visiting

VAI - Ventilator-associated Infections

VAP - Ventilator-associated Pneumonia

WBC - White Blood Count

WHO - World Health Organisation / Wereldgesondheidsorganisasie

CHAPTER 1

OVERVIEW OF THE RESEARCH

1.1 INTRODUCTION

The goal of the research was to develop, implement and evaluate a learning programme for nurses working with adult patients requiring mechanical ventilation, facilitating the prevention and minimising the incidence and severity of ventilator-associated infections.

Despite the large progress in medical treatment over the past 40 years, the incidence and case fatality rates of health-care-related (nosocomial) ventilator-associated infections remain high. Older patients generally have more severe underlying diseases and greater exposure to medical practices that increase colonisation with health care related pathogens (Craven, De Rosa & Thornton, 2002:421). Patients who require mechanical ventilation have a particularly high risk of health-care-related infections. Health-care-related ventilator-associated infections in intubated patients may be caused by endogenous flora or by micro-organisms acquired during hospitalisation (Association for Professionals in Infection Control [APIC], 2000:22). Ventilator-associated infections contribute to 60% of fatal infections (in the intensive care unit) and is the leading cause of death for health-care-related infections (APIC, 2000:23).

Infections are normally treated with antibiotics. The need to decrease excess antibiotic use in ambulatory practice has been intensified by the epidemic increase in antibiotic resistance pneumonia (Gonzales, Bartlett, Besser, Cooper, Hickner, Hoffman & Sande, 2001:479). In contrast to the very low incidence of community-acquired pneumonia/infection *(*where *Pseudomonas* is the pathogen), *Pseudomonas aeruginosa* is regarded as an etiology in 21% to 38% of hospital-acquired pneumonia/infections. *P aeruginosa* as an etiologic agent of community-acquired pneumonia is rare. In the National Health Care related Infections Surveillance (NNIS)-database (*Surveillance of Healthcare-Associated Diseases*, 2004) for hospital-acquired infections in medical intensive care units, hospital-acquired pneumonia was the second most common hospital-acquired infection (urinary tract infection was the most common), and 21% of hospital-acquired pneumonias were attributed to *P aeruginosa* infections, the most common pathogen in the specific survey (Weingarten, Paterson & Yu, 2003:160). Thus, previous antibiotic use in ambulatory/community medicine is a risk factor for carriage of an infection especially if antibiotics were prescribed for non-specific upper

respiratory tract conditions while patients were hospitalised. A large proportion of antibiotics prescribed are unlikely to be of any clinical benefit (Gonzales et al., 2001:479).

Intubation, another contributing factor for respiratory support and anaesthesia, increases the patient's risk of acquiring a health-care-related respiratory tract infection through various mechanisms, such as trauma to the naso-pharynx, impairment following the swallowing of secretions, ischaemia due to cuff pressure and impairment of ciliary clearance and cough, to name just a few. Prolonged breathing of dry gases, especially inadequately humidified gases, desiccate the respiratory mucosa, thereby reducing ciliary function and cough (APIC, 2000:24).

The most common risk factor identified for health-care-related (hospital-acquired) pneumonia (infection) is mechanical ventilation, with *P aeruginosa* for health-care-related *(*hospital-acquired) infection (pneumonia) as the identified pathogen. In a prospective study of 568 mechanically ventilated patients, Rello et al. and Richards et al. (both cited in Weingarten et al., 2003:160) found that chronic obstructive pulmonary disease (COPD) and mechanical ventilation were risk factors for the pathogen *Pseudomonas*, and mechanical ventilation for more than eight days was a risk factor in the case of the pathogen *P aeruginosa.* Previous antibiotic use also contributed to *Pseudomonas* pneumonia/infection. In their consensus on hospital-acquired pneumonia/infection, the American Thoracic Society (ATS) (as cited in Weingarten et al., 2003:160) listed corticoid therapy, malnutrition, structural lung disease, prolonged hospitalisation, indiscriminate antibiotic prescription and mechanical ventilation as risk factors for *P aeruginosa infection.*

- Corticoid therapy

Corticoid therapy suppresses the immune system and in an already compromised immune system, this could enhance mortality further. Treatment of an exacerbation of constrictive pulmonary disease (COPD) with any type of corticosteroid will significantly reduce treatment failure and the need for additional treatment. Dyspnoea and lung function will improve, but at a significantly increased risk of an adverse drug reaction (Wood-Baker, Gibson, Hannay, Walters & Walters, 2005:3).

When immediate antibiotic therapy is required in a seriously ill patient and the choice of antibiotic is dependent on the Gram stain, the following should be borne in mind: concomitant

antibiotic and corticosteroids use reduces the sensitivity of the staining technique, and false negative results are possible (Rello, Paiva, Baraibar, Barencilla, Bodi, Castander, Correa, Diaz, Garnacho, Llorio, Rios, Rodriquez & Sole-Violan, 2001: 955).

- Malnutrition

Malnutrition is associated with an increased stress reaction during the first week of hospitalisation and is therefore an important predictor of poor prognosis. Malnutrition represents a risk of decreased immunity and an increase in health-care-related infections and is further associated with an increased prevalence of complications and a high mortality rate on medical and surgical wards. Early and appropriate nutritional support reduces complications and mortality. The stress response in mechanically ventilated patients may lead to malnutrition by hypercatabolism and visceral consumption. Thus, the morbidity is further enhanced by the combination of both malnutrition and stress and a decrease in cellular immunity (Davalos, Ricart, Gonzalez-Huix, Soler, Marrugat, Molins, Suner & Genis, 1996:1-3).

- Structural lung disease

As described above, the mode of treatment of exacerbations of COPD is corticosteroids but it is advised that for the treatment of early onset pneumonia the monotherapy, treatment should be based on careful consideration of the impact of the presence of COPD, corticosteroids and immunosuppresion as well as antibiotic therapy within the last three months (Rello et al., 2001:966).

- Prolonged hospitalisation

Prolonged hospitalisation exposes the patient to hospital pathogens, of which half are due to Gram-negative organisms and of this 10-20% may result in bacteraemia. The most frequently reported organisms were *Enterbacteriaceae* (34%), s*taphylococcus aureus* (30%, of which 60% were resistant to methicillin) and *Pseudomonas aeruginosa* (29%) (Vincent, Bihari, Suter, Bruining, White, Nicolas-Chanoin, Wolff, Spencer & Hemmer, 1995:639-644). However, the excessive use of parenteral broad-spectrum antibiotics in ICUs results in the infections acquired by patients in ICUs being resistant to first-line antimicrobial agents more often than infections acquired elsewhere in the hospital (Rello et al., 2001:966).

- Indiscriminate antibiotic prescription

Despite the harm related to the indiscriminate prescription of antibiotics, there is still a firm belief on the level of patients and society in the theoretical benefits that antibiotics may have. At the patient level, risks include allergic reactions such as urticaria, rash and anaphylaxis. Adverse reactions may include yeast infections and/or gastrointestinal discomfort. Drug interactions may cause electrocardiographic changes for example a QT-interval prolongation caused by warfarin and oral contraceptives. The increased likelihood that a pneumococcal infection will occur in the ensuing months will be due to an antibiotic-resistant strain (Gonzales et al., 2001:481). The adverse effects of indiscriminate antibiotic use on rates of antibiotic resistance are well established, and the effects on health care costs, in terms of the cost of antibiotics and doctor's visits, are common knowledge (Gonzales et al., 2001:481).

- Mechanical ventilation

Overall mortality rates for hospital-acquired *Pseudomonas* pneumonia ranged from 42% to 75%. The high mortality rates appear to be attributed to infection by *P aeruginosa*, in addition to underlying illness. In a small retrospective study (Weingarten et al., 2003:160), the estimated attributable mortality rate of ventilator-associated pneumonia/infection caused by *P aeruginosa* was 40% to 50%. From a therapeutic perspective *P aeruginosa* is therefore a notable pathogen, as it possesses several important antibiotic resistance mechanisms (Weingarten et al., 2003:160).

Mechanical ventilation also exposes the patient to fluid-filled devices, such as in-line nebulisers and humidifiers. These devices are sources of bacteria and are associated with respiratory infection in patients using it. The mechanisms that ventilators contribute to infections include aspiration of endogenous oro-pharyngeal organisms and inhalation of exogenous organisms via contaminated air and gases. One of the important exogenous causes of colonisation is thought to be contamination of the inhalation therapy equipment (APIC, 2000:23).

The above risk factors are all indicators of a compromised immune system, which increases the risk for a health-care-related infection. The patient with a compromised immune system is more likely to acquire a health-care-related infection. Nurses should therefore focus patient care on the prevention of any further deterioration of the patient's condition through

the strict implementation of effective infection control principles.

1.2 PROBLEM STATEMENT AND DESCRIPTION

Ventilator-associated pneumonia is a common and highly morbid condition in critically ill patients. Epidemiological studies have revealed cumulative incidence rates of 10% to 25%, crude mortality rates of 10% to 40% and attributable mortality rates of 5% to 27%. Hospital stay and cost are increased in patients who develop ventilator-associated infections (Collard, Saint & Matthay, 2003:494).

Considerable intensive care resources are consumed in the treatment of ventilator-associated infections. Not only economic costs, but also expenditure of staff energies, physical resources, treatment expenses and admission to the intensive care unit may be more productively utilised in the preventative area (Bonten, Kollef & Hall, 2004:1141-1149).

Organisms causing ventilator-associated infections generally fall into two groups: those causing early-onset ventilator-associated infection, that is after less than four days of mechanical ventilation, and those causing late onset ventilator-associated infection, that is after four or more than four days of mechanical ventilation (Collard et al., 2003:494). As a result of the artificial airway, a mechanically ventilated patient is exposed to an assortment of micro-organisms in the respiratory tract, leading to colonisation and infection. Early-onset organisms are typically antibiotic-susceptible community-acquired bacteria, while late-onset organisms are commonly antibiotic-resistant health-care-related bacteria. Colonisation of the oropharynx and the stomach with potentially pathogenic organisms precedes the development of ventilator-associated infections in most patients. The pathogenesis of ventilator-associated infections probably involves micro-aspiration of oropharyngeal or gastric secretions (Collard et al., 2003:494).

Several investigators have reported that health-care-related (hospital-acquired) lower respiratory tract infections increase the hospital stay twofold or threefold, when compared to patients without lower respiratory tract infections. Researchers found the mean length of stay was 34 days for patients with ventilator-associated infections and 21 days for matched ventilator-assisted patients (Grossman & Fein, 2000).

The costs of extended intensive care stay and antibiotic treatment regimens are significantly increased, and are rarely fully reimbursed (Nel, 2001:4) (see Appendix One). More patients in the intensive care unit die from ventilator-associated infections than from any other health care related (hospital-acquired) infection.

Ventilator-associated infections have been a major complication for years, but the researcher has found that minimal attempts have been made to educate nurses with regards to the prevention of ventilator-associated infections (Nel, 2001:6) (see Appendix 1). Improved nursing education is crucial if nursing practice is to remain relevant to the health needs and expectations of society. In today's world, where national health systems are operative in many countries, the issue of cost-effectiveness may tend to divert attention from quality (World Health Organisation, 1985:61-68).

> *The Quality Indicator Research Group, composed of representatives from the Society for Hospital Epidemiology of America (SHEA), APIC, and Centres for Disease Control's Hospital Infection Program has provided a detailed discussion of the desired attributes for hospital acquired infections quality indicators. The group has recommended that validation of indicators must occur before they are used for inter-hospital comparisons of quality of care. It has also emphasised the importance of key factors in successful implementation of quality improvement systems in hospitals namely support by all involved staff from management downwards, adequate training of all staff involved including managers, confidentiality of data and completion of the quality improvement cycle with feedback of timely and accurate data to clinicians* (Acute Health Division: Department of Human Services, 1998).

In formal critical care courses in Australia, infection control issues are included in the curriculum but no detailed attention is given to specifics like ventilator-associated infections (VAI) (Australian Nursing Council, 2003).

If education of nursing staff by means of a structured learning programme can contribute to the reduction in health-care-related infections and in particular ventilator-associated infections, it should not be considered an option but a necessity in establishing and maintaining quality nursing care in the intensive care unit. The challenge facing nursing education is to provide educational programmes based on current health care problems thus

not only meeting the diverse needs of all students, but also focus on improved outcomes for the patient population (Van Belkum, 2001:7).

Over the years, researchers have established guidelines to aid in the prevention of ventilator-associated pneumonia. However, the researcher was unable to find a learning programme to facilitate the prevention of ventilator-associated infections, and therefore the researcher decided to develop one (see Appendix 1).

Based on the above, the following questions are therefore relevant to improve the quality of nursing for the adult patient that is mechanically ventilated in an intensive care unit:

- *What should the contents of a learning programme for nurses caring for adult mechanically ventilated patients with VAI in an intensive care unit be*?

(In future, *Learning Programme for nurses caring for adult mechanically ventilated patients with VAI in an intensive care unit* will be abbreviated to *Learning Programme*.)

- *What are nurses' pre- and post-test knowledge with regard to ventilator-associated infections*?

- *What are nurses' opinions regarding the effectiveness of the Learning Programme following its implementation*?

- *What difference did the Learning Programme make to the clinical practice of nurses thereby affecting adult mechanically ventilated patient outcomes*?

1.3 PURPOSE STATEMENT

The purpose of this research was to develop, implement and evaluate a Learning Programme for nurses working with adult ventilated patients with VAI in an intensive care unit. The Botes model (1998:2000:15) distinguishes between three strategies when describing the research purpose. These are exploratory, descriptive and explanatory in nature. These strategies will be described in detail in Chapter 3.

1.4 OBJECTIVES

According to the research strategy, the objectives of this research were divided into three phases.

1.4.1. Phase One

In this phase, the following objectives were identified:

- to utilise the results of the pilot study (Nel, 2001) (see Appendix 1), and
- to conduct an additional literature review on:
  - ventilator-associated infections;
  - preventive measures for infection; and
  - nursing education.
- to develop a Learning Programme for nurses utilising evidence-based research.

1.4.2 Phase Two

This phase entailed the following objectives:

- to pre-test nurses' knowledge with regard to ventilator-associated infections and the prevention thereof;
- to implement a learning programme for nurses;
- to post-test nurses' knowledge with regard to ventilator-associated infections and the prevention thereof;
- to evaluate the implemented Learning Programme (*Learning Programme for nurses caring for adult mechanically ventilated patients with VAI in an intensive care unit*);
- to implement and evaluate a learning programme for medical staff. This was done following a special request from the medical staff. The same Learning Programme that was utilised for the nurses was utilised for the medical staff and results will only be described as an appendix as this does not form part of nursing research (see Appendix 12).

1.4.3 Phase Three

In this final phase, only one objective was identified, namely to evaluate the impact of the Learning Programme on the outcomes of adult patients being mechanically ventilated.

1.5 HYPOTHESES

The following hypotheses were formulated for the research:

Null hypothesis (Phase Two)

- There is no difference in the knowledge base of nurses, following the implementation of the Learning Programme.

Alternative hypothesis (Phase Two)

- There is a difference in the knowledge base of nurses, following the implementation of the Learning Programme.

Null hypothesis (Phase Three)

- There is no difference in the adult ventilated patient outcomes, following the implementation of the Learning Programme for nurses.

Alternative hypothesis (Phase Three)

- There is a difference in the adult ventilated patient outcomes following the implementation of the Learning Programme for nurses.

1.6 RESEARCH DESIGN

The research design is described in detail in Chapter 3 of the research.

*"The research decisions which are made in the design phase deal with the research strategy (overall approach), the methods of data collection, methods of data analysis, the target population and methods of sampling as well as the methods for validating and reliability" (*Botes, 2000:13).

The researcher has made various research decisions based on her pilot research (Nel, 2001:52). The results of the pilot research enabled the researcher to use deductive methods in order to develop a Learning Programme for nurses attending to adult ventilated patients with VAI in the intensive care unit. The research design is briefly described in the section below.

1.6.1 Research strategy

During this research, a focus group discussion, based on Lynn's (1986:382-385) principles for validation, was utilised for Phase One, and a quantitative approach with a pre-experimental design for Phase Two, while a survey was utilised in Phase Three for the evaluation of patient outcomes.

A one-group pre-test post-test strategy was implemented to determine and manipulate the knowledge base of the nursing staff rendering care to adult patients who were mechanically ventilated and who had VAI. At the request of the senior intensivists, the medical staff in the

intensive care units participated in the research and Learning Programme. As it is professionally and ethically inappropriate for a nurse to assess the learning outcomes and practices of medical staff, the sample thus only included nurses for the description in this research (see Appendix 12 for the medical staff data, which was processed and given to the medical directors of the intensive care units).

To realise Phase Three of the research, an impact evaluation was conducted. The change of the nursing staff's knowledge as implemented in clinical practice facilitated the improvement of outcomes for adult patients being mechanically ventilated. The impact evaluation was performed through surveillance of these patients whilst they were being mechanically ventilated.

1.6.2 Data collection

Data collection took place according to the three phases of the research.

In Phase One, data was collected and analysed by the focus (specialist) group to determine the content validity of the Learning Programme. Content validity of the Learning Programme as well as the pre-test and post-test was ensured by means of the pilot study (Nel, 2001), an additional literature review, as well as by four critical care nurses working in the intensive care unit, two medical staff (intensivists) and two infection control nurses, who were identified as the focus (specialist) group, as well as an expert nurse educator (see Chapter 4 Section 4.4.1).

In Phase Two, a pre-test and post-test were done to determine the nurses' scores with regard to their knowledge on ventilator-associated infections, and an open-ended

questionnaire was utilised to collect the data for the evaluation of the implemented Learning Programme. Phase Three consisted of the evaluation of the implemented Learning Programme on outcomes of adult patients being mechanically ventilated in the ICUs of two Australian hospitals. The data was collected at a specific time by means of a structured surveillance instrument included in the impact evaluation process (Pan American Sanitary Bureau, Regional Office of the WHO, 2000:2-40).

1.6.3 Data analysis

The data was analysed according to the phases and are illustrated in tables and pie diagrams in Phases Two and Three of the research (see Chapter 4 Section 4.4.2 for the results).

The focus (specialist) group in Phase One analysed the data to be implemented in the Learning Programme as well as the pre-test and post-test. In Phase Two, a statistician analysed the pre-and post-test results by means of the Sign Rank test and the researcher implemented a partially explanatory strategy (open-ended questionnaire) for the evaluation of the Learning Programme. In Phase Three, a surveillance instrument based on the APIC criteria for VAI and ventilator days as part of the WHO impact evaluation process was utilised to analyse the impact of the Learning Programme on outcomes of adult patients being mechanically ventilated.

1.6.4 Population and sample

The population sample for the research was divided according to the phases of the research, and included in Phase One critical care-qualified nurses, medical staff and infection control nurses. The focus (specialist) group consisted of nine people (see Chapter 4 Section 4.4.1) and included in Phase Two, nurses working in intensive care units in Australia, who were caring for adult patients attached to mechanical ventilators. An additional population sample, on special request of the directors of the intensive cares, was that of the medical staff working in Australia in the two nominated hospitals, who were also caring for adult patients being mechanically ventilated (see Appendix 12 for the population sample for medical staff).

The sample consisting of nurses (635 in total) in two Australian hospitals, were selected according to the criteria in Chapter 4 Section 4.4.1. The population sample for Phase Three consisted of adult patients attached to mechanical ventilators in ICUs of two Australian hospitals, to determine the impact of the Learning Programme on patient outcomes.

1.6.5 Validity and reliability

The Learning Programme was deductively developed based on research done by the researcher during 2001 in a South African hospital as well as an additional extended literature review in 2003. Validation of the Learning Programme was further ensured by means of experts in the field of critical care nursing, infection control nursing as well as two medical staff.

To ensure reliability of the data collection process, the researcher ensured that the Learning Programme was not implemented until all nursing and also medical staff had completed the pre-test. Data collection for the third phase was done by two infection control nurses as part of their daily surveillance tasks in the Infection Control Department.

1.6.6 Research context

The research was done within the context of nursing education, nursing as the basis for the nursing care of adult patients on mechanical ventilators and infection control.

1.6.7 Strategies of reasoning

The strategies of reasoning implemented in the research were analysis, deduction and synthesis. Each strategy is briefly described.

- **Analysis:** Was utilised during clarification and refining of recommendations in the Learning Programme, as well as analysis of the results obtained from the data collection.

- **Deduction:** Deduction is defined as the process of developing specific predictions from general principles of belief (Abdellah & Levine, 1979). Deduction was utilised in developing the Learning Programme and the questionnaires for data collection (see Appendix 3 & 9).

- **Synthesis:** This method uses the process as a whole and constructs global measures from the detailed event data in order to be able to describe and compare the corresponding processes from different subjects (Langley, 1999:691-710).

Analysis and synthesis, though commonly treated as two different methods, are, if properly understood, only two essential parts of the same method. Each is relative to and correlative of the other (The DICT Development, 2005).

1.7 TERMINOLOGY

The following terminology is described to avoid or eliminate misinterpretation.

< ***Expert***

A person who has special knowledge or skill in a certain field (Pearsall, 1999: 501).

An expert is an experienced person or one instructed by experience; one who has skill, experience, or extensive knowledge in his calling or in any special branch of learning (The DICT Development, 2005).

< ***Infection***

An inflammatory response induced by the presence of pathogenic micro-organisms, or the invasion of normally sterile host tissue by microbial pathogens (American College of Chest Physicians/Society of Critical Care Medicine Consensus Conference, 1992:864-874).

Invasion and multiplication of micro-organisms in body tissues, which may be clinically unapparent or result in local cellular injury due to competitive metabolism, toxins, intracellular replication, or antigen-antibody response. The infection may remain localised, subclinical and temporary if the body's defence mechanisms are effective. A local infection may persist and spread by extension to become an acute, subacute or chronic clinical infection or disease state. A local infection may also become systemic when the micro-organisms gain access to the lymphatic or vascular system (Dorland, 2000:895).

< ***Learning Programme***

The Learning Programme includes the identification of goals, objectives and skills as well as the assessment of learners and the programme content. The pre-test and post-test used before and after the Learning Programme, were structured in such a manner that the person being tested, would be assessed using scenarios and problem-based learning strategies (see Appendix 3).

< ***Health Care Related infection***

The CDC defines *a health-care-related infection* as a localised or systemic condition that results from an adverse reaction to the presence of an infectious agent(s) or its toxin(s) and which was not present or incubating at the time of admission to the hospital. For most bacterial health care related infections, this means that the infection usually becomes evident 48 hours (i.e. the typical incubation period) or more after admission. However, because the incubation period varies with the type of pathogen and to some extent with the patient's underlying condition; each infection should be assessed individually for evidence that links it to the hospitalisation. There are two special situations in which an infection is considered health care related:(a) infection that is acquired in the hospital but which does not become evidence until after hospital discharge, and (b) infection in a neonate that results from passage through the birth canal (CDC Guidelines, 2004). A health-care-related infection was previously known as a nosocomial or hospital-acquired infection.

< ***Community-acquired infection***

Any infection acquired in the community, that is contrasted with those acquired in a health care facility (cross infection). An infection would be classified as community-acquired if the patient had not recently been in a health care facility or in contact with someone who had been in a health care facility recently (Biology-Online, 2005).

< ***Intensivist***

A physician who specialises in the provision of care in the intensive care unit (Dorland, 2000:906).

< ***Adult***

A living organism that has attained full growth or maturity (Dorland, 2000:34).
In this thesis "adult" is categorised as a person over the age of 16 years.

< ***Ventilator***

An apparatus designed to qualify the air that passes through it or an apparatus used in artificial respiration, usually in mechanical ventilation (Dorland, 2000:1954). A positive or negative-pressure breathing device that can maintain ventilation and oxygen delivery for a prolonged period (Brunner & Suddarth, 1996:1954).

< ***Ventilation***

Circulation, replacement or purification of air or other gas in a defined or enclosed space or in respiratory physiology, the process of exchange of air between the lungs and the environment, including inspiration and expiration (Dorland, 2000:1954).

< ***QT-Interval***

In electrocardiography, it means the time from the beginning of the Q-wave to the end of the T-wave. It represents the duration of ventricular electrical activity (Dorland, 2000:911).

< ***Nurse (In Australia)***

A person who has graduated from an accredited university course in nursing. A Division 1 nurses is equivalent to a Registered Nurse (RN) in South Africa. A Division 2 nurse in Australia is the equivalent of a Staff Nurse in South Africa. Only Division 1 nurses are allowed to work in the Intensive Care Unit in Australia, unlike South Africa where Staff nurses are allowed to look after patients in the Intensive Care Unit.

1.8 CHAPTER BREAKDOWN

This research consists of five chapters. Chapter 1 provides an overview of the research whilst Chapter 2 encompasses a literature review, and in Chapter 3 the research design and methodology are described. Chapter 4 deals with the data presentation, analysis and interpretation of results. The final chapter includes the synthesis, conclusions and recommendations for all four domains of nursing practice.

1.9 ETHICAL CONSIDERATIONS

Permission was obtained from the authorities at the two Australian hospitals to conduct the research (see Appendix 10). The goal of the research was explained to the respondents participating in the Learning Programme and they were also informed of their right to confidentiality and voluntary participation. Patient confidentiality was maintained and permission was granted to utilise the information to compare the Learning Programme on the patient outcomes.

1.10 EDITORIAL STYLE

The Technical Editing Guidelines of the Faculty of Education at the University of Stellenbosch guided the writing of this thesis. This included style, referencing, editing, formatting and lay out of the thesis.

1.11 SUMMARY

In this chapter, an overview of the problem of ventilator-associated infections, with a simultaneous description of the research design and strategy was given. Simultaneously, the importance of a Learning Programme for nurses caring for adult patients attached to mechanical ventilators was analysed.

The mortality rate remains high for intensive care patients despite dramatic advances in pharmacological and non-pharmacological therapeutics that have been used since the 1970s. There is evidence that mechanical ventilation is the principal risk factor for lower respiratory tract infection in intensive care patients.

Indeed, more than 30% of patients develop at least one episode of a respiratory infection within three weeks of mechanical ventilation. The occurrence of pulmonary infection in ventilated patients could affect the prognosis.

In Chapter 2, the literature applicable to the research is reviewed.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Nurses caring for patients who are mechanically ventilated should participate in programmes aimed at preventing ventilator-associated infections (VAI). Such programmes could be part of a more general local effort directed at preventing nosocomial infections. A programme to prevent ventilator-associated infections should incorporate readily available methods whose efficacy and cost-effectiveness are supported by clinical studies, local experience and the views of experts in the field. To increase the likelihood of their acceptance and success, such efforts should be tailored to the characteristics of the individual hospital. Several resources are available to assist in the development of this type of preventative programme (Tablan, Anderson, Arden, Breiman, Butler & McNeil, 1994:587-627; Goldmann, Weinstein, Wenzel, Tablan, Duma, Gaynes, Schlosser & Martone, 1996:234-240)

The benefits derived from a programme to prevent ventilator-associated infections can be demonstrated in terms of both improved clinical outcomes and reduced costs of healthcare. Among the most important elements of this strategy are the presence of a dedicated person or group that takes charge of the process and a mechanism for tracking rates of nosocomial infections (Salahuddin, Zafar, Sukhyani, Rahim, Noor, Hussain, Siddiqui, Islam & Husain, 2004:223-227).

A literature study and clinical data collection have been performed by the researcher in 2001 in selected hospitals in the Western Cape, South Africa, and repeated in 2003 in selected hospitals in Melbourne and Sydney, Australia. After collecting the data, the researcher was able to recommend evidence-based measures for the prevention of ventilator-associated infections. This information was summarised and used to establish a Learning Programme for nurses working with adult ventilated patients in an intensive care unit (Nel, 2001).

2.2 GOAL OF THE RESEARCH

As described in Section 1.3, the goal of this research was to establish a learning programme for nurses working with adult mechanically ventilated patients in an intensive care unit and to evaluate such a programme once it has been established. The research objectives were divided into three phases according to the strategy (see Chapter 1 Section 1.6.1). In this chapter, the literature review applicable to the first phase is described. The review was divided into three phases.

In Phase One, an additional literature review was done on the following:

- ventilator-associated infections;
- preventive measures for infection; and
- nursing education.

A Learning Programme for nurses was developed based on the literature review described in this chapter and previous work done by Nel (2001).

Phase Two consisted of a pre- and post-test to evaluate nurses' knowledge with regard to ventilator-associated infections and the prevention thereof and the implementation of a Learning Programme. The Learning Programme was also evaluated.

In Phase Three the impact of the Learning Programme on the outcomes of adult patients being mechanically ventilated was evaluated.

2.3 THE CONCEPTUAL FRAMEWORK

The conceptual framework for the research was based on current literature and previous research on the prevention of ventilator-associated infections (Nel, 2001). The literature review is described in this chapter and forms part of Phase One of the research. The last step in Phase One was to develop a Learning Programme for nurses working with ventilated patients in an intensive care unit. The conceptual framework is part of the third order of the model by Botes (1998, 2000) (see Figure 3.1).

2.4 LITERATURE REVIEW

The literature review is described according to the clinical disease (strategies for prevention, pathogenesis, mechanisms of infection and diagnostic criteria, inclusive of treatment) and education. Ventilator-associated infections are a leading cause of death from hospital-acquired infections, with an associated crude mortality rate of approximately 30 percent. Ventilator-associated infections are those that occur within 48 to 72 hours after tracheal intubation, result from aspiration, and/or complication of the intubation process. The criteria for this include infections caused by antibiotic-sensitive bacteria (e.g. oxacillin-sensitive *Staphylococcus aureus, Haemophilus influenzae* and *Streptococcus pneumoniae*). Criteria for diagnosing late onset ventilator-associated infections can often be contributed to antibiotic-resistant pathogens (e.g. oxacillin-resistant *Staphylococcus aureus, Pseudomonas aeruginosa, Acinetobacter* and E*nterobacter*) (Kollef, 1999b:627). The clinical diseases of VAI are described according to the pathogenesis, diagnostic criteria, mechanisms of infections, associated risks, strategies for prevention, education in infection prevention, surveillance and prevention of transmission of organisms.

2.4.1 Ventilator-associated infections (VAI)

In the following pages, the epidemiology of ventilator associated infections will be discussed, with special emphasis toward bacterial causes, new risk factors and emerging pathogens.

2.4.1.1 Pathogenesis

Micro-organisms may invade the lower respiratory tract via several mechanisms, including aspiration of oropharyngeal and/or gastric organisms or continuous extension of oropharyngeal or nasopharyngeal colonisers, inhalation of contaminated aerosol, large-droplet deposition (directly or indirectly via contaminated hands) on the conjunctiva or oral and nasal mucosa, haematogenous spread from a distant body site, and bacterial translocation. In general, the upper airways of severely ill, hospitalised patients become colonised with gram-negative bacilli. Colonisation of the oropharynx by gram-negative bacilli begins with the adherence of the micro-organisms to the patient's oropharyngeal epithelial cells. The micro-organisms have a unique ability to bind directly to the surface cells of the tracheobronchial tree without first having to adhere to the oral or nasal mucosal cells and they can therefore inoculate the lower respiratory tract directly. Adherence is affected by many factors, including the bacteria's pili, cilia or capsule, or the ability to produce particular

enzymes (e.g. mucinase, the host cell's surface proteins and polysaccharides, and the micro-environment's acidity, i.e. pH). Lower respiratory tract infections have a predisposition to multiply with increasing severity of underlying disease, antimicrobial administration and length of hospitalisation (Safdar, Crnich & Maki, 2005:725-729; Kollef, 1999b:627).

Aspiration of oropharyngeal secretions into the tracheobronchial tree occurs during sleep in 45% of normal adults. This phenomenon is enhanced in patients with depressed consciousness or respiratory tract instrumentation, diseases, or post-surgery. Gastric colonisation occurs in patients with gastric secretion pH more than (>) 4 (e.g. the elderly, patients with achlorhydria or ileus, or patients receiving enteral feeding, antacids, or H-2 antagonists). Procedures such as endotracheal intubation, tracheostomy, or orotracheal, nasotracheal, or tracheal suctioning increase the risk of organisms entering the tracheobronchial tree. When the patient uses normal clearance mechanisms and is unable to propel invasive micro-organisms, infection of the lower respiratory tract can ensue. Inhalation of contaminated aerosols is the mechanism of infection for some cases of gram-negative infections, e.g. those acquired from contaminated nebulisation fluids (Safdar et al., 2005:725-729).

Contaminated aerosols generated from contaminated nebulisation equipment may be directly deposited into the lower respiratory tract in patients with tracheal tubes and/or assisted mechanical ventilation (Safdar et al., 2005:725-729; Kollef, 1999b:627). Airborne spores or droplet nuclei containing viral particles (e.g. influenza viruses) are small enough to reach the lower respiratory tract. Large-droplet deposition (directly or indirectly via contaminated hands) onto the conjunctiva or oral or nasal mucosa is the mode of person-to-person transmission of infections. Haematogenous spread from distant body sites occur in a small proportion of nosocomial lower tract respiratory infections. Bacterial translocation, the passage of viable bacteria from the lumen of the gastro-intestinal tract through epithelial mucosa to the mesenteric lymph nodes and to the lung, has been shown to occur in animal models and is hypothesised to occur in patients with severe burns or septic shock (Safdar et al., 2005:725-729).

The pathogenesis of ventilator-associated infections usually requires that two important processes take place: bacterial colonisation of the aerodigestive tract and the aspiration of contaminated secretions into the lower airway. Therefore, the strategies aimed at preventing ventilator-associated infections usually focus on reducing the burden of bacterial colonisation

in the aerodigestive tract, decreasing the incidence of aspiration, or both. When ventilator-associated infections occur, treatment usually consists of supportive care and the administration of antibiotics. One study suggested that the mortality attributable to ventilator-associated infections, particularly late-onset with antibiotic-resistant pathogens, is greater than 10 percent (Chastre & Fagon, 2002:867-903), therefore implying that the deaths among patients with ventilator-associated infections (attributable mortality, 10 percent; crude mortality 30 percent) are due to the infection (one third) and underlying diseases (two thirds). After controlling for confounding factors, other investigators have not found associated attributable mortality from ventilator-associated infections. The importance of adequate initial empiric treatment with antibiotics has been recognised; such treatment may influence the estimates of attributable mortality (Rello, Rue, Jubert, Muses, Sonora, Valles & Niederman, 1997:1862-1867). In addition to higher mortality rates, ventilator-associated infections are associated with prolonged hospitalisations and increased medical costs (Craven & Steger, 1995a:1S-16S).

Patients with suspected ventilator-associated infections should initially be treated with a broad-spectrum antibiotic regimen aimed at covering all likely bacterial gram-negative or positive infections (Kollef & Ward, 1998:412-420). This regimen should then be subsequently be narrowed down according to the results of cultures of respiratory secretions and the sensitivity profiles of the bacteria.

Assessments of the prevalence and incidence of opportunistic infections in certain areas and comparability of the available data are hampered by limited access to care, diagnostic capabilities, and surveillance data. Despite these limitations, we know that tuberculosis (TB) is the most frequent serious opportunistic infection in the developing world. Other such infections common in sub-Saharan Africa include septicemia (of which non-typhoid salmonella is the most common cause), toxoplasmosis, and bacterial pneumonia. *Pneumocystis carinii* infection, for unknown reasons, is uncommon among adults in East and West Africa but appears to be more common in South Africa. *Penicillium marneffei* infection, common in Thailand, is an example of an opportunistic infection of importance in a specific region; risk factors in these regions are largely unknown. Additional challenges are posed by the different HIV subtypes in the developing world and the possibility that some may be associated with a differential risk for opportunistic infections. Prevention efforts in developing countries have been limited. More work is needed to evaluate prophylactic regimens appropriate to different regions. Prevention of TB with isoniazid; of pneumocystosis,

toxoplasmosis, and some bacterial infections with cotrimoxazole; and of pneumococcal infections with 23-valent pneumococcal vaccine have potential (Kaplan, Roselle & Sepkowitz, 1998).

2.4.1.2 Diagnostic criteria

Diagnostic criteria used in hospitals vary according to the institution's patient population, the purpose of the diagnosis (e.g. patient therapy, research, or surveillance), and the available resources. Universally, the diagnostic criteria have included fever (e.g. temperature greater than 38ºC or 100.4ºF), productive cough with the development of purulent sputum, combined with a new or progressive lung infiltrate as seen on chest x-ray examinations, a suggestive sputum gram stain (i.e. many bacteria greater than 25 neutrophils and less than 10 epithelial cells per high-power field) and culture isolation of a pathogenic micro-organism from the patient's sputum or tracheal aspirate, pleural fluid, or blood (Centre for Disease Control [CDC], 2004:1685-1688). The CDC (2004:1685-1688) defines ventilator-associated infection as at least one of the following:

- fever (>38^{0}C or >100.4^{0}F) with no other recognised cause;
- leucopoenia (white blood cell count [WBC] of <4000/mm3) or leukocytes (WBC of >12,000 /mm3); and
- in adults older than 70 years, an altered mental status with no other recognised cause

AND at least (**two)** of the following:

- new onset of purulent sputum, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements;
- new onset or worsening cough, or dyspnoea, or tachypnoea;
- rales or bronchial breath sounds; and
- worsening gas exchange (e.g. O_2 desaturation, increased oxygen requirements, or increased ventilation demands)

In addition, two or more serial chest radiographs with at least one of the following should be present:

- new or progressive and persistent infiltrate;
- consolidation; and

- cavitation.

In patients without underlying pulmonary or cardiac disease (e.g. respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary oedema, or chronic obstructive pulmonary disease), one definitive chest radiograph is acceptable (CDC, 2004:1685-1688).

2.4.1.3 Mechanisms of infections

The risk factors and mechanism that may cause ventilator-associated infections are summarised according to the swallowing and cough reflex, immuno-suppression, airway obstruction, altered oropharyngeal flora and/or gastric colonisation, inhalation of contaminated aerosols, trauma, and other conditions or factors indicated in Table 2.1.

Table 2.1: Risk factors and mechanisms for ventilator-associated infections (Nel, 2001)

Risk factors	Mechanisms of infection
Altered swallowing and cough reflex Coma or depressed consciousness Seizures Dysphagia Endotracheal tube Oroenteral or nasoenteral tube	Aspiration of oropharyngeal and/or gastric secretions or contents
Immuno-suppression ▪ Granulocytopenia, both disease- and therapy-related	Inadequate white cells and/or antibodies response to infectious
Airway obstruction ▪ Tumour ▪ Mucosal oedema ▪ Bronchospasm ▪ Obstructive pulmonary disease ▪ Congenital malformation ▪ Fluid (including water in near drowning	Pooling of secretions; decreased muco-ciliary transport and cough; colonisation of the upper respiratory tract (including oropharynx) by gram-negative bacilli and other potential respiratory pathogens, followed by aspiration, reduced alveolar surfactant; decreased clearing mechanisms
Altered oropharyngeal flora and/or gastric colonisation	Change in patient's upper-airway or gastric flora to antimicrobial-resistant
Antimicrobial therapy, local and/or systemic	Antimicrobial therapy, local and/or micro-organisms and subsequent entry of systemic micro-organisms into lower respiratory tract
Antacids and/or H2-blocker administered to critically ill patients and/or mechanically ventilated patients for stress-bleeding prophylaxis	Growth and multiplication of micro-organism in gastric juice with pH<4 and subsequent aspiration of such micro-organisms

Table 2.1: Risk factors and mechanisms for ventilator-associated infections (continued) (Nel, 2001)

Risk factors	Mechanism of infection
Inhalation of contaminated aerosols	
▪ Use of contaminated nebulising devices ▪ Use of non-sterile fluid for nebulisation	Direct transmission of micro-organisms onto bronchiolar and alveolar surfaces
Other conditions/factors	
▪ Burns ▪ Adult respirators distress syndrome ▪ Post thoracic or upper abdominal surgery	Diminished clearing mechanisms and aspiration; bacterial translocation (movement of bacteria form the lumen of the gastrointestinal tract through the mesenteric nodes to the pulmonary tissues); reduced ciliary activity and inflamed mucosa; pooling of secretions
▪ Viral upper respiratory tract infection	Diminished clearing mechanisms, pooling of secretions
▪ Chronic obstructive lung disease/smoking ▪ Musculoskeletal disorders (e.g. scoliosis) ▪ Extremes of age ▪ Diabetes mellitus	Diminished clearing mechanisms

Table 2.1: Risk factors and mechanisms for ventilator-associated infections (continued) (Nel, 2001)

Risk factors	Mechanism of infection
Trauma ▪ Penetrating wounds ▪ Unintentional ▪ Surgical	Impaired system integrity, direct introduction of micro-organisms into the respiratory tract and diminished clearing mechanisms
▪ Closed wounds (crush injury)	Obstruction, impaired system integrity, and diminished clearing mechanisms
▪ Thermal injury	Impaired system integrity and clearing mechanisms diminished

2.4.1.4 Associated risks

Associated risks of ventilator-associated infections are summarised in Table 2.2 according to the following: gloving, semi-critical devices, mechanical ventilator and attachments, suction equipment, diagnostic equipment, oxygen administration devices, patient feeding and stress ulcer prophylaxis, surgery, antimicrobial administration, the immobile state and the change in seasons.

Table 2.2: Associated risks of ventilator-associated infections (Nel, 2001)

Procedure/device	Associated risk(s)
Gloving	
For contact with respiratory secretions, contaminated devices, or environmental surface	Not changing or removing gloves after contact with respiratory secretions, contaminated devices, or environmental surfaces may result in transmission of micro-organisms via gloved hands to other patients, devices, or environmental surfaces
Semi-critical devices	
Part of respiratory-therapy or diagnostic devices or anaesthesia equipment that comes into direct or indirect contact with patient's respiratory tract (e.g. breathing circuit of mechanical ventilator with humidifier, bronchoscope and its accessories [except biopsy forceps and specimen brush, which are critical items and are sterilised before reuse], endo-tracheal and endo-bronchial tubes, laryngoscope blades, stylets, suction catheters, anaesthesia face masks and tracheal tubes)	Contaminated devices that come into contact with respiratory tract mucosa pose a risk of respiratory infection, albeit lower than the infection risk associated with devices that penetrate normal sterile tissues Tap or locally prepared distilled water may harbour organisms (e.g. Legionella or non-tuberculous mycobacteria that may cause pneumonia)
Bubbling humidifier	When a heated humidifier is used, condensate may accumulate in the inspiratory tubing, become contaminated by orophyaryngeal flora, and be washed down the patient's trachea
Breathing circuit	Low risk of infection from the breathing circuit used by one patient

Table 2.2: Associated risks of ventilator-associated infections (continued) (Nel, 2001)

Procedure/device	Associated risk(s)
Suction equipment	
▪ Catheter ▪ Suction tubing ▪ Suction canister	May introduce micro-organisms into the lower respiratory tract. No outbreaks reported to be directly associated with suction canister
Diagnostic equipment	
▪ Bronchoscopes	Scopes may introduce organisms to lower airway or conduct organisms from upper to lower airway
▪ Pulmonary-function testing equipment	Mouthpiece and tubing may become contaminated with patient's respiratory secretions Organisms may be carried from patient to patient via device
▪ Lung biopsy devices	Risk related to surgical introduction of micro-organisms into site
Oxygen-administration devices	
▪ Nasal cannulae ▪ Masks ▪ Humidifiers ▪ Resuscitation bag and valves ▪ Oxygen tents	Reusable devices may become contaminated with a patient's oropharyngeal flora during use; if used subsequently on another patient, cross-colonisation and infection may occur

Table 2.2: Associated risks of ventilator-associated infections (continued) (Nel, 2001)

Procedure/device	Associated risk(s)
Airway-maintenance devices	
▪ Nasoenteral ▪ Orogastric or ▪ Nasogastric	Nasoenteral tubes may erode mucosal tubes surface or block sinus ducts
▪ Jejunal tubes	Upper gastrointestinal contents may regurgitate and cause aspiration
▪ Antacids and H2 blockers	If indicated, use sucralfates rather than antacids. In patients receiving antacids, the pneumonia rate is higher due to the increased gastric colonisation by gram-negative bacilli in the presence of a neutralised gastric pH
Thoracic and/or abdominal surgery	Impaired swallowing and clearance of secretions from respiratory tract because of post-operative pain and associated use of narcotics or sedatives. Risk is increased in persons who are over 70 years of age, who smoke, are obese, or have chronic obstructive pulmonary disease; a tracheostomy, or long-term intubation
Antimicrobial administration	
▪ Systemic antimicrobial prophylaxis versus infections in patients on mechanically assisted ventilation	Emergence of antibiotic-resistant micro-organisms that may be subsequently aspirated and cause infections
The immobilised state	
May be of any etiology (e.g. trauma, stroke, or other paralytic illnesses)	Decreased clearing mechanisms
Seasonal	
▪ Influenza season	Epidemics of influenza

The modes of transmission of various health-care-related respiratory tract pathogens are illustrated in Figure 2.1 below. Micro-organisms may originate from the environment, invasive devices, other patients or hospital staff (Craven & Steger, 1995: a).

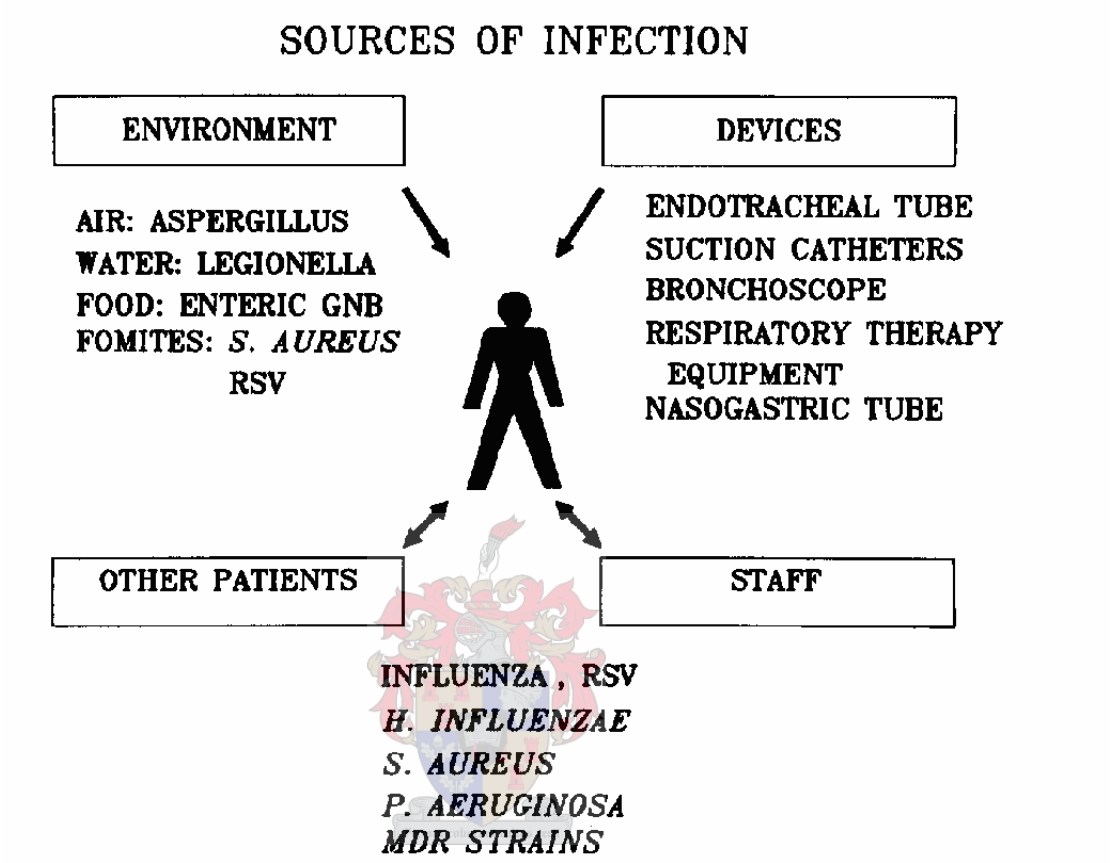


Figure 2.1: Sources of infection (Craven & Steger, 1995:a)

2.4.1.5 Strategies for prevention

Strategies for prevention are described according to staff education and involvement in infection prevention, infection and microbiologic surveillance, the prevention of transmission of micro-organisms. The strategies for prevention of ventilator-associated infections are evidence based and references are given accordingly.

- **Staff education and involvement in infection prevention**

Educate health care workers about the epidemiology of, and infection control procedures for, preventing ventilator-associated infections to facilitate healthcare worker competency according to the worker's level of responsibility in the healthcare setting, and involve the healthcare workers in the implementation of interventions to prevent ventilator-associated

pneumonia by using performance-improvement tools and techniques (Kaye, Ashline & Erickson, 2000:197-201).

- **Infection and microbiologic surveillance**

Conduct surveillances for ventilator-associated infections in critical care patients to determine trends and help identify outbreaks and other potential infection-control measures (Haley, Culver White, Morgan, Emori, Munn & Hooton, 1985,2:182-205). For benchmarking purposes, the new National Nosocomial Infection Surveillance's (NNIS) ventilator-associated infection surveillance definition (CDC, 2003c) was utilised. The NNIS includes data on the causative micro-organisms and their antimicrobial susceptibility patterns (Horan, White, Jarvis, Emori, Culver, Munn, Thornsberry, Olson & Hughes, 1986:17S-29S). NNIS rates (e.g. number of infected patients or infections per 100 ICU days or per 1 000 ventilator days) may be used to facilitate intrahospital comparisons and trend determination (Gaynes & Solomon, 1996:457-467). However, one should bear in mind that these rates were identified in the United States of America and not in Australia. This comparison may be used to link monitored rates, prevention efforts and data to appropriate healthcare personnel for feedback and corrective actions (Gaynes, Richards, Edwards, Emori, Horan, Alonso-Echanove, Fridkin, Lawton, Peavy & Tolson, 2001:295-298).

In the absence of specific clinical, epidemiologic, or infection-control objectives, routine surveillance cultures should not be conducted on patients, equipment or devices used for respiratory therapy, pulmonary-function testing, or delivery of inhalation anaesthesia (Glupczynski, 2001:38-45).

- **Prevention of transmission of micro-organisms**

The following information provides evidence-based practice guidelines for the prevention of transmission of micro-organisms.

- **Sterilisation or disinfection and maintenance of equipment and devices**

This section is described under the following headings: general measures, mechanical ventilators, oxygen humidifiers, small-volume medication nebulisers (in-line and hand-held nebulisers), mist tents, other devices used in association with respiratory therapy, anaesthesia machines and breathing systems or patient circuits, pulmonary-function testing equipment, and room-air "humidifiers" and faucet aerators.

■ **General measures**

Guidelines for general measures are the following:

- Thoroughly clean all equipment and devices to be sterilised or disinfected (Favero & Bond, 1991).
- Whenever possible, use steam sterilisation by autoclaving or high-level disinfection by wet heat pasteurisation at >70°C or 58°F for 30 minutes for reprocessing semi-critical equipment or devices, i.e. items that come into direct or indirect contact with mucous membranes of the lower respiratory tract that are not sensitive to heat and moisture. Use low-temperature sterilisation methods as approved by the Office of Device Evaluation, Centre for Devices and Radiologic Health, Food and Drug Administration [FDA] for equipment or devices that are heat- or moisture-sensitive. After disinfection, proceed with appropriate rinsing, drying, and packaging, taking care not to contaminate the disinfected items in the process (Rutala & Weber, 1995:442-443).
- Preferentially use sterile water for rinsing reusable semi-critical respiratory equipment and devices when rinsing is necessary after chemical disinfection. If this is not feasible, rinse the device with filtered water (water that has been through a 0.2μ filter) or tap water, and then rinse with isopropyl alcohol and dry with forced air or in a drying cabinet (Rutala & Weber, 1995:442-443).
- Adhere to provisions in the FDA's enforcement document for single-use devices that are reprocessed by third parties (FDA, 2000).

■ **Mechanical ventilators**

Do not routinely sterilise or disinfect the internal machinery of a mechanical ventilator, but utilise the following for the external machinery.

- Breathing circuits with humidifiers

Do not change routinely on the basis of duration of use, the breathing circuit (i.e. ventilator tubing and exhalation valve and the attached humidifier) that is in use on an individual patient. Change the circuit when visibly soiled or mechanically malfunctioning (Fink, Krause, Barrett, Schaaff & Alex, 1998:405-411).

- Breathing-circuit-tubing condensate

Periodically drain and discard any condensate that collects in the tubing of a mechanical ventilator, taking precautions not to allow condensate to drain toward the patient because of potential aspiration into airway (Craven, Goularte & Make, 1984:625-628). For the

prevention of infections, gloves should be worn when performing the previous procedure and/or when handling the fluid (Garner, 1996:53-80). Individuals should also routinely wash hands with soap and water (if hands are visibly soiled) or with an alcohol-based hand rub after performing the procedure or handling the fluid (CDC, 2002:51).

- Filters

No recommendations have been made for placing a filter or trap at the distal end of the expiratory-phase tubing of the breathing circuit to collect condensate (unresolved issue) (CDC, 2002).

- Humidifier fluids

Use sterile (not distilled, unsterile) water to fill bubbling humidifiers. No recommendations have been made for the preferential use of a closed, continuous-feed humidification system (unresolved issue) (Rhame, Streifel, McComb & Boyle, 1986:403-407).

- Ventilator breathing circuits with Heat Moisture Exchangers (HME)

No recommendations have been made for the preferential use of either HME or heated humidifiers to prevent infections in patients receiving mechanically assisted ventilation (unresolved issue**)** (Thomachot, Viviand, Arnaud, Boisson & Martin, 1998:1383-1389).

- Changing HME

Change an HME that is in use on a patient when it malfunctions mechanically or becomes visibly soiled. Do not routinely change more frequently than every 48 hours an HME that is in use on a patient (Daumal, Colpart, Manoury, Mariani & Daumal, 1999:347-349). Do not change routinely (in the absence of gross contamination or malfunction) the breathing circuit attached to an HME while it is in use on a patient (Salemi, Padilla, Canola & Reynolds, 2000:737-739).

■ Oxygen humidifiers

Follow manufacturers' instructions for use of oxygen humidifiers. Change the humidifier tubing (including any nasal prongs or mask) that is in use on one patient when it malfunctions or becomes visibly contaminated (FDA, 2000).

■ Small-volume medication nebulisers: in-line and hand-held nebulisers

Between treatments on the same patient clean, disinfect, rinse with sterile water (if rinsing is necessary), and dry small-volume in-line or hand-held medication nebulisers (Craven, Lichtenberg, Goularte, Make & McCabe, 1984:834-838). Use only sterile fluid for nebulisation, and dispense the fluid into the nebuliser aseptically (Mertz, Scharer & McClement, 1967:454-460). Whenever possible, use aerosolised medications in single-dose vials. If multidose medication vials are used, follow manufacturers' instructions for handling, storing, and dispensing the medications (Sheth, Post, Wisniewski & Uttech, 1983:377-379).

■ Mist tents

Between uses on different patients, replace mist tents and their nebulisers, reservoirs, and tubings with those that have been subjected to sterilisation or high-level disinfection. No recommendations have been made regarding the frequency of routinely changing mist-tent nebulisers, reservoirs, and tubings while in use on one patient (unresolved issue) (Dale & Williams, 1986:189-192).

Subject mist-tent nebulisers, reservoirs, and tubings that are used on the same patient to daily low-level disinfection (e.g. with 2% acetic acid) or pasteurisation followed by air-drying (Jakobsson, Hjelte & Nystrom, 2000:37-41).

■ Other devices used in association with respiratory therapy

Between uses on different patients, sterilise or subject the respirometers and ventilator thermometers to high-level disinfection (Irwin, Demers & Pratter, Garrity, Miner, Pritchard & Whittaker, 1980:232-237; Weems, 1993:583-586).

- Resuscitation bags

Between their uses on different patients, sterilise or subject to high-level disinfection reusable hand-powered resuscitation bags. No recommendations have been made about the frequency of changing hydrophobic filters placed on the connection port of resuscitation bags (unresolved issue) (Thompson, Wilder & Powner, 1985:231-232).

■ Anaesthesia machines and breathing systems or patient circuits

Do not routinely sterilise or disinfect the internal machinery of anaesthesia equipment (Du Moulin & Sauberman, 1977:353-358). Between uses on different patients, clean reusable components of the breathing system or patient circuit (e.g. tracheal tube or face mask) inspiratory and expiratory breathing tubing, y-piece, reservoir bag, humidifier, and tubing, and then sterilise or subject them to high-level liquid chemical disinfection or pasteurisation in

accordance with the device manufacturers' instructions for their reprocessing (Rutala & Weber, 1995).

No recommendations have been made about the frequency of routinely cleaning and disinfecting unidirectional valves and carbon dioxide absorber chambers (unresolved issue)(Bengtson, Brandberg, Brinkhoff, Sonander & Stenqvist, 1989:89-92).

Follow published guidelines or manufacturers' instructions about in-use maintenance, cleaning, and disinfection or sterilisation of other components or attachments of the breathing system or patient circuit of anaesthesia equipment (American Association of Nurse Anaesthetists, 1993; American Society of Anaesthesiologists, 1991).

No recommendation have been made for placing a bacterial filter in the breathing system or patient circuit of anaesthesia equipment (unresolved issue) (Vezina, Trepanier, Lessard, Gourdeau & Tremblay, 2001:748-754).

■ Pulmonary-function testing equipment

Do not routinely sterilise or disinfect the internal machinery of pulmonary-function testing machines between uses on different patients (Hiebert, Miles & Okeson, 1999:610-612).

Change the mouthpiece of a peak flow meter or the mouthpiece and filter of a spirometer between patients (Ahmed, Brutus, D'Amato & Glatt, 1994:319-321).

■ Room-air "humidifiers" and faucet aerators

- Room-air "humidifiers"

Do not use large-volume room-air humidifiers that create aerosols (e.g. by venturi principle, ultrasound, or spinning disk, and thus actually are nebulisers) unless they can be sterilised or subjected to high-level disinfection at least daily and filled only with sterile water (Arnow, Chou, Weil, Shapiro & Kretzschmar, 1983:460-467).

- Faucet aerators

No recommendations have been made about the removal of faucet aerators from areas utilised by immunocompetent patients (unresolved issue). If *Legionella* spp. is detected in the water of a transplant unit and until *Legionella* spp. are no longer detected by culture, remove faucet aerators in the unit (CDC, 2003b).

➢ **Prevention of person-to-person transmission of micro-organisms**

This section is described under the following headings: standard precautions; care of patients with tracheostomy; and suctioning of respiratory tract secretions.

■ Standard precautions

- Hand hygiene

Decontaminate hands by washing them with either antimicrobial soap and water or with non-antimicrobial soap and water (if hands are visibly dirty or contaminated with proteinaceous material or are soiled with blood or body fluids) or by using an alcohol-based waterless antiseptic agent (e.g. hand rub) if hands are not visibly soiled after contact with mucous membranes, respiratory secretions, or objects contaminated with respiratory secretions. Decontaminate hands as described previously before and after contact with a patient who has an endotracheal or tracheostomy tube in place, and before and after contact with any respiratory device that is used on the patient. Hand hygiene should be performed whether or not gloves are worn (CDC, 2002:51).

- Gloves and gowns

Wear gloves for handling respiratory secretions or objects contaminated with respiratory secretions of any patient (Garner, 1996:53-80). Change gloves and decontaminate hands as described previously between contacts with different patients; after handling respiratory secretions or objects contaminated with secretions from one patient and before contact with another patient, object, or environmental surface; (e.g. contaminated body site and the respiratory tract of, or respiratory device on, the same patient) (CDC, 2002; Garner, 1996:53-80).

When soiling with respiratory secretions from a patient is anticipated, wear a gown to protect your clothes. Change the gown after soiling occurs and before providing care to another patient (LeClair, Freeman, Sullivan, Crowley & Goldmann, 1987:329-334).

■ Care of patients with tracheostomies

Perform tracheostomy and tracheostomy care under aseptic conditions. When changing a tracheostomy tube, wear gloves and a gown, use aseptic technique, and replace the tube with one that has undergone sterilisation or high-level disinfection (Garner, 1996:53-80). No recommendations have been made for the daily application of topical antimicrobial agent(s) at the tracheostomy site thus an unresolved issue (Morar, Makura, Jones, Baines, Selby, Hughes & van Saene:2000:513-518).

■ Suctioning of respiratory tract secretions

No recommendations have been made for the preferential use of either the multiuse closed-system suction catheter or the single-use open-system suction catheter for prevention of ventilator-associated infections thus it remains an unresolved issue. No recommendations

have been made regarding wearing sterile rather than clean gloves when performing endotracheal suctioning (unresolved issue) (Combes, Fauvage & Oleyer, 2000:878-882). No recommendations have been made about the frequency of routinely changing the in-line suction catheter of a closed-suction system in use on one patient (unresolved issue) (Kollef, Prentice & Shapiro, Frazer, Silver, Trovillion, Weilitz, Von Harz, & St John,1997:466-472).

If the open-system suction is employed, use a sterile, single-use catheter. Use only sterile fluid to remove secretions from the suction catheter if the catheter is to be used for re-entry into the patient's lower respiratory tract. The presence of an endotracheal tube impairs natural host defences against infection and increases the patient's risk for ventilator-associated infections. Leakage around the cuff allows subglottic secretions pooled above the cuff to enter the trachea. Manual intermittent aspiration of subglottic secretions has been reported to decrease and delay the development of ventilator-associated infections (Smulders, van der Hoeven, Weers-Pothoff & Vanderbroucke-Grauls, 2002:858-862; Mahul, Auboyer, Jospe, Ross, Guerin, el Houris, Galliez, Dumont & Gaudin, 1992:20-25). The use of continuous aspiration of subglottic secretions reduced the incidence of ventilator-associated infections from 39.6 episodes per 1000 ventilator-days in the control group to 19.9 episodes in the group randomised to continuous aspiration of subglottic secretions (Valles, Artigas, Rello, Bonsons, Fontanals, Baigorri & Mestre,1995:179-186).

No differences were noted in crude mortality, duration of ventilation or intensive care unit stay. Because there appears to be little risk associated with the use of continuous aspiration of subglottic secretions, these current data suggest this intervention has a favourable risk and cost-benefit ratio (Valles et al., 1995).

Figure 2.2 provides an illustration of an intubated patient with continuous aspiration of subglottic secretions (Valles et al., 1995). Suctioning subglottic secretions decreases the risk of colonisation and ventilator-associated infections. The endotracheal tube is inserted through the mouth rather than the nose, as is the gastric tube to reduce the risk of nosocomial sinusitis and ventilator-associated infections (Craven & Steger, 1995b).

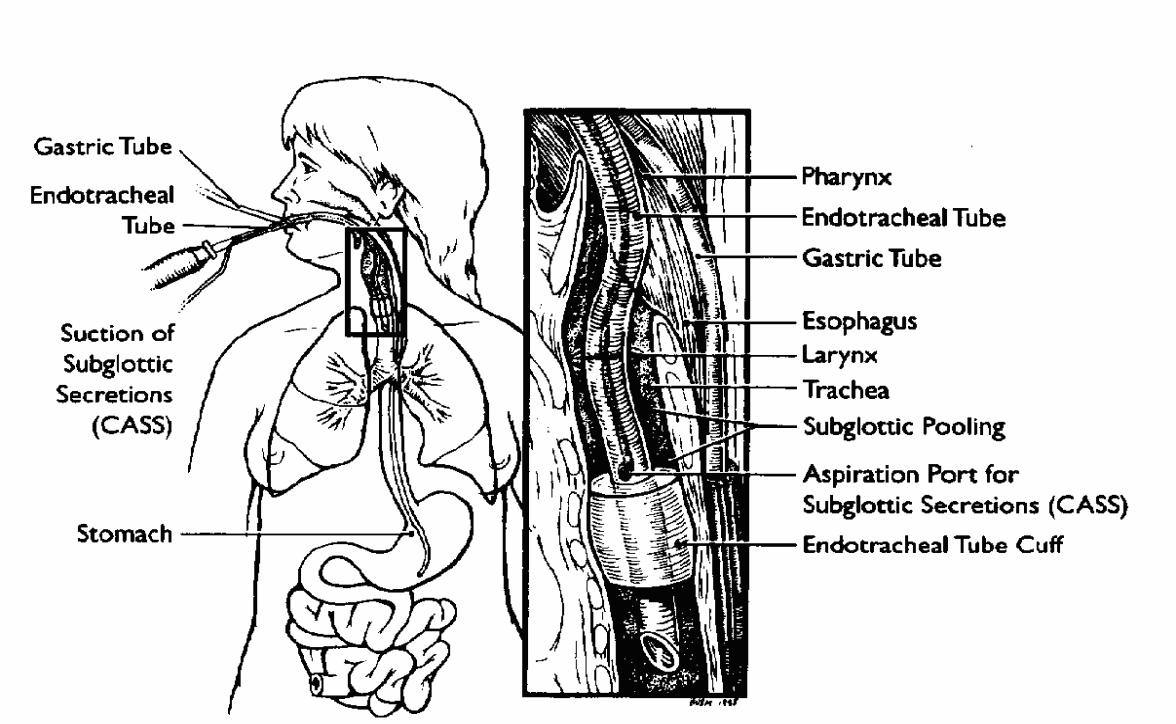


Figure 2.2: An example of an intubated patient with continuous subglottic aspiration (Valles et al., 1995)

- **Modifying host risk for infection**

The host defence response is frequently impaired in critically ill patients, making them more prone to develop nosocomial infections. In the lungs, the endotracheal tube bypasses host defences above the vocal cords and impairs lower respiratory tract defences such as cough and muco-ciliary clearance. Systemic host defences is reduced in the presence of chronic illness, malnutrition, prolonged surgery, and various co-morbid illnesses such as respiratory failure. Reducing factors, which limit host response, and administering agents to modulate host defence directly may prevent ventilator-associated infections (CDC, 2003a). The following section is based on the CDC (2003a) evidence-based practice guidelines for the prevention of transmission of micro-organisms.

➢ **Increasing host defence against infection**

The following headings are used to describe key aspects of the CDC evidence-based practice guidelines: avoidance of excessive sedation; immunosuppressive agents; early nutritional support; and administration of cytokines to enhance host defence.

■ Avoidance of excessive sedation

Numerous studies have shown that coma and an altered level of consciousness can significantly contribute to the development of related infections. Accordingly, sedative agents should be titrated to the individual patient using, for example, a sedation score. By this means the use of excessive sedation can be reduced (Rello, Ausina, Castella, Net & Prats, 1992:525-529; Celis, Torres, Gatell, Almela, Rodriguez & Auguste-Vidal, 1988:318-324.)

■ Immunosuppressive agents

Immunosuppressive agents such as corticosteroids and cytotoxic agents impair various host defence mechanisms including gut barrier function, and immunosuppression has been identified as a risk factor for nosocomial pneumonia in children. Immunosuppressive agents should thus be avoided wherever possible. Where they are necessary, the minimal effective dose should be used and treatment regularly reviewed and stopped at the earliest opportunity (Fayon, Tucci, Lacroix, Farrel, Gauthier, Lafleur & Nadeau, 1997:162-169; Gennari & Alexander, 1997:1207-1214).

■ Early nutritional support

Malnutrition has been shown to be a major contributing factor to the development of ventilator-associated infections. Adequate nutritional support is extremely important in the prevention of ventilated associated infections. The preferred route of administration and nature of the feeds remain debatable. Enteral nutrition, particularly given early, is generally preferred to parenteral feeding as it is associated with fewer septic complications. On the other hand, by raising the gastric pH in the stomach, enteral feeds may encourage bacterial colonisation and thus increase the risk of ventilator-associated infections. Bypassing the stomach by using a jejunal feeding tube, does not increase the gastric pH and is therefore recommended (Montejo, Grau, Acosta, Ruiz-Santana, Planas, Garcia-De-Lorenzo, Mesejo, Cervera, Sanchez-Alvarez, Nunez-Ruiz, Lopez-Morar, Makura, Jones, Selby, Hughes & van Saene, 2002:796-800).

Recently, the use of immune-enhancing feeds enriched with a variety of nutrients (including amino acids, arginine, glutamine, and nucleotides) has been associated with fewer ventilator-associated infections. Further studies are needed to determine the precise combination of nutrients necessary to provide the most beneficial effects. Nevertheless, early enteral nutrition to stimulate gut immunological function should be provided to critically ill patients. When enteral nutrition can only be tolerated in small amounts, parenteral nutrition should be initiated (Valles et al., 1995:179-186; American Thoracic Society, 1996:1711-1725).

■ Administration of cytokines to enhance host defence

As immunosuppression is a major factor in the development of ventilator-associated infections, the restoration of an adequate immune response may represent an important strategy to prevent infections (unresolved issue) (Heard, Fink, Gamelli, Solomkin, Joshi, Trask, Fabian, Hudson, Gerold & Logan1998 :748-754).

➢ **Recommended precautions for the prevention of aspiration**

As soon as the clinical indications for their use are resolved, remove devices such as endotracheal, tracheostomy, and/or enteral (i.e., oro- or nasogastric or jejunal) tubes from patients (Kingston, Phang & Leathley, 1991:589-92).

This section is described under the following headings: prevention of aspiration associated with endotracheal intubation; prevention of aspiration associated with enteral feeding; prevention or modulation of oropharyngeal colonisation; and prevention of gastric colonisation.

■ Prevention of aspiration associated with endotracheal intubation

• Use of non-invasive ventilation (NIV) to reduce the need for and duration of endotracheal intubation:

- When feasible and not medically contra-indicated, use non-invasive positive-pressure ventilation delivered continuously by face or nose mask, instead of performing endotracheal intubation in patients who are in respiratory failure and are not needing immediate intubation (e.g. those who are in hypercapneic respiratory failure secondary to acute exacerbation of COPD or cardiogenic pulmonary oedema) (Girou, Schortgen & Delcaux, 2000:2361-2367; Carlucci, Richard, Wysock, Lopage & Brochard, 2001:874-880).
- When feasible and not medically contra-indicated, use NIV as part of the weaning process (from mechanically assisted ventilation) to shorten the period of endotracheal intubation

(Nava, Ambrosino, Clini, Prato, Orlando, Vitacca, Brigada, Fracchia & Rubini, 1998:721-728).

- Avoid as far as possible repeat endotracheal intubation in patients who have received mechanically assisted ventilation (Torres, Gatell, Aznar, el-Ebiary, Puig, de la Bellacasa, Gonzales, Ferrer & Rodriguez-Roisin,1995:137-141).
- Unless contra-indicated by the patient's condition, perform orotracheal rather than nasotracheal intubation on patients (Holzapfel, Chevret, Madinier, Ohen, Demingeon, Coupry & Chaudet, 1993:1132-1138).
- If feasible, use an endotracheal tube with a dorsal lumen above the endotracheal cuff to allow drainage (by continuous or frequent intermittent suctioning) of tracheal secretions that accumulate in the patient's subglottic area (Smulders et al., 2002:858-862).
- Before deflating the cuff of an endotracheal tube in preparation for tube removal, or before moving the tube, ensure that secretions are cleared from above the tube cuff (Valles et al., 1995:179-186).

■ Prevention of aspiration associated with enteral feeding

- In the absence of medical contraindication(s), elevate the head of the patient's bed at an angle of 30—45 degrees, particularly when receiving mechanically assisted ventilation and/or with an enteral tube in place (Drakulovic, Torres, Bauer, Nicolas, Nogue & Ferrer, 1999:1851-1858).
- Routinely verify appropriate placement of the feeding tube (McClave, DeMeo, DeLegge, DiSario, Heyland, Maloney, Metheny, Moore, Scolapio, Spain & Zaloga, 2002:80-85).
- No recommendations have been made for the preferential use of small-bore tubes for enteral feeding (unresolved issue) (Ferrer, Bauer, Torres, Hernandez & Piera, 1999:991-994).
- No recommendations have been made for preferentially administering enteral feedings continuously or intermittently (unresolved issue) (Skiest, Khan, Feld & Metersky, 1996:138-143).
- No recommendations have been made for preferentially placing the feeding tubes, (e.g. jejunal tubes) distal to the pylorus (unresolved issue)(Heyland, Drover, MacDonald, Novak & Lam, 2001:1495-1500; Kearns, Chin, Mueller, Wallace, Jensen & Kirsch, 2000:1742-1746; Montejo et al., 2002:796-800).

■ Prevention or modulation of oropharyngeal colonisation

- Oropharyngeal cleaning and decontamination with an antiseptic agent: develop and implement a comprehensive oral-hygiene program (that might include the use of an antiseptic agent) for patients in acute-care settings or residents in long-term-care facilities who are at high risk for ventilator-associated infections (Schleder, Scott & Lloyd, 2002:27-30).
- Chlorhexidine oral rinse

  No recommendations have been made for the routine use of an oral chlorhexidine rinse for the prevention of ventilator-associated infections in all post-operative or critically ill patients and/or other patients at high risk for pneumonia (unresolved issue)(DeRiso, Ladowski, Dillon, Justice & Peterson, 1996:1556-1561).

  Use an oral chlorhexidine gluconate (0.12%) rinse during the perioperative period on adult patients who undergo cardiac surgery (DeRiso, et al., 1996:1556-1561).
- Oral decontamination with topical antimicrobial agents.

  No recommendations have been made regarding the routine use of oral topical antimicrobial agents to prevent ventilated associated infections (unresolved issue) (Bergmans, Bonten, Gaillard, Paling, van der Geest, van Tiel, Beysens, de Leeuw & Stobberingh, 2001:382-388).

■ Prevention of gastric colonisation

- No recommendations have been made for the preferential use of sucralfate, H2-antagonists, and/or antacids for stress-bleeding prophylaxis in patients receiving mechanically assisted ventilation (unresolved issue) (Yildizdas, Yapicioglu & Yilmaz, 2002:240-245; Messori, Trippoli, Vaiani, Gorini & Corrado, 2000:1103-1106).
- No recommendations have been made for the routine selective decontamination of the digestive tract (SDD) of all critically ill, mechanically ventilated, or ICU patients (unresolved issue)(Nathens & Marshall, 1999:170-176).
- No recommendations have been made for routinely acidifying gastric feeding (unresolved issue) (Hayland, Cook, Schoenfeld, Frietag, Varon & Wood, 1999:2399-2406).

➢ **Other prophylactic procedures for ventilator-associated pneumonia**

This section is described under the following headings: administration of antimicrobial agents other than in SDD (Selective Decontamination of the Digestive tract); nasal intubation; elevation of the head of the bed, and turning or rotational therapy.

■ Administration of antimicrobial agents other than in Selective Decontamination of the Digestive tract (SDD)

- Systemic antimicrobial prophylaxis
  No recommendations have been made regarding the routine administration of systemic antimicrobial agent(s) to prevent pneumonia in critically ill patients or in those receiving mechanically-assisted ventilation (unresolved issue) (Krueger, Lenhart, Neeser, Ruckdeschel, Schreckhase, Eissner, Forst, Echart, Peter & Unertl, 2002:1029-1037).
- Scheduled changes in the class of antimicrobial agents used for empiric therapy
  No recommendations have been made for scheduled changes in the class of antimicrobial agents used routinely for empiric treatment of suspected infections in a particular group of patients (unresolved issue) (Gruson, Hilbert, Vargas, Valentino, Bebear, Allery, Bebear, Gbikpi-Benissan & Gardinaud, 2000:837-843).

■ Nasal intubation

It was found that patient's intubated orotracheally developed significantly less sinusitis than those intubated nasotracheally. Oedema, local infection of the nasal mucosa, or mechanical obstruction of sinus drainage pathways by the tube are possible explanations. In addition to other reasons, an increased central venous pressure, positive pressure ventilation, and the supine position should be regarded as predisposing factors that increase the incidence of sinusitis. It was concluded that the conditions of critically ill patients predispose to the development of sinusitis. Nasotracheal intubation is to be regarded as an additional risk, and therefore oral intubation should be preferred (Michelson, Kamp & Schuster; 1991:100-104).

■ Elevation of the head of the bed

Elevation of the head of the bed is an integral part of prevention of ventilator-associated infections and the recommended elevation is 30-45 degrees. Drakulovic et al. (1999) conducted a randomised controlled trial in 86 mechanically ventilated patients assigned to semi-recumbent or supine body position. The trial demonstrated that suspected cases of ventilator-associated pneumonia had an incidence of 34 percent, while in the semi-recumbent position suspected cases had an incidence of 8 percent ($p=0.003$). Similarly, confirmed cases were 23 percent and 5 percent respectively ($p=0.018$) (Drakulovic et al., 1999:1851-1858).

■ **Turning or rotational therapy**

No recommendations have been made for the routine use of turning or rotational therapy, either by "kinetic" therapy or by continuous lateral rotational therapy (i.e. placing patients on beds that turn on their longitudinal axes intermittently or continuously) for prevention of ventilator-associated infections in critically ill and immobilised patients (unresolved issue) (Kirschenbaum, Azzi, Sfeir, Tietjen & Astiz, 2002:1983-1986). Education is the focus of the next section.

2.4.2 Education

Educating for entry into the profession is not an easy task; particularly when the teaching methodology used in the classroom and clinical laboratory are different from those used in the workplace. Learners may regard learning that occurs within the educating institution to be unrelated to personal experiences within the 'real' world of professional practice (White & Shackleton, 2003). In this section, the focus is on the following: nursing education, critical thinking and curriculum development.

2.4.2.1 Nursing education

The clinical role of the nurse educator has been the focus of much debate in recent years (Ramage, 2004:287-296; Duffy & Watson, 2001:551-558; Humphreys, Gidman & Andrews, 2000:311-317; Clifford, 1999:179-185). Nurse educators are expected to link with clinical areas to provide support to student nurses and mentors, yet are increasingly criticised for lack of clinical contact and becoming more distanced from practice. This is an important issue within acute and critical care as the reduction in number of acute placements means that there are fewer opportunities for student nurses to acquire skills in caring for acutely ill patients. Critical care areas are known to cause much stress and anxiety amongst students due to the nature of the environment and overwhelming use of technology. To learn and cope, they therefore require increasing support, and (nurse academics) with the appropriate clinical profile should in part provide this.

Internationally, moving nursing education into Higher Education Institutions (HEI's) in the 1990s was viewed as a way to improve the academic status of nursing and strengthen the links between theory and practice. This, in turn, was expected to provide nurses with appropriate academic skills, e.g. critical appraisal, problem solving, to work within a modern National Health Service (NHS) and to develop a practitioner who was committed to life-long

learning. The nurse teacher's role was seen as pivotal to this by maintaining clinical contact that would influence academic development in practice and enhance clinical credibility of courses. However, this has been problematic (Murphy, 2000:704-714).

Murphy (2000:704-714) suggests that during this move into higher education the nurse educator's clinical role was lost. The traditional roles of the nurse teacher also changed, and academic demands increased. As teachers became lecturers, it was expected that they should possess academic credibility and be "research active".

A lecturer's role in practice has the potential to encompass a number of different elements other than direct student and mentor support, e.g. advisor, supporter, regulator, interpreter and networker (Duffy and Watson, 2001), and these can be lost with lack of contact. The development of clinically focused modules, relating to acute and critical care, can offer the critical care practitioner the opportunity to be involved in curriculum development so that the content prepares staff "fit for practice" and mirrors the agendas of the health service (Rattray, 2004:96).

In theory as nursing becomes embedded within Higher Education Institutions (HEI's), a better understanding and recognition of the complex roles of the "nurse academic" should emerge. Perhaps now is the time to re-evaluate these roles and our expectations of each other. We need to develop a shared understanding and respect of each other's contribution to nursing, identify our strengths and work towards maximising these (Rattray, 2004:96). Although there are differences between the two cultures, we need to remember that the ultimate aim of nurse education is to produce practitioners who can deliver high-quality cutting-edge care that is evidence-based, delivered in an environment that fosters enquiry, reflection and research. This can only be achieved by a partnership between those in education and those in practice.

Table 2.3 provides an explanation of nurse educator's roles, some of which are uniquely different from their clinical, manager or research counterparts. Their roles include those of educator, facilitator, designer, change agent, consultant, researcher, leader and life-long learner.

In looking towards the future we see that nursing education in the next millennium indicates change and more change. Education is by definition about preparing for change (Slevin, 1993:241-249). Change is a 'constant' if not the only 'constant' in modern-day life and in modern-day educational systems. This means that as a nursing profession not only do we need to keep abreast of these changes but that we also need to anticipate and manage these changes successfully (Girot, 2001:352-361). In order to keep pace with the changing world and the paradoxes that exists it is vital that a culture of life-long learning is developed. This notion of life-long learning is strongly endorsed, "registration represents an endorsement of the individual's fitness for practice – with the provision that professional updating is an ongoing process" (United Kingdom Central Council for Nursing, Midwifery and Health Visiting [UKCC], 1986). Preparing students to take responsibility for their own learning is an investment in quality and is crucial to ensuring the National Health Service keeps pace with change (Girot, 2001:330-337). In addition key transferable skills such as information technology, research awareness, critical thinking, decision-making in practice and reflection will also assist nurses of the future to continue to cope with a career of change. This may mean a change in culture from a dependence on teachers to each individual taking responsibility for all aspects of their learning.

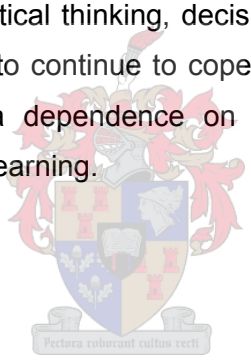


Table 2.3: Nursing Educator's Roles and Specific Activities (Sources: Southern Regional Education Board 2002; American Nurses Association 2000)

Educator Roles	Specific Activities
Educator	❑ Provide an appropriate climate for learning ❑ Facilitate the learning process ❑ Ensure learners are actively involved in process of assessment of needs and outcomes ❑ Demonstrate ability to support and empower learners ❑ Evaluate the effectiveness of outcomes ❑ Collaborate with learners to enable them to develop portfolios
Facilitator	❑ Assist learners to identify their learning needs and effective learning activities ❑ Provide sufficient time for learners to meet their needs, re-mediating as necessary ❑ Serve as a role model for continuing learning and education ❑ Foster positive attitude about benefits and opportunities of lifelong learning
Designer	❑ Identify learning requirements within specific context ❑ Develop, plan and present educational activities within areas of expertise ❑ Design original programme ❑ Select and prepare suitable learning resources ❑ Select, sequence and pace resources sensitive to the holistic needs of the learners

Table 2.3: Nursing Educator's Roles and Specific Activities (continued)
(Sources: American Nurses Association 2000; Southern Regional Education Board 2002)

Educator Roles	Specific Activities
Researcher	❑ Design and implement research ❑ Integrate relevant research outcomes into practice through effective learning activities ❑ Help others utilise the research process in their practice ❑ Foster the use of systematic evaluation research with regard to data ❑ Evaluate outcomes of educational endeavours ❑ Track learner outcomes
Leader	❑ Support organisational and administrative structures to achieve departmental and organisational goals ❑ Manage programme activities, including human and material resources ❑ Ensure educational activities are congruent with organisation's mission, vision, and goals ❑ Evaluate the effectiveness of the overall educational programme ❑ Communicate effectively and efficiently with all levels of organisation ❑ Use problem solving-skills ❑ Model behaviour to reflect participation and leadership in activities
Lifelong learner	❑ Continue developing competencies including teaching and learning theories, curriculum design, measurement evaluation, research and technological options ❑ Demonstrate ongoing personal, academic and professional growth ❑ Utilise reflective practice techniques ❑ Maintain a professional portfolio to document results

Pectora roborant cultus recti

Table 2.3: Educator's Roles and Specific Activities (continued)
(Sources: American Nurses Association 2000; Southern Regional Education Board 2002)

Educator Roles	Specific Activities
Change Agent	❑ Serve as a change agent - organisational, community, national and international levels ❑ Facilitate initiation of, adoption of and adaptation to change ❑ Participate in strategic planning, committees, projects to identify needed changes ❑ Influence the necessary policy, procedures to create and support the change process
Consultant	❑ Act in a formal or informal consultant role ❑ Assist in the integration of new learning into practice or practice environment ❑ Assist nurses to identify and design needed educational experiences ❑ Provide feedback to the learners and organisations related to effectiveness of learning and learning activities

Another aspect of change relates to the environment within which the professional education of nurses is carried out and the strong practice-centeredness that exists within all education programmes. To this end the role of the mentor is of crucial importance as evidenced within the policy documents (UKCC, 1986). The role of the mentor is seen to incorporate support, role modelling, facilitation, supervision and assessment (Lloyd, Walter & Akehurst, 2001:151-160). Girot (2001:352-361) commented that it is within the practice aspect of the programme, where the public are directly exposed to the neophyte practitioner, that it falls to the practitioner, who may have limited experience and training in assessment of learning achievements, to make a pass/fail judgement on the student's performance. Coates and Gormely (1997:91-98) have suggested that while ward-based nurses' felt appropriately qualified to act as role models to students, many felt inadequately prepared to teach and assess clinical skills. "Quinn (2000) warns, that teaching in the clinical area requires different skills from those required in the classroom." Therefore, it seems that all endeavours undertaken to promote teaching in the clinical area depend on collaborative planning and

partnership between clinical and teaching staff (Ferguson & Jinks, 1994:687-695). This partnership needs ongoing support, leadership, vision, investment and a supportive infrastructure from both educational institutions and the National Health Service. In addition, this need for partnership may lead to the potential development of new innovative roles such as the lecturer/practitioner role, link teacher role and practice educator role (Landers, 2000:1550-1556; Glen & Clark, 1999:12-19; Fairbrother & Ford, 1998:274-279).

Whenever we consider the rapidly changing and often conflicting influences on nurse education as outlined previously it is vital that we, as nurse teachers, reflect on our future role in terms of credibility. This raises the question, are we competent teachers of nursing and how is this "measured"? The challenge is for us to evaluate our worth in the present, and to consider how we can maintain our worth or value as teachers in the future. Slevin (1993:248) highlighted the need to pursue 'the dream' of having "time set aside for those activities which are essential to teaching, knowledge, clinical and academic credibility and thus essential to assuring the quality of the individual teacher's actual teaching activities". However, this leads us to question why, nearly a decade later we are still highlighting the same issues and to date 'this dream' (Slevin, 1993:241-249) has not become a reality, the ongoing challenge, therefore, for nurse education is to take the coordinates before us today and navigate our way through the terrain for the future (Kitson, 2001:86-96). For as Bevis and Watson (2000) reminded us, "…here we are with a dream to build, hopes to fulfil, vision to realise and a future to construct".

2.4.2.2 Critical thinking

A common aspect of health care is that each day nurses encounter problems, which they have to solve by making critical decisions. To find solutions to patient problems in the critical care unit it is imperative that nurses develop critical thinking skills so as to enable them to better analyse and solve problems to improve the quality of nursing care. There also seems to be a widely held belief that students will learn by example (Paul, Elder & Bartell, 1997), will be able to discern via overt teaching of content the philosophy and principles that underpin our belief systems, and the "generic" skills that are essential to build, maintain and communicate that content. Critical thinking skills are considered to be invaluable "generic" skills in science education. Critical thinking is described (Webster's New World Dictionary, 2003:292) as "characterised by careful analysis and judgment" and "critical, in its strictest sense, implies an attempt at objective judgment so as to determine both merits and faults".

In an attempt to develop a more stringent and comprehensive definition, Scriven and Paul defined critical thinking as:

The intellectually disciplined process of actively and skilfully conceptualising, applying, analysing, synthesising and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning or communication, as a guide to belief and action (cited in Hargreaves & Grenfell, 2000).

Historically, critical thinking can be traced back as far as Socrates, and has developed through the centuries, via the writings and teachings of such renowned scholars as Thomas Aquinas, Francis Bacon, Descartes and Sir Thomas More. Scientists like Robert Boyle and Sir Isaac Newton developed and used critical processes of thought that challenged the accepted views of the world and demanded a rigorous framework based on carefully gathered evidence and sound reasoning. The contribution of twentieth century educational philosophers such as Dewey, Wittgenstein and Piaget has been to highlight the importance of education in fostering critical thinking abilities, in order to challenge prejudice, over-generalisation, misconceptions, self-deception, rigidity and narrowness (Hargreaves & Grenfell, 2000).

While it would be easy to assume that, given the historical and well-recognised importance of critical thinking skills, and the present recognition by universities of their consequences, that academics would not only be aware of the tenets, but would also be actively seeking ways to teach such skills. Unfortunately this does not appear to be the case. In a large study designed to identify emphasis by academics on critical thinking in instruction, Paul, Elder and Bartell (1997) found that, while an overwhelming majority (89%) claimed critical thinking was a primary learning objective, only a small minority (19%) could clearly explain what critical thinking actually was, and only 9% were clearly teaching for critical thinking in a typical class session. A similarly small cohort were able to provide a clear conception of the critical thinking skills they considered important for students to develop, to enumerate any intellectual criteria or standards they required of students or could give an intelligible explanation of what those criteria and standards were. The critical thinking skills and their related student learning outcomes (Halpern, 1997) are summarised in Table 2.4. The pre-test and post-test used before and after the Learning Programme, were structured in such a manner that the person being tested, would be assessed using scenarios and problem-based learning strategies (see Appendix 2 - 4).

Table 2.4: Critical thinking skills and the related student learning outcomes (Halpern, 1997)

CRITICAL THINKING SKILLS	OBJECTIVES (STUDENT LEARNING OUTCOMES)
Designing experiments and testing hypotheses	In the context of science and mathematics, the student will be able to: • understand the need to isolate and control variables • select appropriate experimental techniques • use adequate sample sizes and avoid sampling bias • distinguish observations from inferences • critically evaluate the validity and reliability of data • establish relationships among variables • use inductive and deductive reasoning • calculate uncertainties • understand the limitations of extrapolation • use sound statistical approaches
Analysing arguments	In the context of science and mathematics, the student will be able to: • distinguish among data, opinions, and interpretations • structure an argument to support a proposal or interpretation • distinguish among premises, reasons, and conclusions • judge the credibility of an information source • identify relevant components that are missing from an argument • recognise common fallacies (e.g. circular reasoning, irrelevant reasons)
Thinking creatively	In the context of science and mathematics, the student will be able to: • demonstrate insight in recognising a problem • recognise patterns and visualise data • recognise and critically evaluate a number of solutions to a problem • select relevant information in relation to a problem and make unusual connections

Table 2.4 Critical thinking skills and the related student learning outcomes (continued) (Halpern, 1997)

CRITICAL THINKING SKILLS	OBJECTIVES (STUDENT LEARNING OUTCOMES)
Solving problems	In the context of science and mathematics, the student will be able to: • restate the problem and the goal in order to consider different problem-solving approaches, particularly with ill-defined problems • represent the problem schematically • develop mathematical models • design algorithms • select appropriate problem-solving strategies • consider useful analogies • make sound decisions on the basis of critically reflective processes • appreciate the value of persistence

2.4.2.3 Curriculum development

What should students learn? How should they learn it? In addition, how can we determine that they have learned it? These questions, at the heart of the curriculum design process, influence what educators do instructionally every day. The curriculum represents the expression of educational ideas in practice. The word curriculum has its roots in the Latin word for track or racecourse. From there it came to mean course of study or syllabus. Today the definition is much wider and includes all the planned learning experiences of a school or educational institution (Prideaux, 2003:268-270).

The curriculum should be in a form that can be communicated to those associated with the learning institution, should be open to critique, and should be able to be readily transformed into practice. The curriculum exists at three levels: what is planned for the students, what is delivered to the students, and what the students' experience.

A curriculum is the result of human agency. It is underpinned by a set of values and beliefs about what students should know and how they come to know it. The curriculum of any institution is often contested and problematic. Some people may support a set of underlying values that are no longer relevant (Prideaux, 2003:268-270).

In contemporary health care education it is argued that the curriculum should achieve a "symbiosis" with the health services and communities in which the students will serve. The values that underlie the curriculum should enhance health service provision. The curriculum should be responsive to changing values and expectations in education if it is to remain useful (Prideaux, 2003:268-270).

A curriculum has at least four important elements: content, teaching and learning strategies, assessment processes, and evaluation processes (Prideaux, 2003:268-270). Curriculum steps are dynamic and interrelated. Although all steps in the situational model (including situational analysis) need to be completed, they do not need to be followed in any particular order. Curriculum design could begin with a thorough analysis of the situation of the curriculum or the aims, objectives, or outcomes to be achieved, but it could also start from, or be motivated by, a review of content, a revision of assessment, or a thorough consideration of evaluation data. What is possible in curriculum design depends heavily on the context in which the process takes place. All the elements in curriculum design are linked (Prideaux, 2003:268-270). They are therefore not separate steps. Content should follow from clear statements of intent and should be derived from considering external and internal context. Equally, content should be delivered by appropriate teaching and learning methods and assessed by relevant tools. No one element—for example, assessment—should be decided without considering the other elements (see Figure 2.3).

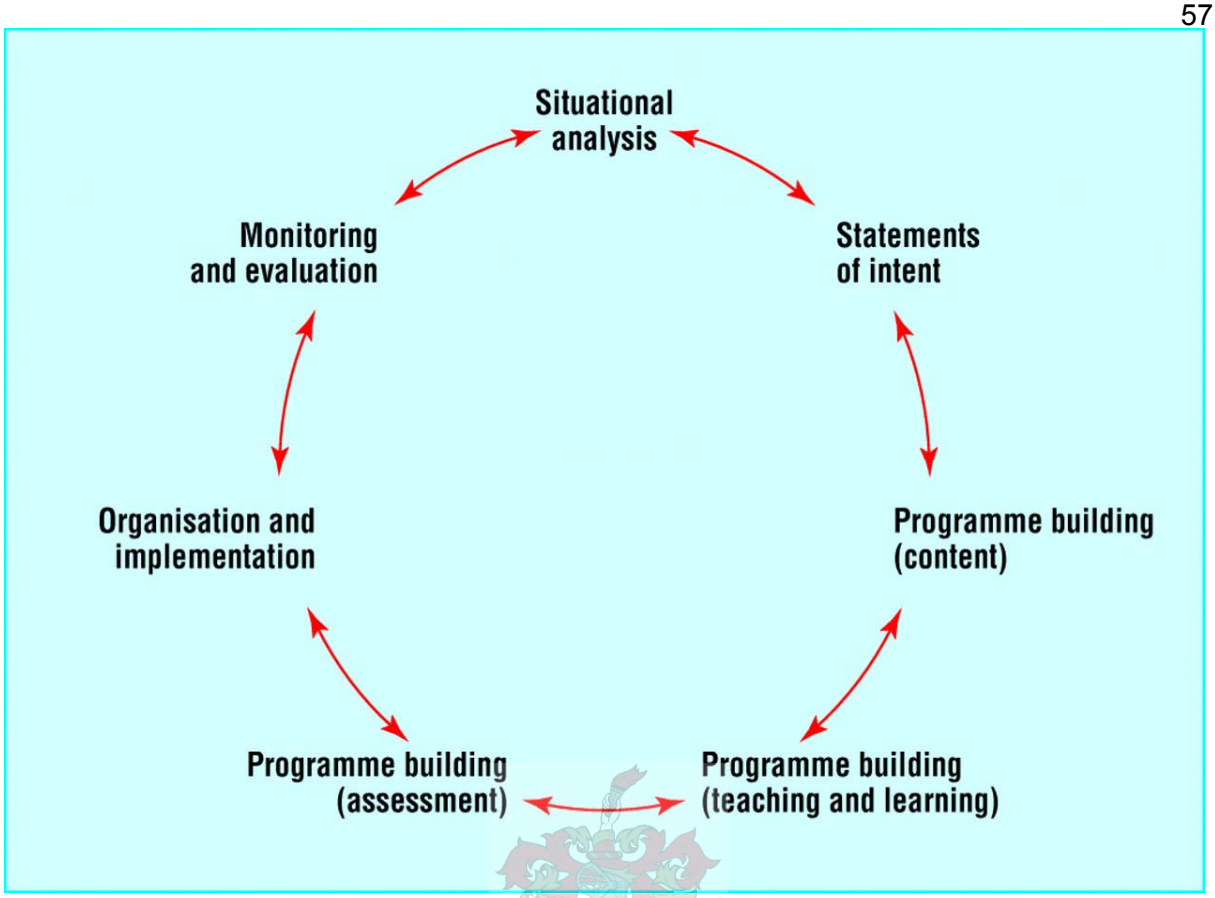


Figure 2.3: The situational model (Prideaux, 2003:270).

Developing a curriculum map should indicate the links between the elements of the curriculum. It should also include the essential features in a clear and succinct manner and provide a structure for the systematic organisation of the curriculum. The starting point for the map may differ depending on the audience. A map for students will place them at the centre and will have a different focus from a map prepared for teachers, administrators, or accrediting authorities, even though they have a common purpose, in illustrating the scope, complexity, and cohesion of the curriculum (Prideaux, 2003:268-270).

The map indicates a way of tracing the links between the curriculum as planned, delivered, and experienced. However, like all maps, a balance should be achieved between detail and overall clarity of representation (see Figure 2.4).

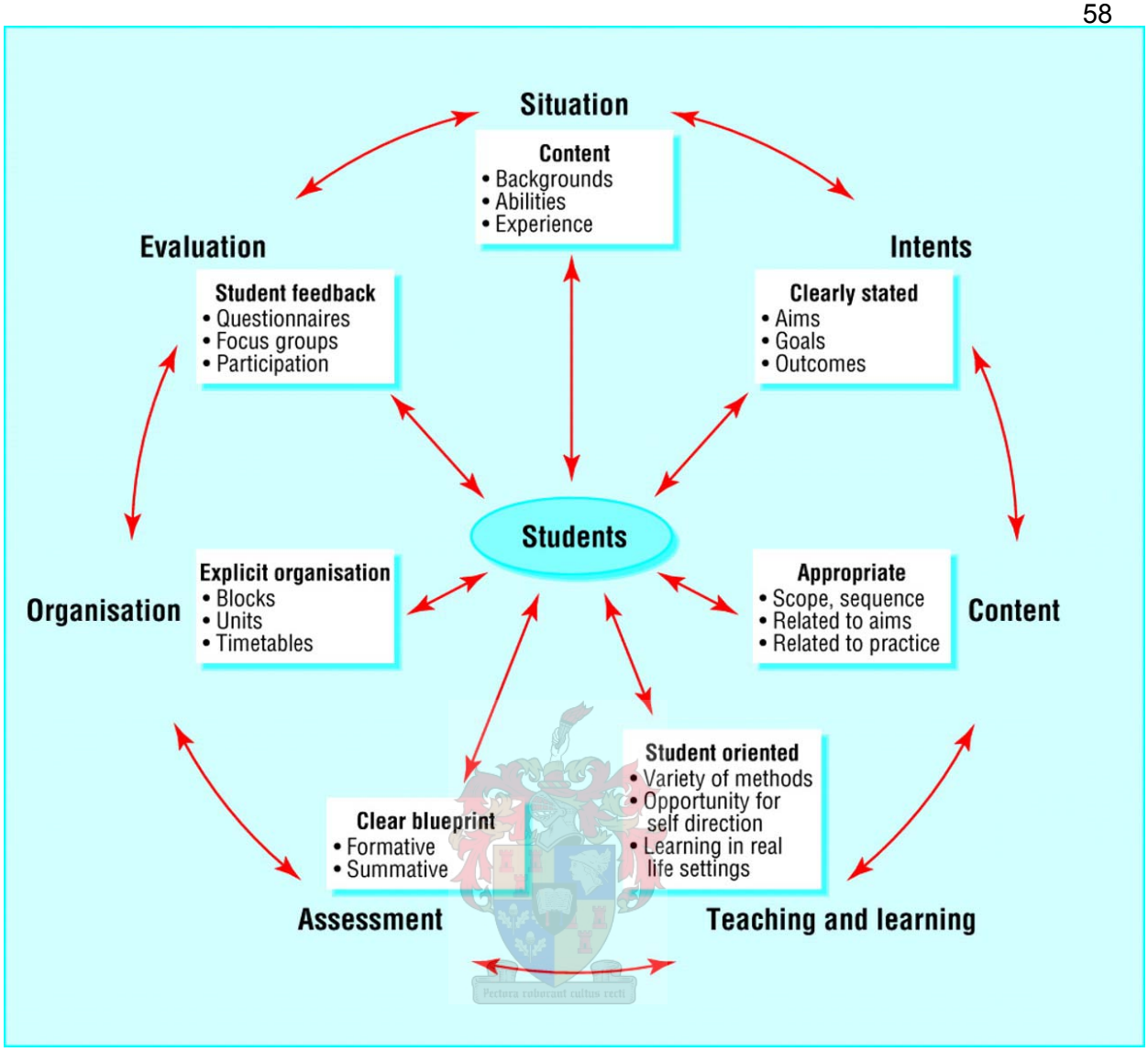


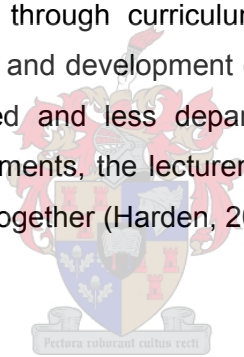
Figure 2.4: An example of a curriculum map

Figure 2.4 depicts an example of a curriculum map from the students' perspective. Each of the boxes representing the elements of design can be broken down into further units and each new unit can be related to the others to illustrate the interlinking of all the components of the curriculum.

As part of the curriculum planning cycle, evaluation should stimulate the further development of problem-based undergraduate programmes. The approach needs to be reflective, iterative and progressive, highlighting the special features of that curriculum (Maudsley, 2001:320). Knowles (1990) noted that educational evaluation should be primarily about improving teaching and learning, not merely justifying current practice.

The curriculum is a sophisticated blend of educational strategies, course content, learning outcomes, educational experiences, assessment, the educational environment and the individual students' learning style, personal timetable and programme of work. Curriculum mapping can help both staff and students by displaying these key elements of the curriculum, and the relationships between them. Students can identify what, when, where and how they can learn. Staff can be clear about their role in the big picture. The scope and sequence of student learning is made explicit, links with assessment are clarified and curriculum planning becomes more effective and efficient. In this way the curriculum is more transparent to all the stakeholders including the teachers, the students, the curriculum developer, the manager, the public and the researcher (Harden, 2001:123-137).

The key to an effective integrated curriculum is to get lecturers to exchange information about what is being taught and to coordinate this so that it reflects the overall goals of the institution. This can be achieved through curriculum mapping, which has become an essential tool for the implementation and development of a curriculum. Faced with curricula that are becoming more centralised and less departmentally-based, and with curricula including both core and optional elements, the lecturer may find that the curriculum map is the glue which holds the curriculum together (Harden, 2001:123-137).



2.5 SUMMARY

Ventilator-associated infections pose a considerable load in terms of morbidity, mortality and cost in the ICU. The prevention of such infections is therefore of considerable clinical and economic interest. A number of measures aimed at reducing the occurrence of ventilator-associated infections have been suggested and investigated. Some methods, such as hand washing, have been unequivocally proved to be beneficial and should be a routine part of ICU patient care. The overzealous use of antibiotics and the administration of excessive sedative agents should certainly be discouraged. Oral intubation and, if possible, placing patients in the semi-recumbent position rather than supine are also important factors in preventing ventilator-associated infections. Other methods are more controversial and cannot be routinely recommended. H2-blockers are of little value in reducing the incidence of ventilator-associated infections and SDD is of benefit only in certain groups of patients. The administration of immunosuppressive agents should be kept to a minimum as these further reduce host defence. Early enteral nutrition should be administered, supported by parenteral nutrition in the early stages if enteral tolerance is poor. Immune-supplemented

feeds may prove to be of greater benefit but further studies are needed. The possibility of stimulating the immune response in its fight against infection is an exciting area of active research, but immuno-modulating agents remain at the experimental stage at the present time.

The appropriate use of some of the techniques discussed can certainly reduce the incidence of ventilator-associated infections in some patients in the ICU. While simple methods such as hand washing should be part of routine practice, the use of predictive models to identify patients at high risk of ventilator-associated infections can help us to focus other, more invasive, preventative measures on those most likely to benefit. The results of ongoing research, particularly into techniques to modulate immune defence, may strengthen our preventative capabilities and help to limit the number of patients who currently develop ventilator-associated infections further.

Across academia, educators are investigating teaching strategies that facilitate students' abilities to think critically. Because these strategies may require low teacher-student ratios or sustained involvement over time, efforts to implement them are often constrained by diminishing resources for education, academic staff reductions, and increasing number of part-time teachers and students (Ironside, 1999:243-7). In nursing, the challenges of teaching and learning critical thinking are compounded by the demands of providing care to patients with increasingly acute and complex problems in a wide variety of settings. To meet these challenges, nurse teachers have commonly used a variety of strategies to teach critical thinking. The rationales students provide for particular nursing interventions are taken as evidence of their critical thinking ability. While this approach is commonly thought to be effective, the evolving healthcare system has placed increased emphasis on community nursing, where it is often difficult to pre-specify learning experiences or to anticipate patient care needs. In addition, teachers are often not able to accompany each student to the clinical site. Thus, the traditional strategies for teaching and learning critical thinking common to hospital-based clinical courses are being challenged, transformed, and extended.

In Chapter 3 the research design and methodology is described.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

As recently as the year 2000, only vital signs were monitored as part of patient evaluation, regardless of the severity of illness. Patients with severe illness or injury typically died within hours or days of onset, because assessment and treatment techniques were very limited and effective therapies were non-existent. The introduction of antibiotics into clinical therapeutics during the 1940s had enormous impact on the outcome of infectious diseases that generally had fatal outcomes. Other new and refined medical therapies also held promise for improvement in the quality of life in patients with chronic and acute illnesses. Intensive therapy as a medical/nursing speciality evolved in tandem with the electronic evolution. Sophisticated techniques vastly improved diagnosis as well as evaluation of therapy specific to critically ill or injured patients (Darovic, 1995:3).

A common aspect of all health care organisations is that each day nurses encounter problems big and small, which they have to solve by making the right decisions. Nurses also need to recognise that most problems are opportunities in disguise, which can be scientifically researched. Research can be described as a systematic, organised effort to investigate a specific problem or opportunity encountered in the work place that needs a solution. Research then comprises a number of steps designed and implemented with the goal of finding answers to the issues that are important to nurses to improve the quality of nursing (Cavana, Delahaye & Sekaran, 2001:5). As the cost of health care is ever increasing, it is therefore essential to facilitate actions continuously through scientific research, for optimal nursing with regards to the prevention of ventilator-associated infections in the intensive care unit.

In this Chapter, the research design and methodology is described.

3.2 GOAL OF THE RESEARCH

The goal of this research was to develop, implement and evaluate a Learning Programme for nurses working with adult ventilated patients in an intensive care unit.

3.3 OBJECTIVES

The objectives of this research were divided into three phases.

Phase One

The aim in this phase was to utilise different resources in order to establish a valid Learning Programme for nurses working with adult ventilated patients in the ICU**.**

- To utilise the results of the pilot study (Nel, 2001) (see Appendix 1); and
- to conduct an additional literature review on:
    - ventilator-associated infections
    - preventive measures for infection
    - nursing education
- To develop a Learning Programme for nurses utilising evidence based research.

Phase Two

The aim in this phase was to pre-test nurses' knowledge with regard to ventilator-associated infections and the prevention thereof in order to:

- implement the Learning Programme for nurses;
- post-test nurses' knowledge with regard to ventilator-associated infections and the prevention thereof; and
- evaluate the implemented Learning Programme.

Phase Three

The aim in this phase was to look at infection rates in order to:

- To evaluate the impact of the Learning Programme on the outcomes of adult patient's being mechanically ventilated

3.4 HYPOTHESES

The following hypotheses were formulated for the research as depicted in Table 3.1 below.

Table 3.1: Hypotheses for the research

PHASE	HYPOTHESES
One	Not applicable
Two	Null hypothesis There is no difference in the knowledge base of nurses following the implementation of the Learning Programme Alternative hypothesis There is a difference in the knowledge base of nurses following the implementation of the Learning Programme
Three	Null hypothesis • There is no difference in adult ventilated patient outcomes, following the implementation of the Learning Programme for nurses Alternative hypothesis • There is a difference in adult ventilated patient outcomes, following the implementation of the Learning Programme for nurses

3.5 RESEARCH METHOD

The Botes Research Model (1998; 2000:15) (see Figure 3.1) was utilised to guide the research process according to the practice. This model provides a holistic perspective of the research process rather than a detailed description of the methods and techniques of the research. The model thus lends itself to both quantitative and qualitative research methodologies (Botes, 1998; 2000:9). The rationale for using this model is its simple, practical, yet comprehensive application to the situation under research.

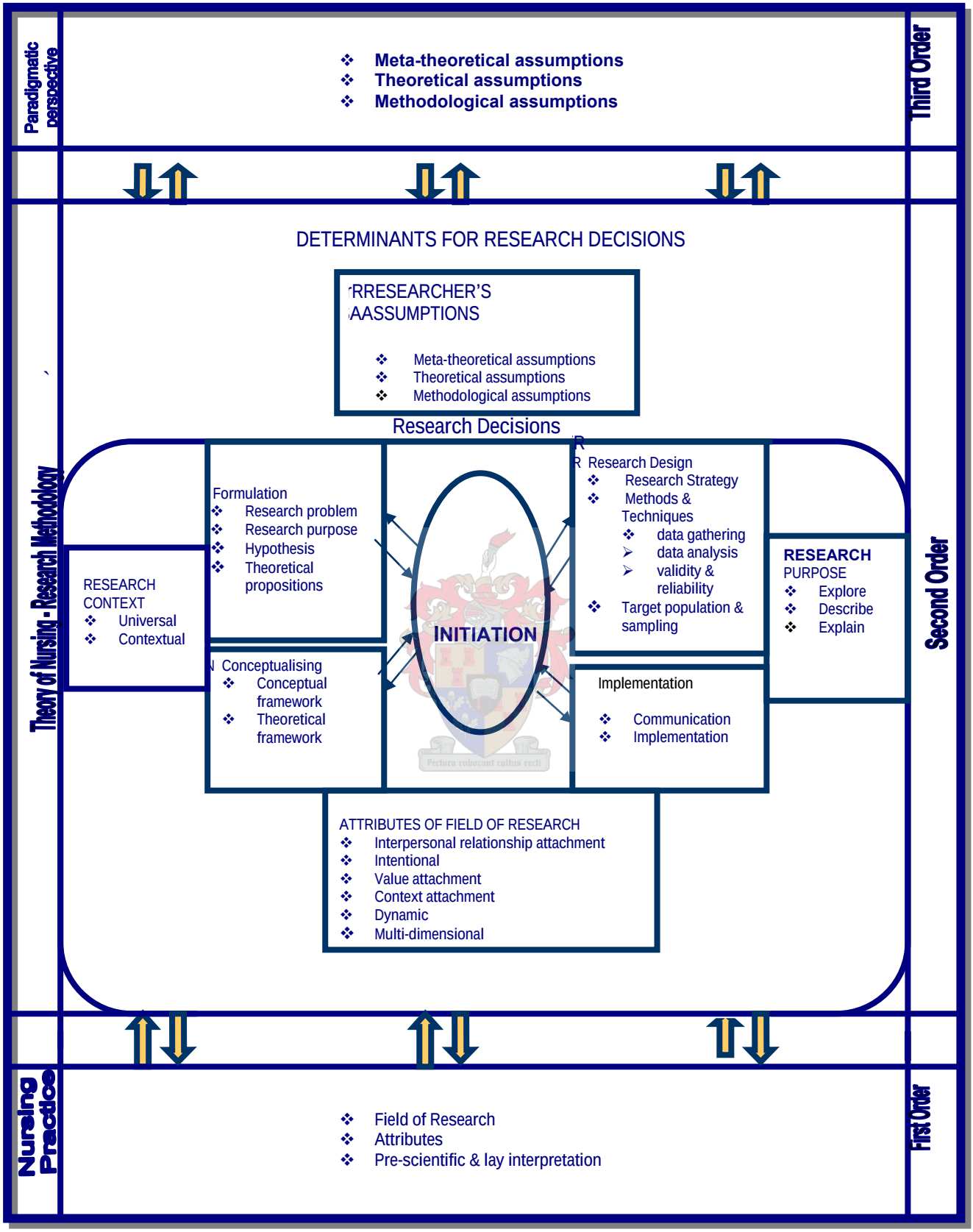


Figure 3.1: Research Model (Botes, 1998)

This model consists of three interacting orders, with the first order being the nursing practice, the second order the determinants of the research decisions thus the research methodology, and the third order the paradigmatic perspective. In this research, the first order reflects education as part of clinical practice in the nursing of ventilated patients in an intensive care unit. The second order reflects the research methodology of the research and the third order the paradigmatic perspective of the research. Each order of the model is described as applied in the research.

3.5.1 First order – nursing practice

Nursing practice consists of four domains, which are clinical, management, education and research. The domain of practice reflected in the first order for this research is therefore education, which will ultimately reflect in the outcome of the clinical practice. A Learning Programme was developed based on previous research done by the researcher (Nel, 2000) and current literature, trends and practices. The Learning Programme was implemented and evaluated by nursing staff working in an intensive care unit and it was also evaluated against adult mechanically ventilated patients' outcomes.

3.5.2 Second order – research methodology

The researcher functions at the second order of the model and is continually in interaction with the practice situation. Therefore, the nursing practice influences the research to a large extent in the same way as the research provides guidelines for quality nursing practice. The inter-dependence of research and practice are thus continuously emphasised this way. The researcher is co-responsible for nursing practice. The nurse in practice in turn is responsible for the application of knowledge, generated through research, into nursing practice in order to confirm the usefulness of the new knowledge (Botes, 1998; 2000:9). The goal of the research was to improve the clinical nursing practice, in this case, the nurses as practitioners, was to prevent/minimise ventilator-associated infections in critically ill adult patients ultimately, by implementing and evaluating a Learning Programme for nurses addressing these specific needs of the patient and by evaluating the impact of such a programme on patient outcomes.

Quantitative approaches, a one group pre- and post-test and an open-ended questionnaire, as well as an impact evaluation on patient outcomes were followed as part of the research methodology. The research methodology is described as those decisions that are taken within the framework of the determinants for research decisions. The determinants of

research are the characteristics of the research domain, the assumptions of the researcher, the research objectives and the research context. The aspects, about which research decisions are made, are initiation, formulation, conceptualisation, research design, research communication and implementation (Botes, 2000). The determinants of research decisions are described according to a purpose, attributes of the research field, the context, the assumptions, the decisions, and implementation thereof.

3.5.2.1 Research purpose

The Botes model (1998; 2000:15) distinguishes between three strategies when describing the research purpose. These are exploratory, descriptive and explanatory by nature. Table 3.2 below, as summarised by Bowman (2001), depicts Neuman's (2000:22) view of the dimensions of the goals of research.

Table 3.2: Goals of research (Neuman, 2000:22)

Exploratory	Descriptive	Explanatory
Familiarise self with the basic facts, settings and concerns	Describe a detailed, highly accurate picture	Evaluate a theory's prediction or principle
Establish a general mental picture of conditions	Procure new data that contradict past data	Provide a thorough description of the theory
Formulate and clarify questions for future research	Generate a set of categories or classify types	Increase the scope of a theory to new issues or topics
Produce new ideas	Define a sequence of steps or stages	Support or reject an explanation or prediction
Establish the feasibility of conducting research	Record a causal process or mechanism	Connect issues or topics with a general principle
Generate techniques for measuring and locating future data	Report on the setting or context of a situation	Determine the best explanation

➢ **Exploratory**

Mouton and Marais (1990:45) state the goal of an exploratory research as the exploration of a relatively unknown field of research. They describe the aims of exploratory studies as

gaining new insight into the phenomenon, pre-investigating for a more structured

investigation of the phenomenon, constructing and defining central concepts, and developing new hypotheses regarding an existing phenomenon.

The following methods can be utilised in an exploratory research:

- exploring existing applicable literature; and
- identifying experts in the field of research (Mouton & Marais, 1990).

The literature was explored to develop a Learning Programme for nurses working with adult ventilated patients in an intensive care unit (see Chapter 2). Nursing experts, as well as medical experts, were utilised to validate the Learning Programme.

➢ **Descriptive**

Mouton and Marais (1990:46) state that descriptive research should include a variety of research methods such as experimental, non-experimental, quasi-experimental and survey methods, which can include qualitative or quantitative strategies. Data consists of observations made by the researcher and/or reported to the researcher by others.

The research strategy is described according to the different phases described below.

- **Phase One**

The purposeful sampling method, which is sometimes called *theoretical sampling*, was utilised in this phase. The use of this kind of sampling method is validated by the literature. Purposeful sampling is described by Burns and Grove (2001:424-425) as a sampling method that is based on the researcher's judgement about subjects/objects that are typical or representative of the phenomenon/topic under study in cases where the researcher is especially knowledgeable about the problem being studied. The researcher in such a case therefore intentionally selects the participants he/she wishes to participate. The advantage of purposeful sampling is that it allows the researcher to select the sample on the basis of his

or her knowledge of the phenomenon which is being studied. Possible sampling bias is identified as a potential disadvantage of this sampling method (Burns & Grove, 2001:419-422).

A focus or specialist group was utilised as the purposeful sample to validate the contents of the Learning Programme. According to Burns and Grove (2001:424-425), a focus (specialist) group "is designed to obtain participants' perceptions in a focused area in a setting that is permissive and non-threatening. One of the assumptions underlying the use of focus groups is that group dynamics can assist people to express and clarify their views in ways that are less likely to occur in a one-to-one interview". The group may give a sense of "safety in numbers". Many different communication forms are utilized e.g. arguing, joking, anecdotes and non-verbal approaches. A focus group will reach the parts that other methods cannot reach, revealing dimensions of understanding that often remain untapped by more conventional data collection methods (see also Chapter 4) (Burns & Grove, 2001:424).

The assumptions underlying a focus (specialist) group are briefly described in the following section. According to these assumptions, the following pertains to a focus group:

- a homogenous group provides the participants freedom to express thoughts, feelings and behaviours openly;
- individuals are important resources of information;
- Individuals are able to report and verbalise their thoughts and feelings;
- dynamics in the group can generate authentic information;
- group interviews are superior to individual interviews; and
- by focusing the interview, the facilitator helps to recover forgotten information (Burns & Grove, 2001:424).

A *focus* (specialist) *group* can be defined as a carefully planned discussion designed to obtain perceptions on a defined area of interest in a permissive, non-threatening environment. It is conducted with approximately seven to ten people by a skilled interviewer. The participants in the discussion are regarded as specialist practitioners in a specific field, in this case critical care and infection control (Krueger, 1988:18).

A *specialist practitioner* is defined in the literature as a person who has been educated to the level of a master's degree (Romaine-Davis, 1997:83). The minimum selection requirement needed for an expert who will participate in this research will be that he or she possesses a suitable degree and has at least 10 years' experience in the field of either critical care or infection control health care. Muller (1995:53) emphasises the importance of academic achievement and demonstrable practical experience as criteria in the selection of participants. Mason (1994:84) states that three experts are needed to ensure the content validity of standards. Muller (1990:53), however, mentions that although Lynn (1986b:383) does not stipulate a maximum number of experts, she nevertheless advises that a maximum number of ten experts be used. For the Learning Programme, the researcher utilised eight experts and one of the supervisors (a critical care and infection control expert).

- **Phase Two**

A quantitative approach with a pre-experimental design was utilised during this phase. A one-group pre-test-post-test strategy was implemented to determine and manipulate the knowledge base of the nursing staff rendering care to adult patients who are mechanically ventilated. Although it is not acceptable for nurses to conduct research on medical staff, the researcher simultaneously, on request of the intensivists, conducted the same research on the medical staff rendering care to adult patients attached to ventilators (see Appendix 12).

The pre-test-post-test design is valuable in describing what occurs after the introduction of the independent variable. This design can answer questions about change over time in that the pre-test is given before the introduction of the independent variable (the Learning Programme). If subjects are tested before the intervention as well as after the intervention, a change in scores on the dependent variable can be reported but cannot be attributed to the influence of the dependent variable (DePoy & Gitlin, 1998:119) (see Section 4.4.2 for application of the pre-tests and post-test design and also Table 3.3 as utilised in the research).

Table 3.3: One-group pre-test-post design as applied in the research

Experimental Group	Measurement of Dependant Variable (Knowledge)	Manipulation of Independent Variable (Learning Programme)	Measurement of Dependant Variable (Knowledge)
Nurses and medical staff	Pre-test	Implementation of Learning Programme	Post-test
Serves as experimental as well as control group		Good researcher control – researcher implements pre- and post-tests and Learning Programme	Comparison of pre- & post-test results

- **Phase Three**

An impact evaluation was done to determine the outcome of the Learning Programme on the outcomes of nursing care on adult patients attached to mechanical ventilators. The impact evaluation was done by means of a structured surveillance instrument utilised by two infection control practitioners, and the process followed was according to the WHO (Pan American Sanitary Bureau, Regional Office of the WHO, 2002:2-40) guidelines for impact evaluation.

An impact evaluation is described as a very specific type of evaluation design that determines how much of the observed change in patient outcomes can be attributed to specific programme efforts. Impact evaluations are carried out by following specific scientific designs and involving complex data collection and analysis procedures. Impact evaluation is not undertaken routinely and is usually reserved for specific situations to determine the success of the project (World Health Organisation, 2004).

Surveillance is the routine collection of epidemiological data to track trends in disease incidence or prevalence, in this case ventilator-associated infections. Data may be collected actively or passively through routine reporting. In this case, it was an active daily process. Surveillance data provides outcome-level information on disease status, but little or no information on programme activities. Surveillance data must be linked with other sources of programmatic data in a monitoring system (World Health Organisation, 2004). The surveillance instrument for ventilator-associated infections was based on criteria as set out

by Garner (1996) and summarised in Table 4.5 and included a calculation of the ventilator-associated infection rate in ICU per 1 000 ventilator days.

Calculation of the ventilator-associated infection rate in ICU per 1 000 ventilator days is calculated according to the following steps (CDC Guidelines.2004: 1-179):

- **Intervention:** Learning Programme
- **Definition:** The number of ventilator-associated infections per 1 000 ventilator days is the standard measure for surveillance by the CDC. The specific surveillance criteria are outlined in the CDC Guidelines (CDC Guidelines, 2004:1-179; Gaynes & Horan, 1999:1285-331)
- **Goal:** Decrease the ventilator-associated infection rate in the ICUs
- **Numerator definition:** Total number of ventilator-associated infection cases in all ICUs in the organisation during the set time interval
- **Numerator exclusions**
- Same as the denominator
- **Denominator definition:** Number of ventilator days in all ICUs in same time interval used in numerator
- **Denominator exclusions:**
  • Patients less than 16 years of age at the date of ICU admission
  • Patients with documentation of a pre-existing respiratory infection
- **Measurement period length:** Measure monthly
- **Definition of terms:**
  - ***Ventilator-associated infection*:** Healthcare-associated infection in a patient on mechanical support (by endotracheal tube or tracheostomy) for greater than or equal to 48 hours
  - ***Ventilator day*:** Total number of days of exposure to ventilators by all patients in the selected population during the selected time period
- **Calculate as:** Number of ventilator-associated infections/number of ventilator days [x 1000] = ventilator-associated infection (VIA) rate per 1 000 ventilator days

For example

If in February there were 12 cases of ventilator-associated infections, the number of cases would be 12 for that month. The number has to be understood as a proportion of the total

number of days that patients are attached to ventilators. Thus, if 25 patients were ventilated during the month and each, for purposes of example, was on mechanical ventilation for 3 days, the number of ventilator days would be 25 x 3 = 75. The ventilator-associated infection rate per 1 000 ventilator days would then be 12/75 x 1000 = 160, and therefore the total number of VAI cases/ventilator days) x 1000 = ventilator-associated infection rate.

The process of the impact evaluation in health care consists of eight different steps. A purpose with objectives should be identified, and the conceptual model should be based on the evaluation model. The evaluation model is defined as analysis of the impact, analysis of the actions that produced the changes and the operational level at which services are provided. Characteristics of the model are integration of the health care aspects, and a multidisciplinary approach including the nature of participation and group work.

The methodology of impact evaluation should be aimed at discovering, controlling, and preventing conditions. Healthcare policy should be part of the methodology. An evaluation group should be established. Responsibility for the evaluation of the impact should be clearly identified. Planning of the impact evaluation should be structured according to whom to target, where and how it should happen. Interviews form part of the structure of the methodology. The individual responsible for organising the impact evaluation should be identified. Instruments to be utilised in the impact evaluation should be developed, validated and reliable. Analysis and interpretation of findings should be valid and reliable. All the above actions should be done according to a structured timetable.

Outcome evaluation measures the extent to which stated objectives are met in relation to the research goals and objectives. Table 3.4 illustrates this process and how this was implemented in the research.

- **Explanatory**

The aim of explanatory research is to identify and explain the cause between variables and incidences (Mouton & Marais, 1990:47) and thus explanatory research looks for causes and reasons (Neuman, 2000:22). Explanation builds on exploratory and descriptive research and goes on to identify the reason why something occurs and goes beyond focusing on a topic or providing a picture of it.

A pre-test was done to determine respondents' basic knowledge with regard to the risk factors, clinical manifestations complications and treatment of healthcare-associated infections due to mechanical ventilation. The pre-test consisted of 20 questions with subdivisions. The same test was utilised for the post-test (see Appendix 2 & 4).

Table 3.4: Process of Impact Evaluation on patient outcomes (Pan American Sanitary Bureau, Regional Office of the WHO, 2000)

STEPS	IMPLEMENTED IN RESEARCH
Purpose	❑ To improve outcomes for adult patients being mechanically ventilated
Specific objectives	❑ To implement a Learning Programme ❑ To evaluate the effect of the Learning Programme against patient outcomes
Methodology	Aimed at ❑ Discovering conditions influencing poor outcomes of mechanically ventilated patients ❑ Prevention and controlling of ventilator-associated infections
- Policy decision	Clinical policies for nurses and medical staff were established before commencement of the Learning Programme
- Evaluation group	The research was continuously evaluated by medical staff in the ICU and infection control nurses and a statistician was responsible for the data analysis
-Responsibility	It was the researcher's responsibility to implement, collect and analyse the data
- Evaluation Process	Data were collected from June 2002 till November 2004. Data analysis was undertaken by a statistician, the researcher, two infection control nurses and two medical staff from January 2005 till March 2005.

Table 3.4 Process of impact evaluation on patient outcomes (continued)(Pan American Sanitary Bureau, Regional Office of the WHO, 2000)

STEPS	IMPLEMENTED IN RESEARCH
- Components	Included: ❑ Focus group to develop a policy and a Learning Programme ❑ Planning of whom to target, where it should happen and, when, who has to implement it, how it should be done and evaluation was done by the researcher for the Learning Programme
- Interviews	Permission was obtained for implementation and participation of the Learning Programme and the utilisation of patient data to evaluate the outcome of the Learning Programme
Organising an evaluation	The researcher was responsible and accountable for this aspect
Utilisation of instruments	The following instruments were developed and utilised: ❑ Learning Programme ❑ Pre- and post-test ❑ An evaluation instrument for the Learning Programme ❑ Surveillance instrument for collecting patient data
Analysis and interpretation of findings	A statistician utilised the Sign-Rank test and infection control nurses assisted the researcher with the data analysis.
Monitoring timetable of action	❑ The pre-intervention period was from June 2002 till December 2002 ❑ The Learning Programme was introduced during January 2003 and January 2004 ❑ The post-intervention period was from February 2004 till November 2004

The Learning Programme consisted of a self-study package, which addressed the following aspects:

- the definition
- persons at risk
- the risk factors
- prevention of risk factors
- the causes of infections
- principles of ventilator care
- procedures for
  - draining ventilator circuit condensate
  - collection of a suctioned sputum specimen
- summary
- references

The post-test was only implemented after all the respondents completed the pre-test and had participated in the Learning Programme. Statistical analysis of the results was done by means of the Sign Rank test and this is illustrated in the form of pie diagrams (see also Chapter 4).

After the operationalisation of the Learning Programme for nurses working with adult ventilated patients in the ICU, the researcher utilised a structured questionnaire to determine the effectiveness of the programme. The questionnaire consisted of ten open-ended questions, which was used to identify problem areas and recommendations for improvement of the Learning Programme (for the questionnaire, see Appendix 9).

3.5.2.2 Attributes of field of research

The criteria as identified in the Botes Model (1995:6) for the attributes of the nursing practice domain under research consisted of the following:

- Registered Nurses working in an ICU (see also section 4.3); and
- value and context attachment is found in the professional, ethical attachment of the registered nurse practitioner as regulated by the Nursing Act (Australia, 1993).

3.5.2.3 The research context

Both a universal as well as a contextual determinant (Botes, 2000:12; Mouton & Marais, 1990:46) is founded in the context of the research. The universal determinants are based in

the universal theoretical overview of the literature. The contextual determinant of the current research includes the foundations of infection control, current practices in treating adult ventilated patients in the ICU, clinical nursing practice and nursing education.

3.5.2.4 Research assumptions

No research is value-free and therefore the researcher states her assumptions. The researcher selected certain assumptions from the paradigm perspective in response to her interaction with the research field. Neuman (2000:44) argues that concepts contain built-in assumptions, statements about the nature of things that are not observable or testable.

Concepts and theories build on assumptions about the nature of human beings, social reality or a particular phenomenon. Assumptions often remain hidden or are not stated (Botes, 2000:12). The meta-theoretical, theoretical and methodological research assumptions (Botes, 2000:10) are described according to the researcher's perspectives. These realised as follows in the third order of the model:

- *Meta-theoretical*: The meta-theoretical assumptions are not testable and deal with the values of the human being and society and are based on a philosophical perspective. Although these assumptions give no epistemic statements, they influence the research throughout. The researcher approached the research from a Christian perspective.
- The *theoretical* assumptions generated from a holistic approach in nursing (which includes physical, mental, social and spiritual aspects), with the priority in this research on the physical.
- *Methodological*: These assumptions have their origin in science-philosophy (Botes, 1995:7). They deal with purpose, methods and criteria for the validity of the research. Methodological assumptions concern the researcher's view of the nature and structure of science and research in nursing. The researcher has no preferences for any method and utilised the method that suited the research best, thus different methods were utilised in the three phases.

3.5.2.5 Research decisions

The research decisions should be taken within the framework of the determinants of research in order to be justified. There should be a logical relationship between the determinants and the research decisions. Botes (2000:12-14) describes initiation, formulation of a research problem, research design, implementation of the research and

conceptualisation as the concepts for research decisions:

- **Initiation**

The researcher started the research process with the initiation phase that is a research theme or research topic (Botes, 2000:13). When initiating research the following aspects were relevant:

- background and rationale for the research;
- problem statement;
- purpose of the research;
- conceptualisation and the research design; and
- planning for the research (see Chapter 1).

- **Formulation of the research problem**

Formulation of the research problem, purpose and objectives were described in Chapter 1 (see Sections 1.2, 1.3 and 1.4).

- **Research design**

The research design included the following: target population, data gathering and data analysis, and strategies of reasoning, validity and reliability. See Section 3.4.2 for a detailed description.

* **Target population**

Experts who best contributed to the purpose of this research were selected for the sample, and served as the basis of the Learning Programme. Nursing experts in the field of intensive care and infection control nursing as well as medical staff working with adult ventilated patients in the intensive care unit validated the Learning Programme.

The population sample for the research was divided according to the phases of the research and included in:

Phase One

Intensive care qualified nurses, medical staff and infection control nurses in two Australian hospitals (see also 3.5.2.1. ii. and Chapter 4 section 4.4.1) were utilised.

Phase Two

Nurses working in two intensive care units in Australia, who were caring for adult patients attached to mechanical ventilators were selected for the sample and thus was convenient for the researcher to conduct the research at her place of employment. An additional population sample, on special request by the senior intensivists, was that of the medical staff working in the two Australian hospitals, who were caring for adult patients being mechanically ventilated (see Appendix 12 for medical population).

CRITERIA

Criteria for sampling included the following:

Registered nurses in two Australian hospitals who were working in the intensive care units and rendering nursing care to adult patients attached to mechanical ventilators. It was also essential that they had completed the pre-test and the self-study Learning Programme.

Phase Three

Adult patients attached to mechanical ventilators in the intensive care units at the two Australian hospitals, following implementation of the Learning Programme for nurses, to determine the impact of the Learning Programme on patient outcomes.

- **Data gathering**

In Phase one, the focus (specialist) group suggested changes to be implemented for the Learning Programme and the researcher thus simultaneously gathered and analysed the data (see also Chapter 4 Section 4.4.1).

Before any research project is implemented in a unit, all staff sign a confidentiality agreement stating that the content of the research project would not be discussed with other staff or any other person. The Ethics committee at each hospital also does regular monitoring visits to ensure that patient privacy is protected and that confidentiality is assured. The researcher utilised a pre-test and post-test strategy for gathering data in the second phase. Using this design is valuable in describing what occurs after the introduction of an independent variable, which in this case was the introduction of a Learning Programme. This design can answer questions about change over time in that the pre-test is given before and the post-test after the intervention.

A structured questionnaire was compiled to gather the data for the identification of problem areas and recommendations for improvement of the Learning Programme. The questionnaire consisted of 10 open-ended questions, including a section for recommendations (see Appendix 9 for the questionnaire). The data were interpreted in a partially explanatory format.

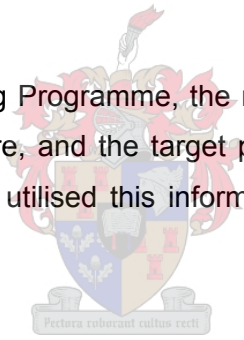
In the third phase, the infection control nurses utilised a structured surveillance instrument based on CDC Guidelines (2004) to gather the data to determine the effect of the Learning Programme on adult mechanically ventilated patient outcomes (see Chapter 4 section 4.4.3).

- **Data analysis**

Data was analysed according to the three phases of the research.

Phase One

For the development of the Learning Programme, the researcher utilised previous research and current evidence-based literature, and the target population in this phase (see section 4.4.1) simultaneously analysed and utilised this information to establish the content of the Learning Programme.



Phase Two

Structured pre-and post-tests were utilised as well as a structured evaluation questionnaire to establish the effectiveness of the Learning Programme. The target population in Phase one also established the content validity of the pre- and post-tests and questionnaire (see Section 4.4.1 and Appendix 9).

The Sign Rank Test was utilised to analyse the pre- and post-test scores and the researcher utilised a partially explanatory method to analyse the questionnaire (See Section 4.4.2 for analysis of the results).

Phase Three

The impact evaluation was done according to the steps in the process as set out by the WHO (WHO, 2000:2-40). To analyse the data the infection control nurses utilised a surveillance instrument with VAI criteria as set out in Table 4.5. This was done on a quarterly basis and analysed according to the VAI criteria (see section 4.4.3). Due to ethical

reasons, the surveillance instrument for determination of VAI cannot be included, as the researcher was not granted permission to publish it.

The strategies of reasoning implemented in this research for analysing the data were analysis, synthesis and deduction.

- ***Analysis*:** Clarification and refining of objects, assumptions and theories, especially where there is an existing source of knowledge. Concept analysis examines the attributes or characteristics of a concept, and statement analysis examines the presentation form of the rational statements and the relationship of concepts within the statements (Wolcott, 1994:23)

- ***Deduction*:** The process of developing specific predictions from general principles of belief (Abdellah & Levine, 1979). Deduction was used to compile the Learning Programme.

- ***Synthesis*:** This method used the process as a whole and constructs global measures from the detailed event data in order to be able to describe and compare the corresponding processes from different subjects (Langley, 1999).

➢ **Validity**

Pelto and Pelto (1978:33) describe validity as the degree to which scientific observations actually measure or record what they purport to measure. LeCompte and Goetz (1982:31-60) state that validity is concerned with the accuracy of scientific findings. According to the authors, establishing validity requires determining the extent to which conclusions effectively represent empirical reality; and assessing whether constructs devised by researchers represent or measure the categories of human experience that occur.

Internal validity is defined as the extent to which variations in a (dependent) variable can be attributed to controlled variation in an independent variable. Internal validity is referred to as "the approximate validity (the best available approximation of the truth or falsity of a statement) with which we infer that a relationship between two variables is causal, or that the absence of a relationship implies the absence of a cause" (Cook & Campbell, 1979:37). Threats towards the internal validity of research were excluded as follows:

- The *history*: The specific external events that take place between the first and second measurement apart form the external variables. All the pre-tests were done between June 2002 and December 2002. During 2003, all nurses who did the pre-test were handed the self-study Learning Programme and the contents, attended various in-service talks and were exposed to posters and flyers in the ICUs. At the end of January 2004, all flyers and posters where removed. Post-tests were done during February 2004 and November 2004. During 2003, the Learning Programme was the only new intervention that was implemented for nurses in the participating ICUs. Thus the history was excluded as a threat.

- *Maturation*: Processes operating within respondents as a function of time per se. The pre-test was implemented during June 2002 and December 2002. The Learning Programme was then implemented and the post-test was done from February 2004 to November 2004. Enough time lapsed between the two tests to overcome this threat.

- *Testing*: The effects of taking a test upon the scores of a re-test. The second test was performed in the exact same manner as the first test thus the testing effect as a threat was excluded. A year lapsed between the two tests, which also contributed to reducing the effect of this threat.

- *Instrumentation*: Changes in the calibration of a measuring instrument, or changes in the observers or scores used. The same test was utilised for the post-test and was thus not considered as a threat.

- *Statistical regression*: The inclination to move to the mean when comparison groups have been selected on the basis of extreme scores. A *one-group pre-test-post-test* was utilised and thus statistical regression could not be identified as a threat.

- *Differential selection*: The effect of comparing fundamentally non-comparable groups. Only one group was utilised and selection as a threat was excluded.

- *Experimental mortality*: The effects of the differential loss of respondents. Of the 792 635 nurses completed the Learning Programme. Of these, 157 were considered as “drop-outs” since they did not complete both tests. In the medical group, 215 of the 239 completed the programme. Of these, 24 participants were considered as “drop-outs”.

- Only participants who completed both the pre-and the post-test were included in the final analysis and experimental mortality was thus minimal.

The internal validity of a research requires that rival hypotheses that are represented by the above threats, be declared invalid (Lincoln & Guba, 1985:291). In the current research, a single questionnaire containing ten open-ended questions on the Learning Programme for staff working with adult ventilated patients in an ICU, were completed by the respondents. The null and alternative hypothesis were stated for the pre- and post-tests and patient outcomes.

External validity is defined as the approximate validity with which we infer that the presumed causal relationship can be generalised to and across alternate measures of the cause and effect and across different types of persons, settings and times (Cook & Campbell, 1979:37). It is the purpose of randomised sampling from a given, defined population to make this criterion attainable. If a sample is selected in accordance with the rule that every element of the population has a known probability of being included in the sample, then it is possible to assert that, with confidence limits, the a the sample will hold for the population (Lincoln & Guba, 1982:291). Threats to the external validity of research according to LeCompte and Goetz (1982) are the following:

- *Selection effects*: Constructs being tested are specific to a single group.
- *Setting effects*: the fact that results may be a function of the context under examination.
- *History effects*: unique historical experiences may compromise comparisons.
- *Construct effects*: the constructs studied may be peculiar to the studied group.

All nurses from two different hospitals working in ICUs with adult patients being mechanically ventilated were selected to be part of this study. The information given to them was an extension of the curriculum of the Intensive Care Course. Their knowledge was tested before the programme was started, as well as a few months after completion. The participants were also not aware that the post-test would be the exact same test as the pre-test. Each nurse was given a self-study Learning Programme and was subjected to a series of in-service sessions, flyers and posters in ICU. The above could have been threats to the external validity of the research.

In research, objectivity is determined by intersubjective agreement: when several observers reach independent agreement regarding a phenomenon, it can be agreed that their collective judgement is objective. Methodology also contributes to objectivity, by using methods that by their character render the research beyond contamination by human interaction (Lincoln & Guba, 1985:292). The Learning Programme was validated by experts in the field of nursing and medicine and different research methods were utilised in the second and third phases.

➢ **Implementation**

Practical implementation of the Learning Programme for nursing staff working with adult ventilated patients in an ICU was done in two hospitals in Australia.

3.5.3 Third order – paradigmatic perspective of the research

The third order consisted of the following:

- *Meta-theoretical*: This is described as part of Section 3.4.2.4.
- *Methodological perspective*: This is described in Section 3.4.2.5.
- *Theoretical perspective*: The conceptual framework for the research was based on ventilator-associated infections as the priority, with the emphasis on the physical nursing actions and support from a universal literature review. The literature review was described in Chapter 2.

3.6 SUMMARY

In Chapter 3, the research design and methodology was described, according to the Botes Research Model (1998, 2000). The search for strategies of empirical inquiry that will allow the researcher to make connections among lived experience, larger social and cultural structures; and the here and now. These connections are forged out of empirical materials that are gathered in any given investigation. Empirical inquiry is shaped by paradigm commitments and by the recurring questions that any given paradigm, or interpretive perspective, enquires about human experience (Denzin & Lincoln, 1998b:xi; 1998c:195). The data presentation, analysis and interpretation of results are described in Chapter 4.

CHAPTER 4

DATA PRESENTATION, ANALYSIS AND INTERPRETATION OF RESULTS

4.1 INTRODUCTION

A ventilator-associated infection is the most common hospital acquired infection among patients requiring mechanical ventilation, resulting in excess mortality, prolonged lengths of hospitalisation, and increased medical care costs. Colonisation of the aerodigestive tract with pathogenic bacteria and subsequent aspiration of contaminated secretions into the lower airways appear to be the most important mechanisms for the development of ventilator-associated infections. Therefore, clinical strategies aimed at preventing bacterial colonisation of the host and subsequent aspirations have been most investigated for the prevention of these healthcare-associated infections (Babcock et al, 2004:2224).

Although the optimal approach to reducing ventilator-associated infections is unclear, it has been indicated that educating healthcare workers who care for patients receiving mechanical ventilation can decrease the rate of ventilator-associated infections. In times of limited resources, focusing healthcare workers' efforts on the prevention of ventilator-associated infections is important, especially given the association between inadequate staffing in the ICU setting and the occurrence of healthcare-associated infections. Despite the importance of preventing healthcare-associated infections, available information suggests that such infections are on the rise, resulting in warnings from professional and national agencies to refocus efforts on their prevention. Additionally, Babcock et al. (2004) states that there are limited data documenting the influence of infection control education-based interventions targeting healthcare systems.

The purpose of this chapter was to describe the realisation of the research according to the three phases described in Chapter 3.

Strategies of reasoning implemented in this chapter were analysis, deduction, and synthesis. These strategies were utilised during the analyses of the pre-and post-test, the questionnaire and evaluation of the impact of the Learning Programme on the outcomes of adult patients being mechanically ventilated.

4.2 GOAL OF THE RESEARCH

The goal of the research was to develop, implement and evaluate a Learning Programme for nurses working with adult ventilated patients in an intensive care unit.

4.3 RESEARCH LOCATION, PATIENT POPULATION AND TARGET

The research took place in two tertiary teaching hospitals, with an adjacent private hospital, each in a different state in Australia. The hospital selected in New South Wales, is a 700-bed primary and tertiary care facility affiliated with a university medical school and included a private hospital. An average of 5 800 patients are admitted annually to the five ICUs (medical, 10 beds; surgical/trauma/burns, 14 beds; medical/surgical, 12 beds; surgical cardiothoracic, 10 beds; and neurology/neurosurgical, 12 beds). The hospital selected in Victoria is a 400-bed primary and tertiary care facility, also affiliated with a university medical school and which has a private hospital affiliated to it. An average of 2600 patients is admitted annually to the two amalgamated ICUs (trauma/burns/surgical/medical, 42 beds).

During the research, no other protocols were introduced into these ICUs aimed at influencing the rate of ventilator-associated infections. The ICUs utilised in this research are all closed units with multidisciplinary teams providing patient care under the direction of attending physicians who are board certified in adult critical care medicine.

The leadership of the ICUs, including unit medical directors and clinical nurse specialists, remained constant during this study, and the staffing ratio of one nurse to one ventilated patient was also uniform throughout this time period. Overall, there was limited turnover in the medical and nursing staff in the ICUs during the period the research was carried out (approximately 15% during the study period). Each ICU also had an established protocol for the weaning of mechanical ventilation employed by the nursing and medical staff.

4.4 REALISATION OF THE RESEARCH

Realisation of the research is described according to the strategy in the three phases as identified in Section 3.3 of Chapter 3.

4.4.1 Phase One realised as follows (see objectives Section 1.4)

A retrospective, non-experimental, quantitative research survey was used to answer the research questions and to justify the objectives of the pilot study. The method of data collection was done by means of a checklist, as well as structured observation. Patients' files were selected randomly, and information was obtained by using a checklist. Two hospitals in the Western Cape, South Africa, were chosen from different sectors and adult patients were selected over 18 months. In Phase One, the researcher utilised the results of the pilot study (Nel, 2001), (see Appendix 1) to recommend contents for a Learning Programme for nurses for the prevention of VAI. Strategies for the prevention and control of ventilator-associated infections were recommended with regards to the checklist that was used for the collection of the data and these (strategies) were included in the Learning Programme.

To update the recommendations in the pilot study an additional literature review on ventilator-associated infections, preventive measures for ventilator infections and nursing education was conducted. Realisation of this objective was done in Chapter 2 of this research and was utilised to complete the development and refining of the Learning Programme.

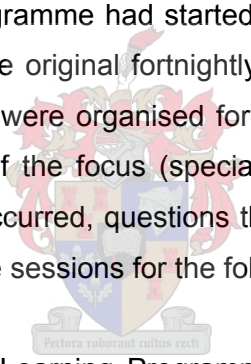
Development of the Learning Programme for nurses caring for adult mechanically ventilated patients based on current evidence-based research commenced six months after completion of the pilot study and the researcher left South Africa and commenced nursing in an intensive care unit in Australia. A focus (specialist) group consisting of a multidisciplinary task force including two medical staff, two infection control nurses and four senior intensive care qualified nurses was formed in June 2002 to help develop a policy and a Learning Programme regarding the prevention of ventilator-associated infections. This policy and Learning Programme were based on the study carried out by the researcher in 2001 and further literature reviews. The focus (specialist) group also compared the new policy to the Centre for Diseases Control's prevention recommendations for ventilator-associated infections. Based on this information, the researcher was able to design a Learning Programme to facilitate the improvement of nursing practice related to the prevention of ventilator-associated infections.

The focus (specialist) group at each hospital had a one-hour meeting every fortnight for three months (From June till August 2002). The meetings concentrated on developing a

policy and a Learning Programme regarding the prevention of ventilator-associated infections in the ICUs. The guidelines for the Learning Programme were discussed in detail and changed where necessary. Assistance and guidance were also given towards preparing for the ethics application that was required for such a programme to be implemented in the participating ICUs.

Once ethics approval was granted in September 2002 (See Appendix 10), the meetings during the following months concentrated on streamlining the Learning Programme and the successful implementation of the programme. Each person's role for the implementation of the Learning Programme was defined to make sure that confusion was eliminated once the process was ready to be started in January 2003.

It was also decided that the focus (specialist) group meetings would continue once the implementation of the Learning Programme had started in order to keep tract of possible problems that might occur. After the original fortnightly meetings and implementation of the Learning Programme, meetings were organised for the first Monday of every month. At these meetings, each member of the focus (specialist) group gave feedback on the data collected, problems that had occurred, questions that were asked and an update on organised speakers for the in-service sessions for the following month.



Once the period of introducing the Learning Programme was over, meetings continued once a month to analyse and discuss the data that had been collected. The final meeting was held in December 2004, and everybody was thanked for participating in the successful implementation of the Learning Programme. The final Learning Programme was validated by the members of the focus (specialist) group and one of the supervisors, a consultant and practitioner in nursing education and also a member of the Editorial Board of the *American Journal of Infection Control (AJIC)*.

Before implementation of the Learning Programme, the objectives of the programme were clarified. These objectives were stated as:

- to identify and analyse the epidemiology pertaining to ventilator-associated infections;
- to analyse and debate the impact of ventilator-associated infections in adult ICU patients; and
- to identify and debate the practicality of measures for prevention of ventilator-associated infections.

The Learning Programme consisted of a 10-page self-study package. The package included information on the topics related to ventilator-associated infections, such as epidemiology and scope of the problem, risk factors, etiology, definitions, methods to decrease risk, procedures for collecting suctioned sputum specimens, and clinical and economic outcomes influenced by ventilator-associated infections.

Risk factors for ventilator-associated infections that were specifically addressed included those promoting aspiration (supine positioning and gastric over distension) and those associated with bacterial colonisation of the upper airway and stomach (prior antibiotic exposure and the use of stress ulcer prophylaxis). The topics addressed in the Learning Programme were summarised with the acronym WHAP VAP, in which

- W stood for *Wean the patient* as soon as possible,
- H for *Hand hygiene*,
- A for *Aspiration precautions*, and
- P for *Prevent contamination* (CDC, 2004)

This acronym was also used on posters and fact sheets posted in the ICUs and infection control departments of the two participating tertiary hospitals. The self-study package (Learning Programme) is included in Appendix 3.

Implementation of the Learning Programme took place according to the following 10 steps

❖ Use data (infection rates), prioritise which educational intervention to launch first. Again, use data, obtain administrative approval and support for conducting the Learning Programme with staff delivering care to an adult patient populations at risk for VAI. Include:
  - administrative and clinical leaders in infection control and healthcare epidemiology (experts);
  - administrative and clinical leaders who have authority in clinical areas where interventions will take place (sponsors, director, nurse managers, ICU medical director, chief of surgery);
  - physician groups involved with intubations or care of adult patients on ventilators, or performing surgical procedures;
  - nursing staff caring for adult at-risk patient groups; and

- other staff involved in adult at-risk patient groups (physiotherapists, occupational therapists, dieticians).

❖ Prior to receiving the self-study Learning Programme, have all participants in the department complete the pre-test to determine their pre-intervention knowledge of VAI. Do not allow anyone to see the Learning Programme until everyone in the department has completed the pre-test. Reassure participants that the pre-test is only to gain baseline knowledge (no one expects them to be experts in this area … yet), thus ensuring reliability of the post-test.

❖ Provide in-service sessions at scheduled meeting times. In-service sessions may include group discussions, Power Point presentations that review highlights of the prevention strategies, or poster presentations with dissemination of pertinent fact sheets. If experienced speakers are available, presentations at physician grand rounds or staff meetings will facilitate physician education on prevention strategies (e.g. the hospital epidemiologist can present a lecture on the pathogenesis and prevention of ventilator-associated infections during medical grand rounds).

❖ Distribute the Learning Programme, followed by the post-test. Ensure that management and staff both realise the post-test will take between 30 – 60 minutes to complete.

❖ Reinforce the information provided at in-service sessions with fact sheets and posters visible throughout the ICU, nursing units or appropriate areas (e.g. lounges and over scrub sinks). Switch posters and fact sheets regularly ensuring staff will not become so used to seeing the material that they no longer pay attention to the information. If possible, find innovative ways to display posters or distribute fact sheets. Make this fun whenever possible.

❖ Compare scores from the pre-test and the post-test. It is suggested that individuals who scored less than 80% in the post-test repeat the self-study Learning Programme, then retake the test.

❖ Provide incentives if possible for staff participating in the educational intervention. Buttons, colourful posters, drawings for movie tickets or a free lunch in the cafeteria, and articles in the organisation's newsletter about nurses' dedication to prevention of infections, which will often incite others to participate.

❖ Provide feedback of data and information to appropriate administrative and clinical leaders (percentage of staff participating in educational intervention, percentage with post-test scores over 80%, staff's acceptance of the educational intervention).

- ❖ Administer the post-test six months after completion of the self-study Learning Programme to measure analysis and implementation of the information.
- ❖ Evaluate the impact of the intervention on ventilator-associated infections. Provide feedback to administrative and clinical management members; celebrate if education has impacted rates positively. Consider whether to repeat the intervention entirely and routinely, consider incorporating into skills or competency testing for staff working in the adult ICU. Consider exploring other (non-educational) risk reduction/prevention strategies, e.g. use of waterless hand disinfectants, trial of new technologies (in-line suction systems, and new skin disinfecting agents).

4.4.2 Phase Two realised according to the objectives (see Table 4.1)

In this phase, three objectives were formulated as depicted in Table 4.1 A pre-test was done and according to the results, the Learning Programme was then implemented and the difference in nurses' knowledge base was measured with the post-test. The results are illustrated in frequencies and percentages (see Table 4.2). A score of 80% and above in both the pre-and post-test was graded as acceptable as the mortality rate of VAI adult patients are high and is aimed at the prevention thereof through an increased knowledge base. Statistical significance was accepted on a 5% scale. Graphic presentations of data are given in the form of tables, pie diagrams and histograms. For the statistical analysis, the researcher utilised a null and alternative hypothesis. A null as well as an alternative hypothesis were stated for the dependant variable (knowledge base of nurses in Phase Two and patient outcomes in Phase Three).

- ➢ Results of the pre-test for nurses caring for adult mechanically ventilated patients

A statistician, who used the Signed-Rank test to compare the results analysed the results. In Table 4.2, the results of the pre-test are summarised and in Table 4.4 the results of the pre-test and post-test are compared. The results for medical staff are summarised in Appendix 12.

Table 4.1: Objectives in Phase Two

Objectives	Actions
❖ *Pre-test knowledge*	❖ Utilise and implement developed test ❖ Utilise the Signed Rank test to analyse results
❖ *Implement and evaluate Learning Programme*	❖ Describe research methodology: o Study location o Population o Data gathering and handling o Results
❖ *Post-test knowledge*	❖ Utilise and implement developed post-test ❖ Utilise the Signed Rank test to analyse results

The results of the pre-test were analysed according to the scores obtained for each question. In Table 4.2 the pre-test results according to the correct, wrong and ($\overline{X}$) mean scores (in percentages) respondents obtained, are depicted. Even if nurses scored more than 60% it is not acceptable when a patient's life is at stake.

Question One: Which of the mentioned groups are at risk for VAI?

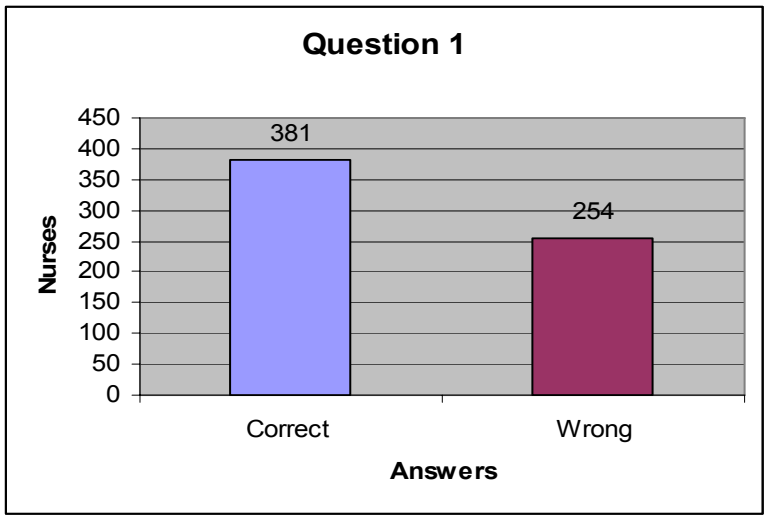


Figure 4.1: Groups mentioned at risk for VAI (n=635)

Of the total (n=635) number of nurses only 60% (n=381), knew the correct answer, namely all groups mentioned are at risk for VAI. This presented a slight majority of the total thus indicating a knowledge deficit (see Figure 4.1 and Table 4.2 for the graphic presentation).

Question Two: Which two factors may lead to the development of VAI?

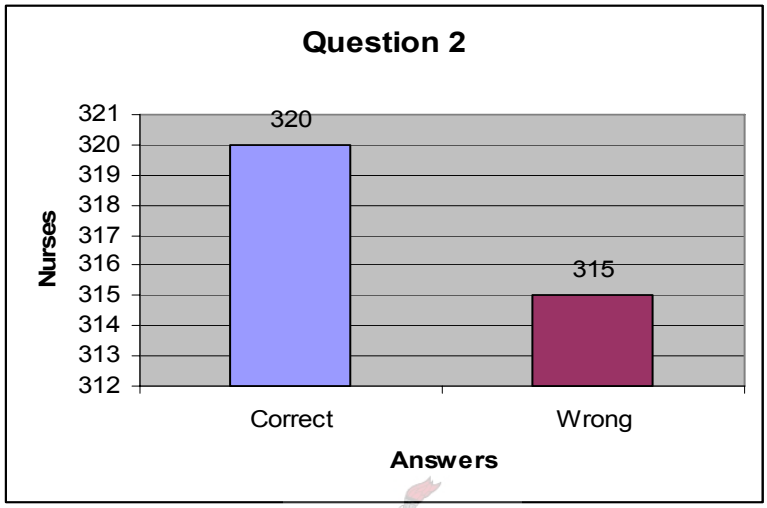


Figure 4.2: Two factors leading to VAI (n=635)

The two factors that frequently lead to VAI development are bacterial colonisation of the aero-digestive tract and aspiration of the contaminated secretions. Of the total number of nurses (n=635), slightly more than half answered correctly (n=320), with a mean ($\overline{X}$) score of 50%. A knowledge deficit was thus demonstrated (see Figure 4.2 and Table 4.2).

Question Three: Where should oral suction catheters be stored?

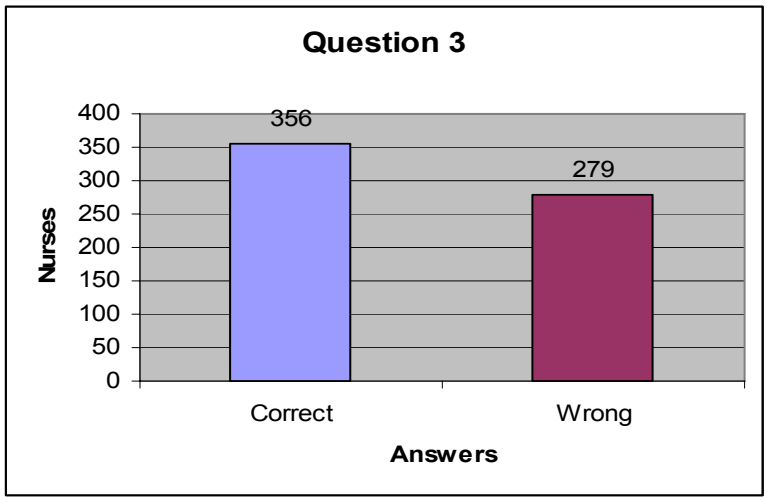


Figure 4.3: Correct storage of suction catheters (n=635)

Of the 635 nurses, only 56% (n=356) representing the $\overline{X}$ score (see Table 4.2), knew how to store the oral suction catheter in a non-sealed paper or plastic bag to reduce contaminating clean supplies or becoming contaminated, which can contribute to VAI (see Figure 4.3). Nurses' knowledge with regard to storage of suction catheters was thus inadequate.

Question Four: While emptying your patient's Foley bag, you look up and realise that the condensate in the ventilator tubing needs to be drained. Your patient starts to cough, what do you do?

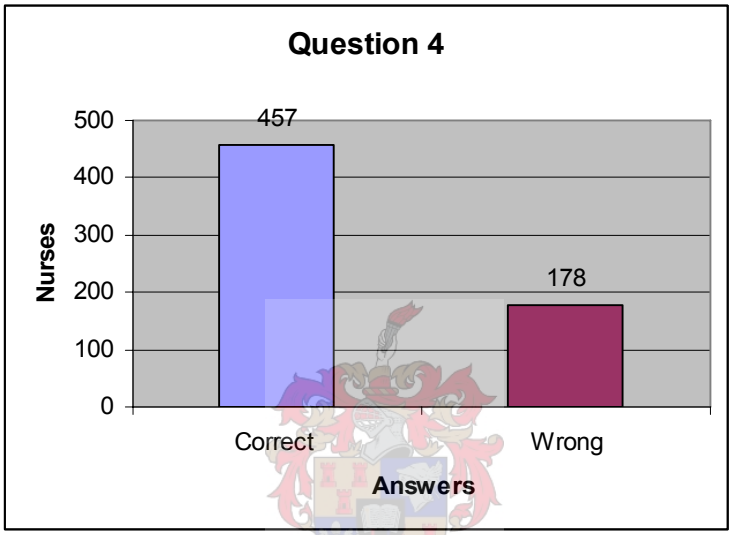


Figure 4.4: How to prioritise infection control actions (n=635)

In Figure 4.4, only 72%, the ($\overline{X}$) score, of the nurses (n=457) knew they always have to remove their gloves and wash their hands or use a waterless hand antiseptic after completing a "dirty" task. This is a basic procedure in nursing and only 100% compliance is acceptable, although the nurses have scored 72% (see Table 4.2 for the $\overline{X}$ scores).

Question Five: Which is the proper procedure for draining ventilator circuit condensate?

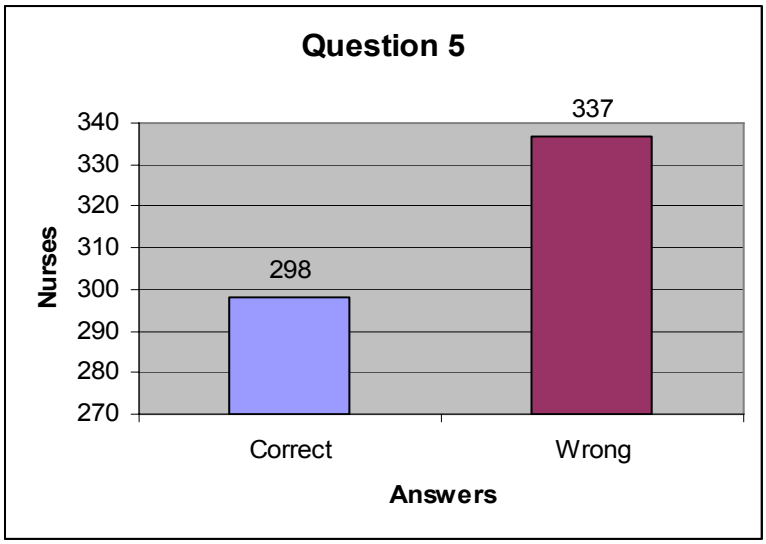


Figure 4.5: Proper procedure for draining ventilator circuit condensate (n=635)

Figure 4.5 depicts that less than half, 47% (n =298), of the total (n =635) nurses answered correctly, which is that you do not need sterile gloves or a sterile container for this procedure. In addition, you need to carry and empty the condensate into a hopper and not into a trashcan or sink thus competency compliance of a basic intensive care procedure was poor as indicated in Table 4.2, which reflects a mean $\overline{X}$ score of 47% for the correct answers.

Question Six: True or false – The use of multiple antibiotics increases a patient's risk of developing VAI.

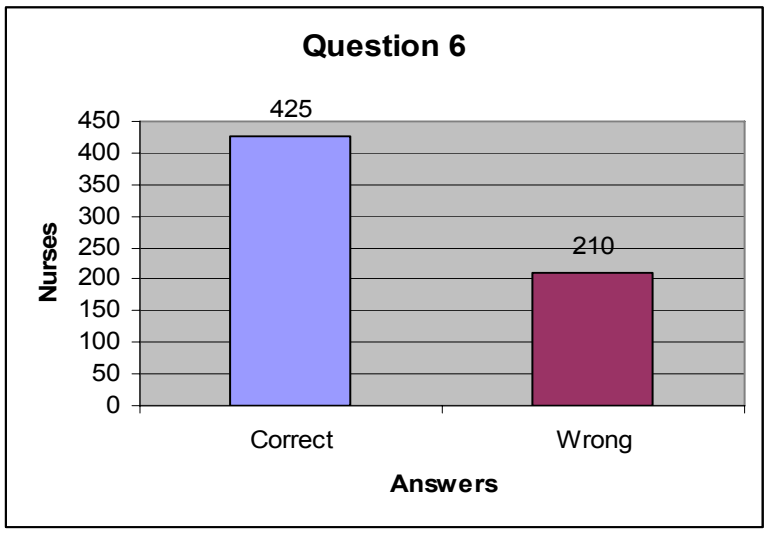


Figure 4.6: Use of antibiotics as a risk for VAI(n=635)

Of the total (n=635), 67% (n=425) knew that multiple use of antibiotics, especially when used for empiric treatment, increases the risk for developing resistant organisms that can cause infection (see Figure 4.6 and Table 4.2). A $\overline{X}$ score of 67% indicates a knowledge deficit of critical care nurses that needed definite attention.

Question Seven: True or false – Frequent suctioning of the patient is the single best way to prevent VAI.

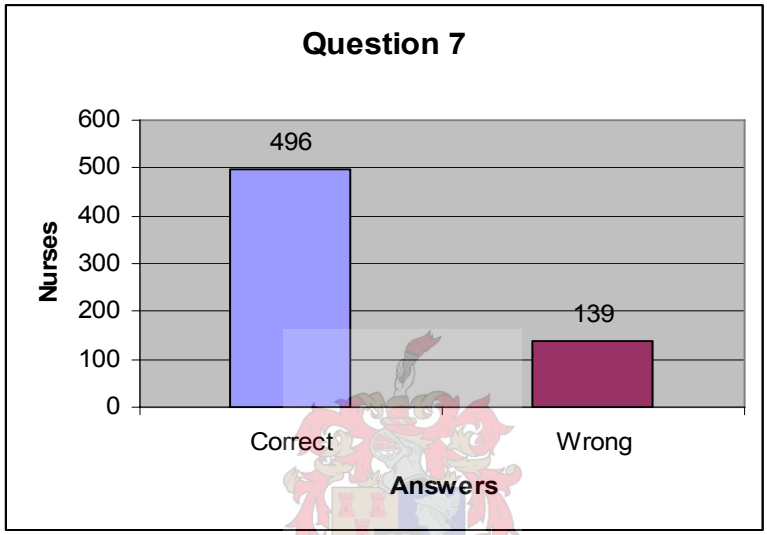


Figure 4.7: Frequent suctioning as a way to prevent VAI (n=635)

Figure 4.7 depicts that 78% (n=496) of the nurses stated that the statement is false, also reflecting the mean $\overline{X}$ score (see Table 4.2) and that the patient only needs suctioning when necessary. Frequent unnecessary suctioning may introduce organisms into the lower respiratory tract. Only 100% compliance to this question is acceptable, therefore the score indicated a serious knowledge deficit.

Question Eight: True or false – In ICUs, VAI is the leading cause of healthcare-associated infection, accounting for 60% of all deaths attributable to healthcare-associated infections.

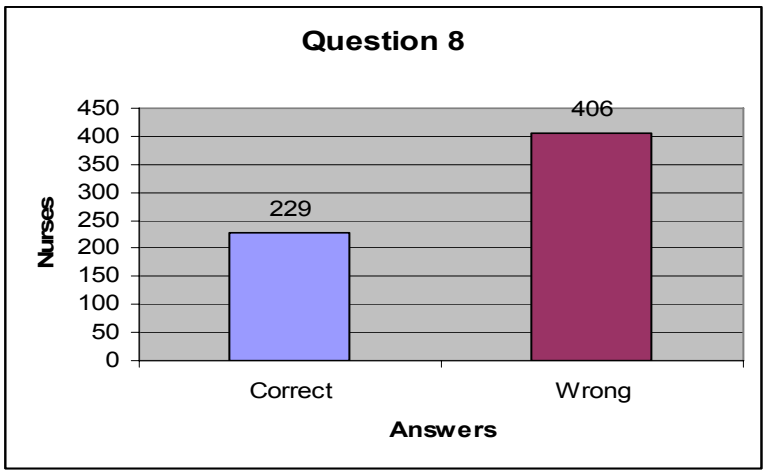


Figure 4.8: Leading cause of VAI (n=635)

Of the all the nurses (n=635), only 36% (n=229) answered correctly, which represented the $\overline{X}$ score, and realised that VAI is responsible for 60% of all deaths attributable to healthcare-associated infections. Only 100% compliance to this question is acceptable, therefore the score indicated a serious knowledge deficit (see Figure 4.8 and Table 4.2 for a graphic presentation of the results).

Question Nine: True of false – HMEs (heat & moisture exchangers) should be changed every 24 hours to maintain proper function.

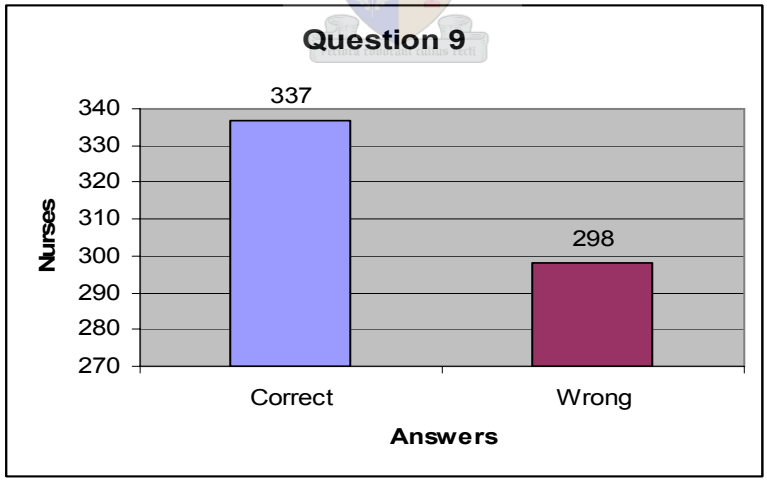


Figure 4.9: Effective time changes for HMEs (n=635)

Just more than half, 53% (n=337) of the nurses (see Figure 4.9) knew that heat and moisture exchangers (HMEs) cannot maintain proper function if not changed according to manufacturer's instructions and may be a risk factor for VAI development. This also represented the $\overline{X}$ score (see Table 4.2). Only 100% compliance to this question is acceptable, therefore the score indicated a serious knowledge deficit.

Question Ten: True or false – Ventilator circuits and in-line suction catheters should be changed every (7) seven days while the patient is in the ICU.

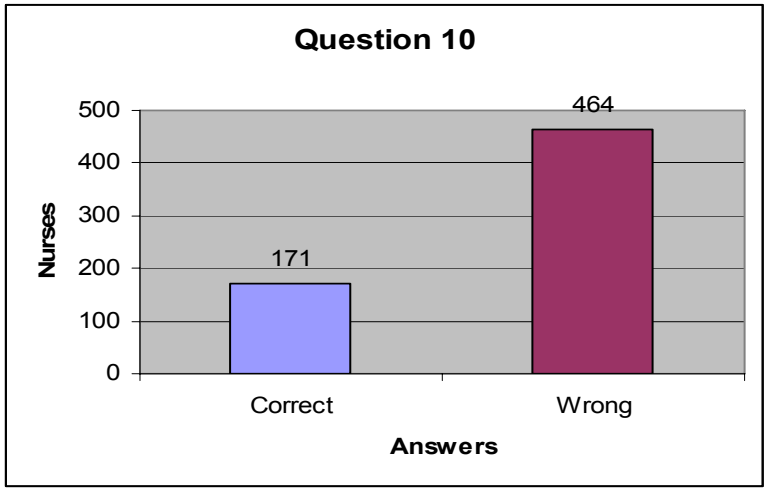


Figure 4.10: Time for changing of ventilator circuits (n=635)

A disappointing 27% (n=171) of the total number of nurses (n=635) answered correctly, which represented the $\overline{X}$ score (see Table 4.2) and knew that data from studies shows an increase in VAI when the circuit was changed every 7 days compared to not changing the circuit unless it is soiled or malfunctioning. Only 100% compliance to this question is acceptable, therefore the score indicated a serious knowledge deficit (see Figure 4.10).

Question Eleven: True of false – Nasal intubation is preferred whenever possible to prevent aspiration of the oral secretions.

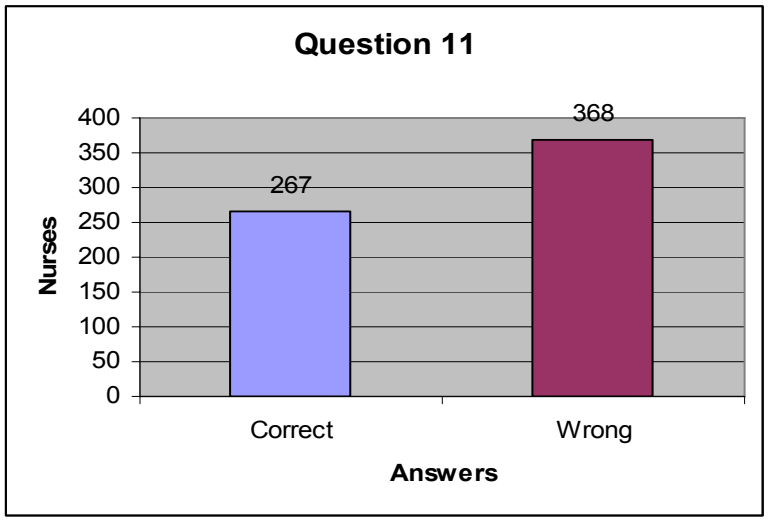


Figure 4.11: Nasal intubation as a risk factor for VAI (n=635)

Only 42% (n=267) also indicating the $\overline{X}$ score (see Table 4.2) of the nurses knew that nasal intubation is associated with sinusitis and increases the risk for VAI. Only 100% compliance to this question is acceptable, therefore the score indicated a serious knowledge deficit (see Figure 4.10).

Question Twelve: True of false – Tap water should be used in humidifiers.

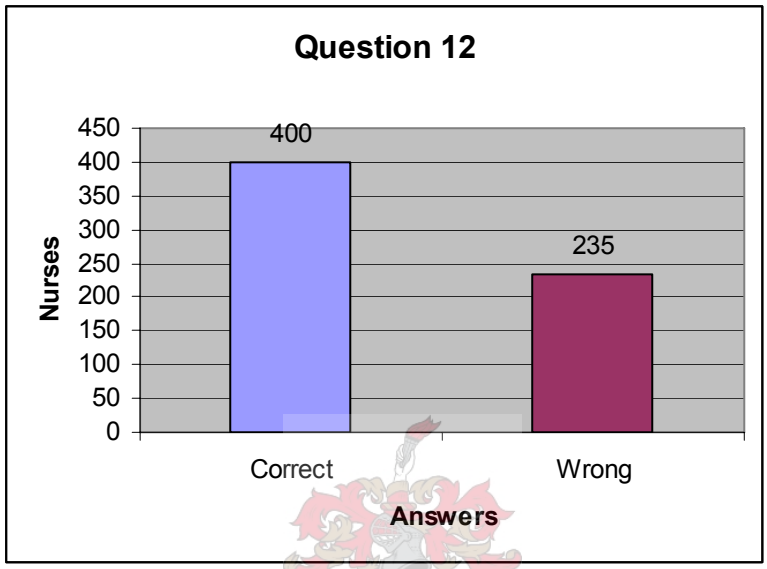


Figure 4.12: The use of tap water in humidifiers (n=635)

Figure 4.12 gives a graphic presentation of the scores on this question where only 63% (n=400) nurses answered correctly and use sterile water to fill humidifiers, which also indicated the $\overline{X}$ score (see Table 4.2). Tap or distilled water can harbour *Legionella spp.* Only 100% compliance to this question is acceptable, therefore the score indicated a knowledge deficit.

Question Thirteen: True or false – Ventilator condensate should always be drained before repositioning the patient.

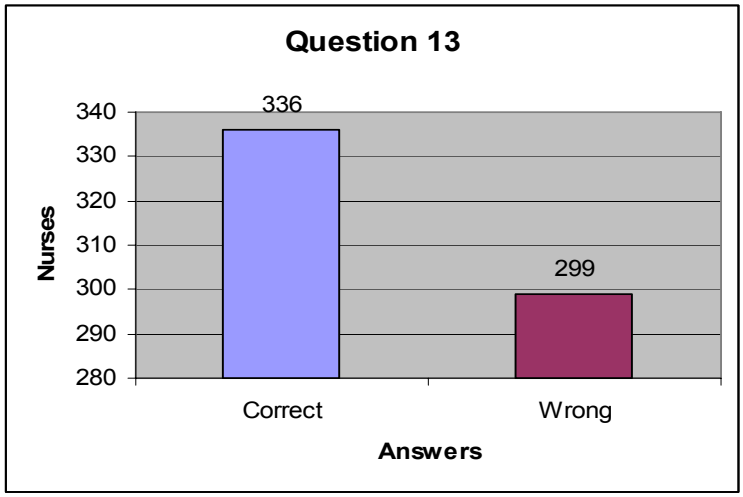


Figure 4.13: Drainage of ventilator condensate before positioning patient (n=635)

Of the total (n=635) number of nurses, 53% (n=336) answered correctly and said that they would drain ventilator circuit condensate before repositioning their patient. Only 100% compliance to this question is acceptable, therefore the $\overline{X}$ score 53% indicated a serious knowledge deficit (see Figure 4.13).

Question Fourteen: True or false – Patients on ventilators should have the head of the bed elevated to 30 degrees to prevent condensate from draining into the patient.

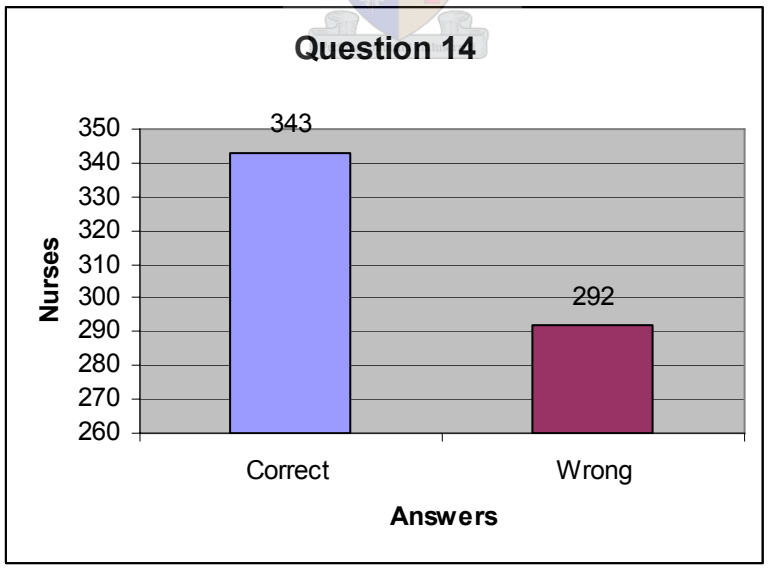


Figure 4.14: Head of bed elevated at 30 degrees for ventilated patients (n=635)

Just more than half, namely 54% (n=343), which also represented the $\overline{X}$ scores of the nurses agreed that they need to place ventilated patients in a semi-recumbent position

with the head of the bed elevated 30° as tolerated, even during transport. Only 100% compliance to this question is acceptable, therefore the score indicated a knowledge deficit (see Figure 4.14 and Table 4.2).

Question Fifteen: True or false – The nurse should monitor gastric residual volumes before each feeding to prevent aspiration in ventilated patients receiving tube feedings.

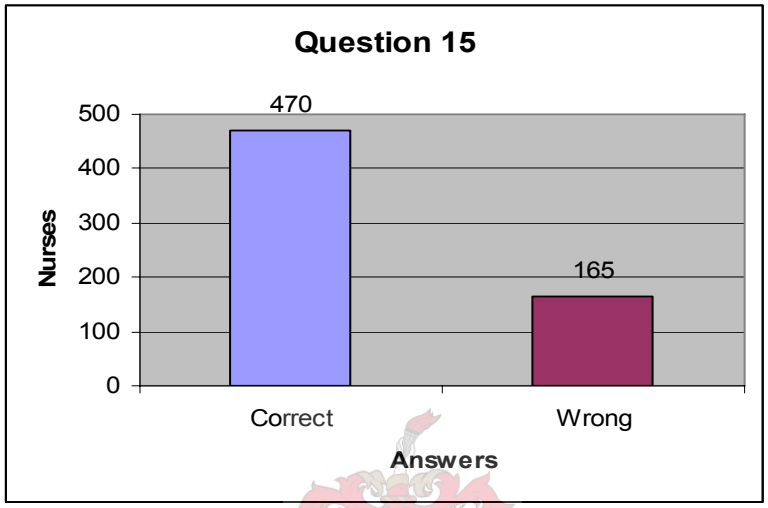


Figure 4.15: Monitoring of gastric residual volumes (n=635)

Only 74% (n=470) of the nurses answered correctly and confirmed that it is important to monitor gastric residual volumes before feedings to avoid gastric distension. This also represented the $\overline{X}$ score. Only 100% compliance to this question is acceptable, therefore the score indicated a serious knowledge deficit (see Figure 4.15 and Table 4.2).

Question Sixteen: True or false – A patient has a temperature of 37.2°C, minimal amounts of clear sputum, and a normal chest x-ray. White blood cells are 8k/cm and the sputum culture is positive for *Staphylococcus aureus*. Does the patient have pneumonia and should the patient be treated with antibiotics?

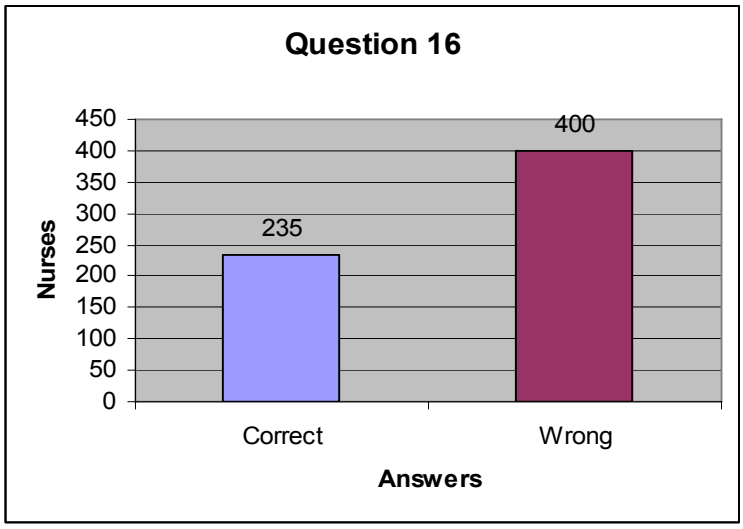


Figure 4.16: Identification of clinical manifestations for pneumonia (n=635)

Only 37% (n=235) of the nurses agreed that there is no evidence of infection or pneumonia, only colonisation. Only 100% compliance to this question is acceptable, therefore the score indicated a knowledge deficit (see Figure 4.16).

Question Seventeen: After one day that this patient was urgently intubated, this patient's chest x-ray shows consolidation, the patient has a productive cough with yellow sputum, her temperature is 38.9°C and her WBCs are 15,000. The physician orders a broad-spectrum antibiotic. Which of the following is true?

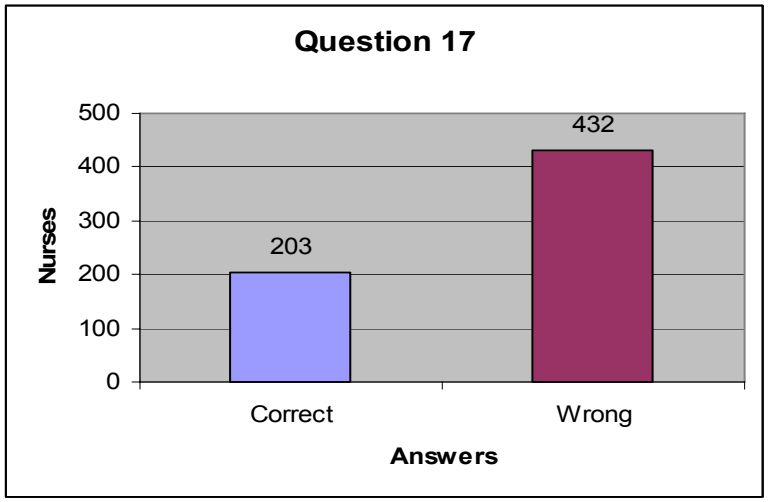


Figure 4.17: Definition for healthcare-associated pneumonia (n=635)

The Centre for Disease Control and Prevention (CDC) (2004) has developed standardised definitions for healthcare-associated pneumonia and ventilator-associated infections.

Patients with VAI should have had mechanical ventilation for **more than 48 hours** to fall into this category. Only 32% (n=203) of the total number of nurses (n=635) answered this question correct this also indicated the $\overline{X}$ score. Only 100% compliance to this question is acceptable, therefore the score indicated a knowledge deficit (see Figure 4.17 and Table 4.2).

Question Eighteen: After a sputum sample of the same patient was obtained, the culture grew *Pseudomonas aeruginosa*. Which of the following is true?

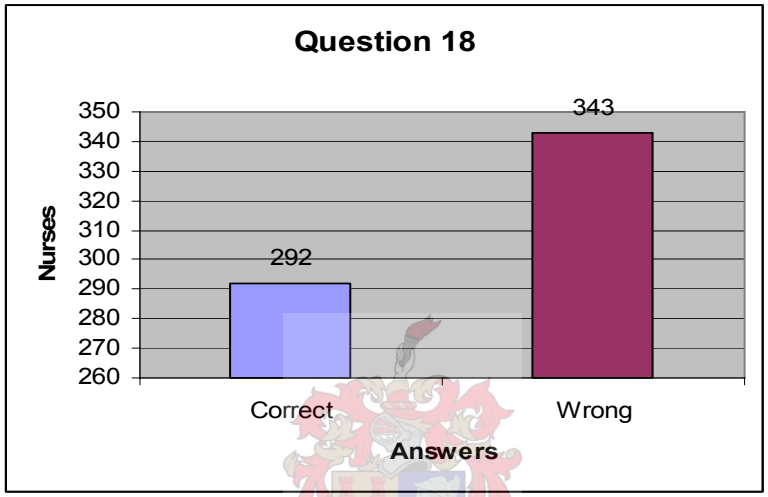


Figure 4.18: *Pseudomonas aeruginosa* indicators (n=635)

Less than half, 46% (n=292) of the nurses answered correctly and knew that a deep suctioned specimen should provide accurate culture results when the patient is symptomatic and VAI is suspected. Figure 4.18 and Table 4.2 and the $\overline{X}$ score of this question reflects clearly the nurses' knowledge deficit.

Question Nineteen: A patient, who suffered a cardiac arrest, was admitted to ICU about a week ago. He was intubated and NG-feeds were started. During your shift, he spikes a temperature of 39.1°C and you suction copious amounts of thick yellow sputum from his ETT-tube. When you check his gastric residual, it is 250cc. What should you do?

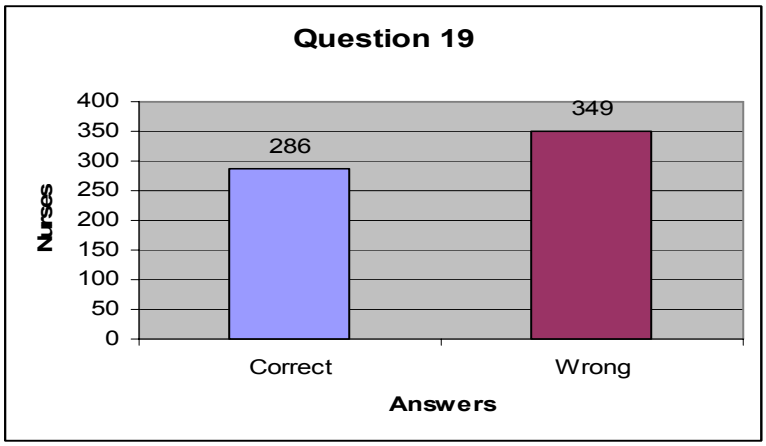


Figure 4.19: Acceptable gastric residual volume (n=635)

Again, only 45% (n=286) of the nurses answered correctly and said that they would hold the tube feeding. The patient has 250cc still in his stomach and is at risk for aspiration. Do not use HMEs for patients with excessive secretions or haemoptysis. Only 100% compliance to this question is acceptable, therefore the $\overline{X}$ score indicated a knowledge deficit (see Figure 4.19 and Table 4.2).

Question Twenty: What information should you bring to the physician's attention?

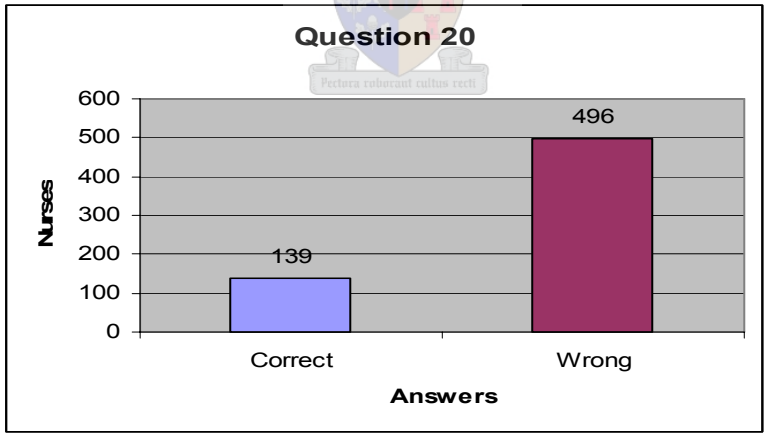


Figure 4.20: Physician information to be communicated (n=635)

Figure 4.20 gives a graphic presentation of information to be communicated to the physician, and only 22% (n=139) of the total number of nurses (n=635) agreed that the following is important to bring to the physician's attention: Oral intubation is preferred over naso-tracheal intubation, and an oral gastric tube should be considered since nasogastric tubes may increase the possibility of aspiration of gastric contents or bacterial migration via the tube from the stomach to the upper airway. Only 100% compliance to this question is acceptable, therefore the $\overline{X}$ score indicated a knowledge deficit (see Table 4.2).

Conclusion

To pass the pre-test, a minimum score of 80% was required (four wrong answers only). The overall pass rate in the pre-test was 0.79% (n =5). Of the total number of nurses (n=635), 62.2% (n=389) scored between 50 – 79% (That is 5 – 10 wrong answers), and 37% (n=241) scored between 0 – 49%, that is more than 10 answers wrong which is not acceptable for the nursing management of adult mechanically ventilated patients in the intensive care unit (see table 4.2 for the results of the pre-test).

It may appear that nurses had adequate knowledge with regard to the prevention of VAI in adult mechanically ventilated patients, but when lack of knowledge contributes to a higher mortality rate it is not acceptable as patients lives are at stake.

Table 4.2: Results of the pre-test for nurses (n=635)

	QUESTION	n =CORRECT ANSWER	n = WRONG ANSWER	MEAN (CORRECT ANSWERS) %
1	Risk groups	381	254	60
2	Factors	320	315	50
3	Suction catheter	356	279	56
4	Gloves	457	178	72
5	Circuit condensate	298	337	47
6	Antibiotics	425	210	67
7	Suctioning	496	139	78
8	Healthcare-associated infection	229	406	36
9	HMEs	337	298	53
10	Ventilator circuits	171	464	27
11	Intubation	267	368	42
12	Humidifiers	400	235	63
13	Ventilator condensate	336	299	53
14	Elevate head of bed	343	292	54
15	Aspiration	470	165	74
16	Pneumonia	235	400	37
17	VAI	203	432	32
18	Sputum specimen	292	343	46
19	NG-feeds	286	349	45
20	Information	139	496	22

- **Implementation of the Learning Programme**

Implementation of the Learning Programme was the second last objective in Phase Two prior to receiving the self-study Learning Programme. Participants were required to undergo a 20-question pre-test, evaluating their baseline knowledge on the prevention of ventilator-associated infections. An identical post-test was administered after completion of the Learning Programme. Individuals who scored less than 80% on the post-intervention test were required to repeat the self-study Learning Programme.

In addition to the self-study Learning Programme, the intervention included posters and fact sheets and in-service training for nursing and medical staff. The in-service sessions were provided by infection control nurses and medical specialists educated on the policy aimed at preventing ventilator-associated infections. In-service sessions were provided at monthly intervals for the first three months of the initial implementation of the Learning Programme and during scheduled staff development times and staff meetings or double staffing times so as to gain access to the majority of nursing and medical staff.

The self-study Learning Programme was encouraged for all medical and nursing staff working in the two nominated tertiary hospital adult ICU settings during the time of the study. It was incorporated into the mandatory competency training for nurses in the ICU and for medical staff. An ICU infection control specialist promoted acceptance of the Learning Programme, aiming to prevent ventilator-associated infections, used attendance at the scheduled in-service sessions. Post-tests were only administered to staff that had completed the pre-test and the self-study Learning Programme.

- **Research design for the evaluation of the Learning Programme**

An exploratory, descriptive and partially explanatory design was implemented to evaluate the Learning Programme. The Learning Programme was initiated in January 2003. All patients admitted to the participating adult ICUs were followed up (screened) in a similar fashion throughout the study period. The pre-intervention period was defined as June 2002 – December 2002, six months before the intervention was introduced.

The post-intervention period was defined as February 2004 – November 2004, 10 months after the intervention was completed at both facilities. A 10-month post-intervention period

was selected to minimise the influence of early changes associated with the introduction to the Learning Programme that eroded with time.

- **Data gathering and data handling**

The data was gathered according to a semi-structured questionnaire after each staff member had completed the self-study Learning Programme. The researcher explained the goal of the research and gathered the data by means of ten open-ended questions with a section for comments (see Appendix 9). It took each respondent approximately 40 minutes to complete the questionnaire.

To ensure trustworthiness of the responses, respondents could remain anonymous and 362 respondents participated in the completion of the questionnaires. This constituted a saturated sample, as these 362 staff members had done the self-study programme. Staff that had not completed the self-study programme was not included in the final sample. The results of the questionnaires received from the medical staff are summarised in Appendix 12.

- **Results for the evaluation of the Learning Programme**

Results are described according to completion rates and answers given in the questionnaires. Results for medical staff are given in Appendix 12.

- **Completion rates of questionnaires**

Overall, for both hospitals, 635 out of 792 adult ICU nurses (80.1%) and 215 out of 239 medical staff (89.9%) completed the Learning Programme. The staff completion rates at the two individual hospitals for the self-study Learning Programme are shown in Table 4.3. The high completion rate for the Learning Programme amongst nurses could be due to the fact that the self-study Learning Programme was included in the mandatory competency requirement for nurses. The high completion rate for medical staff may be due to other factors not identified. The results of the pre- and post-test for medical staff are shown in Appendix 12.

Table 4.3: Staff completion rates for the self-study Learning Programme

Hospital	Nursing Completion Completion Rate, %	Medical Staff Completion Rate, %	Ventilator-associated infections Reduction, %
Hospital 1	77.6	98.5	53.3
Hospital 2	82.6	81.3	60.7
Both	80.1	89.9	57.0

❖ **Results: Questionnaires on the evaluation of the Learning Programme**

The responses to the open-ended questionnaire are summarised below. A total of 362 respondents (who completed both the pre-and post-test) filled in the questionnaire by the given date for collection (see Appendix 9 for the questionnaire). Comments were clustered according to the same responses.

Question One. What is your overall impression of the Learning Programme?

General responses with regard to the overall impression of the Learning Programme were positive. Of the respondents, 88% (n=319) regarded the programme as very good. The programme was described as "well structured, well thought through, simple but effective and excellent". After familiarising themselves with the contents of the Learning Programme, the respondents became aware of the importance of the programme and their enthusiasm increased. It can thus be concluded that the Learning Programme left an overall good impression on respondents.

Question Two. What are the positive aspects of the Learning Programme?

Responses on the positive aspects on the Learning Programme were regarding the quality, quantity, timeframe, applicability and other. Of the respondents, 50% (n=181) commented positively on the quality of the Learning Programme, 18% (n=64) on the efficient quantity of

the programme, 10% (n=36) on the good timeframe, 20% (n=72) on the applicability of the programme and 2% (n=9) had other positive comments regarding the Learning Programme.

Some of the feedback received was as follows:

- The Learning Programme is a short summary of a lot of information.
- It is straight to the point.
- It allows one to re-assess what you are doing, e.g. aseptic technique.
- It ensures that quality care is given to all patients and it supports better patient outcome and survival.

The overwhelming consensus on the positive aspects of the programme as reflected by respondents stated that it would facilitate improvement of patient outcomes and survival.

Question Three. What are the negative aspects of the Learning Programme?

Responses on the negative aspects on the Learning Programme were also regarding the quality, quantity, timeframe, applicability and other / none. Only 7% (n=27) of the respondents gave negative comments on the quality of the Learning Programme, 10% (n=36) on the quantity of the programme, 18% (n=64) on the insufficient timeframe, 10% (n=37) on the applicability of the programme and 55% (n=198) had no or other comments regarding the Learning Programme.

Some of the feedback received was the following:

- The Learning Programme takes too long to complete.
- It requires a lot of time and financial resources to implement, which may not necessarily be available.
- Too many projects already in the ICU.
- It is more time spent away from patients.

Of all the respondents, 198 could not identify any negative aspects of the Learning Programme. The rest of the respondents, that is 18% (n=64), cited time as the main negative factor. It can thus be concluded that the Learning Programme had a few areas to be remediated before implementation to the next group of nurses.

Question Four. Do you think a Learning Programme similar to this one is appropriate in the current management of ventilated patients?

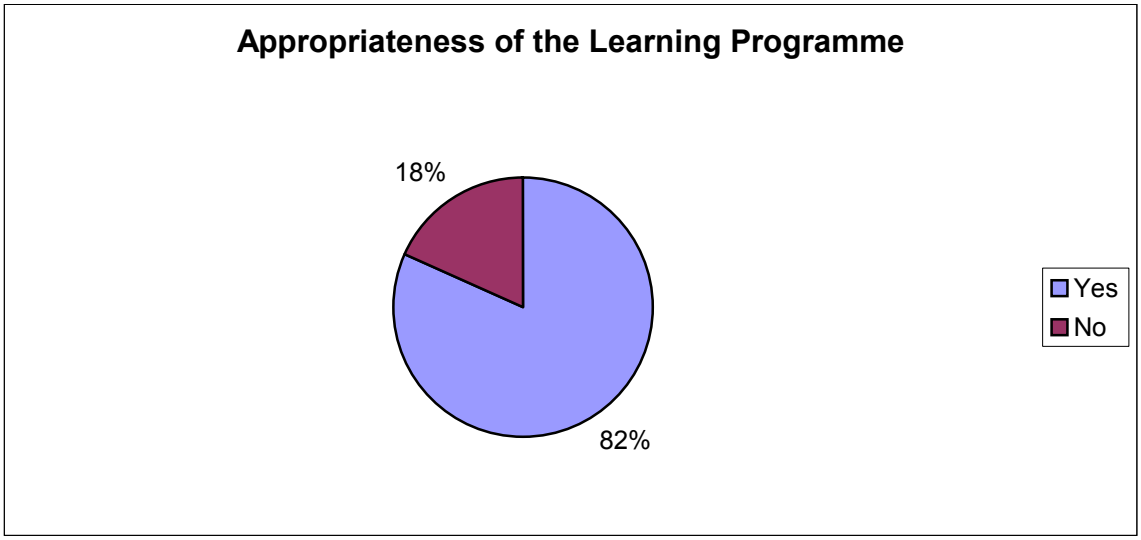


Figure 4.21: Appropriateness of the Learning Programme (n=635)

Only 18% of the respondents (n =66) identified the learning programme as inappropriate in the current management of ventilated patients, mainly due to financial constraints and the length of time it takes to implement, therefore the appropriateness of the Learning Programme was established (see Figure 4.21).

Question Five. Do you recommend other Learning Programmes, similar to this, covering other infection control subjects, e.g. management and care of central venous catheters, in the future? Please motivate your answer.

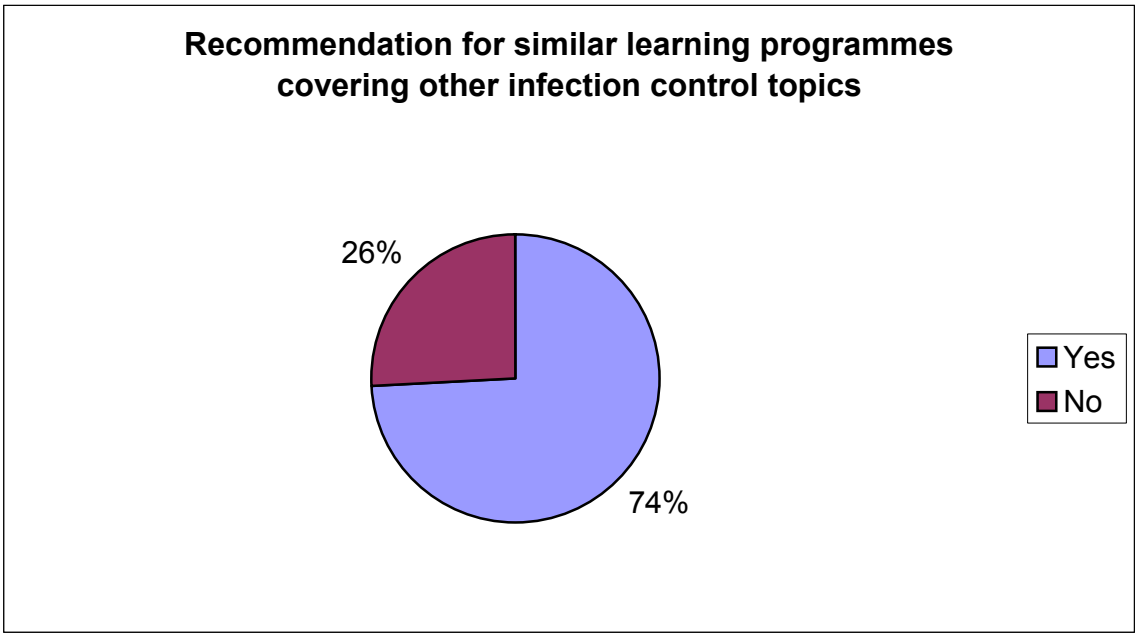


Figure 4.22: Recommendations for other Learning Programmes (n=635)

Figure 4.22 illustrates general responses on similar Learning Programmes, namely:

- A positive response was received from 74% (n=268) of the respondents for the implementation of similar programmes on infection control aspects related to critical care nursing.
- Negative responses came from 26% (n =94) of the respondents.

Comments received were inter alia:

- It will help with decreasing infections in the ICU;
- It is an interesting topic to cover during study days;
- It is good to include on a CV;
- It is too time-consuming and
- It is really a problem for the medical team to deal with.

More than two-thirds 74% (n=268) of the respondents recommended the Learning Programme for other infection control topics. It can thus be concluded that similar learning programmes will be of value in improving the quality of infection control in ICU.

Question Six. Did you find the self-study Learning Programme helpful and easy to use? Please explain your answer.

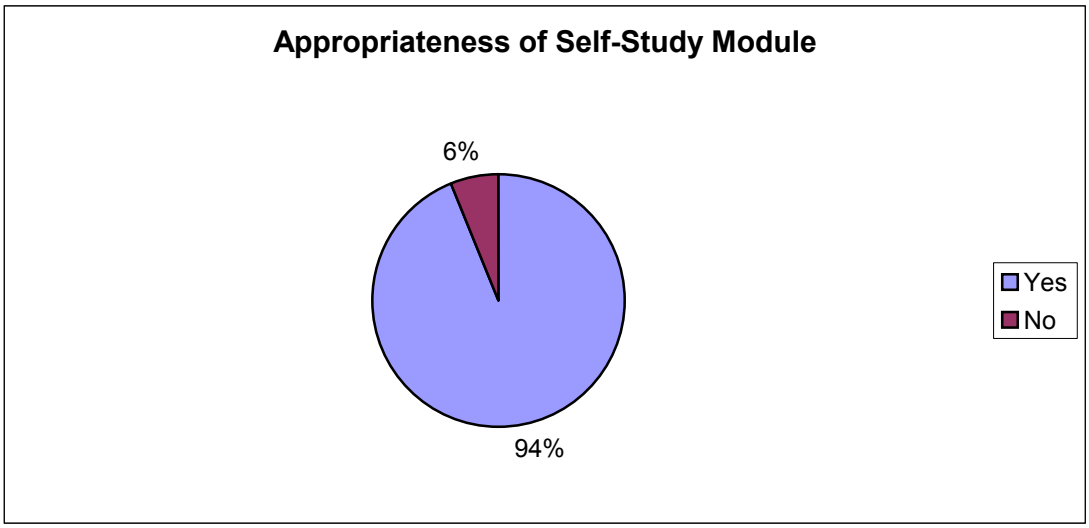


Figure 4.23: Appropriateness of self-study module (n=635)

In general, responses (94%, or n=340) on the appropriateness of the programme were positive and 6% (n=22) were negative.

Comments received were inter alia:

- The programme is well structured.
- The Learning Programme is easy to use and understand.
- The Learning Programme has all the relevant information condensed into a few pages.
- The programme was updated with the latest information.

As only 6% (n=22) found the self-study Learning Programme inappropriate, it can thus be concluded that the self-study aspect of the Learning Programme was appropriate for nurses caring for adult patients being mechanically ventilated (see Figure 4.23).

Question Seven. Did you find the in-service provided helpful and of any value? Please motivate your answer.

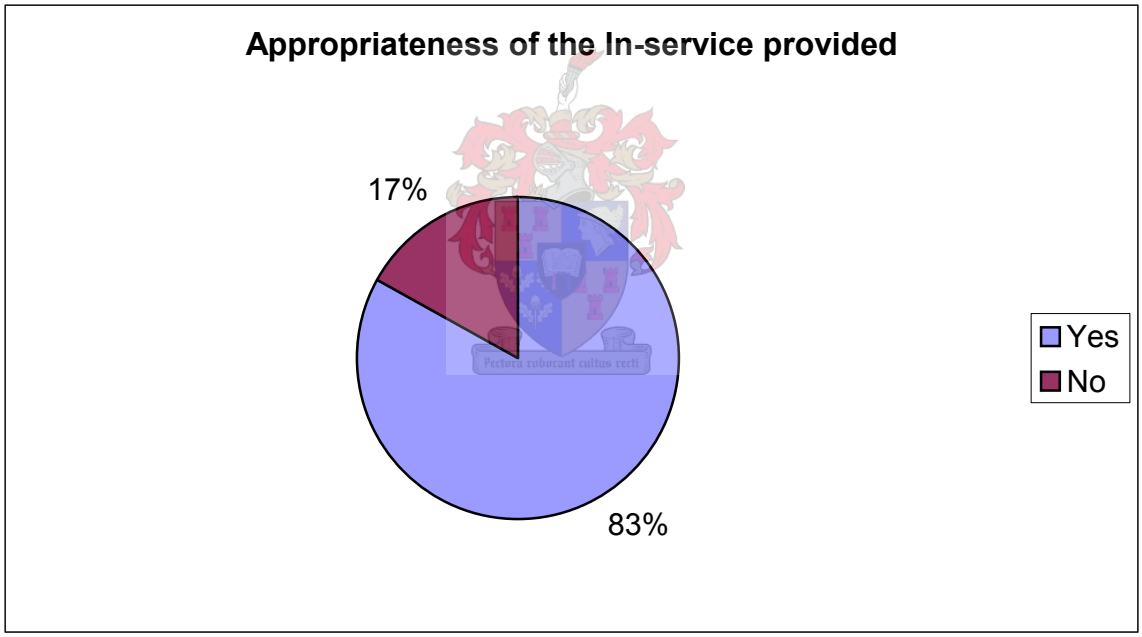


Figure 4.24: Appropriateness of in-service (n=635)

In general, responses (83%, or n=301) on the appropriateness of the in-service were positive and 17% (n=61) were negative. Comments received were inter alia:

- The in-service sessions were interesting.
- It was quality time spent away from the patient (was not a waste of time).
- The speakers where experts in their field of practice.
- Some of the sessions took too long.

It can thus be concluded that the in-service provided was appropriate to the needs of nurses working in an adult intensive care unit (see Figure 4.24).

Question Eight. Were the fact sheets and posters of any value/significance? Please motivate your answer.

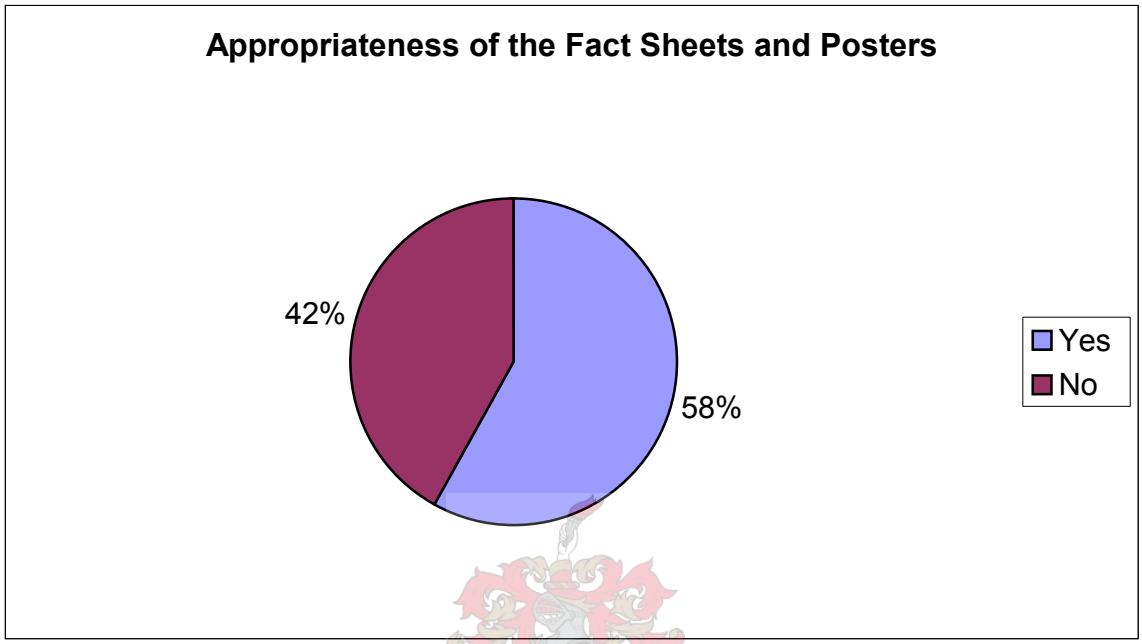


Figure 4.25: Appropriateness of fact sheets and posters (n=635)

Of the responses on the question regarding appropriateness of the fact sheets and posters, 58% (n=210) were positive and 42% (n=152) were negative (see Figure 4.25).

Comments received were clustered and included:

- The fact sheets and posters complete the programme.
- It served as good reminders.
- It was not as useful as the in-service.
- The posters were more effective and of more value than the fact sheets.
- A lot of the fact sheets got lost.
- The fact sheets did not get read.

Almost half the staff 42% (n=152) who filled out the questionnaire did not find the fact sheets and posters as useful and effective as the self-study Learning Programme and the in-service sessions.

Question Nine. Were senior members of staff available and able to answer questions regarding this Learning Programme?

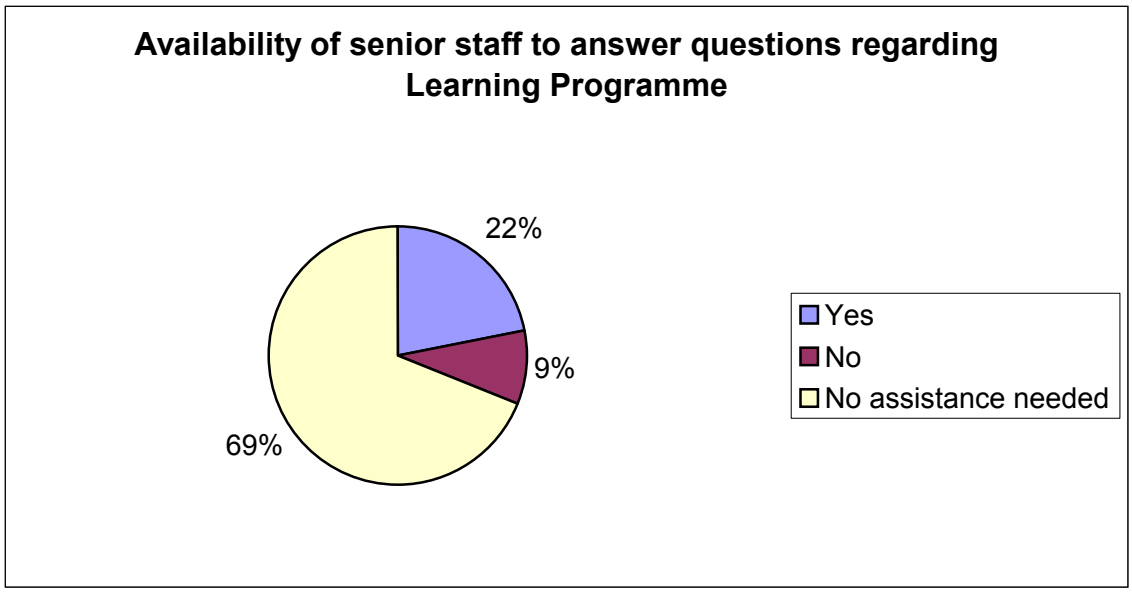


Figure 4.26: Availability of senior staff (n=635)

Of the responses on the availability of senior staff for help with the Learning Programme, 69% (n=249) indicated that they needed no help, 22% (n=79) found staff available and 9% (n=34) did not find staff available (see Figure 4.26).

It can thus be concluded that overall senior members of staff were available to answers questions with regard to the Learning Programme.

Question Ten. What suggestions do you have for future upgrading of the Learning Programme?

No suggestions were forthcoming from 81% (n=294) of the respondents with regard to future upgrading of the Learning Programme. Other suggestions were the following:

- 2% (n=6) commented on integrating the programme in the ICU course
- 5% (n=19) suggested publishing articles regarding the success of the Learning Programme in medical journals
- 3% (n=11) suggested that the hospital should continue to keep track of infection rates to make sure that the Learning Programme is still effective
- 9% (n=32) suggested that staff should be given incentives for participating in the programme

Other comments included the following:

Of the participants, 84% (n=304) made no further comments on the Learning Programme, 10% (n=36) of the respondents commented that the programme is very time-consuming and takes a long time to implement successfully, 6% (n=22) felt that it were also not a good idea considering the staff shortages in the ICU, and 13% (n=47) of the respondents congratulated the researcher on the quality of the programme and the way it was managed.

➢ **Results of the post-test for nurses caring for adult patients attached to mechanical ventilators**

The results were analysed by a statistician who used the Signed-Rank test to compare the results. In Table 4.4, the results of the pre-test are summarised and in Table 4.4, the results of the pre-test and post-test are compared. The results for medical staff are summarised in Appendix 12.

Question One: Which of the mentioned groups are at risk for VAI?

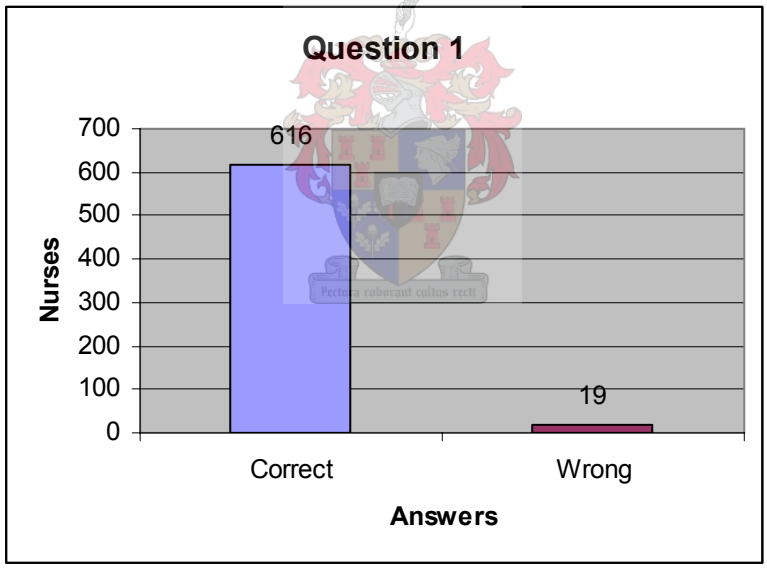


Figure 4.27: Groups mentioned at risk for VAI (n=635)

Of the total (n=635) number of nurses, only 60% (n=381) knew the correct answer in the pre-test, whereas in the post-test 97% (n=616) also indicating the $\overline{X}$ score, knew the correct answer, thus giving a statistically significant p-value = 0.0102, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.27 and Table 4.4).

Question Two: Which two factors may lead to the development of VAI?

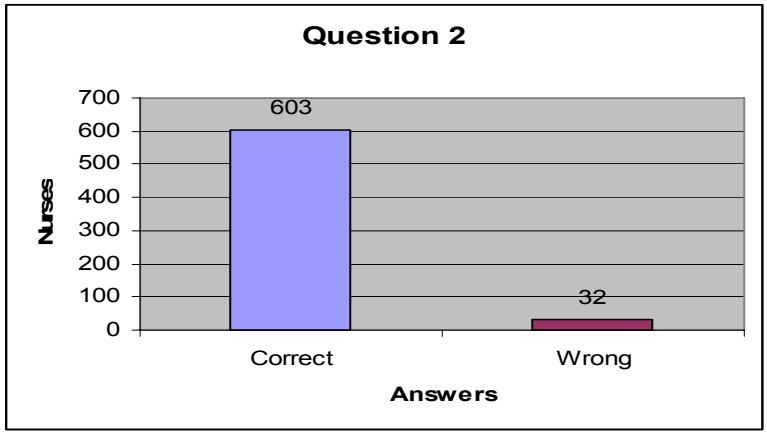


Figure 4.28: Two factors leading to VAI (n=635)

The two factors that frequently lead to VAI development are bacterial colonisation of the aero-digestive tract and aspiration of the contaminated secretions. Of the total number of nurses (n=635), half of them answered correctly (n=320) in the pre-test. In the post-test, 95% (n=603) also indicating the $\overline{X}$ score, answered correctly, thus giving a statistically significant p-value = 0.0008, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.28 and Table 4.4).

Question Three: Where should oral suction catheters be stored?

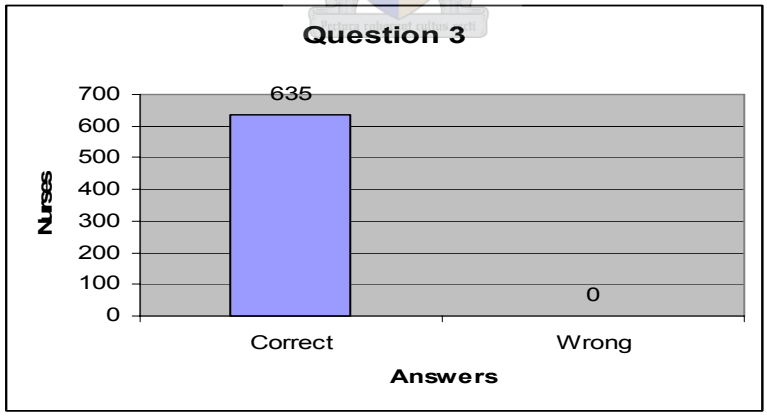


Figure 4.29: Correct storage of suction catheters (n=635)

Of the 635 nurses, 56% (n=356) knew to store the oral suction catheter in the correct manner when doing the pre-test, as to 100% (n=635) nurses when undergoing the post-test, also indicating the $\overline{X}$ score, thus giving a statistically significant p-value = 1.000, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.29 and Table 4.4).

Question Four: While emptying your patient's Foley bag, you look up and realise that the condensate in the ventilator tubing needs to be drained. Your patient starts to cough, what do you do?

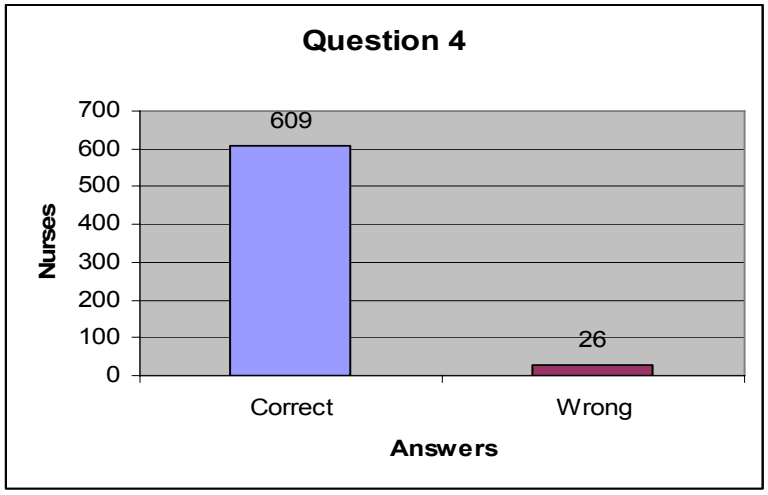


Figure 4.30: Prioritising infection control nursing actions (n=635)

During the pre-test, 72% of the nurses (n=457) knew that they always have to remove their gloves and wash their hands or use a waterless hand antiseptic after completing a "dirty" task. After completing the Learning Programme and taking the post-test, 96% (n=609) of the nurses answered correctly also indicating the $\overline{X}$ score, thus giving a statistically significant p-value =0.3820, which indicated an overall improvement in the nurses' knowledge (For a graphic presentation see Figure 4.30 and Table 4.4).

Question Five: Which is the proper procedure for draining ventilator circuit condensate?

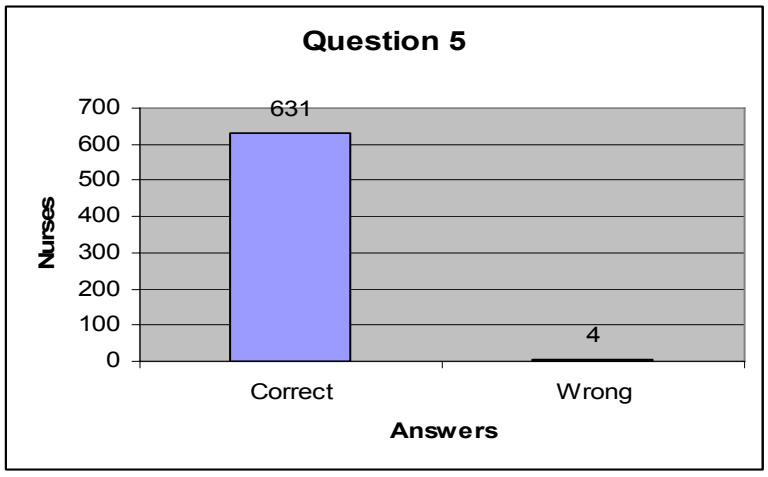


Figure 4.31: Proper procedure for ventilator circuit drainage (n=635)

Less than half, 47% (n=298) of the total number of nurses (n =635) answered correctly in the pre-test, that one does not need sterile gloves or a sterile container for this procedure. You also need to carry and empty the condensate into a hopper and not into a trashcan or sink. After taking the post-test, 99% (n=631) also indicating the $\overline{X}$ score of the nurses answered correctly thus giving a statistically significant p-value =0.6525. This indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.31 and Table 4.4).

Question Six: True or False – The use of multiple antibiotics increases a patient's risk of developing VAI.

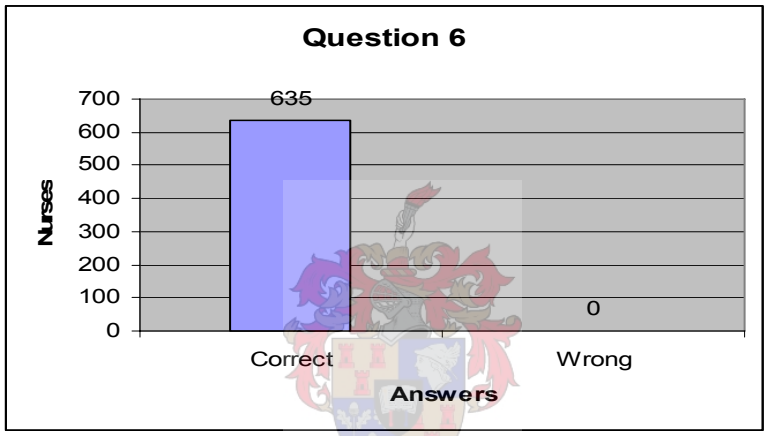


Figure 4.32: Use of antibiotics as a risk factor for VAI (n=635)

Of the total number of nurses (n=635) taking the pre-test, 67% (n=425) knew that multiple use of antibiotics, especially when used for empiric treatment, increase the risk for developing resistant organisms that can cause infection. After completing the Learning Programme and after taking the post-test, 100% (n=635) also indicating the $\overline{X}$ score, of the nurses answered the question correctly, thus giving a statistically significant p-value =0.3125, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.32 and Table 4.4)

Question Seven: True or false – Frequent suctioning of the patient is the single best way to prevent VAI.

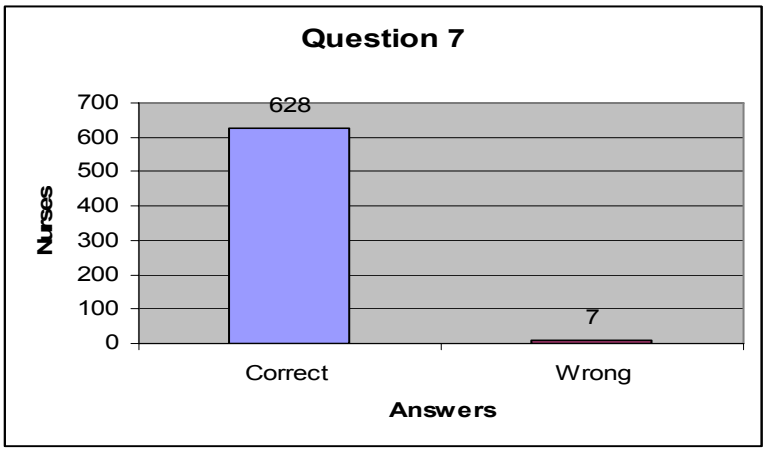


Figure 4.33: Frequent suctioning as a way to prevent VAI (n=635)

In the pre-test, 78% (n=496) nurses said that the statement is false, which is correct and that the patient only needs suctioning when necessary. Frequent unnecessary suctioning may introduce organisms into the lower respiratory tract. In the post-test, 99% (n=628) also indicating the $\overline{X}$ score, nurses answered correctly thus giving a statistically significant p-value =0.1218 which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.33 and Table 4.4).

Question Eight: True or false – In ICUs, VAI is the leading cause of healthcare-associated infection, accounting for 60% of all deaths attributable to healthcare-associated infections.

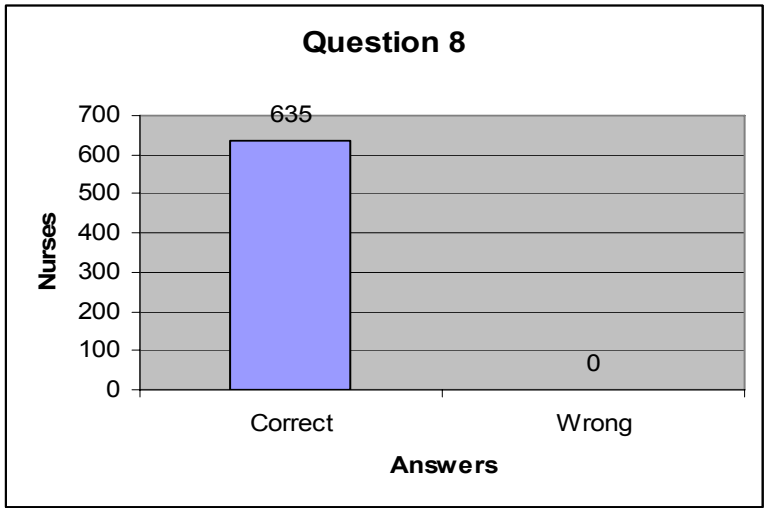


Figure 4.34: VAI as the leading course of healthcare-associated infections (n=635)

Of the all the nurses (n=635), only 36% (n=229) answered correctly and realised that VAI is responsible for 60% of all deaths attributable to healthcare-associated infections. However, after doing the Learning Programme, 100% (n=635) also representing the $\overline{X}$ score, of the nurses answered correctly when undergoing the post-test thus giving a statistically significant p-value =1.000, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.34 and Table 4.4).

Question Nine: True of false – HMEs (heat & moisture exchangers) should be changed every 24 hours to maintain proper function

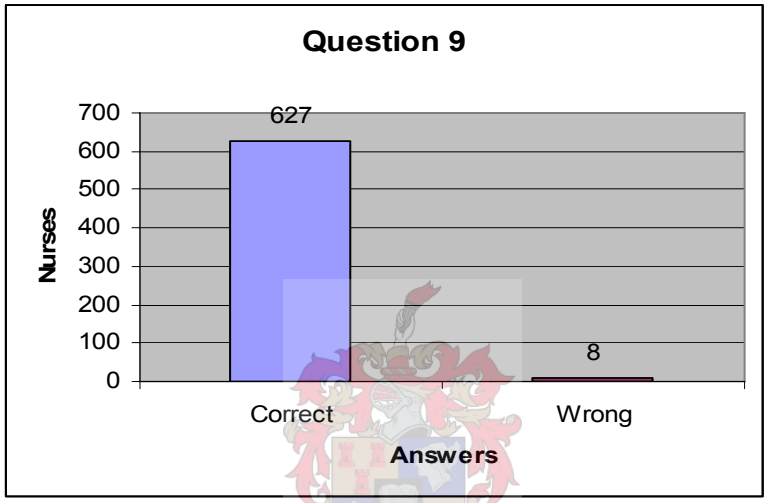


Figure 4.35: Effective time change of HMEs (n=635)

Just more than half, 53% (n=337) of the nurses during the pre-test knew that heat and moisture exchangers (HMEs) cannot maintain proper function if not changed according to manufacturer's instructions and may be a risk factor for VAI development. In the post-test, 99% (n=627) of the nurses also representing the $\overline{X}$ score, knew the correct answer, thus giving a statistically significant p-value =0.0979, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.35 and Table 4.4).

Question Ten: True or false – Ventilator circuits and in-line suction catheters should be changed every 7 days while the patient is in an ICU.

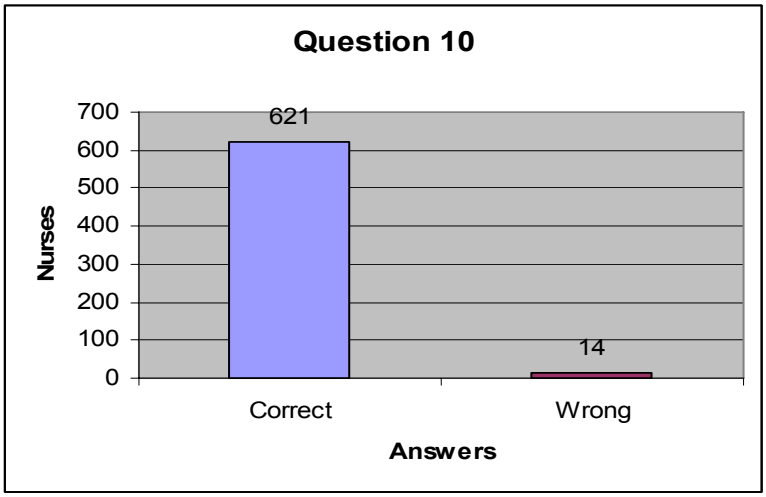


Figure 4.36: Changing regimen for ventilator circuits (n=635)

A disappointing 27% (n=171) of the total number of nurses in the pre-test (n=635) answered correctly and knew that data from studies shows an increase in VAI when the circuit was changed every seven (7) days, compared to not changing the circuit unless it is soiled or malfunctioning. Of the nurses, 98 % (n=621) also indicating the $\overline{X}$ score answered correctly in the post-test, thus giving a statistically significant p-value =0.0279, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.36 and Table 4.4).

Question Eleven: True of false – Nasal intubation is preferred whenever possible to prevent aspiration of the oral secretions.

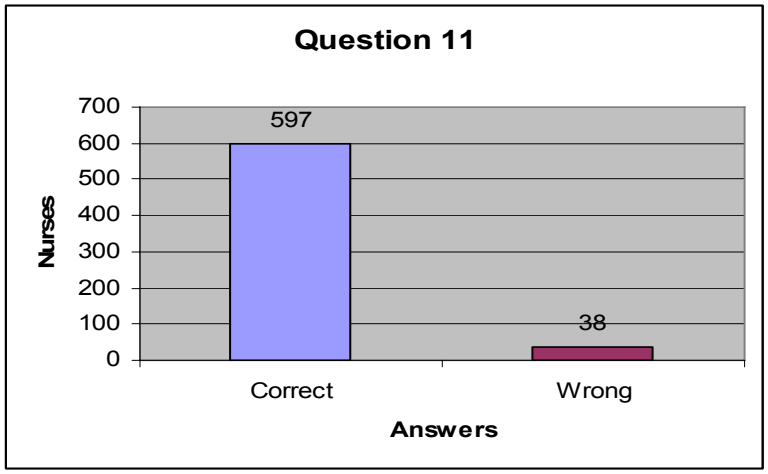


Figure 4.37: Nasal intubation as a risk factor (n=635)

Only 42% (n=267) of the nurses undergoing the pre-test knew that nasal intubation is associated with sinusitis and increases the risk for VAI. After completing the post-test, it was calculated that 94% (n=597) also indicating the $\overline{X}$ score, answered correctly, giving a statistically significant p-value =0.0002 for the post-test and indicated an overall improvement in the nurses' knowledge (see Figure 4.37 and Table 4.4).

Question Twelve: True of false – Tap water should be used in humidifiers.

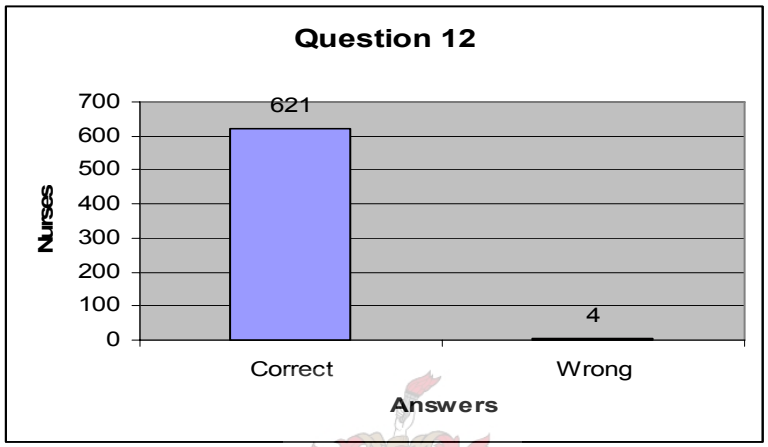


Figure 4.38: The use of tap water in humidifiers (n=635)

Of the nurses, 63% (n=400) answered correctly in the pre-test and use sterile water to fill humidifiers. In the post-test, 98% (n=621) also indicating the $\overline{X}$ score, of the nurses agreed that the use of sterile water was the correct answer, thus giving a statistically significant p-value =0.0279, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.38 and Table 4.4).

Question Thirteen: True or false – Ventilator condensate should always be drained before repositioning the patient.

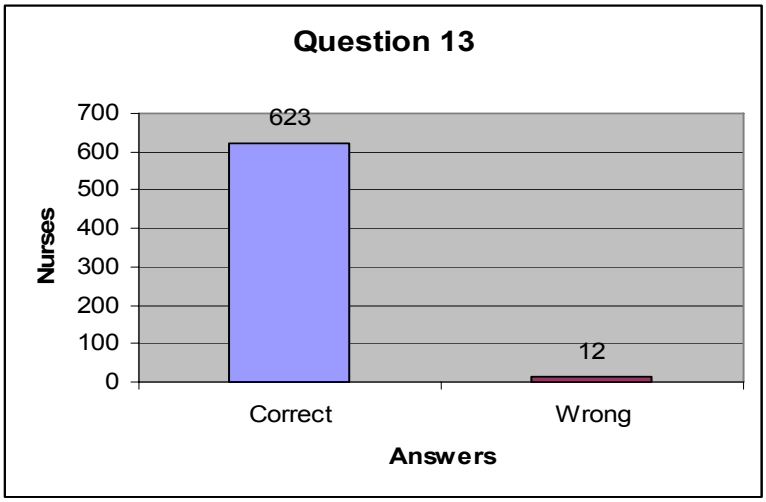


Figure 4.39: Draining of ventilator condensate before positioning of patient (n=635)

Of the total number of nurses (n=635), 53% (n=336) answered correctly in the pre-test and said that they would drain ventilator circuit condensate before repositioning their patient. When answering the same question in the post-test, 98% (n=623) also indicating the $\overline{X}$ score, of the nurses answered correctly, giving a statistically significant p-value =0.0421, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.39 and Table 4.4).

Question Fourteen: True or false – Patients on ventilators should have the head of the bed elevated to 30 degrees to prevent condensate from draining into the patient.

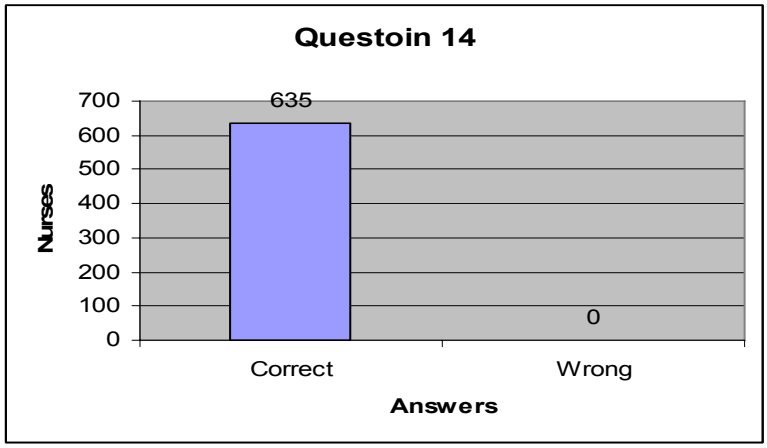


Figure 4.40: Elevation of head of bed at 30 degrees for ventilated patients (n=635)

Just more than half, 54% (n=343) of the nurses taking the pre-test, agreed that they need to place adult ventilated patients in a semi-recumbent position with the head of the bed

elevated 30° as tolerated, even during transport. In the post-test, 100% (n=635) also indicating the $\overline{X}$ score, of the nurses agreed to elevate the head of the bed 30°, giving a statistically significant p-value =1.000, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.40 and Table 4.4).

Question Fifteen: True or false – The nurse should monitor gastric residual volumes before each feeding to prevent aspiration in ventilated patients receiving tube feedings.

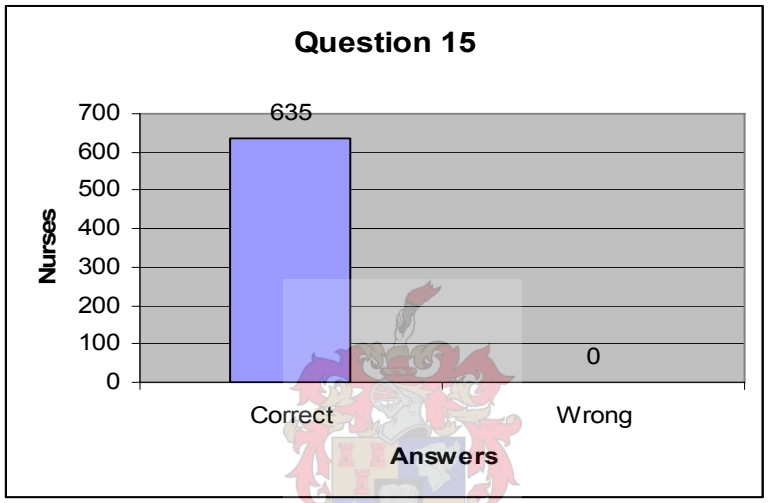


Figure 4.41: Monitoring of gastric residual volume (n=635)

Of the nurses, 74% (n=470) in the pre-test answered correctly and confirmed that it is important to monitor gastric residual volumes before feedings to avoid gastric distension. In the post-test, 100% (n=635) also indicating the $\overline{X}$ score, of the nurses answered this question correctly, giving a statistically significant p-value =1.0000, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.41 and Table 4.4).

Question Sixteen: True or false – A patient has a temperature of 37.2°C, minimal amounts of clear sputum, and a normal chest x-ray. White blood cells are 8k/cm and the sputum culture is positive for *Staphylococcus aureus*. Does the patient have pneumonia and should the patient be treated with antibiotics?

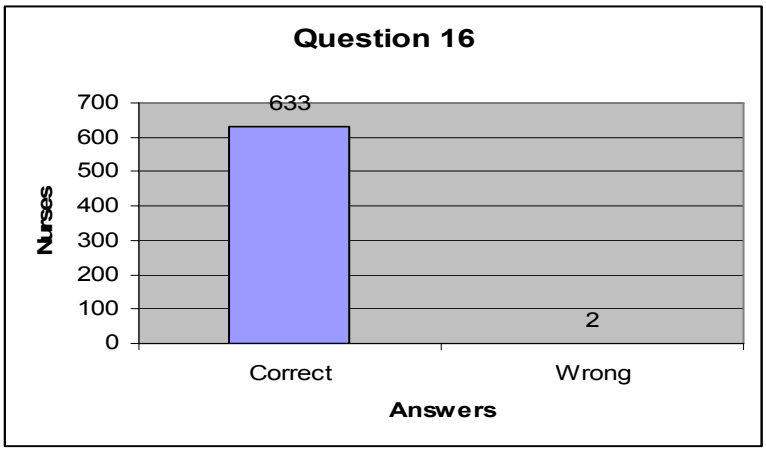


Figure 4.42: Identification of clinical manifestations for pneumonia (n=635)

In the pre-test only 37% (n=235) of the nurses agreed that there is no evidence of infection or pneumonia, only colonisation. In the post-test, 100% (n=633) also indicating the $\overline{X}$ score, agreed that there was no evidence of infection, giving a statistically significant p-value =0.4099, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.42 and Table 4.4).

Question Seventeen: After one day that this patient was urgently intubated, this patient's chest x-ray shows consolidation, the patient has a productive cough with yellow sputum, her temperature is 38.9°C and her WBCs are 15,000. The physician orders a broad-spectrum antibiotic. Which of the following is true?

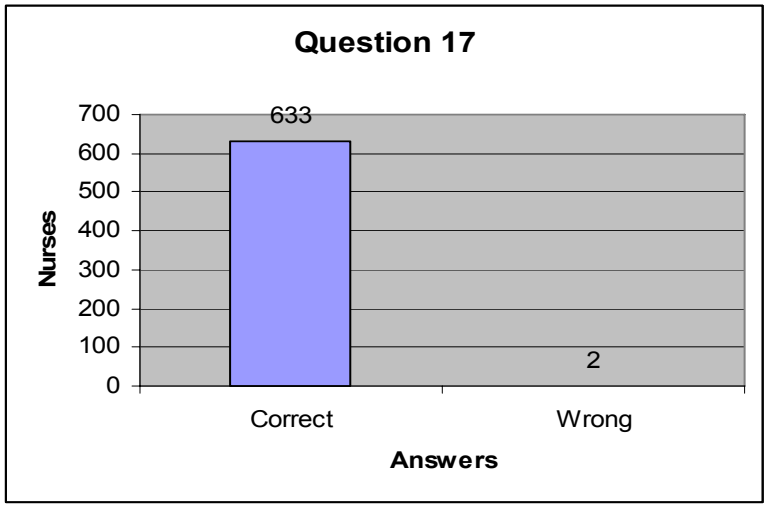


Figure 4.43: Definition for healthcare-associated pneumonia (n=635)

The Centre for Disease Control and Prevention (CDC) (2004) has developed standardised definitions for healthcare-associated pneumonia and ventilator-associated infections. Patients with VAI should have mechanical ventilation for **more than 48 hours**. Only 32% (n=203) of the total number of nurses (n=635) answered his question correctly in the pre-test. When asked the same question in the post-test, 97% (n=612) of the nurses answered correctly, also representing the $\overline{X}$ score, giving a statistically significant p-value =0.0056, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.43 and Table 4.4).

Question Eighteen: After a sputum sample of the same patient was obtained, the culture grew *Pseudomonas aeruginosa*. Which of the following is true?

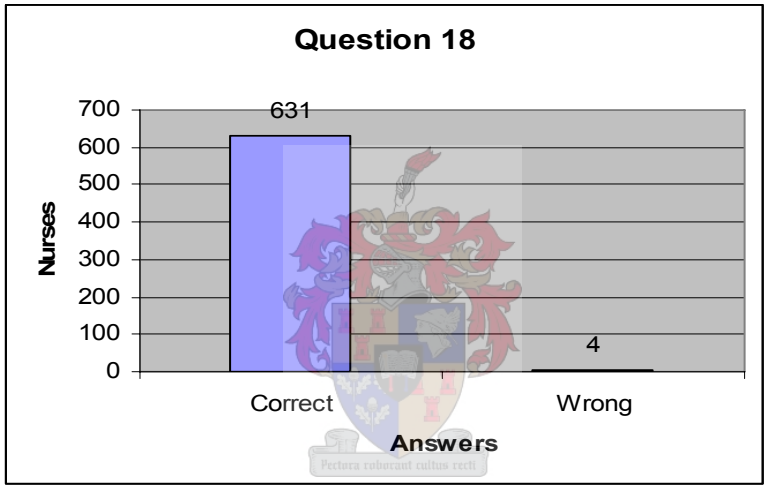


Figure 4.44: Indicators for *Pseudomonas aeruginosa* (n=635)

Less than half, 46% (n=292) of the nurses in the pre-test answered correctly and knew that a deep-suctioned specimen should provide accurate culture results when the patient is symptomatic and VAI is suspected. In the post-test, 99% (n=631) of the nurses answered correctly, giving a statistically significant p-value =0.2432, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.44 and Table 4.4 for the $\overline{X}$ scores).

Question Nineteen: A patient, who suffered a cardiac arrest, was admitted to ICU about a week ago. He was intubated and NG-feeds were started. During your shift, he spikes a temperature of 39.1°C and you suction copious amounts of thick yellow sputum from his endotracheal (ET) tube. When you check his gastric residual, it is 250cc. What should you do?

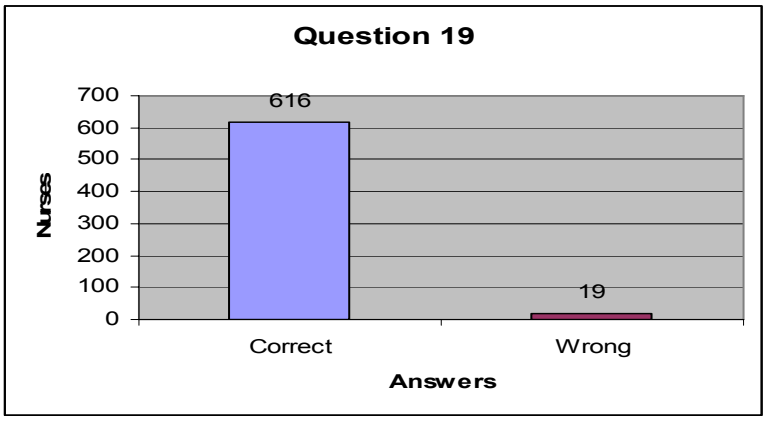


Figure 4.45: An acceptable gastric residual volume (n=635)

Again, only 45% (n=286) of the nurses answered correctly in the pre-test and said that they would start by holding the tube feeding and then remove the HME. The mean score indicated that 97% (n=616) of the nurses answered correctly in the post-test, giving a statistically significant p-value =0.3741, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.45 and Table 4.4).

Question Twenty: What information should you bring to the physician's attention?

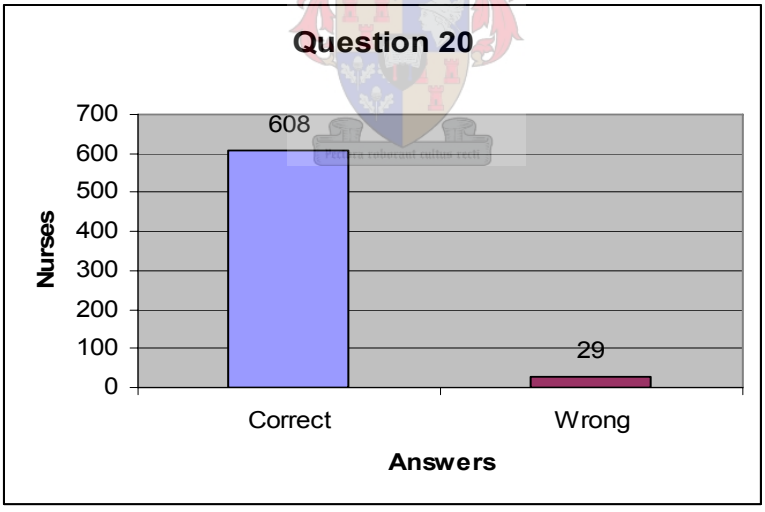


Figure 4.46: Physician information to be communicated (n=635)

Of the total (n=635), 22% (n=139) nurses agreed that the following is important to bring to the physician's attention when tested during the pre-test:

- oral intubation is preferred over naso-tracheal intubation; and
- an oral gastric tube should be considered, since NG tubes may increase the possibility of aspiration of gastric contents or bacterial migration via the tube from the stomach to the upper airway.

After completing the post-test, it was evident that 96% (n=608) the $\overline{X}$ score, of the nurses identified the correct information to bring to the physician's attention, thus giving a statistically significant p-value =0.0021, which indicated an overall improvement in the nurses' knowledge (for a graphic presentation see Figure 4.46 and Table 4.4).

General conclusions

To pass the test, a minimum of 80% was required (four wrong answers only). The overall pass rate for the post-test was 98.9% (n=628), as to only five nurses (0.79%) in the pre-test. Only 1.1% (n=7) of the nurses scored less than 80% in the post-test. Nobody scored less than 50% (more than 10 wrong answers) for the post-test, in comparison to the 37% (n=241) of nurses who scored less than 50% in the pre-test. In Table 4.4, a comparison of the results of the pre- and post-tests is given.

Due to the large number of participants, a valid outcome was established and a statistical significance was seen in all questions after the Learning Programme was initiated. The null hypothesis, namely there is no difference in the knowledge base of nurses following the implementation of the Learning Programme, is thus rejected and the alternative hypothesis, there is a difference in the knowledge base of nurses following the implementation of the Learning Programme, is supported.

The realisation of the following two objectives are described in Appendix 12, as this was done on special request by the medical staff:

- To implement and evaluate the implemented Learning Programme for medical staff (this was done as a special request from the medical intensivists.
- To post-test medical staff' knowledge with regard to ventilator-associated infections and the prevention thereof

Table 4.4: A comparison of the results of the pre and post-test for nurses (n=635)

QUESTION	n = CORRECT ANSWER		n = WRONG ANSWER		MEAN (CORRECT ANSWERS) %		T-test Value (p-value)	Sign Rank-test (Difference between the pre-and post-tests) p-values
	Pre	Post	Pre	Post	Pre	Post		
1 Risk groups	381	616	254	19	60	97	.0102	<.0001
2 Factors	320	603	315	32	50	95	.0008	<.0001
3 Suction catheter	356	635	279	0	56	100	1.000	<.0001
4 Gloves	457	609	178	26	72	96	.3820	<.0001
5 Circuit condensate	298	631	337	4	47	99	.6525	<.0001
6 Antibiotics	425	632	210	3	67	100	.3125	<.0001
7 Suctioning	496	628	139	7	78	99	.1218	<.0001
8 Healthcare-associated infection	229	635	406	0	36	100	1.000	<.0001
9 HMEs	337	627	298	8	53	99	.0979	<.0001
10 Ventilator circuits	171	621	464	14	27	98	.0279	<.0001
11 Intubation	267	597	368	38	42	94	.0002	<.0001
12 Humidifiers	400	621	235	14	63	98	.0279	<.0001
13 Ventilator condensate	336	623	299	12	53	98	.0421	<.0001
14 Elevate head of bed	343	635	292	0	54	100	1.000	<.0001
15 Aspiration	470	635	165	0	74	100	1.000	<.0001
16 Pneumonia	235	633	400	2	37	100	.4099	<.0001
17 VAI	203	612	432	23	32	97	.0056	<.0001
18 Sputum specimen	292	631	343	4	46	99	.2432	<.0001
19 NG-feeds	286	616	349	19	45	97	.3741	<.0001
20 Information	139	608	496	27	22	96	.0021	<.0001

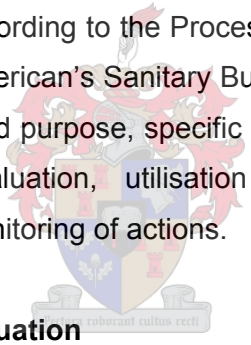
4.4.3 Phase Three

Implementation of the objective, to evaluate the implemented Learning Programme on the nursing care of adult mechanically ventilated patients **realised as follows:**

At each of the hospitals, ventilator-associated infections were tracked by the infection control specialists of that facility through prospective surveillance. All episodes of ventilator-associated infections are reported to a common database at the Infection Control Department of that hospital. The definitions of ventilator-associated infections used for surveillance are based on the Centre for Disease Control and prevention National Healthcare-associated Infection Surveillance definitions, and are shown in Table 4.5. Rates of ventilator-associated infections per 1 000 ventilator days were followed from June 2002 until November 2004 (see Figure 4.48).

4.4.3.1 Steps in the process of Impact Evaluation

This objective was implemented according to the Process of Impact Evaluation on Patient Outcomes described by the Pan American's Sanitary Bureau, Regional Office of the WHO (2000). Steps in the process included purpose, specific objectives, conceptual framework, methodology, organising the evaluation, utilisation of instruments, analysis and interpretation of findings and the monitoring of actions.



- **Purpose of the Impact Evaluation**

The ultimate purpose for the development and implementation of the Learning Programme was to improve outcomes for adult patients being mechanically ventilated by improving the knowledge base of nurses and medical staff.

- **Specific objectives of the Impact Evaluation**

The specific objectives identified for the impact evaluation to determine the changes in adult mechanically ventilated patients outcomes were identified as:

- To implement and evaluate a Learning Programme for nurses caring for adult patients attached to mechanical ventilators.
- To evaluate the effect of the implemented Learning Programme against adult mechanically ventilated patient outcomes.

Table 4.5. Definition of ventilator-associated infections for adults (Garner et al., 1996)

Group 1: Patient has rales or dullness to percussion on physical examination of the chest and at least one of the following:

- New onset of purulent sputum or change in character of sputum.
- Organisms isolated form blood culture.
- Isolation of pathogens from a specimen obtained by BAL, transtracheal aspirate, bronchial brushing or biopsy.

Group 2: Patient has a chest radiographic examination that shows new or progressive infiltrates, consolidation, cavitation, or pleural effusion that persists for >48 h at least one of the following:

- New onset of purulent sputum or change in character of sputum.
- Organisms isolated from blood culture.
- Isolation of pathogens from a specimen obtained by BAL, transtracheal aspirate, bronchial brushing or biopsy.
- Isolation of virus or detection of viral antigen in respiratory secretions.
- Diagnostic single antibody titre (IgM) or fourfold increase in paired sera (IgG) for pathogen.
- Histopathologic evidence of ventilator-associated infections / pneumonia

Group 3: Patient has a chest radiographic examination that shows new or progressive infiltrates, consolidation, cavitation, or pleural effusion that persists for >48 h and the following two criteria:

- Temperature > 38°C.
- WBC count > 10 000/μ L.

➢ Conceptual framework of the Impact Evaluation

The conceptual framework is defined according to the Evaluation Model, which included impact, process being implemented and the operational level.

- *Impact*

The impact is described as the analysis carried out to estimate to degree to which actions (Learning Programme) produced changes for the prevention of ventilator-associated infections. A pre- and post-test was done with a Learning Programme as the basis for analysis. Adult mechanically ventilated patient outcomes were monitored to determine the effect of the altered knowledge base of nurses on their clinical practice thus facilitating better patient outcomes.

- *Process*

The process utilised included analysis (see Sections 4.4.2.2) of action to produce changes. A statistical test, the Sign-Rank test, was utilised to analyse the process and the infection control nurses utilised a surveillance instrument based on the criteria as set out in Table 4.5.

- *Operational level*

The operational level is the level at which services are provided. In this research, the level is tertiary in intensive care units in two Australian hospitals and postgraduate nursing education (see Section 4.3).

Characteristics of the model for Impact Evaluation included:

- *Integration* which included of aspects of preventative, promotive, primary and tertiary health care, as addressed in the Learning Programme as well as the clinical nursing management of adult mechanically ventilated patients
- A multidisciplinary approach was followed. Participants in the impact evaluation included nurses and medical staff as the selected members of the health care team.
- The model is participatory by nature. Medical staff and nurses participated in the development and participation of the Learning Programme and the pre- and post-tests.

➢ **Methodology of the Impact Evaluation**

The methodology was aimed at:

- Discovering conditions influencing poor outcomes of adult mechanically ventilated patients and controlling and prevention of ventilator-associated infections (See Chapter 2 for the literature review). The methodology included policy decision, the evaluation group, responsibility, the evaluation process, components to be included and interviews to be conducted which is now described.

- Policy decision

Clinical policies for all health care personnel were established before commencement of the Learning Programme. The focus (specialist) group developed a policy as well as the Learning Programme for nurses caring for adult mechanically ventilated patients (see Section 4.4.1).

- Evaluation group

The evaluation group for the impact evaluation consisted of the researcher, medical staff and critical care nurses in the ICU and two infection control nurses who continuously evaluated the research as well as a statistician were responsible for the data analysis, by utilising the Sign Rank test.

- Responsibility

It was the researcher's responsibility to implement, collect and analyse the data for the impact evaluation. The infection control nurse practitioners were responsible for collecting the surveillance data for patients attached to mechanical ventilators.

- Evaluation process

The evaluation process took place from January 2005 until March 2005. The researcher, a statistician, two infection control nurses and two medical staff did the data analysis (see Table 4.6 for the time frame for the evaluation process).

- Components

Components included in the Impact Evaluation were:

- A focus (specialist) group to develop a policy and the Learning Programme
- Planning actions of **whom to target** (in this instance adult mechanically ventilated patients); **where it should happen** (the two targeted Australian hospitals), **when it should** (the exact timeframe had to be decided and was planned as shown in Table 4.6), **who will implement** (as the researcher initiated the research it was her responsibility to implement the process), **how it should be done** were collaboratively decided by the focus (specialist) group and are described in Section 4.1.1 of this chapter, and who should do the evaluation was collaboratively decided and included the researcher, infection control nurses and the statistician (see Section 3.5.2.1).

- Interviews

Permission was obtained for implementation and participation of the Learning Programme and the utilisation of patient data to evaluate the adult mechanically ventilated patient outcomes following the implementation of the Learning Programme

➢ **Organising an Impact Evaluation**

The researcher was responsible and accountable for this aspect, and permission was granted from the two different hospital authorities to conduct the research (see Table 4.6 for the timeframe).

Table 4.6: Time schedule for research

Pilot study	**June 2000 – December 2001**
Pre-intervention period	**June 2002 – December 2002**
Implementation of Learning Programme	**January 2003 – January 2004**
Post-intervention period	**February 2004 – November 2004**

To get started, the researcher contacted both infectious diseases departments and arranged meetings with the heads of the departments and the nurses involved in the data collection in the adult intensive care units. The project and the desired outcomes were discussed in detail and all parties were very interested in being part of this project. After obtaining permission from the infectious diseases departments, meetings were arranged with both ICU leadership teams. Leadership meetings were held weekly, so the researcher was asked to present the proposed study at these meetings. The leadership team consisted of all the intensivists working in these adult ICUs, the nurse managers, the associated nurse managers, the clinical teachers, the heads of the physiotherapy and occupational therapy departments and an infection control nurse, dedicated to the ICU.

A PowerPoint presentation was given at these meetings and the study was discussed in detail. After all questions regarding this study were answered satisfactory, the Director of the Intensive Care confirmed they are commitment to this study and the implementation thereof. Interested parties volunteered to be part of the focus (specialist) group (see Chapter 4 Section 4.4.1) and dates were set for regular meetings.

The Ethics application is an extensive document that consists of six modules. With the help of the focus groups, an ethics application was lodged in both hospitals. After several weeks, the ethics committees approved the study and the focus groups were informed. At the next focus group meeting, chores were allocated and a timeframe was established. Minutes were taken at all the focus group meetings for the researcher's records. Decisions were made/finalised after consensus has been established. In situations where a dispute evolved, both parties were given an opportunity to state their case by producing evidence in the form of current literature. After the debate a consensus where established and the change was implemented.

All relevant paperwork were photocopied and distributed to the participating ICUs. At the next ward meeting, the project was announced and everybody's cooperation was asked for this project. Everything was set and all parties were ready for the implementation of the study. The pre-tests were distributed and staff members got adequate time to complete it. After a few months, the Learning Programme was implemented and posters and flyers were distributed throughout both hospitals.

After the year of implementation of the Learning Programme, the post-tests were given to staff who had completed the pre-test and who had worked through the self-study module. Six months later, after the programme has finished, a questionnaire was distributed to all staff members who completed the pre- and post-tests, as well as worked through the self-study Learning Programme.

After all the information was received, a senior statistician at one of the hospitals was asked to help with the processing and evaluation of the results. The results were discussed at the focus group meetings and it was decided to incorporate the Learning Programme in the intensive care nursing course. It was also decided that the results would be published in the form of an article in a relevant medical journal.

- **Utilisation of instruments**

The following instruments (see Appendices 2-4 and 9) were developed and utilised:

- a Learning Programme (see Section 4.4.1).
- a pre- and post-test (see Section 4.4.2).
- an evaluation instrument for the Learning Programme (see Section 4.4.2).
- a surveillance instrument for collecting patient data (see Table 4.5). As the researcher

did not have permission to publish the instrument, only the criteria as set out in Table 4.5 are available.

Two infection control nurses in each of the participating hospitals gathered the infection rates on a daily bases by means of a structured surveillance instrument based on the criteria in Table 4.5, as noted in the patient's notes and adult ICU charts. Data was sent to the researcher on a monthly basis and infection rates where also discussed during the focus (specialist) group meetings.

- **Analysis and interpretation of findings**

A statistician utilised the Sign-Rank test and assisted the researcher with the data analysis (see sections 4.4.2 of this chapter for the analysis and interpretation of the findings) for the pre-and post-test for nurses. All patients who acquired a healthcare-associated respiratory infection while on mechanical support (by endotracheal tube or tracheostomy) for greater than or equal to 48 hours, during the given timeframes, and that was admitted in the participating adult ICUs, were included in this research.

In Figure 4.48 the ventilator-associated infection rates are summarised by quarterly reviews that was done. Data was obtained from the Infection Control departments of the two participating hospitals. The graph shows Quarterly rates from January 2002 till June 2005.

During 2002, the year before the intervention, the overall ventilator-associated infection rate for both hospitals combined was 8.75/1000 ventilated days (See section 3.5.2.1.ii for calculation details and Figure 4.48). The intervention was introduced and completely implemented during 2003 and the combined annual rate during that year did not change significantly (7.81/1000 ventilator days, $p= 0.161$). In the 10 months after the intervention was completed (February 2004 through to the end of November 2004), the overall rate dropped to 4.74/1000 ventilator days ($p< 0.001$). Both hospitals had a statistically significant drop in their ventilator-associated infection rates from the pre-intervention year to the post-intervention period (see Figure 4.47).

The results revealed an improvement in patient outcomes after implementation of a structured Learning Programme directed at nursing and medical staff working with adult ventilated

patients in an ICU thus decreasing the incidence of ventilator-associated infections. Results at both participating hospitals supported the positive patient outcomes. Decreases in ventilator-associated infection rates ranged from 53.3% to 60.7%. The results suggest that participation by medical and nursing staff and incorporation of the self-study Learning Programme into mandatory competency training for staff are important for reducing ventilator-associated infection rates. These findings suggest that the intervention improved ventilator management and care, rather than eliminating a particular healthcare-associated reservoir of infection. In this research, the educational intervention that is the Learning Programme, facilitated the prevention of a large number of lower respiratory tract infections, and saved an estimated $525 000 in one of the selected hospitals.

The null hypothesis, that there is no difference in the adult mechanically ventilated patient outcomes following the implementation of the Learning Programme for nurses, is rejected and the alternative hypothesis, that there is a difference in adult mechanically ventilated patient outcomes following the implementation of the Learning Programme for nurses, is thus supported.

- **Monitoring timetable of action for the Impact Evaluation.**

Table 4.47 gives an overview of the timeframe in this research.

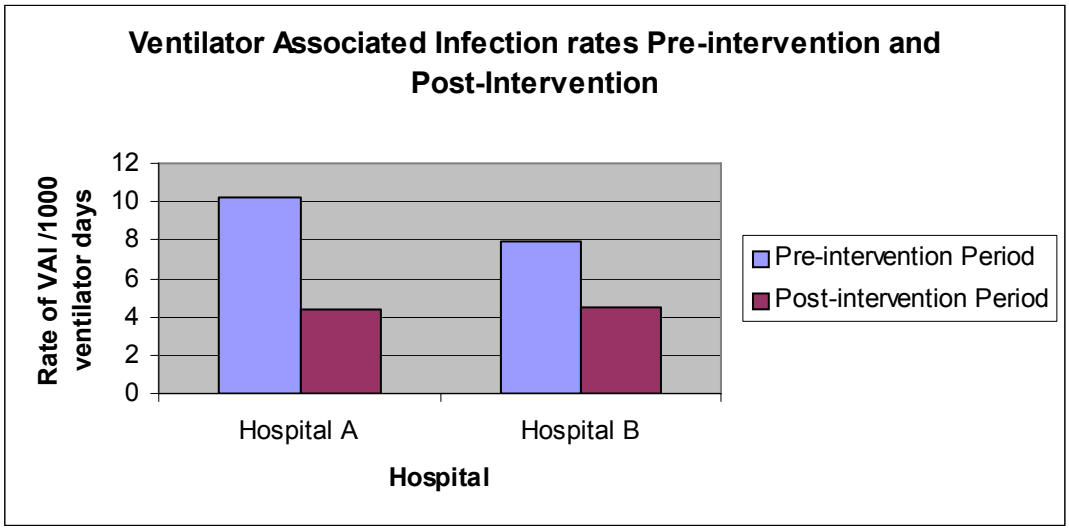


Figure 4.47: Ventilator-associated infection rates pre-intervention and post-intervention for the different hospitals (February 2004 to November 2004)

- **4.4.3.2 Calculation of ventilator-associated infection rate in ICU per 1000 ventilator days**

In Section 3.5.2.1.ii, the process for the calculation of ventilator-associated rates is described as utilised by the two infection control nurses in their calculation of the incidence of VAI in the two specific hospitals.

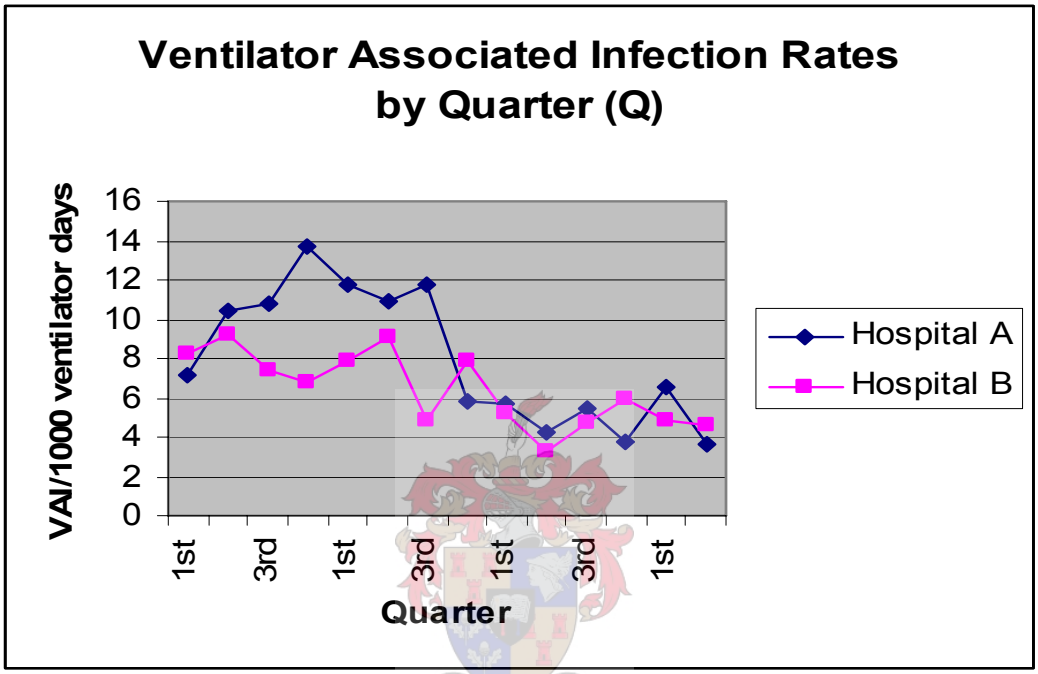


Figure 4.48: Ventilator-associated infection rates by quarter (January 2002 to June 2005)

4.5 SUMMARY

Healthcare-associated infections are common causes of excess morbidity and hospital costs among patients requiring intensive care. Ventilator-associated infections have been associated with excess attributable mortality in several well-controlled studies, as well as significant attributable costs. These studies, as well as several risk factor intervention studies, suggest that prevention of these healthcare-associated infections could improve patient outcome (Richards, Edwards, Culver & Gaynes, 1999:887-892).

Prevention of healthcare-associated (hospital-acquired infections), including ventilator-associated infections, is advocated as an important management objective for all hospitals. Several reviews have outlined the available strategies to prevent ventilator-associated infections that have been effective. However, other studies suggest that these interventions

are not being widely implemented. The most common reasons for non-adherence were disagreement with the interpretation of clinical trials (35.0%), lack of resources (31,3%) and costs associated with the implementation of specific interventions (16,9%) (CDC Guidelines, 2004:1-77).

A Learning Programme provides another strategy for preventing healthcare-associated infections. The results have shown that the implementation of a Learning Programme to prevent healthcare-associated infections in adult mechanically ventilated patients can result in cost savings, which can justify the initial investment required for the development and implementation of such interventions.

In Chapter 5, the synthesis, conclusions and recommendations of the research are described.

CHAPTER 5
SYNTHESIS, CONCLUSIONS AND RECOMMENDATIONS

5.1. INTRODUCTION

In Chapter 1 the introduction, overview and the problem statement of the research were described. Chapter 2 dealt with the literature research, which included the pathogenesis of ventilator-associated infections, the diagnostic criteria, the mechanisms of infection, strategies for prevention of ventilator-associated infections and nursing education. In Chapter 3, the research design, research methodology and the development of a Learning Programme were described. Chapter 4 includes the data presentation, analysis and interpretation of results. In this chapter, the synthesis, conclusions, limitations and recommendations were also described.

A pilot research was done during 2001 and guidelines were proposed for the prevention and control of ventilator-associated infections. From June to December 2002, guidelines were updated (see Chapter 2 for the literature review) in order to establish objectives and the content for the Learning Programme. A focus (specialist) group finalised the Learning Programme and this was approved by the two selected tertiary hospitals in Australia. The Learning Programme was implemented between January 2003 and January 2004. The results clearly indicated the pre- vs. post-test improvement of the nurses' knowledge with regard to VAI. The impact evaluation revealed the improvement of mechanically ventilated patient outcomes following the nurses' improvement in their knowledge of VAI.

5.2 SYNTHESIS OF THE RESEARCH

Despite the large progress in medical treatment over the past 40 years, the incidence and case fatality rates of health-care- ventilator-associated infections remain high. Older patients generally have more severe underlying diseases and greater exposure to medical practices that increase colonisation with health-care-associated pathogens. Ventilator-associated infections contribute to 60 % of the fatal infections in the intensive care and are the leading cause of death for health-care-associated infections (APIC, 2000:23). The synthesis of the research is described according to the rationale and goal.

5.2.1 RATIONALE

Considerable intensive care resources are consumed in the treatment of ventilator-associated infections. Not only economic costs, but expenditure of staff energies, physical resources, treatment expenses and admission to the intensive care unit, which can be more productively utilised in the preventative area. Mechanically ventilated patients, due to the association with artificial airways, have been accompanied by an assortment of micro- organisms in the respiratory tract, leading to colonisation and infection (Bonten, Kollef & Hall, 2004:1141-1149).

The increased costs of extended intensive care stay and antibiotic treatment regimens, even for survivors, are rarely fully reimbursed by medical insurances. Funds have the potential to reduce significantly throughout the stay of ventilated patients in the intensive care unit due to the high costs and specialised nursing and medical care (Collard, Saint & Matthay, 2003:494).

More patients die from ventilator-associated infections than from any other health-care-related infection (Kollef, 2005:714-721). Ventilator-associated infections have been a major complication for years and although guidelines have been published, the researcher has found that no formal learning programme for nurses, to address active prevention of ventilator-associated infections. Enquiries to the effect were also negative. Through prevention of VAI in mechanically ventilated patients' outcomes can be improved and costs can be drastically reduced (see Chapter Section 4.5) and therefore it became imperative for the researcher to develop a Learning Programme for nurses to facilitate better outcomes for adult patients being mechanically ventilated.

5.2.2. GOAL OF THE RESEARCH

The research goal was to establish and evaluate a Learning Programme for nurses caring for adult ventilated patients with VAI in an ICU. Objectives were formulated to structure the realisation of the goal. The objectives of the research were thus divided into three phases, according to the research questions and strategy (see Chapter Sections 1.2,1.3,1.4 and 1.5 for the research questions, objectives and hypotheses). The research questions are also given under the three phases below and the strategies implemented to answer the questions are also described in the following phases.

5.2.2.1 Phase One

This phase was based on the research question, namely "*What should the contents of a Learning Programme for nurses caring for mechanically ventilated adult patients with VAI in an intensive care unit be?"* and objectives supporting this for the development of the Learning Programme.

Evidenced-based literature on the above concepts was utilised by the researcher and deductively implemented by the focus (specialist group) to develop the Learning Programme. The contents and validation of the Learning Programme was thus decided by the focus (specialist group), and an expert in infection control nursing and education (see Chapter 2 for the literature review, Chapter Section 4.4.1 for the design and validation and Chapter 3 for the population sample in Section 3.5.2.5, Target population). No hypothesis was formulated for this phase of the research (see also Appendix 3 for the Learning Programme).

5.2.2.2 Phase Two

This phase was based on the research questions pertaining to pre-and post-test knowledge of nurses regarding ventilator-associated infections and the effectiveness of the Learning Programme (see also Sections 1.2 and 1.4). A one group pre-test post-test for nurses was utilised in realising the objectives and answering the research question for this phase (see Chapter 3 Section 3.5.2.1 and also Chapter 4 Section 4.4.2). The Signed-Rank test was utilised to analyse the data for the pre-and post-tests. To pass the post-test, a minimum of 80% was required (four wrong answers only). The overall pass rate for the post-test was 98.9% (n=628), and only 0.79% of respondents answered incorrectly in the pre-test. Overall only 1.1% of the nurses (n=7) scored less than 80% in the post-test. Nobody scored less than 50% (more than 10 wrong answers) for the post-test, in comparison to the 37% (n=241) of nurses who scored less than 50% in the pre-test. In Table 4.4, a comparison is given of the results of the pre- and post-tests.

A partially explanatory method was utilised to analyse the evaluation data for the questionnaire for the Learning Programme. The null hypothesis, namely there is no difference in the knowledge base of nurses after the implementation of the Learning Programme, was rejected and the alternative hypothesis, there is a difference in the knowledge base of nurses following the implementation of the Learning Programme, was supported. Results also revealed the need for a Learning Programme for nurses caring for adult patients being mechanically ventilated.

5.2.2.3 Phase Three

This phase was based on the question "What difference did the Learning Programme make to the clinical practice of nurses thus affecting mechanically ventilated patient outcomes?" and objectives included an impact evaluation to determine the difference. The ultimate purpose for the development and implementation of the Learning Programme was to improve outcomes for patients being mechanically ventilated by improving the knowledge base of nurses. To realise this phase of the research, the WHO Process of Impact Evaluation was utilised (see Chapter 4 Section 4.4.3).

Adult patient outcomes were monitored and evaluated over a two and a half year period and revealed a change in the reduction of ventilator-associated infections. The null hypothesis, namely there is no difference in the adult patient outcomes following the implementation of the Learning Programme for nurses, was thus rejected and the alternative hypothesis, namely there is a difference in adult patient outcomes following the implementation of the Learning Programme for nurses, was supported.

5.3 LIMITATIONS

The use of additional educational materials may also have resulted in other changes in behaviour, in addition to or instead of the directly related to the Learning Programme, which could have accounted for the results. Although this is possible, the end result of a reduction in the rate of ventilator-associated infections appears to be associated with the implementation of this Learning Programme. Therefore, the goal of decreasing infections was accomplished.

There was no record keeping and comparison of nurses taking the Learning Programme versus the in-service sessions and how this may have influenced the overall success of the intervention.

5.4 CONCLUSIONS

It was thus clear from numerous literature reviews done over an extensive period of time, that there was no formal or existing programme to prevent and or minimise ventilator-associated infections. In formal critical care courses in Australia, infection control issues are included in the curriculum, but no detailed attention is given to specifics like VAI (Australian Nurses Federation, 1997).

Nurses were tested before the implementation of the Learning Programme and the pre-test revealed that nurses had inadequate knowledge with regard to the prevention of ventilator-associated infections. The overall pass rate in the pre-test was 0.79% (n = 5). Only 62.2% scored between 50 - 79% (that is 5 -10 wrong answers), and 37% (n=241) scored between 0 - 49%, that is more than 10 answers wrong, which is not acceptable for the nursing management of mechanically ventilated patients in the intensive care unit (for the results please refer to Section 4.4.2). The post-test scores for nurses as regards the prevention of ventilator-associated infections revealed a significant improvement in their scores, thus the conclusion could be made that the concepts included in the Learning Programme were conducive to enhance the knowledge base of nurses caring for mechanically ventilated adult patients. Quality nursing care is based on standards. The foundation of standards is the nurse's scientific and experiential knowledge.

Respondents were in favour of a Learning Programme for the prevention of VAI in mechanically ventilated adult patients and suggested the concepts included in the Learning Programme be included in the critical care courses offered by the universities (see Section 4.4.2 for the evaluation of the Learning Programme and Appendix 9 for the questionnaire).

During 2002, the year before the intervention, the overall ventilator-associated infection rate for adult patients for both hospitals combined was 8.75/1000 ventilated days (see Section 3.5.2.1 Phase Three for calculation details). The intervention was introduced and completely implemented during 2003 and the combined annual rate during that year did not change significantly (7.81/1000 ventilator days, p= 0.161). In the 10 months after the intervention was completed (February 2004 through to the end of November 2004), the overall rate dropped to 4.74/1000 ventilator days (p< 0.001). Both hospitals had a statistically significant drop in their ventilator-associated infection rates from the pre-intervention year to the post-intervention period (see Figure 4.47 and 4.48).

The need to reduce ventilator-associated infections in adult mechanically ventilated patients is imperative and the results in Phases Two and Three clearly indicated the success of the Learning Programme (see also Section 1.2). It was evident from the scores in the pre-test that nurses had a knowledge deficit with regard to the prevention of VAI and the Impact Evaluation done according to the WHO Guidelines revealed a reduction in ventilator-associated infections following the implementation of the Learning Programme (see Chapter 4 Section 4.4.3 and Table 5.1).

5.5 RECOMMENDATIONS

Recommendations for the research are based on the four domains of nursing practice: clinical nursing, nursing management, nursing education and future research (see Table 5.1).

5.5.1. Recommendations for clinical nursing practice and nursing management

5.5.1.1 Quality improvement programme

Based on recommendations by the Australian Government (see Section 1.2, Section 2.4.5.1 and Section 5.4), quality improvement programmes should be regarded as essential for improving health care (Acute Health Division, 1998).

- It is thus recommended that a performance (quality) improvement programme be implemented in the critical care unit. Utilise the **P**(Plan) **D**(Do) **S**(Study) **A**(Act) process, for instance (Kerridge & Kerridge, 2000)(see website in Reference Section)).

5.5.1.2 Patient/nurse compliance instrument

To support the quality improvement programme in 5.5.1.1 (see Section 4.4.3)

- It is furthermore recommended a patient/nurse compliance instrument be developed to measure compliance with the identified risk factors for ventilated patients and should include at least:
    - patient biographical data;
    - day number in the intensive care unit;
    - medical/surgical history;
    - physical assessment;
    - specific concepts as well as risk factors;
    - goals set for the patient; and
    - tests/procedures/consultations/laboratory investigations.

(see website for details of the instrument)(Institute for Healthcare Improvement, 2005).

Table 5.1: Summary of conclusions, text reference and recommendations

CONCLUSION	TEXT REFERENCE	RECOMMENDATION
Management and clinical practice • Poor quality of nursing practice due to VAI knowledge deficit	• 1.2 & 2.4.5.1 • Table 4.4 • Figure 4.47 • Figure 4.48	• Improvement of quality of practice. • Patient/ nurse compliance instrument to support quality improvement project
Education • No formal programme for VAI • Poor knowledge of VAI • Maintain competency on VAI	• 1.2 • Table 4.4 & 4.4.2.1 • Table 4.4 & 4.4.2.1 & 4.4.2.2	• Implement in critical care courses. • Include in orientation programme. • Design an on-line competency based practice programme.
Research • Improvement of patient outcomes • Maintenance of competencies	• 1.2 • Figure 4.4.7 • Figure 4.4.8 • Table 4.4 • Section 4.4.2.1	• Performance improvement project to improve patient outcomes. • Continuous monitoring with a patient/ nurse compliance instrument • On-line competency-based programme

5.5.2 Recommendations for nursing education

For nursing education, recommendations are based on non-formal and formal education.

5.5.2.1 Non-formal Education

Non-formal education should include aspects of continuous professional development, e.g. orientation, in-service and competency-based clinical practice.

It is recommended that the Learning Programme on the prevention of ventilator-associated infections, be included in the orientation programme of all critical care nursing staff based on the inadequate knowledge in the pre-test (see Table 4.4 for a comparison of the pre and post-test results and Section 4.4.2 for the evaluation of the Learning Programme and Appendix 9 for the questionnaire).

- In addition, to maintain competency on the prevention of ventilator-associated infections it is recommended to design an on-line competency-based programme for nursing staff on prevention and treatment of ventilator-associated infections (see Table 4.4 for a comparison of the pre and post-test results).

5.5.2.2 Formal Education

Recommendations for formal nursing education are based on the results as revealed in Chapter 4 Section 4.4.2 & 4.4.3. It is therefore recommended that the learning content of the Learning Programme be included in the curriculum of the Critical Nursing Care Course.

5.5.3 Recommendations for nursing research

Recommendations for future nursing research are based on the following hypotheses

- A performance improvement project based on the prevention and or elimination of ventilator-associated infections will improve patient outcomes.
- The continuous monitoring by means of a patient-nurse compliance instrument will facilitate the elimination and or reduction of ventilator-associated infections.
- An on-line competency-based Learning Programme addressing the prevention of VAI, will facilitate improved patient outcomes.

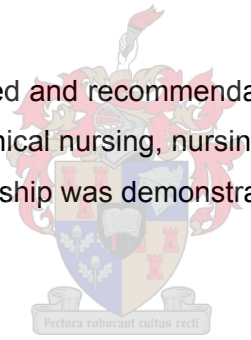
5.6 FINAL SUMMARY

The goal of the research was to establish a Learning Programme for staff working with adult ventilated patients in an ICU and to evaluate this programme once established. A quantitative approach was implemented and the research was conducted in three phases. Phase One consisted of the development of the Learning Programme, Phase Two entailed a pre-and post-test to determine nurses' knowledge with regard to adult patients being mechanically ventilated and evaluation of the implemented Learning Programme, and the last phase included an impact evaluation of the Learning Programme on patient outcomes. The Learning Programme was successfully implemented in two tertiary teaching hospitals in Australia and was also evaluated accordingly. The pre-test revealed

that nurses had a great knowledge deficit with regard to ventilator-associated infections. The Signed-Rank test was utilised in the pre-and post-test and showed a significant improvement of nurses' knowledge following implementation of the Learning Programme. The feedback received from the completed questionnaires of nursing staff that followed the Learning Programme, indicated the usefulness and value of the Learning Programme.

The infection control surveillance statistics were also complementing the feedback indicating a significant reduction in ventilator-associated infection rates. The uniqueness of the research lies in the fact that this was the first time such a programme had been established and implemented in two Australian hospitals. It had been evaluated and accepted by members of the multidisciplinary team with the specific goal to prevent ventilator-associated infections. The fact that the programme had a positive effect on outcomes of patients being mechanically ventilated also contributed to the uniqueness of the research.

All research questions were answered and recommendations were made according to the four domains in nursing practice: clinical nursing, nursing management, nursing education and future research and thus scholarship was demonstrated.



REFERENCES

Abdellah, FG & Levine, E. 1979. Better Patient Care through Nursing Research. Second Edition. New York: MacMillan Publishing, in H.M.M. Uys, & AA. Basson (Eds.). (1895). *Research Methodology in Nursing*. Pretoria: Kagiso.

Acute Health Division: Department of Human Services, 1998. *Infection control – Literature Review* [Online] Available: http://www.health.vic.gov.au/infcon/infcon/surv.htm [Accessed: 2005-07-02].

Ahmed, J, Brutus, A, D'Amato, RF & Glatt, AE. 1994. *Acinetobacter calcoaceticus anitratus* outbreak in the intensive care unit traced to a peak flow meter. *American Journal of Infection Control*, 22:319-321.

American College of Chest Physicians/Society of Critical Care Medicine Consensus Conference. 1992. Definition of Sepsis and Organ Failure and guidelines for the use of innovative therapy in sepsis. *Chest,* 20:864-874.

American Nurses Association. 2000. *Scope and standards of practice for nursing professional development.* Washington: Author.

American Society for Anesthesiologists. 1991. *Prevention of nosocomial infections in patients: recommendations for Infection Control for the Practice of Anesthesiology.* Park Ridge, Illinois: American Society of Anesthesiologists.

American Thoracic Society, 1996. Hospital-acquired pneumonia in adults: diagnosis, assessment of severity, initial antimicrobial therapy and preventive strategies. A consensus statement, American Thoracic Society, November 1995. *American Journal of Respiratory and Critical Care Medicine.* May; 153(5):1711-1725. Review.

APIC (Association for Professionals in Infection Control). 2000. *Guidelines.* [Online] Available: http://www.apic.org/AM/Template.cfm?Section=Guidelines&Template=/TaggedPage/TaggedPageDisplay.cfm&TPLID=6&ContentID=519 [Accessed: 2002-08-23]

Arnow, PM, Chou, T, Weil, D, Shapiro, EN & Kretzschmar, C. 1982. Nosocomial Legionnaires' disease caused by aerosolized tap water from respiratory devices. *Journal of Infectious Diseases*, 146:460-467.

Australian Nursing Council. 2003. 4th Meeting of the Regulatory Authorities from the Western Pacific and South East Asian Regions: Minimum Core Competencies to Standards of Practice, Issues and Challenges 21-26 November 2002. Canberra: ANC.

Babcock, HM, Zack, JE, Garrison, T, Trovillion, E, Jones, M, Fraser, VJ & Kollef MH. 2004. An Educational Intervention to Reduce Ventilator Associated Pneumonia in an Integrated Health System, *Chest* 125:2224-2231.

Bengtson, JP, Brandberg, A, Brinkhoff, B, Sonander, H & Stenqvist, O. 1989. Low-flow anesthesia does not increase the risk of microbial contamination through the circle absorber system. *ACTA Anaesthesiologica Scandinavica*, 33:89-92.

Bergmans, DC, Bonten, MJ, Gaillard, CA, Paling, JC, van der Geest, S, van Tiel, FH, Beysens, AJ, de Leeuw, PW & Stobberingh, EE. 2001. Prevention of ventilator-associated pneumonia by oral decontamination: a prospective, randomized, double-blind, placebo-controlled study. *American Journal of Respiratory and Critical Care Medicine*. August 1; 164(3):382-388.

Bevis, EO & Watson, J. 2000. Toward a caring curriculum: a new pedagogy for nursing. National League for Nursing, New York.

Biology-Online, 2005. *Dictionary.* [Online] Available: http://www.biology-online.org/dictionary/community-acquired_infections [Assessed 2005-02-16].

Black, PJ. 1998. Testing: Friend or Foe? Theory and Practice of Assessment and Testing. London, Falmer Press.

Bonten, MJM, Kollef, MH & Hall, JB. 2004. Risk Factors for Ventilator-Associated Pneumonia: From Epidemiology to Patient Management; *Clinical Infectious Diseases,* 38:1141-1149.

Botes, A. 1995. The operationalization of a research model in a qualitative methodology. RAUCUR, 1(1):4-9.

Botes, A. 1998. A model for research in nursing. In Rand Afrikaans University (Ed). Department of nursing paradigm: vision and mission statement, theory for health promotion in nursing, research model in nursing. Johannesburg: Rand Afrikaans University.

Botes, A. 2000. A model for research in nursing. In Rand Afrikaans University (Ed). Department of nursing paradigm: vision and mission statement, theory for health promotion in nursing, research model in nursing. Johannesburg: Rand Afrikaans University.

Bowman, WE. 2001. The Evaluation of an Accreditation Programme for quality improvement in private physiotherapy practice in South Africa. Unpublished doctoral dissertation. Cape Town: University of Stellenbosch [University of Stellenbosch].

Brunner & Suddarth's Textbook of medical-surgical nursing/ [edited by] Suzanne C. Smeltzer, Brenda G. Bare. 1996. 8th Edition. Philadelphia: Lippincott.

Burns, N & Grove, SK. 2001. The Practice of Nursing Research: Conduct, Critique & Utilisation. Philadelphia: W.B. Saunders.

Carlucci, A, Richard, JC, Wysocki, M, Lepage, E, Brochard, L & SRLF Collaborative Group on Mechanical Ventilation. 2001. Non-invasive versus conventional mechanical ventilation. An epidemiologic survey. *American Journal of Respiratory Critical Care Medicine,* 163(4): 874-880.

Cavana, RY, Delahaye, BL & Sekaran, U. 2001. Applied Business Research: Qualitative and Quantitative Methods. Australia: John Wiley.

CDC Guidelines.2004. MMWR March 36; 53 (RR-3):1-179.

CDC. 2002. Guidelines for hand hygiene in health-care settings. MMWR; 51 (No. RR-16).

CDC, 2003a. MMWR: 53 (RR03);1-36.March 26, 2004 / 53(RR03);1-6March 26, 2004 / 53(RR03);1-36March 26, 2004 / 53(RR03);1-36.

CDC. 2003b. Guidelines for environmental control in health-care facilities. MMWR; 52 (No.RR-10).

CDC. 2003c. *NNIS criteria for determining nosocomial pneumonia*. Atlanta, GA: U.S. Department of Health and Human Services.

Celis, R, Torres, A, Gatell, JM, Almela, M, Rodriguez-Roisin, R & Agusti-Vidal, A. 1988. Nosocomial pneumonia. A multivariate analysis of risk and prognosis. *Chest.* February; 93(2):318-324.

Centres for Disease Control and Prevention - Federal Government Agency [U.S.]. 2004. *Guidelines for preventing health-care--associated pneumonia, 2003: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee;* Mar 26:1685-1688.

Centres for Disease Control and Prevention, US. Department of Health and Human Services. 1997. Guidelines for prevention of nosocomial pneumonia. MMWR *Morbidity and Mortality Weekly Report: MMWR*, 46:1-77.

Chastre, J & Fagon, JY. 2002. Ventilator-associated Pneumonia. *American Journal of Respiratory and Critical Care Medicine*, Volume 165, Number 7, April: 867-903.

Clifford, C. 1999. The clinical role of the nurse teacher: a conceptual framework. *Journal of Advanced Nursing*, 30:179–185.

Coates, VE & Gormley, E. 1997. Learning the practice of nursing: views about preceptorship. *Nurse Education Today,* 17(2): 91-98.

Collard, HR, Saint, S & Matthay, MA. 2003. Prevention of ventilator associated pneumonia: An evidence-based systematic review. *Annals of Internal Medicine*, 138:494-501.

Combes, P, Fauvage, B and Oleyer, C. 2000. Nosocomial pnemonia in mechanically ventilated patients: a prospective randomized evaluation of the Stericath closed suctioning system. *Intensive Care Medicine*, 26:878-882.

Cook, TD & Campbell, DT. 1979. *Quasi-experimentation: Design and Analysis Issues for Field Setting.* Chicago, Rand McNally.

Craven, DE & Steger, KA. 1995a. Epidemiology of nosocomial pneumonia. New perspectives on an old disease. *Chest.* August; 108(2): 1S-16S.

Craven, DE & Steger, KA. 1995b. Nosocomial pneumonia in mechanically ventilated adult patients: epidemiology and prevention in 1995. *Seminars in Respiratory Infections,* In Press.

Craven, DE, De Rosa, FG & Thornton, D. 2002. Nosocomial pneumonia: emerging concepts in diagnosis, management and prophylaxis. *Current Opinion in Critical Care.* October; 8(5): 421-429.

Craven, DE, Goularte, TA & Make, BJ. 1984. Contaminated condensate in mechanical ventilator circuits: a risk factor for nosocomial pneumonia? *American Review of Respiratory Disease*, 129:625-628.

Craven, DE, Lichtenberg, DA, Goularte, TA, Make BJ & McCabe, WR. 1984. Contaminated medication nebulizers in mechanical ventilation circuits. Source of bacterial aerosols. *American Journal of Medicine*, 77:834-838.

Dale, BA & Williams, J. 1986. *Pseudomonas paucimobilis* contamination of cool mist tents on a paediatric ward. *Journal of Hospital Infections,* March; 7(2):189-192.

Daumal, F, Colpart, E, Manoury, B, Mariani, M & Daumal, M. 1999. Changing heat and moisture exchangers every 48 hours does not increase the incidence of nosocomial pneumonia. *Infection Control and Hospital Epidemiology*, 20:347-349.

Davalos, MD, Ricart, W, Gonzalez-Huix, F, Soler, S, Marrugat, J, Molins, A, Suner, R & Genis, D. 1996. Effect of malnutrition after acute stroke on clinical outcome. *American Heart Association*, 27:1028-1032.

Davoric, GO. 1995. Haemodynamic monitoring: Invasive and Non-invasive Clinical Application. Philadelphia: W.B. Saunders.

Denzin, NK & Lincoln, YS. 1998a. *Collecting and Interpreting Qualitative Materials.* London: Sage Publications.

Denzin, NK & Lincoln, YS. 1998b. *The Landscape of Qualitative Research: Theories and Issues.* London: Sage Publications.

DePoy, E & Gitlin, LN. 1998. Introduction to Research, Mosby, USA

DeRiso, AJII, Ladowski, JS, Dillon, TA, Justice, JW & Peterson, AC. 1996. Chlorhexidine gluconate 0.12% oral rinse reduces the incidence of total nosocomial respiratory infections and non-prophylactic antibiotic use in patients undergoing heart surgery. *Chest*, 109:1556-1561.

Dorland, WAN. 2000. *Dorland's illustrated medical dictionary, 29th Edition.* Philadelphia: Saunders

Drakulovic, MB, Torres, A, Bauer, TT, Nicolas, JM, Nogue, S & Ferrer, M. 1999. Supine body position as a risk factor for nosocomial pneumonia in mechanically ventilated patients: a randomised trial. *Lancet*, November, 27; 354 (9193):851-1858.

Du Moulin, GC & Sauberman, AJ. 1977. The anesthesia machine and circle system are not likely to be sources of bacterial contamination. *Anesthesiology,* 47:353-358.

Duffy, K & Watson, HE. 2001. An interpretive study of the nurse teacher's role in practice placement areas. *Nurse Education Today*, 21:551–558.

Fagon, JY, Chastre, J, Hance, AJ, Montravers, P, Novara, A & Gibert, C. 1993. Nosocomial pneumonia in ventilated patients: a cohort study evaluating attributable mortality and hospital stay. *American Journal of Medicine*. March; 94(3):281-288.

Fairbrother, P & Ford, S. 1998. Lecturer practitioners: a literature review. *Journal of Advanced Nursing.* February; 27(2):274-279.

Favero, MS & Bond, WW. 1991. Clinical disinfection of medical and surgical materials. In: Block S, ed. Disinfection, sterilization, and preservation. Philadelphia, PA: Lea and Febiger.

Fayon, MJ, Tucci, M, Lacroix, J, Farrel, CA, Gauthier, M, Lafleur, L & Nadeau, D. 1997. Nosocomial pneumonia and tracheitis in a paediatric intensive care unit: a prospective study. *American Journal of Respiratory and Critical Care Medicine.* January; 155(1):162-169.

Ferguson, KE & Jinks, AM. 1994. Integrating what is taught with what is practised in the nursing curriculum: a multi-dimensional model. *Journal of Advanced Nursing.* October; 20(4): 687-695. Review.

Ferrer, M, Bauer, TT, Torres, A, Hernandez, C & Piera, C. 1999. Effect of nasogastric tube size on gastroesophageal reflux and microaspiration in intubated patients. *Annals of Internal Medicine*, 130:991-994.

Fink, JB, Krause, SA, Barrett, L, Schaaff, D & Alex, CG. 1998. Extending ventilator circuit change interval beyond 2 days reduces the likelihood of ventilator-associated pneumonia. *Chest*, 113:405-411.

Food and Drug Administration (FDA). 2000. Enforcement priorities for single-use devices reprocessed by third parties and hospitals. Rockville, MD: US DHHS.

Garner, JS, Jarvis, WR, Emori, TG, Horan, TC & Hughes, JM. 2004. CDC Definitions for Nosocomial Infections. APIC Infection Control and Applied Epidemiology: Principles and Practice. St. Louis: Mosby; 1996: A-1--A-20.

Garner, JS. 1996. Guideline for isolation precautions in hospitals: the Hospital Infection Control Practices Advisory Committee. *Infection Control and Hospital Epidemiology*, 17:53-80.

Gaynes, R, Richards, C, Edwards, J, Emori, TG, Horan, T, Alonso-Echanove, J, Fridkin, S, Lawton, R, Peavy, G & Tolson, J. 2001. Feeding back surveillance data to prevent hospital-acquired infections. *Emerging Infectious Diseases,* March – April; 7(2):295-298.

Gaynes, RP & Horan, TC. 1999. Surveillance of nosocomial infections, in CG Mayhall (ed.). *Hospital epidemiology and infection control*. 2nd edn. Philadelphia; Lippincott Williams and Wilkens:1285-331.

Gaynes, RP & Solomon, S. 1996. Improving hospital-acquired infection rates: the CDC experience. *Joint Commission Journal on Quality Improvement*, 22:457-467.

Gennari, R & Alexander, JW. 1997. Arginine, glutamine and dehydroepiandrosterone reverse the immunosuppressive effect of prednisone during gut-derived sepsis. *Critical Care Medicine.* July; 25(7):1207-1214.

Girot, E. 2001. Nurse Eduction in the new millennium. A review of current reports. *British Journal of Perioperative Nursing.* August; 11(8): 352-361.

Girou, E, Schortgen, F, Delcaux, C, Brun-Buisson, C, Blot, F, Lefort, Y, Lemaire, F & Brochard, L. 2000. Association of noninvasive ventilation with nosocomial infections and survival in critically ill patients. *The Journal of the American Medical Association (JAMA).* November 8; 284(18):2361-2367.

Glen, S & Clarke, A. 1999. Nurse Education: a sill mix for the future. *Nurse Eduction Today.* January; 19(1):12-19.

Glupczynski, Y. 2001. Usefulness of bacteriologic surveillance cultures for monitoring infection in hospitalized patients. *ACTA Clinica Belgica*, 56:38-45.

Goldmann, DA, Weinstein, RA, Wenzel, RP, Tablan, OC, Duma, RJ, Gaynes, RP, Schlosser, J & Martone, WJ. 1996. Strategies to prevent and control the emergence and spread of antimicrobial-resistant micro-organisms in hospitals: a challenge to hospital leadership. *The Journal of the American Medical Association (JAMA)*. January 27; 275(3):234-240. Review.

Gonzales, R, Bartlett, JG, Besser, RE, Cooper, RJ, Hickner, JM, Hoffman JR & Sande, M. 2001. Principles of antibiotic use for treatment of acute respiratory tract infections in adults: Background, specific aims and methods. *Annals of Internal Medicine*, 134:479-486.

Grossman RF & Fein A. 2000. *Evidence-based assessment of diagnostic tests for ventilator-associated pneumonia.* Executive summary. *Chest.* Apr;117(4 Suppl 2): 177S-181S. [Online] Available: http://www.guideline.gov/summary/summary.aspx?ss15&doc_id=2718&nbr=194

[Accessed: 2002-07-13].

Gruson, D, Hilbert, G, Vargas F, Valentino, R, Bebear, C, Allery, A, Bebear, C, Gbikpi-Benissan, G & Cardinaud, JP. 2000. Rotation and restricted use of antibiotics in a medical intensive care unit: impact on the incidence of ventilator-associated pneumonia caused by antibiotic-resistant gram-negative bacteria. *American Journal of Respiratory Critical Care Medicine*. September; 162(3):837-843.

Haley RW, Culver DH, White JW, Morgan, WM, Emori, TG, Munn, VP & Hooton, TM. 1985. The efficacy of infection surveillance and control programs in preventing nosocomial infections in U.S. hospitals. *American Journal of Epidemiology*. February; 121(2):182-205.

Haley, RW, Hooton, TM, Culver, DH, Stanley, RC, Emori, TG, Hardison, CD, Quade, D, Shachtman, RH, Schaberg, DR, Shah, BV & Schatz, GD. 1981. Nosocomial Infections in US hospitals, 1975-1976: estimated frequency by selected characteristics of patients. *American Journal of Medicine.* April; 70(4):947-959.

Halpern, D.F. 1997. Critical thinking across the curriculum: a brief edition of thought and knowledge. New Jersey, Lawrence Erlbaum.

Harden, RM. 2001. AMEE Guide No. 21: Curriculum mapping: a tool for transparent and authentic teaching and learning, *Medical Teacher*. Mar; 23(2):123-137.

Hargreaves, MH & Grenfell, AT. 2000. The Use of Assessment Strategies to Develop Critical Thinking Skills in Science. Conference abstract.

Haydel, J, Oescher, J & Banbury, M. 1995. *Assessing classroom teachers' performance assessments.* Paper presented at the Annual Meeting of AERA, April 1995, San Francisco.

Hayland, DK, Cook, DJ, Schoenfeld, PS, Frietag, A, Varon, J & Wood, G. 1999. The effect of acidified enteral feeds on gastric colonization in critically ill patients: results of a metacentre randomized trial. Canadian Critical Care Trials Group. *Critical Care Medicine*. November; 27(11):2399-2406.

Healthcare Infection Control Practices Advisory Committee; Centers for Disease Control and Prevention (U.S). 2004. Guidelines for preventing health-care-associated pneumonia, 2003 recommendations of the CDC and the Healthcare Infection Control Practices Advisory Committee. *Respiratory Care,* August; 49(8):926-939.

Heard, SO, Fink, MP, Gamelli, RL, Solomkin, JS, Joshi, M, Trask, AL, Fabian, TC, Hudson, LD, Gerold, KB & Logan, ED. 1998. Effect of prophylactic administration of recombinant human granulocyte colony-stimulating factor (filgrastim) on the frequency of nosocomial infections in patients with acute traumatic brain injury or cerebral hemorrhage. *Critical Care Medicine*. April; 26(4):748-754.

Heyland, DK, Drover, JW, MacDonald, S, Novak, F & Lam, M. 2001. Effect of postpyloric feeding on gastroesophageal regurgitation and pulmonary microaspiration. *Critical Care Medicine*, 29:1495-1500.

Hiebert, T, Miles, J & Okeson, GC. 1999. Contaminated aerosol recovery from pulmonary function testing equipment. *American Journal of Respiratory and Critical Care Medicine*, 159: 610-612.

Holzapfel, L, Chevret, S, Madinier, G, Ohen, F, Demingeon, G, Coupry, A & Chaudet, M. 1993. Influence of long-term oro- or naso-tracheal intubation on nosocomial maxillary sinusitis and pneumonia: results of a prospective, randomized clinical trial. *Critical Care Medicine*. August; 21(8):1132-1138.

Horan TC, White JW, Jarvis WR, Emori, TG, Culver, DH, Munn, VP, Thornsberry, C, Olson, DR & Hughes, JM. 1984. Nosocomial infection surveillance, 1984. MMWR CDC Surveillance Summary. 1986; 35(1):17SS-29SS.

Humphreys, A, Gidman, J & Andrew, M. 2000. The role of the personal tutor: a literature review. *Nurse Education Today*, 20:311–317.

Institute for Healthcare Improvement. 2005. *Preventing Ventilator-Associated Pneumonia.* [Online] Available: http://www.ihi.org/IHI/Programs/Campaign [Accessed: 2005-07-10].

Ironside, PM. 1999. *Nursing Health Care Perspective*, Sep-Oct; 20(5):243-247.

Irwin, RS, Demers, RR, Pratter, MR, Garrity, FL, Miner, G, Pritchard, A & Whitaker, S. 1980. An outbreak of *Acinetobacter* infection associated with the use of a ventilator spirometer. *Respiratory Care*. February; 25(2):232-237.

Jakobsson, B, Hjelte, L & Nystrom, B. 2000. Low level of bacterial contamination of mist tents used in home treatment of cystic fibrosis patients. *Journal of Hospital Infection*, 44:37-41.

Kaplan, JE, Roselle, G & Sepkowitz, K, 1998. Oppurnistic Infections in Immunodeficient Populations. *Emerging Infectious Diseases.* July-September. Volume 4, Number 3, Special Issue [Online] Available: http://www.cdc.gov/ncidod/eid/vol4no3/kaplan.htm [Accessed: 2005-07-11].

Kaye, J, Ashline, V & Erickson D. 2000. Critical care bug team: a multidisciplinary team approach to reducing ventilator-associated pneumonia. *American Journal of Infection Control*, 28:197-201.

Kearns, PJ, Chin, D, Mueller, L, Wallace, K, Jensen, WA & Kirsch, CM. 2000. The incidence of ventilator-associated pneumonia and success in nutrient delivery with gastric versus small intestinal feeding: a randomized clinical trial. *Critical Care Medicine*, 28:1742-1746.

Kerridge, D & Kerridge, S. 2000. *Scientific method and continual improvement*. [Online] Available: http://deming.eng.clemson.edu/pub/den/pdsa.pdf [Accessed: 2002-08-09].

Kingston, GW, Phang, PT and Leathley, MJ. 1991. Increased incidence of nosocomial pneumonia in mechanically ventilated patients with subclinical aspiration. *American Journal of Surgery*, 161:589-592.

Kirschenbaum, L, Azzi, E, Sfeir, T, Tietjen, P & Astiz, M. 2002. Effect of continuous lateral rotational therapy on the prevalence of ventilator-associated pneumonia in patients requiring long term ventilatory care. *Critical Care Medicine*, 30:1983-1986.

Kitson, AL. 2001. Does nursing education have a future? *Nurse Eduction Today.* February; 21(2):86-96.

Knowles, M. 1990. The Adult Learner: a Neglected Species. Gulf Publishing Company, Houston.

Kollef, MH, Prentice, D, Shapiro, SD, Fraser, VJ, Silver, P, Trovillion, E, Weilitz, P, von Harz, B & St John, R. 1997. Mechanical ventilation with or without daily changes of in-line suction catheters. *American Journal of Respiratory and Critical Care Medicine*. August; 156:466-472.

Kollef, MH. 2005. Ventilator-Associated Pneumonia. *Respiratory Care,* 50(6):714-721.

Kollef, MH. 1993. Ventilator-associated pneumonia: a multivariate analysis. *The Journal of the American Medical Association (JAMA),* 270:1965-1970.

Kollef, MH. 1999a. Epidemiology and risk factors for nosocomial pneumonia: emphasis on prevention. *Clinics in Chest Medicine*, 20:653-670.

Kollef, MH. 1999b. The prevention of ventilator-associated pneumonia. *New England Journal of Medicine*, 340:627-634.

Kollef, MH & Ward, S. 1998. The influence of mini-BAL cultures on patient outcomes: implications for the antibiotic management of ventilator-associated pneumonia. *Chest,* 113 (2):412-420.

Krueger, RA. 1988. Focus Groups: A practical guide for Applied Research, Newbury Park, California.

Krueger, WA, Lenhart, FP, Neeser, G, Ruckdeschel, G, Schreckhase, H, Eissner, HJ, Forst, H, Echart, J, Peter, K & Unertl, KE. 2002. Influence of combined intravenous and topical antibiotic prophylaxis on the incidences of infections, organ dysfunction, and mortality in critically ill surgical patients: a prospective, stratified, randomized, double-blind, placebo-controlled clinical trial. *American Journal of Respiratory and Critical Care Medicine*. October 15; 166(8):1029-1037.

Landers, MG. 2000. The theory-practice gap in nursing: the role of the nurse teacher. *Journal of Advanced Nursing.* December; 32(6):1550-1556.

Langley, A. 1999. Strategies for theorizing from process data. *Academy of Management Review* 24(4):691–710.

LeClair, JM, Freeman, J, Sullivan, BF, Crowley, CM & Goldmann, DA. 1987. Prevention of nosocomial respiratory syncytial virus infections through compliance with glove and gown isolation precautions. *New England Journal of* Medicine, 317:329-334.

LeCompte, MD & Goetz, JP. 1982. Problems of Reliability and Validity in Ethnographic Research. *Review of Educational Research,* 52:31-60.

Lincoln, YS & Guba, EG. 1985. *Naturalistic Inquiry.* Beverley Hills: Sage Publications.

Lindsay, A. Quality and management in Australian universities. *Journal of Tertiary Education Administration,* 16(1):55-68.

Lloyd, JM, Walter, S & Akehurst, R. 2001. The implications of contact with the mentor for pre-registration nursing and midwifery students. *Journal of Advanced Nursing.* 35(2):151-160.

Lynn, M.R. 1986. Determination and quantification of content validity. Nursing Research, 33 (6): 382-385. In M.E. Muller (Ed.). Navorsingsmetodologie vir die Formulering van Verpleegstandaarde [Research methodology for the formulation of nursing standards]. Curationis, 13 (3&4):49-54.

Lynn, MR. 1986. Determination and Qualification of content validity. *Nursing Research,* November/December; 35(6):382-385.

Mahul, PH, Auboyer, C, Jospe, R, Ross, A, Guerin, C, el Houris, Z, Galliez, M, Dumont, A & Gaudin, O. 1992. Prevention of nosocomial pneumonia in intubated patients: respective role of mechanical subglottic secretions drainage and stress ulcer prophylaxis. *Intensive Care Medicine,* 18(1):20-25.

Mason, EJ. 1994. *How to Write Meaningful Nursing Standards.* New York: John Wiley and Sons.

Maudsley, G. 2001. What issues are raised by evaluating problem-based undergraduate medical curricula? Making healthy connections across the literature. *Journal of Evaluation in Clinical Practice*, 7, 3:311-324.

McClave, SA, DeMeo, MT, DeLegge, MH, DiSario, JA, Heyland, DK, Maloney, JP, Metheny, NA, Moore, FA, Scolapio, JS, Spain, DA & Zaloga, GP. 2002. North American summit on aspiration in the critically ill patient: consensus statement. *Journal of Parenteral and Enteral Nutrition*. November – December; 26(6 Supplement): S80-85. Review.

Mertz, JJ, Scharer, L & McClement, JH. 1967. A hospital outbreak of *Klebsiella pneumonia* from inhalation therapy with contaminated aerosol solutions. *American Review of Respiratory Disease,* 95:454-460.

Messori, A, Trippoli, SL, Vaiani, M, Gorini, M & Corrado, A. 2000. Bleeding and pneumonia in intensive care patients given ranitidine and sucralfate for prevention of stress ulcer: meta-analysis of randomized controlled trials. *British Medical* Journal, 321:1103-1106.

Michelson, A, Kamp, HD & Schuster, B. 1991. Sinusitis in long-term intubated, intensive care patients: nasal versus oral intubation. *Anaesthetist.* February; 40(2):100-104.

Moffet, HL & Allan, D. 1967. Survival and dissemination of bacteria in nebulizers and incubators*. American Journal of Diseases of Children*, 114:13-20.

Montejo, JC, Grau, T, Acosta, J, Ruiz-Santana, S, Planas, M, Garcia-De-Lorenzo, A, Mesejo, A, Cervera, M, Sanchez-Alvarez, C, Nunez-Ruiz, R & Lopez-Morar, P, Makura Z, Jones A, Baines, P, Selby, A, Hughes, J & van Saene, R. 2000. Topical antibiotics on tracheostoma prevents exogenous colonization and infection of lower airways in children. *Chest*. February; 117(2):513-518.

Morar, P, Makura, Z, Jones, A, Bains, P, Selby, A, Hughes, J & Van Saene, R. 2000. Topical antibiotics on tracheostoma prevents exogenous colonization and infection of lower airways in children. *Chest*, 117 (2): 513-518.

Mouton, J & Marais, HC. 1990. *Basiese Begrippe: Metodologie van die Geesteswetenskappe* [Basic Concepts: Methodology of the Human Sciences]. Pretoria: Raad vir Geesteswetenskaplike Navorsing (Human Science Research Group).

Muller, M. 1998. *Nursing Dynamics*. Second Edition. Sandton: Heinemann.

Muller, M. 1999. The Quality of Critical Care Service Management in South African Hospitals. *Health SA Gesondheid*, 4(2):12-18.

Murphy, FA. 2000. Collaborating with practitioners in teaching and research: a model for developing the role of the nurse lecturer in practice areas. *Journal of Advanced Nursing*, 31: 704–714.

Nathens, AB & Marshall, JC. 1999. Selective decontamination of the digestive tract in surgical patients: a systematic review of the evidence. *Archives of Surgery*, 134:170-176.

Nava, S, Ambrosino, N, Clini, E, Prato, M, Orlando, G, Vitacca, M, Brigada, P, Fracchia, C & Rubini, F. 1998. Noninvasive mechanical ventilation in the weaning of patients with respiratory failure due to chronic obstructive pulmonary disease: a randomized, controlled trial. *Annals of Internal Medicine*. May 1; 128(9):721-728.

Nel, J. 2001. Guidelines for the Prevention of Ventilator Associated Infections in selected Hospitals in the Western Cape Metropole. Unpublished honours dissertation. Cape Town: University of Stellenbosch [University of Stellenbosch].

Neuman, WL. 2000. Social Research Methods: Qualitative and Quantitative Approaches. Boston: Allyn and Bacon.

Pan American Sanitary Bureau, Regional Office of the WHO. 2000. Geneva: Author.

Paul, R, Elder, L & Bartell, T. 1997. California teacher preparation for instruction in critical Thinking: Research findings and policy recommendations. California Commission on Teacher.

Pearsall, J. 1999. *The Concise Oxford Dictionary,* 10th Edition. New York: 501: Oxford University Press.

Pelto, PJ & Pelto, GH. 1978. *Anthropological Research: The Structure of Inquiry.* 2nd edn.. New York: Cambridge University Press.

Prideaux, D, 2003. ABC of learning and teaching in medicine: Curriculum design. *British Medical Journal (BMJ),* 1 February; 326:268-270.

Quinn, FM. 2000. Principles and Practice of Nursing Education, Fourth Edition. Chapman & Hall. London.

Ramage, C. 2004. Negotiating multiple roles: link teachers in clinical nursing practice.

Rattray, J. 2004. In the firing line: the nurse academic in practice. *Nursing in Critical Care.* May-June; 9(3):95-97.

Rello, J, Ausina, V, Castella, J, Net, A & Prats, G. 1992. Nosocomial respiratory tract infections in multiple trauma patients. Influence of level of consciousness with implications for therapy. *Chest*. August; 102(2):525-529.

Rello, J, Paiva, JA, Baraibar, J, Barencilla, F, Bodi, M, Castander, D, Correa, H, Diaz, E, Garnacho, J, Llorio, M, Rios, M, Rodriquez, A & Sole-Violan, J. 2001. International conference for the development of consensus on the diagnosis and treatment of ventilator associated pneumonia. *Chest* (120) (3) September:955-970.

Rello, J, Rue, M, Jubert, P, Muses, G, Sonora, R, Valles, J & Niederman, MS. 1997. Survival in patients with nosocomial pneumonia: impact of the severity of illness and the etiologic agent. *Critical Care Medicine*, 25:1862-1867.

Rhame, FS, Streifel, A, McComb, C & Boyle, M. 1986. Bubbling humidifiers produce micro-aerosols which can carry bacteria. *Infection Control*, 7:403-407.

Richards, MJ, Edwards, JR, Culver, DH & Gaynes, RP. 1999. Nosocomial infections in medical intensive care units in the United States: National Nosocomial Infections Surveillance System. *Critical Care Medicine*. May; 27(5):887-892.

Romaine-Davis, A. (1997). *Advanced Practice Nurses: Education, Roles, Trends*. London: Jones and Bartlett Publishers.

Rutala, WA & Weber, DJ. 1995. Environmental interventions to control nosocomial infections. *Infection Control Hospital Epidemiology.* August; 16(8):442-443.

Safdar, N, Crnich, CJ & Maki, DG. 2005. The pathogenesis of ventilator-associated pneumonia: its relevance to developing effective strategies for prevention. *Respiratory Care. June; 50(6):*725-729.

Salahuddin, N, Zafar, A, Sukhyani, L, Rahim, S, Noor, MF, Hussain, K, Siddiqui, S, Islam, M & Husain, SJ. 2004. Reducing ventilator associated pneumonia rates through a staff eduction programme. *Journal of Hospital Infections.* July; 57(3):223-227.

Salemi, C, Padilla, S, Canola, T & Reynolds, D. 2000. Heat-and-moisture exchangers used with biweekly circuit tubing changes: effect on costs and pneumonia rates. *Infection Control and Hospital Epidemiology*, 21:737-739.

Schleder, B, Stott, K & Lloyd, RC. 2002. The effect of a comprehensive oral care protocol on patients at risk for ventilator-associated pneumonia. *Journal of Advocate Health Care*, 4:27-30.

Sheth, NK, Post, GT, Wisniewski, TR & Uttech, BV. 1983. Multi-dose vials versus single-dose vials: a study in sterility and cost-effectiveness. *Journal of Clinical Microbiology*, 17: 377-379.

Skiest, DJ, Khan, N, Feld, R & Metersky, ML. 1996. The role of enteral feeding in gastric colonization: a randomized controlled trial comparing continuous to intermittent enteral feeding in mechanically ventilated patients. *Clinical Intensive Care,* 7:138-143.

Slevin, OD.1993. Facing the future: credibility in a changing world. *Nurse Education Today.* August; 13(4): 241-249.

Smulders, K, van der Hoeven, H, Weers-Pothoff, I & Vanderbroucke-Grauls, C. 2002. A randomized clinical trial of intermittent subglottic secretion drainage in patients receiving mechanical ventilation. *Chest*, 121:858-862.

Southern Regional Education Board. 2002. *Nurse educator competencies*. Council on Collegiate Education for Nursing: Atlanta, Georgia. [Online] Available: From World Wide Web: www.sreb.org [Accessed: 2004-09-18].

Spady, W. 1994. Choosing outcomes of significance, *Educational Leadership*, 51(6):18-22.

Surveillance of Healthcare-Associated Diseases. [Online]. 2004, Available: http://www.cdc.gov/ncidod/hip/SURVEILL/NNIS.HTM [Accessed: 2005-03-12].

Tablan, OC, Anderson, LJ, Arden, NH, Breiman, RF, Butler, JC & McNeil, MM. 1994. Guidelines for prevention of nosocomial pneumonia: the Hospital Infection Control Practices Advisory Committee, Centers for Disease Control and Prevention. *Infection Control and Hospital Epidemiology*, 15:587-627.

Tablan, OC, Anderson, LJ, Besser, R, Bridges, C & Hajjeh, R. 2003. Guidelines for Preventing Health-Care-Associated pneumonia, 2003. *Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee.* 1-36.

The Australian College of Critical Care Nurses (ACCCN). 2002. *Nursing Education*. [Online] Available: http://www.acccn.com.au/index.php?option=content&task=view&id=9&Itemid=32 [Accessed: 2004-08-25].

The DICT Development, 2005. *Dictionary.* [Online] Available: http://www.dict.org/bin/Dict [Accessed: 2005-04-18].

Thomachot, L, Viviand, X, Arnaud, S, Boisson, C & Martin, CD. 1998. Comparing two heat and moisture exchangers, one hydrophobic and one hygroscopic, on humidifying efficacy and the rate of nosocomial pneumonia. *Chest,* 114:1383-1389.

Thompson, AC, Wilder, BJ & Powner, DJ. 1985. Bedside resuscitation bags: a source of bacterial contamination. *Infection Control*, 6:231-232.

Torres, A, Gatell, JM, Aznar, E, el-Ebiary, M, Puig de la Bellacasa, J, Gonzalez, J, Ferrer, M & Rodriguez-Roisin, R. 1995. Re-intubation increases the risk of nosocomial pneumonia in patients needing mechanical ventilation. *American Journal of Respiratory and Critical Care Medicine*. July; 152(1):137-141.

United Kingdom Central Council for Nursing, Midwifery and Health Visiting, 1986. *Project 2000. A New Preparation for Practice.* UKCC, London.

Valles, J, Artigas, A, Rello, J, Bonsoms, N, Fontanals, D, Blanch, L, Fernandez, R, Baigorri, F & Mestre, J. 1995. Continuous aspiration of subglottic secretions in preventing ventilator-associated pneumonia. *Annals of Internal Medicine*. February 1; 122(3):179-186.

Van Belkum, C. 2001. A process of quality improvement for outcomes based critical care nursing education. Unpublished PhD dissertation. University of Stellenbosch, Stellenbosch, South Africa.

Vezina, DP, Trepanier, CA, Lessard, MR, Gourdeau, M & Tremblay, C. 2001. Anesthesia breathing circuits protected by the DAR Barrierbac S breathing filter have a low bacterial contamination rate. *Canadian Journal of Anaesthesia*, 48:748-754.

Vincent, JL, Bihari, DJ, Suter, PM, Bruining, HA, White, J, Nicolas-Chanoin, MH, Wolff, M, Spencer, RC & Hemmer, M. 1995. The prevalence of nosocomial infection in intensive care units in Europe. Results of the European Prevalence of Infection in Intensive Care (EPIC) Study. EPIC International Advisory Committee. *Journal of the American Medical Association.* August 23-30. 274(8):639-644.

Warren, DK, Shukla, SJ, Olsen, MA, Kollef, MH, Hollenbeak, CS, Cox, MJ, Cohen, MM & Fraser, VJ. 2003. The outcome and attributable cost of ventilator-associated pneumonia among intensive care unit patients in a suburban medical centre. *Critical Care Medicine*. May, 31(5):1312-1317.

Webster's New World College Dictionary, Fourth Edition, 2003. New York: Oxford University Press.

Weems, JJ, Jr. 1993. Nosocomial outbreak of *Pseudomonas cepacia* associated with contamination of reusable electronic ventilator temperature probes. *Infection Control and Hospital Epidemiology*, 14:583-586.

Weingarten, JA, Paterson, DL & Yu, VL. 2003. Pneumonia caused by *Pseudomonas aeriginosa*. *Current Treatment Options in Infectious Diseases* 5:159-169.

White, F & Shackleton, P. 2004. Preparing students of nursing for "Real" practice. *Conference abstract.*

Wolcott, HF. 1994. *Transforming Qualitative Data: Description, Analysis and Interpretation.* Thousand Oaks: Sage Publications.

Wood-Baker, RR, Gibson, PG, Hannay M, Walters, EH & Walters, JAE. 2005. Systemic corticosteroids for acute exacerbations of chronic obstructive pulmonary disease. *The Cochrane Library, Volume* (1).

World Health Organisation. 2004. *Compendium of indicators for monitoring and evaluating national tuberculosis programs*. Geneva: WHO.

World Health Organization, 1985. *Weekly Epidemiological Record*, Geneva, 9:61-68.

Yildizdas, D, Yapicioglu, H & Yilmaz, HL. 2002. Occurrence of ventilator-associated pneumonia in mechanically ventilated pediatric intensive care patients during stress ulcer prophylaxis with sucralfate, ranitidine, and omeprazole. *Journal of Critical Care*, 17:240-245.

APPENDICES

Appendix 1: Pilot study

PREVENTION OF
VENTILATOR-ASSOCIATED INFECTIONS

Contents:

Pilot study

GUIDELINES FOR THE PREVENTION OF VENTILATOR-ASSOCIATED INFECTIONS IN SELECTED HOSPITALS IN THE WESTERN CAPE METROPOLE

by

JULIANA NEL (Bcur)

Submitted for the partial fulfilment of the requirements for the degree

HONOURS IN BCUR

in

MEDICAL AND SURGICAL NURSING

at the

UNIVERSITY OF STELLENBOSCH

November 2001

SUMMARY OF THE RESEARCH

The overall goal the research was to develop guidelines for the prevention and control of ventilator-associated infections for a public as well as a private hospital in the Western Cape Metropole. As a member of a multi-disciplinary team, the researcher remains responsible and accountable for quality patient care. Quality care involves minimising infections, minimising hospital costs, minimising the patient mortality rate (involving infections) and by making the other members of the multi-disciplinary team aware of risk factors and control measures of these infections.

In view of existing problems such as the rapid increase of infections in ventilated patients, the misuse of antibiotics and antacids, the use of ventilator filters and suctioning equipment, there was a need to standardise and develop guidelines for the prevention of ventilator-associated infections.

Emanating from the above, the question arose with regard to what measures had to be put in place to limit the development of infections in ventilated patients. Objectives were based on the identification of the most common organism for infecting patients being mechanically ventilated in a public as well as a private hospital in the Western Cape Metropole as well as guidelines to formulate guidelines for the prevention and control of ventilator-associated infections.

A retrospective, non-experimental, quantitative research survey was used to answer the research questions and to justify the objectives. The method of data collection was done by means of a checklist, as well as doing structured observation. Patients files were selected randomly, and information were obtained by using a checklist. Two hospitals were chosen from different sectors and patients were selected over 18 months.

The result of the research revealed the organisms differ from those found in a public hospital and those found in a private hospital in the Western Cape Metropole. Guidelines for the prevention and control of ventilator-associated infections formulated were generalised so as to cover the prevention of ventilator-associated infections in both hospitals.

Recommendations for the implementation of the guidelines for the prevention of ventilator infections were proposed.
The complete study is available on request.

GUIDELINES FOR THE PREVENTION OF LOWER RESPIRATORY TRACT INFECTIONS

A. Compliance with standard precautions and hand washing guidelines

B. Assess for risk factor associated with the development of nosocomial pneumonia

B.1 Altered functional status of the respiratory system
- B.1.1 Decreased reflexes - gag, swallow, and cough
- B.1.2 Altered respiratory defence mechanisms due to
  - B.1.2.1 Intubation
  - B.1.2.2 Nasogastric tube
  - B.1.2.3 Abdominal/thoracic/head or neck surgery
- B.1.3 Aspiration
- B.1.4 Prolonged use of mechanical ventilation
- B.1.5 Receipt of anaesthesia

B.2 Altered general health status
- B.2.1 Extremes of age
- B.2.2 Increased severity of illness
- B.2.3 Decreased level of consciousness
- B.2.4 Decreased immune function
- B.2.5 Underlying chronic lung disease such as COPD, cystic fibrosis

C. Preoperative measures for prevention of postoperative pneumonia

C.1 Patient should receive instruction and therapy designed to prevent postoperative pneumonia:

- C.1.1 Frequent coughing and deep breathing.
- C.1.2 Incentive spirometry.
- C.1.3 Change of position, and ambulating as soon as medically indicated.
- C.1.4 Pain that interferes with coughing and deep breathing should be controlled via support for incisions while coughing and through use of pain medication.

C.2 Systemic antibiotics should not be routinely used to prevent postoperative pneumonia.

D. Measures for prevention of aspiration

D.1 Endotracheal, tracheotomy, nasogastric and/or enteral tubes should be removed from patients as soon as clinically indicated.
D.2 The head of the bed of a patient who id receiving mechanical ventilation or has a feeding tube in place should be elevated at the angle of 30-45 ^{o}, if there is no contraindication to this manoeuvre.

D.3 The appropriate placement of the feeding tube should be verified every 8 hours and/or prior to starting a feeding or instilling fluids or medication.
D.4 The patient's intestinal motility should be routinely assessed by auscultating for bowel sounds, by measuring residual gastric volumes, and by measuring abdominal girth. The rate and volume of tube feeds should be adjusted to avoid regurgitation.
D.5 Tube feeds should be administered in small quantities rather than continuously, if clinically feasible.
D.6 Consider using sterile water for dilution of feedings and irrigation of nasogastric tubes in immunocompromised patients or in intensive care unit patients.

E. Fluids and medications administration via the respiratory tract

E.1 Only sterile fluids, dispensed aseptically, should be nebulised or used in a humidifier.
E.2 If multi-dose vials of medication are used, they should be stored according to the manufacturer's directions, dispensed aseptically, and used no longer than the expiration date on the vial. Remove vial from use id contamination has occurred of if expiration date has passed.

F. Maintenance of in-use respiratory therapy equipment

F.1 Fluid reservoirs should be filled immediately before use. Use sterile water to fill bubbling humidifiers. Fluid should not be added to replenish partially filled reservoirs.
F.2 Residual fluid should be discarded and the reservoir filled with fresh fluid.
F.3 Periodically drain water that has condensed in tubing should be discarded and not allowed to drain back into the reservoir. Drain all condensate away from the patient.
F.4 Disposable nebulisers, breathing circuits, and hand-held nebulisers should be replaced every 24 hours. Between treatments, the small volume nebulisers should be disinfected or rinsed with sterile water and air-dried.
F.4 Disposable humidifiers for use with wall oxygen should be replaced when depleted.
F.5 Disposable supplies such as nasal prongs, tubing, masks, ventilator and breathing circuits are for single patient use only.
F.6 Ventilator circuits and accompanying valves and probes should be changed and replace every seven days and as needed.
F.7 When a respiratory therapy machine is used to treat multiple patients, the breathing circuit must be changed between patients.

G. Processing reusable equipment

G.1 All equipment to be sterilised or disinfected should be thoroughly cleaned first to remove organic material such as blood, secretions, or other residue.
G.2 Respiratory therapy equipment that touches mucous membranes or that is a non-disposable part of a breathing circuit should be sterilised or receives high-level disinfectant. If sterilisation is no feasible, use high-level disinfection.

G.3 Use sterile water only for rinsing reusable equipment after they have been chemically disinfected.
G.4 Single use respiratory equipment should not be reprocessed unless data shows and cost effective to do so.
G.5 Portable respirometers, oxygen sensors and other multiple patient respiratory devices are to be sterilised or receive high level of disinfection before use on each patient.
G.6 Resuscitation bags that have been used for a patient should receive high-level disinfection or be sterilised (unless disposable) between patients.

H. Patient with a tracheostomy

H.1 Tracheostomy should be performed under sterile conditions in an operating room, except when clinical indications for emergency bedside tracheostomy intervene.
H.2 When changing a tracheostomy tube. Use aseptic technique and replace the tube with one that has undergone sterilisation or high-level disinfection.
H.3 Tracheostomy care requires clean technique (unless otherwise ordered) with both hands gloved.
H.4 Tracheostomy site and dressing should be kept clean and free of secretions.

I. Suctioning of the respiratory tract

I.1 Risk of cross- contamination and excessive trauma increases with frequent suctioning. Suctioning should not be done routinely but only when needed to reduce substantial secretions.
I.2 Suctioning should be performed using gloves on both hands. Use of protective eyewear and mask are strongly encouraged.
I.3 A sterile catheter should be used for each series of suctioning (defined as a single suctioning or repeated suctioning done with only brief periods intervening, to clear or flush the catheter).
I.4 If flushing of the catheter is required, sterile fluid is used.
I.5 Suction connecting tubing and suction canisters should be changed between patients, and daily in patients requiring continual suctioning.

J. Protection of patients from infected patients or health care personnel

J.1 Person with mild upper respiratory tract infections should not be assigned to high-risk patients (infants, patients with chronic obstructive lung disease, or immunocompromised patients).
J.2 Personnel with or without upper respiratory infections should wash their hands after touching their own eyes, nose, or mouth and before touching patients.

K. Glove use

K.1 Sterile gloves should only be used for procedures requiring aseptic technique.
K.2 The intact skin of personnel is an excellent barrier against transmission of infections from patient to personnel, and gloves are not needed for many contacts with patients.
K.3 Unsterile gloves should be worn for anticipated contact with blood, mucous membranes, non-intact skin, secretions, and moist body substances of any patient.
K.4 The same gloves are not to be worn from patient to patient.
K.5 Hands are to be washed after gloves are removed because breaks in gloves can and do occur.

REFERENCES

Akca, O., Koltka, K., et al. 2000. Risk factors for early-onset ventilator-associated pneumonia in critical care patients: selected multi resistant versus non-resistant bacteria. Anaesthesiology, 93(3): 638-645.

APIC. 2000. APIC: Infection control manual. Washington: Mosby.

Combes, P., Fauvage, B., et al; 2000. Nosocomial pneumonia in mechanically ventilated patients: a prospective randomised evaluation of the Stericath closed suctioning system. Intensive Care Medicine, 26(7): 878-882.

Cook, D. 2000. Ventilator associated pneumonia: Perspectives on the burden of illness. Intensive Care Medicine, 26: 31-37.

Craven, D.E. 2000. Epidemiology of ventilator associated pneumonia. Chest, 117(4):186-187.

Creamer, E., & Smyth, E.G. 1996. Suction apparatus and the suctioning procedure: reducing the infection risks. Journal of Hospital Infection, 38:163-177.

Croser, M.A. 2000. Postoperative pneumonia. American Journal of Surgery, 66(2): 133-137.

Davis, K., Evans, S.L. et al. 2000. Prolonged use of heat and moisture exchangers does not affect device efficiency of frequency rate of nosocomial pneumonia. Critical Care Medicine, 28(5): 1412-1418.

Flanagan, P.G., & BURNS, R.A. 1998 Fungal infection in the intensive care unit. Journal of Hospital Infection, 38:163-177.

Flanagan, P.G. 1999. Diagnosis of ventilator associated pneumonia. Journal of Hospital Infections, 41:87-99.

Grenvik, A., Shoemaker, W.C., et al. 2000. Textbook of Critical Care, Fourth Edition. Philadelphia: WB Saunders Company

Gruson, D, Hilbert, G., et al. 2000. Rotation and restricted use of antibiotics in a medical intensive care unit. Impact on the incidence of ventilator associated pneumonia caused by antibiotic-resistant Gram-negative bacteria. American Journal of Respiratory Critical Care Medicine, 162(3): 837-843.

Kollef, M.H. 1999. The prevention of ventilator associated pneumonia. Pulmonary and Critical Care, 340(8): 627-633.

Koontz, C.S., Chang, M.C., et al. 2000. Effects of empiric antibiotic administration for suspected pneumonia on subsequent opportunistic pulmonary infections. American Journal of Surgery, 66(12): 1110-114.

Lynch, P., Jackson, M., et al. 1997. Infection Prevention with limited resources. Chicago: ETNA Communications

Malangoni, M.A. 2000, Single versus combination antimicrobial therapy for ventilator associated pneumonia. American Journal of Surgery, 179(2A): 58-62.

Markowicz, P., Wolff, M., et al. 2000. Multicenter prospective study of ventilator associated pneumonia during acute respiratory distress syndrome: incidence, prognosis and risk factors. American Journal of Respiratory Critical Care Medicine, 161(6): 1942-1948

Polk, H.C., & Mizuguchi, N.N. 2000. Multifactorial analyses in the diagnosis of pneumonia arising in the surgical intensive care unit. American Journal of Surgery, 179(2A): 31-35.

Raasch, R.H. 1995. Infections in the intensive care unit. A Hospital Practice Special Report, 53-64.

Reese, R.E., & Betts, R.F. 1996.A practical approach to infectious diseases, Fourth Edition. Boston: Little Brown and Company.

Richardson, C.J., & Rodriquez, J.L. 2000. Identification of patients at higher risk for pneumonia in the surgical intensive care unit. American Journal of Surgery, 179(2A): 8-11.

Smeltzer, S.C.& Bare, B.G. 1996. Brunner and Suddarth's Textbook of Medical-Surgical Nursing. Eight Edition. Philadelphia: Lippincott-Raven Publishers.

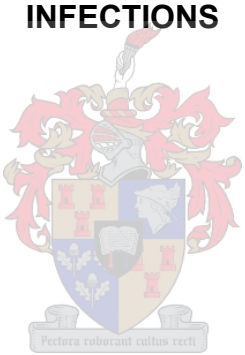
Spain, D.A. 2000. Pneumonia in the surgical patient: duration of therapy and does the organism matter? American Journal of Surgery, 179(2A): 36-39

Vandenbroucke-Grauls, C.M.J.E., et al. 1995. Bacterial and Viral removal efficiency, heat and moisture exchange properties of four filtration devices; Journal of Hospital Infection, 29: 45-56.

Yavagal, D.R., Karnad, D.R. et al. 2000 Metoclopramide for preventing pneumoniain critically ill patients receiving enteral tube feeding: A randomized controlled trial. Critical Care Medicine, 28(5): 1408-1411.

Appendix 2: Pre-test

PREVENTION OF VENTILATOR-ASSOCIATED INFECTIONS



Contents:

Pre-test

PREVENTION OF VENTILATOR-ASSOCIATED INFECTIONS

Pre-test
January 2003

VAI Self Study Pre-Test

Test your Ventilator-Associated Infections Knowledge

Please circle the correct answer.

1)The following groups are at risk for VAI:

A) Elderly
B) Infants & young children
C) Immunosuppressed patients
D) Patients with decreased levels of consciousness
E) Cardiothoracic patients
F) All of the above
G) A & D

2) What are *two* factors that may lead to the development of VAI?

1. Colonisation of the aero-digestive tract;
2. Lack of proper handwashing;
3. Aspiration of contaminated secretions;
4. Contaminated Respiratory Therapy equipment

A) 1 & 3
B) 2 & 4
C) 2 & 3

3) Oral suction catheters (e.g., Yankauer) should be stored between uses:

A) on the ventilator
B) in a non-sealed paper or plastic bag
C) on the patient's bed

4)You are the nurse taking care of Pinky Puffer today. You notice that the night nurse accidentally forgot to empty the Foley catheter urine bag. First you put on a pair of clean gloves and empty the bag before it bursts. Pinky begins to cough. You look up and realise that the condensate in the ventilator tubing needs to be drained. What do you do?

A) Call another nurse to drain the ventilator tubing.

B) You finish with the Foley catheter urine bag, empty the contents then move to the ventilator tubing, open it and drain the condensate.

C) You finish with the Foley catheter urine bag, empty the contents remove soiled gloves & wash hands; then put on clean gloves and move to the ventilator tubing, open it and drain the condensate.

5) What is the correct procedure for draining ventilator circuit condensate?

A)Wash hands or use waterless antiseptic agent
Put on clean gloves
Open ventilator circuit carefully
Drain fluid into wide-mouthed container
Empty container into trash can.

B) Wash hands or use waterless antiseptic agent
Put on clean gloves
Open ventilator circuit carefully
Drain fluid into wide-mouthed container
Carefully reconnect ventilator tubing to avoid contamination
Empty container into a hopper or dispose per policy.

C)Wash hands or use waterless antiseptic agent
Put on sterile gloves
Open ventilator circuit carefully
Drain fluid into wide-mouthed container
Carefully reconnect ventilator tubing to avoid contamination
Empty container into the sink.

Circle the correct answer where T = True and F = False

T F **6) The use of multiple antibiotics increases a patient's risk of developing VAI.**

T F **7) Frequent suctioning of the patient is the single best way to prevent VAI.**

T F **8) In ICUs, VAI is the leading cause of nosocomial infection, accounting for 60% of all deaths attributable to nosocomial infections.**

T F **9) HMEs (heat & moisture exchangers) should be changed every 24 hours to maintain proper function.**

T F **10) Ventilator circuits and in-line suction catheters should be changed every seven (7) days while the patient is in ICU.**

T F **11) Nasal intubation is preferred whenever possible to prevent aspiration of the oral secretions.**

T F **12) Tap water should be used in humidifiers.**

T F **13) Ventilator condensate should always be drained before repositioning the patient.**

T F **14) Patients on ventilators should have the head of the bed elevated to 30 degrees to prevent condensate from draining into the patient.**

T F **15) The nurse should monitor gastric residual volumes before each feeding to prevent aspiration in ventilated patients receiving tube feedings.**

T F **16) A patient has a temperature of 37.2ºC, minimal amounts of clear sputum, and a normal chest x-ray. White blood cells are 8/mm3 and the sputum culture is positive for Staphylococcus aureus. The patient has pneumonia and should be treated with antibiotics**

17) Patient Ima Sicky is a 63 year old female admitted to the ICU on Monday with diabetes mellitus. Upon admission to the unit, she is immediately intubated and attached to a ventilator. On admission she has a non-productive cough and thin watery sputum is suctioned. Her chest X-ray is clear on Monday. On Tuesday, the chest X-ray shows a consolidation in the left lower lobe and the patient has developed a productive cough with yellow sputum. Her temperature is 38.9 ^{o}C and her WBC is 15,000/mm3. The physician orders a broad-spectrum antibiotic.

Which of the following is true?

A) This patient is exhibiting normal symptoms of a ventilated patient.
B) This patient probably has pneumonia, but it's not VAI.
C) This patient probably has VAI.
D) Nothing can be determined until sputum cultures are obtained.

18) A suctioned sputum specimen is obtained on Ms. Sicky and the culture grew *Pseudomonas aeruginosa*. Which of the following is true?

A) The culture was obviously contaminated.
B) Respiratory Therapy must have exposed the patient to the organism.
C) The in-line suction catheter must be colonised and should be discarded immediately.
D) Pseudomonas is the likely source for the patient.s infection

19) Mr. I.M. Shortabreath is a 58-year-old man who was admitted to the ICU one week ago. On admission to the unit he suffered a cardiac arrest, was nasally intubated and attached to a ventilator. He was commenced on tube feedings per NG tube Q 6 hours on Day 1 and continues to receive them. There is an HME filter in place and an in-line suction catheter on the ventilator circuit. During your shift, Mr. Shortabreath spikes a temperature of 39.1 degrees° C and you suction copious amounts of thick yellow sputum from him. Before the 6 am feed, you check his gastric residual, which is 250 cc.

What should you do?

1) Hold the tube feeding.
2) Change the HME.
3) Change the in-line suction catheter.
4) Remove the HME and provide alternative humidification source.

A) 1 & 2
B) 2 & 3
C) 1 & 4
D) All of the above

20) What information should you bring to the physician's attention?

1) Oral intubation is the preferred route.

2) An in-line suction catheter is inappropriate for this patient.

3) A HME filter should be used for every patient.

4) The patient has a fever and purulent sputum

5) An NG tube is not the best feeding method for this patient.

A) 1 & 3

B) 1, 4, & 5

C) 2 & 4

D) All except 3

Appendix 3: Learning Programme

Prevention of

Ventilator-Associated

Infections

Contents:
Learning Programme
Contents for learning units in Learning Programme

LEARNING PROGRAMME

PREVENTION OF VENTILATOR-ASSOCIATED INFECTIONS

COMPILED BY:

Juliana van der Merwe B Cur, HonsBCur (Critical Care)

VALIDATED BY:

Prof David Tuxen

Prof Jamie Cooper

Glenys Harrington (Infection Control)

Karen Hutchinson (Infection Control)

Shain Rayn (Critical Care Registered Nurse)

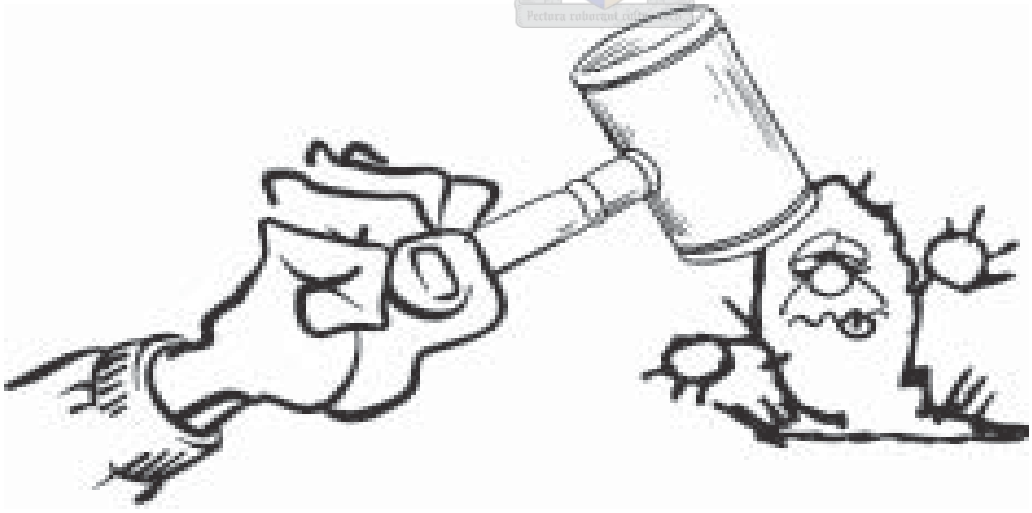
Martin Keogh (Critical Care Registered Nurse)

Nat Ballan (Critical Care Registered Nurse)

Dr Thelma van der Merwe BA Nurs , HonsB Nurs(Crit Care), MCur, DCur, Member Editorial Board American Journal for Infection Control

DATE: January 2003

TABLE OF CONTENTS



1. INTRODUCTION

We invite you to join a campaign/study by means of a self-study Learning Programme, to make the nursing care of patients on ventilators safer and more effective, thus participating in ensuring that your hospital achieves the best possible outcomes for their patients. Mechanical ventilators are essential to modern hospital practice. The use of ventilators can lead to complications such as aspiration, pneumonia, or sepsis.

The benefits derived from a Learning Programme to prevent ventilator-associated infections can be demonstrated in terms of both improved clinical outcomes and reduced costs of medical care. Among the most important elements of this strategy are the presence of a dedicated person or group that takes charge of the process and a mechanism for tracking rates of hospital-related infections (Salahuddin, Zafar, Sukhyani, Rahim, Noor, Hussain, Siddiqui, Islam & Husain, 2004:223-227). Micro-organisms may invade the lower respiratory tract via several mechanisms, including aspiration of oropharyngeal and/or gastric organisms or continuous extension of oropharyngeal or nasopharyngeal colonisers; inhalation of contaminated aerosol; large-droplet deposition (directly or indirectly via contaminated hands) on the conjunctiva or oral and nasal mucosa; hematogenous spread from a distant body site; and possibly bacterial translocation. In general, the upper airways of severely ill, hospitalised patients become colonised with gram-negative bacilli.

Colonisation of the oropharynx by gram-negative bacilli begins with the adherence of the micro-organism to the host's oropharyngeal epithelial cells, which has the unique ability to bind directly to the surface cells of the tracheobronchial tree without first having to adhere to the oral or nasal mucosal cells and thus can be directly inoculated into the lower respiratory tract. Adherence is affected by many factors, including the bacteria's pili, cilia, capsule, or ability to produce some ensymes (e.g. mucinase; the host cell's surface proteins and polysaccharides, and the micro-environment's pH). The predispostion for lower respiratory tract infection increases with increasing severity of underlying disease, antimicrobial administration, and increasing length of hospitalisation (Kollef, 1999:627; Safdar, Crnich and Maki, 2005:725-729).

Aspiration of oropharyngeal secretions into the tracheobronchial tree, which occurs during sleep in 45% of normal adults, is enhanced in patients with depressed consciousness or respiratory tract instrumentation or diseases or in those who have just undergone surgery. Gastric colonisation, which can occur in patients with gastric juice pH > 4 (e.g. the elderly, patients with achlorhydria or ileus, and patients receiving enteral feeding, antacids, or H-2 antagonists), can also be complicated by aspiration. Procedures such as endotracheal intubation, tracheostomy, or orotracheal, nasotracheal, or tracheal suctioning permit the access of organisms to the tracheobronchial tree either by aspiration or by contiguous extension of microorganisms from the upper airway to the lower respiratory tract. When the normal clearance mechanisms cannot eliminate the microorganisms, infection of the lower respiratory tract ensues. Inhalation of contaminated aerosols is the mechanism

of infection for some cases of gram-negative infections e.g. those acquired from contaminated nebulisation fluids (Safdar, et al. 2005: 725-729).

Contaminated aerosols generated from contaminated nebulisation equipment may be directly deposited into the lower respiratory tract in patients with tracheal tubes and/or assisted mechanical ventilation (Kollef, 1999: 627; Safdar, et al. 2005: 725-729). Airborne spores or droplet nuclei containing viral particles (e.g. influenza viruses) are small enough to reach the lower respiratory tract. Large-droplet deposition (directly or indirectly via contaminated hands) onto the conjunctiva or oral or nasal mucosa is the mode of person-to-person transmission of infections. Hematogenous spread from distant body site occurs in a small proportion of hospital-related lower tract respiratory infections. Bacterial translocation, the passage of viable bacteria from the lumen of the gastro-intestinal tract through epithelial mucosa to the mesenteric lymph nodes and to the lung, has been shown to occur in animal models and hypothesised to occur in patients with severe burns or septic shock.

Thus, to summarise, the pathogenesis of ventilator-associated infections usually requires that two important processes take place: bacterial colonisation of the aerodigestive tract and the aspiration of contaminated secretions into the lower airway. Therefore, the strategies aimed at preventing ventilator-associated infections usually focus on reducing the burden of bacterial colonisation in the aerodigestive tract, decreasing the incidence of aspiration, or both. When ventilator-associated infections occur, treatment usually consists of supportive care and the administration of antibiotics. Several studies have suggested that the mortality attributable to ventilator-associated infections, particularly late-onset infection with antibiotic-resistant pathogens, is greater than 10 percent (Chastre & Fagon, 2002: 867-903). Chastre and Fagon further imply that approximately one third of the deaths among patients with ventilator-associated infections (attributable mortality of 10% and a crude mortality of 30%) are due to the infection and two thirds are due to underlying diseases. However, other investigators have not found associated attributable mortality from ventilator-associated infections after controlling for confounding factors. More recently, the importance of adequate initial treatment with antibiotics has been recognised; such treatment may influence the estimates of attributable mortality (Rello, Rue, Jubert, Muses, Sonora, Valles & Niederman, 1997: 1862-1867).

This Learning Programme consists of a 10-page self-study package. The package includes information on the following topics related to ventilator-associated infections:

- epidemiology and scope of the problem,
- risk factors,
- etiology,
- definitions,
- methods to decrease risk,
- procedures for collecting suctioned sputum specimens, and
- clinical and economic outcomes influenced by ventilator-associated infections.

2. DURATION OF THE LEARNING PLAN

The learning programme will come into effect as from January 2003 and will last for 12 months, depending on the individual critical care nurse.

3. CRITICAL CARE NURSE/LEARNER RESPONSIBILITIES

The critical care nurse/learner:

3.1 accepts and demonstrates responsibility for her/his own learning. Please note teaching does not ensure learning has taken place
3.2 carefully study the information provided and
- take the self-test included with this Learning Programme

- *A score of at least 80% is to be achieved.*
- *If you do not achieve a score of 80%, **please** review the studied contents of the information on ventilator-associated infections*
- *Focus on the areas that are not clear and then*
- *Retake the test.*

3.3 Critically reflects on issues concerning ventilator-associated infections in the practice of critical care nursing practice and recommend changes (Evidence Based Practice) for improvement. This aspect can be given in writing as part of the evaluation of the Learning Programme
3.4 Verbalises her/his learning needs to the researcher so as to facilitate a collaborative approach to optimal orientation and learning

4. PERSONNEL INVOLVED

4.1 Juliana van der Merwe Researcher
Her telephone number is 03- 9276 2663 and pager 4475.

5. GOAL AND OBJECTIVES

The critical care nurse integrates the theory of the prevention of ventilator-associated infections into her/his clinical practice in the critical care unit through realising the following objectives:

- To identify and analyse the epidemiology pertaining to ventilator-associated infections
- To analyse and debate the impact of ventilator-associated infections in ICU patients
- To identify and debate the practical measures for prevention of ventilator-associated infections

6. LEARNING UNITS

6.1 Epidemiology
Criterium:
To identify and analyse the epidemiology pertaining to ventilator-associated infections

Range:
Definition of VAI
Patients at risk for VAI
Causes of VAI

6.2 Impact of VAI
Criterium:
To identify and debate the impact of ventilator-associated infections.

Range:
Mortality and morbidity
Costs involved

6.3 Practical Measures for the prevention of VAI
Criterium:
To identify and debate the practical measures for prevention of ventilator-associated infections.

Range:
Nurses' personal measures for risk reduction
Ventilator care key points
Procedure for draining ventilator circuit condensate
Procedure for collecting a suctioned sputum specimen

7. CONCLUSION

Risk factors for ventilator-associated infections that are specifically addressed include those promoting aspiration (supine positioning and gastric over distension) and those associated with bacterial colonisation of the upper airway and stomach (prior antibiotic exposure and the use of stress ulcer prophylaxis). The topics addressed in the Learning Programme are summarised with the acronym WHAP VAP, in which

W is for "Wean the Patient" as soon as possible,
H is for "Hand Hygiene",
A is for "Aspiration Precautions," and
P is for "Prevent Contamination" (Babcock, 2000)

8. REFERENCES

- APIC guidelines for hand washing and hand antisepsis in healthcare settings. APIC Guideline for Infection Control Practice. AJIC Am J Infect Control, 1995; 23:251-269.

- Association for Professionals in Infection Control and Epidemiology Inc., Olmsted RN, Ed. APIC infection control and applied epidemiology, principles and practice. St. Louis: Mosby-Year Book, Inc. 2000.

- Association for Professionals in Infection Control and Epidemiology, Inc. (APIC). Pfeiffer, J. Apic Text of Infection Control and Epidemiology. Washington, D.C., 2002 supplemental.

- Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. Guidelines for prevention of nosocomial pneumonia. MMWR 1997; 46:1-77, No. RR-1.

- Cook DJ, Walter SD, Cook RJ, Griffith LE, Guyatt GH, et al. Incidence of and risk factors for ventilator associated pneumonia in critically ill patients. Ann Intern Med 1998; 129:433-440.

- George DL. Epidemiology of nosocomial ventilator-associated pneumonia. Infect Control Hosp Epidemiol 1993; 14:163-169.

- Kollef MH. The prevention of ventilator-associated pneumonia. NEJM 1999; 340:627-634.

- Mayhall C. Glen, Ventilator-Associated Pneumonia or Not? Contemporary Diagnosis. Emerging Infect Dis Special Issue Vol. 7, No. 2 Mar.Apr 2001

- Perry AG, Potter PA. Clinical nursing skills and techniques, Ed 5. St. Louis: Mosby, 2001:1164-1172.

CONTENTS FOR LEARNING UNITS

What Causes VAI to Occur?

Two factors that may lead to VAI development are bacterial colonisation of the aerodigestive tract and aspiration of the contaminated secretions. Meticulous respiratory care and careful handling of the ventilator and all equipment in contact with the patient's aero-digestive tract is critical in preventing contamination.

Factors contributing to **bacterial colonisation** of the aero-digestive tract include:

√ Contaminated hands of healthcare workers.
√ Contaminated respiratory therapy equipment.
√ Aspiration of contaminated secretions into the lower airway.

Risk for aspiration of contaminated secretions is increased with:

√ The patient lying in a flat, supine position (to decrease aspiration risk, elevate the head of the bed to 30º when tolerated by the patient).
√ Insertion of a nasogastric tube and enteral feedings.
√ Inadequate endotracheal tube cuff pressure.

How Do I Reduce the Risk of VAI in My Patients?

The primary intervention to prevent any nosocomial infection is hand washing. Careful infection control practices related to respiratory care are also essential to preventing VAI. Healthcare workers should use the following recommendations for all ventilated patients.

How to prevent bacterial colonisation of the aero-digestive tract:

√ Meticulous hand hygiene with the use of soap and water or a waterless hand antiseptic agent is essential before and after ventilator contact or patient suctioning.
√ Do not change ventilator circuits and/or in-line suction catheters unless visibly soiled or malfunctioning.
√ Do not use heat moisture exchangers (HME) for patients with excessive secretions or hemoptysis (be sure to provide an alternative form of humidification).
√ Change HME every 24 hours, or when visibly soiled with secretions.
√ Drain condensate from ventilator circuits per policy using appropriate technique to avoid contamination of circuit.

Prevention of aspiration of contaminated secretions:

√ Maintain adequate ventilation and cuff pressure.
√ Place ventilated patients in semi-recumbent position with **head of bed elevated to at least 30º**, as tolerated, even during transport.
√ Drain ventilator circuit condensate before repositioning patient.
√ To avoid gastric distention monitor gastric residual volumes before initiating gastric feedings via nasogastric (NG), percutaneous endoscopic gastrostomy, or gastrostomy tubes.
√ Remove NG tubes as soon as possible.

To reduce risk of VAI when suctioning a ventilated patient:

√ Use clean gloves for in-line suctioning and sterile gloves for single use catheter suctioning.
√ Do not store catheter where it can become contaminated, or contaminate clean supplies.
√ Oral suction catheters (e.g., Yankauer®) should be stored in a non-sealed paper or plastic bag when not in use.
√ Do not lay oral suction catheter on ventilator.
√ Suction when necessary. Frequent unnecessary suctioning may introduce organisms into lower respiratory tract.

Other key points to reduce the risk of VAI include:

√ Avoid nasal intubation.
√ Adequately secure endotracheal tube and take measures to prevent accidental extubation.
√ Avoid overuse of multiple antibiotics.
√ Limit stress ulcer treatment if possible.
√ Use daily chlorhexidine oral rinse (only for patients undergoing cardiothoracic surgery).
√ Provide immunisations (e.g., Influenza, Pneumococcus, Haemophilus B).

Ventilator Care Key Points

√ Do not routinely change ventilator circuits unless visibly soiled or malfunctioning.
√ Use sterile water to fill humidifiers; tap water or distilled water can harbor Legionella spp.
√ Use clean gloves to drain condensate from ventilator circuits regularly. Do not allow condensate to flow toward patient while draining. Clean gloves reduce possible spread of microorganisms from healthcare worker's hands.

√ Wash hands or use waterless antiseptic agent (e.g. alcohol foam) after contact with any part of the ventilator. Keyboard knobs, dials, etc. are all considered contaminated equipment.

What Is the Correct Procedure for Draining Ventilator Circuit Condensate?

1. Wash hands or use waterless antiseptic agent.
2. Put on clean gloves and safety glasses (to protect from aerosolised particles).
3. Allow fluid to accumulate into the collection/trap jar.
4. Open ventilator circuit carefully and avoid spillage.
5. Drain accumulated fluid into a wide mouthed canister for immediate disposal. Do not drain or dispose fluid directly into a sink or trashcan!
6. Carefully reconnect ventilator tubing to avoid contamination.
7. Remove gloves and wash hands or use waterless antiseptic agent.

If your facility uses a closed drainage system (e.g. Safety Drain):

1. Wash hands or use waterless antiseptic agent.
2. Put on clean gloves.
3. Allow fluid to accumulate into the collection/trap jar
4. Use wand to suction fluid into suction canister. Do not open the ventilator circuit.
5. Remove gloves and wash hands or use waterless antiseptic agent.

What is the Correct Procedure for Collecting a Suctioned Sputum Specimen?

1. Wash hands or use waterless antiseptic agent.
2. Put on clean gloves.
3. Connect suction tube adapter to sputum trap.
4. Put on sterile gloves.
5. Connect sterile suction catheter to rubber tubing on sputum trap.
6. If secretions are thick and tenacious, instill small amount of normal saline into endotracheal tube.
7. Insert the tip of the catheter into the endotracheal tube or tracheostomy. Do not apply suction. Advance catheter until patient coughs.
8. As patient coughs, apply intermittent suction for collection of 2-10 ml sputum.
9. Remove gloves and wash hands or use waterless hand antiseptic agent.
10. Transport specimen within 2 hours when kept at room temperature or within 24 hours when refrigerated.

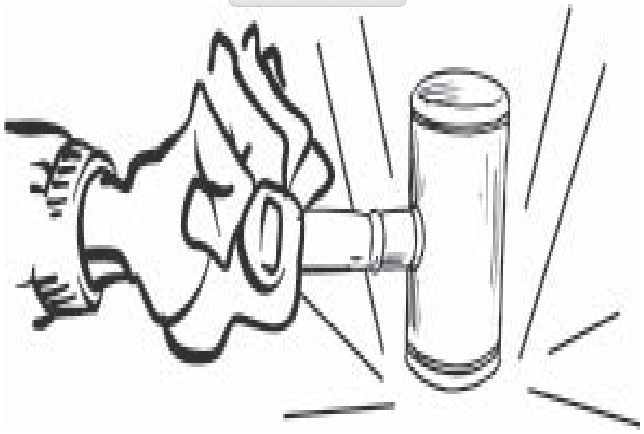
In conclusion ... **W.H.A.P. VAI!**

√ Wean Patient
- From the ventilator as soon as clinically indicated.

√ Hand Hygiene
- Wash hands before and after contact with patient or ventilator.
- Waterless hand antiseptic agents such as foam or gel are appropriate alternatives.

√ Aspiration Precautions
- Elevate head of bed 30°.
- Drain ventilator condensate away from the patient before repositioning the patient.
- Check gastric residual before administering tube feedings.

√ Prevent Contamination
- Of respiratory therapy equipment.
- Of ventilator circuits.
- Wear gloves when in contact with ventilator.
- Wash hands or use waterless hand antiseptic agents.



Appendix 4: Post-test

Prevention of

Ventilator-Associated

Infections

Contents:
Self-Study Post-Test

Self-Study Post-Test
January 2003

Name & Signature:……..……

Hospital:……

Date:……

VAI Self-Study Learning Programme Post-Test
Test your Ventilator-Associated Pneumonia Knowledge

Instructions: Please circle the correct answer.

Questions

1)The following groups are at risk for VAI:

A) Elderly
B) Infants & young children
C) Immunosuppressed patients
D) Patients with decreased levels of consciousness
E) Cardiothoracic patients
F) All of the above
G) A & D

2)What are *two* factors that may lead to the development of VAI?

1. Colonisation of the aero-digestive tract;
2. Lack of proper hand washing;
3. Aspiration of contaminated secretions;
4. Contaminated respiratory therapy equipment

A) 1 & 3
B) 2 & 4
C) 2 & 3

3) Oral suction catheters (e.g., Yankauer) should be stored between uses:

A) on the ventilator
B) in a non-sealed paper or plastic bag
C) on the patient's bed

4) You are the nurse taking care of Pinky Puffer today. You notice that the night nurse accidentally forgot to empty the Foley catheter urine bag. First you put on a pair of clean gloves and empty the bag before it bursts. Pinky begins to cough. You look up and realise that the condensate in the ventilator tubing needs to be drained. What do you do?

A) Call another nurse to drain the ventilator tubing.
B) You finish with the Foley catheter bag empty the contents, then move to the ventilator tubing, open it and drain the condensate.
C) You finish with the Foley catheter bag, empty the contents, remove soiled gloves & wash hands; then put on clean gloves and move to the ventilator tubing, open it and drain the condensate.

5) What is the correct procedure for draining ventilator circuit condensate?

A) Wash hands or use waterless antiseptic agent
Put on clean gloves
Open ventilator circuit carefully
Drain fluid into wide-mouthed container
Empty container into trash can.

B) Wash hands or use waterless antiseptic agent
Put on clean gloves
Open ventilator circuit carefully
Drain fluid into wide-mouthed container
Carefully reconnect ventilator tubing to avoid contamination
Empty container into a hopper or dispose per policy.

C) Wash hands or use waterless antiseptic agent
Put on sterile gloves
Open ventilator circuit carefully
Drain fluid into wide-mouthed container
Carefully reconnect ventilator tubing to avoid contamination
Empty container into the sink.

Circle the correct answer where T = True and F = False

T F **6) The use of multiple antibiotics increases a patient's risk of developing VAI.**

T F **7) Frequent suctioning of the patient is the single best way to prevent VAI.**

T F **8) In ICUs, VAI is the leading cause of nosocomial infection, accounting for 60% of all deaths attributable to nosocomial infections.**

T F **9) HMEs (heat & moisture exchangers) should be changed every 24 hours to maintain proper function.**

T F **10) Ventilator circuits and in-line suction catheters should be changed every 7 days while the patient is in an ICU.**

T F **11) Nasal intubation is preferred whenever possible to prevent aspiration of the oral secretions.**

T F **12) Tap water should be used in humidifiers.**

T F **13) Ventilator condensate should always be drained before repositioning the patient.**

T F **14) Patients on ventilators should have the head of the bed elevated to 30 degrees to prevent condensate from draining into the patient.**

T F **15) The nurse should monitor gastric residual volumes before each feeding to prevent aspiration in ventilated patients receiving tube feedings.**

T F **16) A patient has a temperature of 37.2ºC, minimal amounts of clear sputum, and a normal chest x-ray. White blood cells are 8/mm3 and the sputum culture is positive for *Staphylococcus aureus.* The patient has pneumonia and should be treated with antibiotics.**

17) Patient Ima Sicky is a 63 year old female with diabetes mellitus on was admitted to the ICU on Monday. On admission to the unit, she is immediately intubated and attached to a ventilator. On admission she has a non-productive cough and thin watery sputum is suctioned. Her chest X-ray is clear on Monday. On Tuesday, the chest X-ray shows a consolidation in the left lower lobe and the patient has developed a productive cough with yellow sputum. Her temperature is 38.9 ^{o}C and her WBC is 15,000/mm3. The physician orders a broad-spectrum antibiotic.

Which of the following is true?

A) This patient is exhibiting normal symptoms of a ventilated patient.
B) This patient probably has pneumonia, but it's not VAI.
C) This patient probably has VAI.
D) Nothing can be determined until sputum cultures are obtained.

18) A suctioned sputum specimen is obtained on Ms. Sicky and the culture grew *Pseudomonas aeruginosa*. Which of the following is true?

A) The culture was obviously contaminated.
B) Respiratory Therapy must have exposed the patient to the organism.

C) The in-line suction catheter must be colonised and should be discarded immediately.

D) Pseudomonas is the likely source for the patient's infection.

19) Mr. I.M. Shortabreath is a 58-year-old man who was admitted to the ICU one week ago. On admission to the unit he suffered a cardiac arrest, was nasally intubated and attached to a ventilator. He started NG tube feeding every Q6 hours on Day 1 and continued these. There is a HME in situ and an in-line suction catheter on the ventilator circuit. During your shift, Mr. Shortabreath spiked a temperature of 39.1° C and you suctioned copious amounts of thick yellow sputum. Before the 6 am feed, you checked his gastric residual, which was 250 cc.

What should you do?

1) Hold the tube feeding.
2) Change the HME.
3) Change the in-line suction catheter.
4) Remove the HME and provide alternative humidification source.

A) 1 & 2
B) 2 & 3
C) 1 & 4
D) All of the above

20) What information should you bring to the physician's attention?

1) Oral intubation is the preferred route.
2) An in-line suction catheter is inappropriate for this patient.
3) HMEs should be used for every patient.
4) The patient has a fever and purulent sputum
5) An NG tube is not the best feeding method for this patient.

A) 1 & 3
B) 2 & 4
C) 1, 4, & 5
D) All except 3

Appendix 5: Self-study test answers

Prevention of

Ventilator-Associated Infections

Contents:
Self-Study Test Answers
January 2003

VAI Self Study Learning Programme
Pre-Post-Test Answers

1. F *All groups mentioned are at risk for VAI.*

2. A *Two factors that frequently lead to VAI development are bacterial colonisation of the aero-digestive tract and aspiration of the contaminated secretions.*

3. B *Store oral suction catheter (Yankauer) in a non-sealed paper or plastic bag to reduce contaminating clean supplies or ecoming contaminated.*

4. C *Always remove gloves and wash hands or use waterless hand antiseptic agent after completing a "dirty" task.*

5. B *You do not need sterile gloves or a sterile container for this procedure. Always carry to hopper to discard. Do* ***not*** *drain into trash can or sink.*

6. T *Multiple antibiotics, especially when used for empiric treatment increase risk for developing resistant organisms that can cause infection.*

7. F *Suction when necessary. Frequent unnecessary suctioning may introduce organisms into lower respiratory tract.*

8. T *In ICU's, VAI is the leading cause of nosocomial infection and is responsible for 60% of all deaths attributable to nosocomial infections.*

9. T *Heat and moisture exchangers (HMEs) cannot maintain proper function if not changed according to manufacturer's instructions and may be a risk factor for VAI development.*

10. F *Data from studies shows an increase in VAI when the circuit was changed every 7 days compared to not changing the circuit unless it is soiled or malfunctioning.*

11. F *Nasal intubation is associated with sinusitis and increases the risk for VAP*

12. F *Use sterile water to used to fill humidifiers; tap water or distilled water can harbor Legionella spp.*

13. T *Drain ventilator circuit condensate before repositioning patient.*

14. T *Place ventilated patients in semi-recumbent position with head of bed elevated 30° as tolerated, even during transport.*

15. T *Monitor gastric residual volumes before feedings to avoid gastric distention.*

16. F *There is no evidence of infection or pneumonia, only colonisation.*

17. B *The Centers for Disease Control and Prevention (CDC) has developed standardised definitions for nosocomial pneumonia. Patients with VAI must have mechanical ventilation* ***greater than 48 hours****.*

18. D *A deep suctioned specimen should provide accurate culture results when the patient is symptomatic and VAI is suspected.*

19. C *Hold the tube feeding. The patient has 250 cc. still in his stomach and is at risk for aspiration. Then remove the HME. Do not use HMEs for patients with excessive secretions or hemoptysis.*

20. C *Oral intubation is preferred over naso-tracheal intubation; the patient is febrile and has purulent sputum; and an oral gastric tube should be considered since NG tubes may increase the possibility of aspiration of gastric contents or bacterial migration via the tube from the stomach to the upper airway.*

Appendix 6: Certificate of Completion

Prevention of Ventilator-Associated Infections

Contents:
Certificate of Completion

Certificate of Completion

awarded to:

_____

For completing the Prevention of Ventilator-Associated Infections Learning Programme

_____ _____

Date Signature

Appendix 7: Fact Sheets

Infection Control Fact Sheets

Contents

InfectionControl Fact Sheet #1

Ventilator-Associated Infections(VAI)

Mechanical ventilators are essential to modern hospital practice. The use of ventilators can lead to complication such as aspiration, pneumonia, or sepsis. Ventilator-associated Infections(VAI) is associated with increased morbidity, mortality, prolonged hospitalisation (mean of 4-9 days) and increased costs, up to $8,000 per hospitalisation. In Australia, VAI is one of the most common nosocomial infections. In ICU's, VAI is the leading cause of nosocomial infection and is responsible for 60% of all deaths attributable to nosocomial infections. VAI rates are much higher in mechanically ventilated patients due to the artificial airway, which increases the opportunity for aspiration and colonisation.

January 2003

Facts About Ventilator-Associated Infections

#1 Risk Factors

√ Reintubation/self-extubation.

√ Prolonged ventilatory support.

√ Infants, young children, and people over 65.

√ Compromised health conditions such as

- **organ failure,**
- **trauma/burns,**
- **a chronic disease**
- **immunosuppression**
- **depressed level of consciousness**
- **cardiothoracic surgery**

√ Lying flat in bed.

√ Gastric distention.

√ Inadequate pressure in the endotracheal tube cuff.

√ Nasogastric tubes.

√ Routine changing of ventilator circuits (tubing).

√ Non-specific antibiotic therapy or use of multiple antibiotics.

√ Stress ulcer treatment.

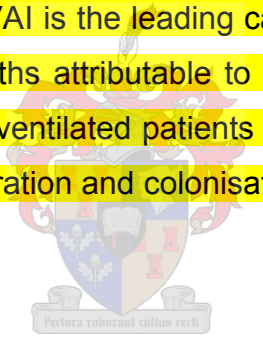
√ Hospitalisation in the fall or winter season.

√ Admission to an ICU.

InfectionControl Fact Sheet #2

Ventilator-Associated Infections (VAI)

Mechanical ventilators are essential to modern hospital practice. The use of ventilators can lead to complications such as aspiration, pneumonia, or sepsis. Ventilator-associated Infections (VAI) is associated with increased morbidity, mortality, prolonged hospitalisation (mean of 4-9 days) and increased costs, up to $8,000 per hospitalisation. In Australia, pneumonia is one of the most common nosocomial infections. In ICU's, VAI is the leading cause of nosocomial infection and is responsible for 60% of all deaths attributable to nosocomial infections. VAI rates are much higher in mechanically ventilated patients due to the artificial airway, which increases the opportunity for aspiration and colonisation.



January 2003

Facts About
Ventilator-Associated Infections #2

Causes of VAI

Two factors that may lead to VAI development are: **bacterial colonisation** of the aero-digestive tract and **aspiration of the contaminated secretions.** Meticulous respiratory care and careful handling of the ventilator and all equipment in contact with the patient's aero-digestive tract is critical in preventing contamination.

Factors contributing to bacterial colonisation of the aero-digestive tract include:

√ Contaminated hands of health care workers.

√ Contaminated respiratory therapy equipment.

√ Aspiration of contaminated secretions into the lower airway.

Risk for aspiration of contaminated secretions is increased with:

√ The patient lying in a flat, supine position (to decrease aspiration risk, **elevate the head of the bed to 30º**, when tolerated)

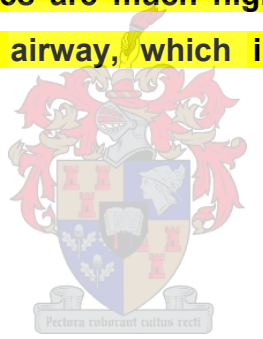
√ Insertion of a nasogastric tube and enteral feedings.

√ Inadequate endotracheal tube cuff pressure.

InfectionControl Fact Sheet #3

Ventilator-Associated Infections(VAI)

Mechanical ventilators are essential to modern hospital practice. The use of ventilators can lead to complications such as aspiration, pneumonia, or sepsis. Ventilator-associated Infections (VAI) is associated with increased morbidity, mortality, prolonged hospitalisation (mean of 4-9 days) and increased costs, up to $8,000 per hospitalisation. In Australia, pneumonia is one of the most common nosocomial infections. In ICU's, VAI is the leading cause of nosocomial infection and is responsible for 60% of all deaths attributable to nosocomial infections. VAI rates are much higher in mechanically ventilated patients due to the artificial airway, which increases the opportunity for aspiration and colonisation.



January 2003

Facts About
Ventilator-Associated Infections #3

Decreasing the Risk for Patients

To prevent bacterial colonisation:

√ Meticulous hand hygiene is essential before and after ventilator contact or suctioning.
√ Change ventilator circuits & in-line suction catheters when soiled or malfunctioning.
√ If with excessive secretions or hemoptysis, avoid heat moisture.
√ Change HME every 24 hours, or when visibly soiled with secretions.
√ Drain condensate from ventilator circuits per policy avoiding contamination of circuit.

To prevent aspiration of contaminated secretions:

√ Maintain adequate ventilation and cuff pressure.
√ Keep head of bed elevated to at least 30º, as tolerated, even during transport.
√ Drain ventilator circuit condensate before repositioning patient.
√ Monitor gastric residual volumes before initiating gastric feedings.
√ Remove NG tubes as soon as possible.

Other key points to reduce the risk of VAI include:

√ Use clean gloves for in-line suctioning & sterile gloves for single use catheter suctioning.
√ Store suction catheters to prevent contamination.
√ Avoid nasal intubation.
√ Adequately secure endotracheal tube and take measures to prevent accidental extubation.
√ Avoid overuse of multiple antibiotics.
√ Limit stress ulcer treatment when possible.
√ Provide immunisations (e.g., Influenza, Pneumococcus, Haemophilus B).

InfectionControl Fact Sheet #4

Ventilator-Associated Infections (VAI)

Mechanical ventilators are essential to modern hospital practice. The use of ventilators can lead to complications such as aspiration, pneumonia, or sepsis. Ventilator-associated Infections (VAI) is associated with increased morbidity, mortality, prolonged hospitalisation (mean of 4-9 days) and increased costs, up to $8,000 per hospitalisation. In Australia, pneumonia is one of the most common nosocomial infections. In ICU's, VAI is the leading cause of nosocomial infection and is responsible for 60% of all deaths attributable to nosocomial infections. VAI rates are much higher in mechanically ventilated patients due to the artificial airway, which increases the opportunity for aspiration and colonisation.

January 2003

Facts About
Ventilator-Associated Infections #4

Correct Procedure for Draining Ventilator Circuit Condensate

1. Wash hands or use waterless antiseptic agent.
2. Put on clean gloves and safety glasses (to protect from aerosolised particles).
3. Allow fluid to accumulate into the collection/trap jar.
4. Open ventilator circuit carefully and try to avoid spillage.
5. Drain accumulated fluid into a wide mouthed canister for immediate disposal. Do not drain or dispose fluid directly into a sink or trash can!
6. Carefully reconnect ventilator tubing to avoid contamination.
7. Remove gloves and wash hands or use waterless antiseptic agent.

If your facility uses a closed drainage system (e.g.,Safety Drain):

1. Wash hands or use waterless antiseptic agent.
2. Put on clean gloves.
3. Allow fluid to accumulate into the collection/trap jar.
4. Use wand to suction fluid into suction canister. Do not open the ventilator circuit.
5. Remove gloves and wash hands or use waterless antiseptic agent.

InfectionControl Fact Sheet #5

Ventilator-Associated Infections(VAI)

Mechanical ventilators are essential to modern hospital practice.The use of ventilators can lead to complications such as aspiration, pneumonia, or sepsis. Ventilator-associated Infections (VAI) is associated with increased morbidity, mortality, prolonged hospitalisation (mean of 4-9 days) and increased costs, up to $8,000 per hospitalisation. In Australia, pneumonia is one of the most common nosocomial infections. In ICU's, VAI is the leading cause of nosocomial infection and is responsible for 60% of all deaths attributable to nosocomial infections. VAI rates are much higher in mechanically ventilated patients due to the artificial airway, which increases the opportunity for aspiration and colonisation.

January 2003

Pectora roborant cultus recti

Facts About
Ventilator-Associated Infections #5

Collecting a Suctioned Sputum Specimen

1. Wash hands or use waterless antiseptic agent.
2. Put on clean gloves.
3. Connect suction tube adapter to sputum trap.
4. Put on sterile gloves.
5. Connect sterile suction catheter to rubber tubing on sputum trap.
6. If secretions are thick and tenacious, instill small amount of normal saline into endotracheal tube.
7. Insert the tip of the catheter into the endotracheal tube or tracheostomy. Do not apply suction. Advance catheter until patient coughs.
8. As patient coughs, apply intermittent suction for collection of 2-10 ml. sputum.
9. Remove gloves and wash hands or use waterless hand antiseptic agent.
10. Transport specimen within 2 hours when kept at room temperature or within 24 hours when refrigerated.

Appendix 8: Poster

Contents:
Poster

WHAP VAP!

Ventilator-Associated Pneumonia

VAP is the leading cause of nosocomial infection in the ICU and reflects 60% of all deaths attributable to nosocomial infections. Pneumonia rates are much higher in mechanically ventilated patients due to the artificial airway, which increases the opportunity for aspiration and colonization.

W
Wean Patient

Wean Patient...

- From the ventilator as soon as clinically indicated.

H
Hand Hygiene

Hand Hygiene...

- Wash hands before & after contact with patient or ventilator.
- Waterless hand antiseptic agents such as foam or gel are appropriate alternatives.

A
Aspiration Precautions

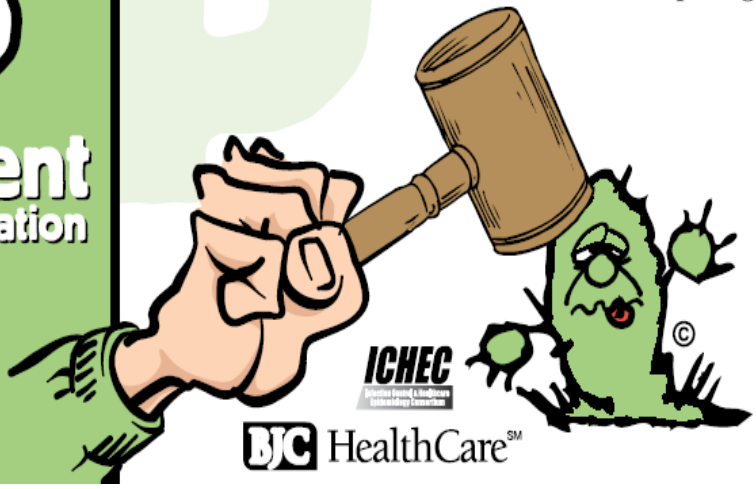
Aspiration Precautions...

- Elevate head of bed 30°.
- Drain ventilator circuit condensate away from patient before repositioning patient.
- Check gastric residual before administering tube feedings.

P
Prevent Contamination

Prevent Contamination...

- Of respiratory therapy equipment.
- Of ventilator circuits.
- Wear gloves when in contact with ventilator.
- Wash hands or use waterless hand antiseptic agents.



ICHEC

BJC HealthCare℠

Controlling infections is ***YOUR*** *responsibility!*
Protect your patients ...
wash your hands!

Appendix 9: The questionnaire for the evaluation of the Learning Programme

Contents:
The Questionnaire for the evaluation of the Learning Programme

QUESTIONNAIRE

Evaluation of the Learning Programme implemented for staff working with ventilated patients in an ICU.

Aim:

This questionnaire is circulated to identify the positive and negative factors experienced during the implementation of the Learning Programme in the ICU.

The information gathered will assist in future updates of the programme.

Instructions:
Please give your honest, detailed opinion in the spaces provided. Should the space provided be insufficient, use additional pages. Please make sure to number the answers on the additional pages.

1. What is your overall impression of the learning programme?

_____
_____
_____
_____

2. What are the positive aspects of the learning programme?

_____
_____
_____
_____

3. What are the negative aspects of the learning programme?

_____
_____
_____
_____

4. Do you think a learning programme like this is appropriate in the current management of ventilated patients?

_____
_____
_____
_____

5. Do you recommend other learning programmes, similar to this, covering other infection control subjects, e.g. Management and Care of Central Venous Catheters, in the future? Please motivate your answer.

_____

_____

_____

_____

6. Did you find the self-study Module helpful and easy to use? Please explain your answer.

_____

_____

_____

_____

7. Did you find the in-service provided helpful and of any value? Please motivate your answer.

_____

_____

_____

_____

8. Where the Fact Sheets and Posters of any value/significants? Please motivate your answer.

_____

_____

_____

_____

9. Was senior staff available and able to answer questions regarding this learning programme?

_____
_____
_____
_____

10. What suggestions do you have for future use and upgrading of this learning programme?

_____
_____
_____
_____

- Any other comments:

_____
_____
_____
_____
_____

Thank you for completing the questionnaire.

Appendix 10: Ethical approval

Contents:
Ethics Approval

ETHICS COMMITTEE CERTIFICATE OF APPROVAL

This is to certify that

Project No: 101/02

Project Title: A Learning Programme for Nurses for the Prevention of Ventilator Associated Infections

Principle Researcher: Juliana van der Merwe

Protocol No: p-6708

The study and protocol, version 4, dated: 5 August 2002, has been considered by the Ethics Committee and is **APPROVED.**

Approval date: 25/09/2002 **Expiry date:** 25/09/2004

It is the Principle Researcher's responsibility to ensure that all researchers associated with this project are aware of the conditions of approval and which documents have been approved.

The Principle Researcher is required to notify the Secretary of the Ethics Committee, via amendment or progress report, of

- Any significant change to the project and the reason for that change, including an indication of ethical implications (if any);
- Serious adverse effects on participants and the action taken to address those effects;
- Any other unforeseen events or unexpected developments that merit notification;
- The inability of the Principle Researcher to continue in that role, or any other change in research personnel involved in the project;
- Any expiry of the insurance coverage provided with respect to sponsored clinical trials and proof of re-insurance;
- A delay of more than 12 months in the commencement of the project; and
- Termination or closure of the project.

Additionally, the Principle Researcher is required to submit

- A Progress Report every 12 months for the duration of the project (*forms to be provided);*
- A Request for Extension of the project prior to the expiry date, if applicable; and,
- A detailed Final Report at the conclusion of the project.

The Ethics Committee may conduct an audit at any time.

All research subject to the Alfred Hospital Ethics Committee review must be conducted in accordance with the National Statement on Ethical Conduct in Research Involving Humans (1999).

SPECIAL CONDITIONS

None

SIGNED: _____ **DATE:** 25/09/02

Chair, Ethics Committee (or delegate)

Please quote Project No and Title in all correspondence

R. FREW
SECRETARY
ETHICS COMMITTEE

Appendix 11: Guidelines for antibiotic use

Contents:
ATS reference guidelines for Antibiotic Treatment

Based on the ATS REFERENCE guidelines, the following recommendations can be made (see Table ?)

- Patients with an early onset of a ventilator-associated infection and no risk factors: Core organisms such as community endogenous pathogens Staphylococcus aureus, Streptococcus pneumoniae and Haemophilus influenzae) and non-resistant Gram negative enterobacteriaceae (GNEB, including Escherichia coli, Klebsiella pneumoniae, Enterobacter spp, Serratia spp, Proteus spp) should be appropriately treated with antibiotics.
- Patients with a later onset of a ventilator-associated infection and no risk factors: Potentially drug resistant micro-organisms must also be taken into account. This is particularly true when mechanical ventilation is required for more than seven (7) days and against a background of broad spectrum antimicrobial treatment. These include multiresistant MRSA, GNEB, and Pseudomonas aeruginosa, Acinetobacter spp, as well as Stenotrophomonas maltophilia.
- Although not proven by randomised studies, it seems prudent to administer combination treatment. Vancomycin may be added where MRSA is a concern.
- Patients with an early or late onset of a ventilator-associated infection, and with risk factors: Treatment is identical to a late onset ventilator-associated infection without risk factors, except when Legionella spp is suspected.
- The guidelines do not make specific recommendations for non-ventilated patients. Instead, patients not meeting severity criteria are treated as an early onset ventilator-associated infection with modifications in the presence of additional risk factors. It would be useful to compare this severity based approach with an algorithm that separates respiratory infections in non-intubated and intubated patients, and that differentiates early and later onset of a respiratory infection, and that considers the presence of risk factors. This is the direction of the recently published German guidelines for the treatment and prevention of nosocomial respiratory infections (Reference).
- This general framework for empirical initial antimicrobial treatment must be modified according to local requirements. Regular updates of data on potential pathogens of ventilator-associated infections indicating trends in microbial and

resistance patterns are mandatory. Although data on antimicrobial treatment failures are scarce, it was recommended that each case be investigated.

- Separate recording of such data is particularly useful in detecting patients at risk, as well as micro-organisms typically associated with treatment failures. Although few micro-organisms are responsible for the vast majority of antimicrobial treatment failures, the distribution of pathogens is widely divergent between hospitals.

Table 11.1 The General Framework for Empirical Initial Antimicrobial Treatment of Ventilator-associated Infection

Ventilated Patients	Class of Antimicrobial Agents	Agents and Dosages
Early onset, no	Cephalosporin II	• Cefuroxime 3 x 1.5g
Risk Factors	*Or*	
	Cephalosporin III	• Cefotaxime 3 x 2g *or*
		• Ceftriaxone 2 x 1g
	Or	
	Aminopenicillin /β-lactamase inhibitor	• Amoxicillin /clavulanic acid 3 x 2.2g
	Or	
	Third or fourth G quinolone	• Levofloxacin 2 x 500mg
		• Moxifloxacin 1 x 400mg
	Or	
	Clindamycin /aztreonam	• Clindamycin 3 x 600mg
		• Aztreonam 3 x 2g
Late onset, no	Quinolone	• Ciprofloxacin 3 x 400mg
Risk factors	*Or*	
	Aminoglycoside	• Gentamycin 5 - 7 mg/kg
		• Tobramycin 5 – 7 mg/kg
		• Amikacin 1 x 15 mg/kg
	Plus	
	Antipseudomonal β-lactam/	• Piperacillin /tazobactam
	β-lactamase inhibitor	3 x 4.5g
	Or	
	Ceftazidime	• Ceftazidime 3 x 2g
	Or	
	Carbapenems	• Imipenem /cilastatin 3 x 1g
		• Meropenum 3 x 1g
	Plus /Minus	
	Vancomycin	• Vancomycin 2 x 1g
Early or late	Risk factors for *P aeruginosa*	• See late onset
Onset, with	Risk factors for MRSA	• Vancomycin 2 x 1g
Risk factors	Risk factors for Legionellosis: Macrolide	• Erythromycin 4 x 1g
	Or	• Azithromycin 1 x 500mg
	Or	• Clarithromycin 2 x 500mg
	Or	• Levofloxacin 2 x 500mg
	Or	• Moxifloxacin 1 x 400mg

Appendix 12: Medical staff survey and results

Contents:

Medical Staff survey and results

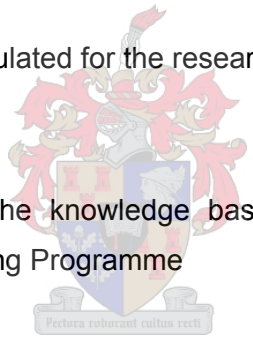
OBJECTIVES

Phase Two

- To pre-test medical staff' knowledge with regard to ventilator-associated infections and the prevention thereof
- To implement the implemented Learning Programme for Medical staff **(This was done as a special request from the medical staff)**
- To post-test medical staff' knowledge with regard to ventilator-associated infections and the prevention thereof
- To evaluate the implemented Learning Programme

HYPOTHESES

The following hypotheses were formulated for the research:



Null hypothesis (Phase two)

- There is no difference in the knowledge base of medical staff following the implementation of the Learning Programme

Alternative hypothesis (Phase two)

- There is a difference in the knowledge base of medical staff following the implementation of the Learning Programme

Null hypothesis (Phase three)

- There is no difference in adult mechanically ventilated patient outcomes following the implementation of the Learning Programme for medical staff

Alternative hypothesis (Phase three)

- There is a difference in adult mechanically ventilated patient outcomes following the implementation of the Learning Programme for medical staff

Data Collection

Data collection took place according to the three phases of the research:

In Phase one data was simultaneously collected and analysed by the focus (specialist) group to determine the content validity of the Learning Programme. Content validity of the Learning Programme as well as the pre-test and post-test were ensured by means of the pilot study (Nel, 2001), an additional literature review, four critical care medical staff working in the intensive care unit, two medical staff (intensivists) and two infection control medical staff who were identified as the focus (specialist) group as well as an expert nurse educator (see Chapter four section 12.5.1).

In Phase two a pre-test and post-test were done to determine the medical staff' scores with regard to their knowledge on ventilator-associated infections and an open ended questionnaire was utilised to collect the data for the evaluation of the implemented Learning Programme. Phase three consisted of the evaluation of the implemented Learning Programme on outcomes of adult patient's being mechanically ventilated in the ICU's of two Australian Hospitals at a specific time and the data were collected by means of a structured surveillance instrument included in the impact evaluation process (Pan American Sanitary Bureau, Regional Office of the WHO, 2000: 2-40).

Population and Sample

The population sample for the research was divided according to the Phases of the research and included in Phase one, critical care qualified medical staff, medical staff and infection control medical staff. The focus (specialist) group consisted of 9 people (see chapter four section 12.5.1) and in Phase two, medical staff working in intensive care units in two Australian hospital, who were caring for adult patients attached to mechanical ventilators. An additional population sample, on special request by the medical intensivists, was that of the medical staff working in Australia, who were caring for adult patients being mechanically ventilated (see Appendix 12 for the population sample for medical staff).

The sample consisting of medical staff (215 in total) in two Australian hospitals were according to the criteria in Chapter four section 12.5.1. The population sample for Phase three consisted of adult patients attached to mechanical ventilators in ICU's of two Australian hospitals, to determine the impact of the Learning Programme on patient outcomes at a specific given time (see Section 4.12.4).

GOAL OF THE RESEARCH

As described in section 1.3, the goal of this research was to establish a Learning Programme for medical staff working with adult mechanically ventilated patients in an intensive care unit and to evaluate such a programme once it has been established. The research objectives were divided into three phases according to the strategy (see chapter one: section 1.6.1). In this chapter the literature review applicable to the first phase is described. The research was divided into three phases.

In phase one an additional research was done on the following:

- Ventilator-associated infections
- Preventive measures for infection
- Education

A Learning Programme for medical staff was developed based on the literature review described in this chapter and previous work done by Nel (2001). Phase two consisted of a pre- and post-test to evaluate medical staff' knowledge with regard to ventilator-associated infections and the prevention thereof and the implementation and evaluation of a Learning Programme.

In phase three the impact of the Learning Programme on the outcomes of adult patients being mechanically ventilated was evaluated.

OBJECTIVES

The objectives of this research were divided into three phases according to the strategy.

Phase One

- To utilise the results of the pilot study (Nel, 2001) (See Appendix One)
- To conduct an additional literature review on:
  - Ventilator-associated infections
  - Preventive measures for infection
  - Nursing education
- To develop a Learning Programme for medical staff utilising evidence based research.

Phase Two

- To pre-test medical staff' knowledge with regard to ventilator-associated infections and the prevention thereof
- To implement the Learning Programme for medical staff.
- To post-test medical staff' knowledge with regard to ventilator-associated infections and the prevention thereof
- To evaluate the implemented Learning Programme

Phase Three

- To evaluate the impact of the Learning Programme on the outcomes of adult patient's being mechanically ventilated

HYPOTHESES

The following hypotheses were formulated for the research as depicted in the Table below.

Table 12.1: Hypotheses for the research

PHASE	HYPOTHESES
One	Not applicable
Two	Null hypothesis There is no difference in the knowledge base of medical staff following the implementation of the Learning Programme Alternative hypothesis There is a difference in the knowledge base of medical staff following the implementation of the Learning Programme
Three	Null hypothesis • There is no difference in adult ventilated patient outcomes, following the implementation of the Learning Programme for medical staff Alternative hypothesis • There is a difference in adult ventilated patient outcomes, following the implementation of the Learning Programme for medical staff

Target population

Experts who best contributed to the purpose of this research were selected for the sample, and served as the basis of the Learning Programme. Nursing experts in the field of adult intensive care and infection control nursing as well as medical medical staff working with adult ventilated patients in the intensive care unit validated the Learning Programme.

The population sample for the research was divided according to the phases of the research and included in:

Phase one:
Intensive care qualified nurses, medical staff and infection control nurses in two Australian hospitals (See also 3.5.2.1. ii. and chapter four section 12.5.1) were utilised.

Phase two:

Medical staff working in two adult intensive care units in Australia, who were caring for adult patients attached to mechanical ventilators were selected for the sample as thus was convenient for the researcher to conduct the research at her place of employment. An additional population sample, on special request by the medical intensivists was that of the medical staff working in the two Australian hospitals, who were caring for adult patients being mechanically ventilated. (See Appendix 12 for medical population).

Criteria for the sample were the following:

Medical staff in two Australian hospitals who were working in the adult intensive care units and rendering medical care to adult patients attached to mechanical ventilators. It was also essential that they had completed the pre-test and the self-study Learning Programme.

Phase three:
Adult patients attached to mechanical ventilators in the intensive care units at the two Australian hospitals, following implementation of the Learning Programme for medical staff, to determine the impact of the Learning Programme on patient outcomes.

- Medical medical staff in two Australian hospitals were according to the following criteria they:
- were registered medical medical staff
- were working in the Adult Intensive Care Unit
- were rendering medical care to adult patients attached to mechanical ventilators
- had completed a pre-test
- had completed the self study Learning Programme

GOAL OF THE RESEARCH

The goal of the research was to develop, implement and evaluate a Learning Programme for medical staff working with adult ventilated patients in an intensive care unit.

Phase two realised according to the objectives (see Table 12.2)

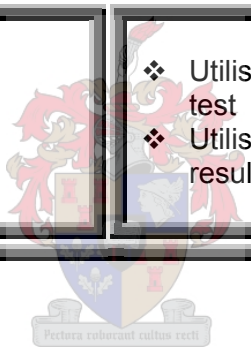
In this phase three objectives were formulated as depicted in Table 4.1 A pre-test was done and according to the results the Learning Programme was then implemented and the difference in medical staff' knowledge base was measured with the post-test. The results are depicted in frequencies and percentages (See Table 12.3). A score of 80% in both the pre-and post-test is graded as significant knowledge. A score between 80-90% is being regarded as highly significant. Statistical significance was accepted on a 5% scale. Visual presentations of data are given in the form of tables, pie diagrams and histograms. For the statistical analysis the researcher utilised a null and alternative hypothesis. A null as well as an alternative hypothesis were stated for the dependant variable (knowledge base of medical staff in phase two and patient outcomes in phase three).

Results of the pre-test for medical staff caring for adult mechanically ventilated patients

A statistician who used the Sign-Rank test to compare the results analysed the results. In Table 12.3 the results of the pre-test are summarised and in Table 12.5 the results of the pre-test and post-test are compared. The results for medical staff are summarised in Appendix 12.

Table 12.2 Actions of objectives in Phase Two

Objective	Actions
❖ *Pre-test knowledge*	❖ Utilise & implement developed test ❖ Utilise the Sign Rank test to analyse results
❖ *Implement & evaluate Learning Programme*	❖ Describe research methodology: o Study location o Population o Data gathering & handling o Results
❖ *Post-test knowledge*	❖ Utilise & implement developed post-test ❖ Utilise the Sign Rank test to analyse results



Results of the pre-test

The results of the pre-test were analysed according to the scores obtained for each question. In Table 12.3 the pre-test results according to the correct, wrong and ($\overline{X}$) mean scores (in percentages) respondents obtained, are illustrated.

Question One: Which of the mentioned groups are at risk for VAI?

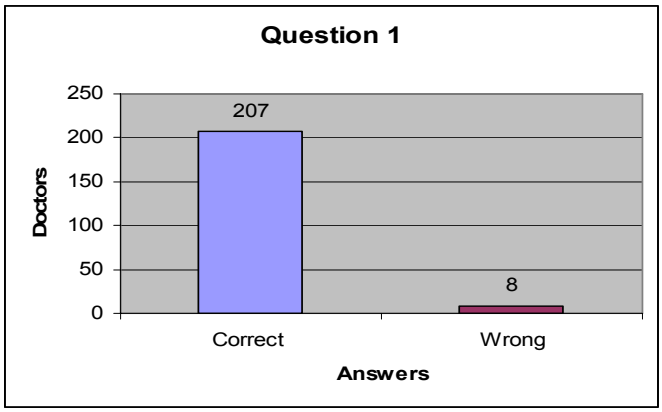


Figure 12.1 Groups at risk for VAI

Of the total (n= 215) number of medical staff (n=207) 96%, knew the correct answer namely all groups mentioned are at risk for VAI. This presented a minority of the total thus indicating a knowledge deficit (see also Figure 12.1 and Table 12.3 for the visual presentation).

Question Two: Which two factors may lead to the development of VAI?

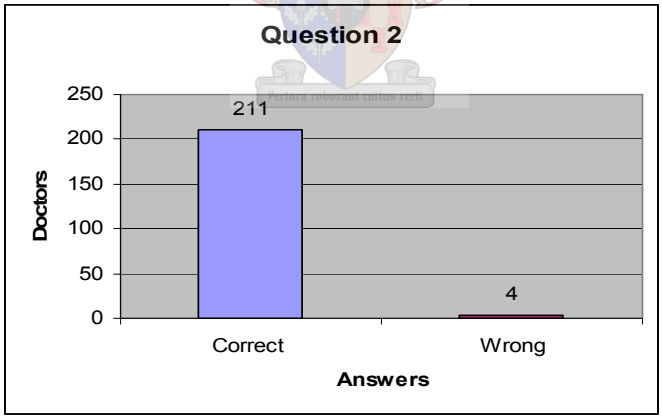


Figure12.2 Factors leading to VAI

The two factors that frequently lead to VAI development are bacterial colonisation of the aero-digestive tract and aspiration of the contaminated secretions. Of the total number of medical staff (n= 215), the majority answered correctly (n=211) with a mean ($\overline{X}$) score of 98%. A small knowledge deficit was demonstrated (see also Figure 12.2 and Table 12.3).

Question Three: Where should oral suction catheters be stored?

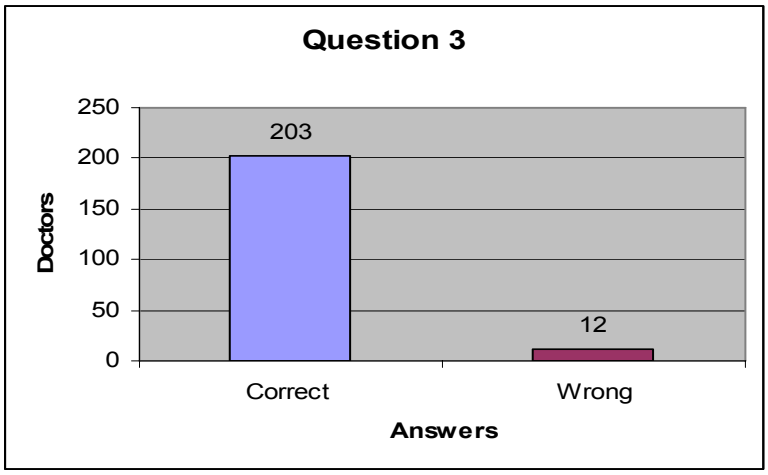


Figure 12.3 Storage of suction catheters

Of the 215 medical staff, 94% (n= 203), representing the $\overline{X}$ score (see Table 12.3), knew how to store the oral suction catheter in a non-sealed paper or plastic bag to reduce contaminating clean supplies or becoming contaminated, which can contribute to VAI (see also figure 12.3). Medical staff' knowledge with regard to storage of suction catheters was thus adequate.

Question Four: While emptying your patient's Foley bag, you look up and realise that the condensate in the ventilator tubing needs to be drained. Your patient starts to cough, what do you do?

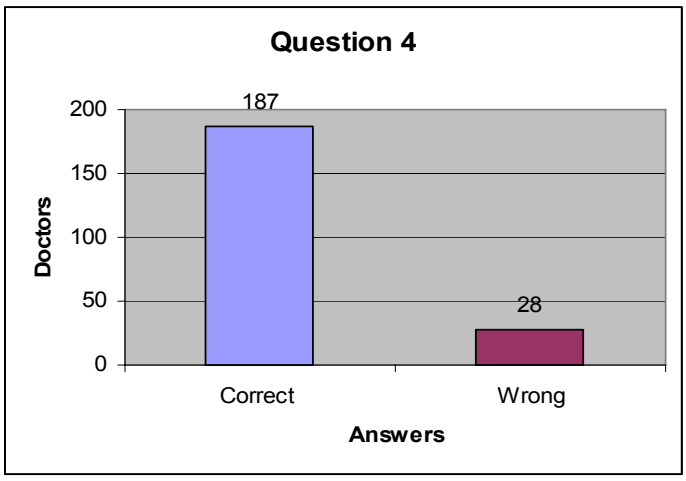


Figure 12.4 How to prioritise infection control actions

In figure 12.4 only 87% the ($\overline{X}$) score, of the medical staff (n=187) knew to always remove their gloves and wash their hands or use a waterless hand antiseptic after completing a "dirty" task. This is a basic procedure and only 100% compliance is acceptable, thus indicating a knowledge deficit (see Table 12.3 for the $\overline{X}$ scores).

Question Five: Which is the proper procedure for draining ventilator circuit condensate?

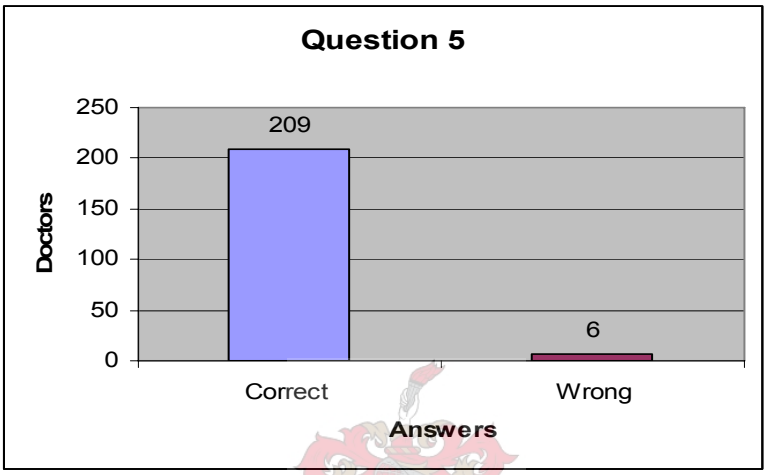


Figure 12.5 Procedure for draining ventilator circuit condensate

Figure 12.5 depicts that 97% (n =209) of the total (n = 215) medical staff answered correctly, which is that you do not need sterile gloves or a sterile container for this procedure. Also, you need to carry and empty the condensate into a hopper and not into a trashcan or sink thus competency compliance of a basic intensive care procedure was acceptable as indicated in Table 12.3, which depicts a mean $\overline{X}$ score of 97% for the correct answers.

Question Six: True or false – The use of multiple antibiotics increases a patient's risk of developing VAI?

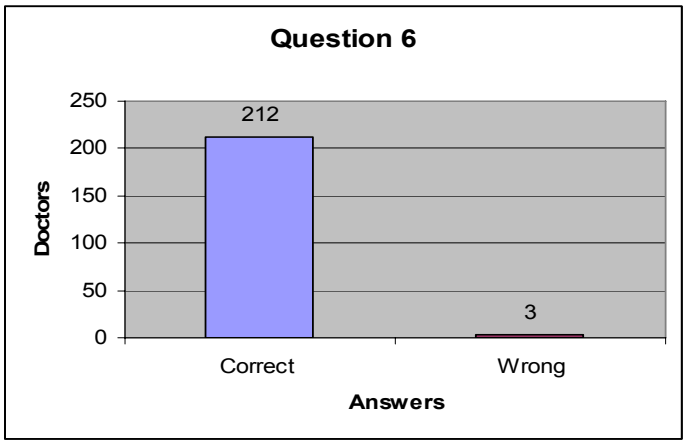


Figure 12.6 Use of antibiotics

Of the total (n= 215) medical staff, 98.6% (n= 212) knew that multiple use of antibiotics, especially when used for empiric treatment, increases the risk for developing resistant organisms that can cause infection (see Figure 12.6 and Table 12.3). A $\overline{X}$ score of 98.6% indicates a knowledge deficit of critical care medical staff that needed some attention.

Question Seven: True or false – Frequent suctioning of the patient is the single best way to prevent VAI?

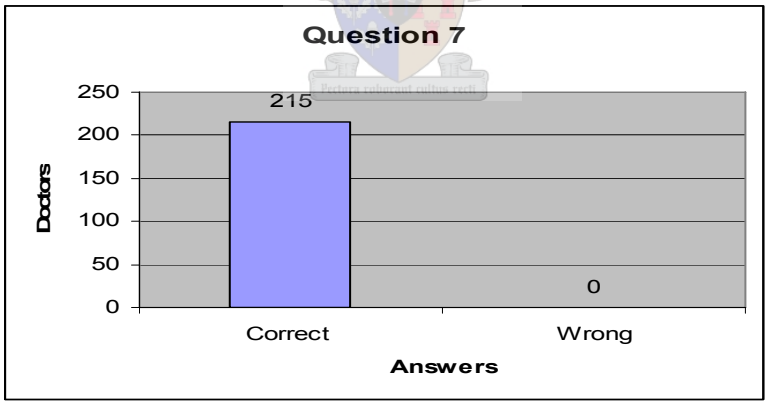


Figure 12.7 Frequent suctioning

Figure 12.7 depicts that 100% (n=215) of medical staff stated that the statement is false, also reflecting the mean $\overline{X}$ score (see Table 12.3) and that the patient only needs suctioning when necessary. Frequent unnecessary suctioning may introduce organisms into the lower respiratory tract.

Question Eight: True or false – In ICU's, VAI is the leading cause of health-care-associated infection, accounting for 60% of all deaths attributable to health-care-associated infections?

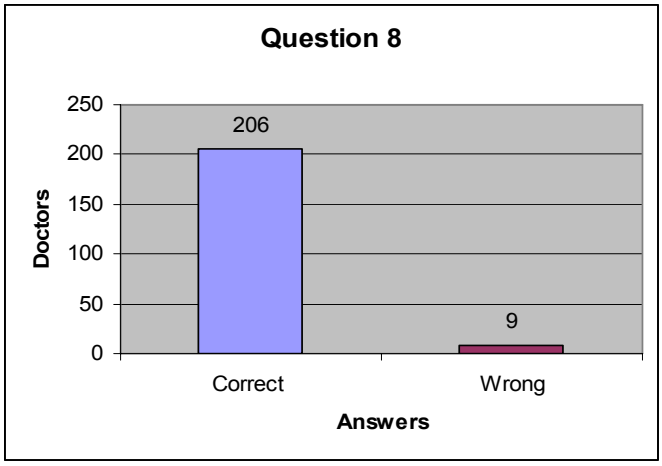


Figure 12.8 Leading causes of VAI

Of the all the medical staff (n= 215), only 95.8% (n=206) answered correctly which represented the $\overline{X}$ score and realised that VAI is responsible for 60% of all deaths attributable to health-care-associated infections. Only 100% compliance to this question is acceptable therefore the score indicated a knowledge deficit (see Figure 12.8 and Table 12.3 for a visual presentation of the results).

Question Nine: True of false – HME's (heat & moisture exchangers) should be changed every 24 hours to maintain proper function?

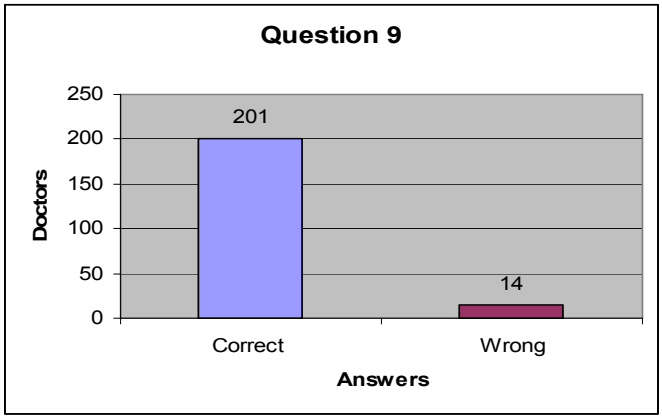


Figure 12.9 Changing of HME's

Just 93% (n=201) of the (see figure 12.9) medical staff knew that heat and moisture exchangers (HME's) cannot maintain proper function if not changed according to

manufacturer's instructions and may be a risk factor for VAI development. This also represented the $\overline{X}$ score (see Table 12.3). Only 100% compliance to this question is acceptable therefore the score indicated a knowledge deficit.

Question Ten: True or false – Ventilator circuits and in-line suction catheters should be changed every (7) seven days while the patient is in an ICU?

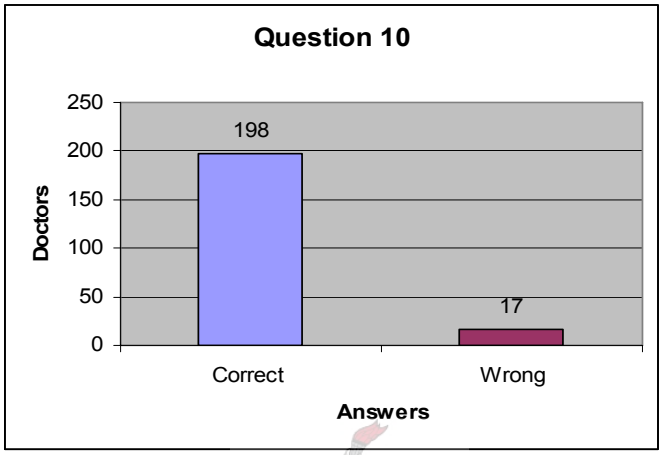


Figure 12.10 Changing of ventilator circuits

A disappointing 92% (n= 198) of the total (n= 215) medical staff answered correctly which represented the $\overline{X}$ score (see Table 12.3) and knew that data from studies shows an increase in VAI when the circuit was changed every 7 days compared to not changing the circuit unless it is soiled or malfunctioning. Only 100% compliance to this question is acceptable therefore the score indicated a knowledge deficit (see also Figure 12.10).

Question Eleven: True of false – Nasal intubation is preferred whenever possible to prevent aspiration of the oral secretions?

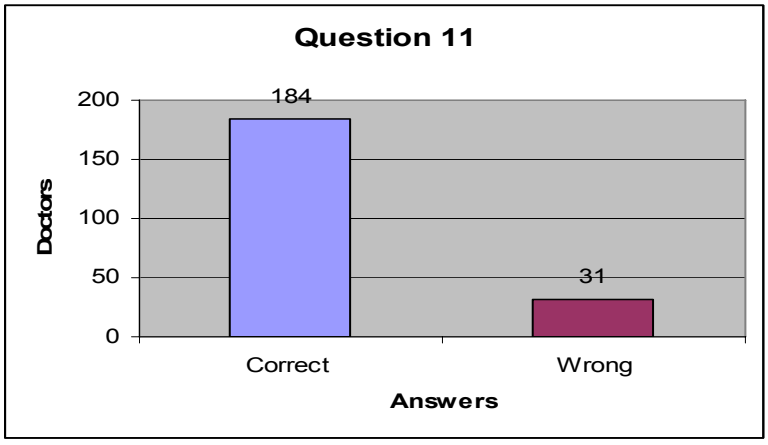


Figure 12.11 Nasal intubation

Only 85.6% (n= 184) also indicating the $\overline{X}$ score (see Table 12.3) of the medical staff knew that nasal intubation is associated with sinusitis and increases the risk for VAI. Only 100% compliance to this question is acceptable therefore the score indicated a knowledge deficit (see also Figure 12.11).

Question Twelve: True of false – Tap water should be used in humidifiers?

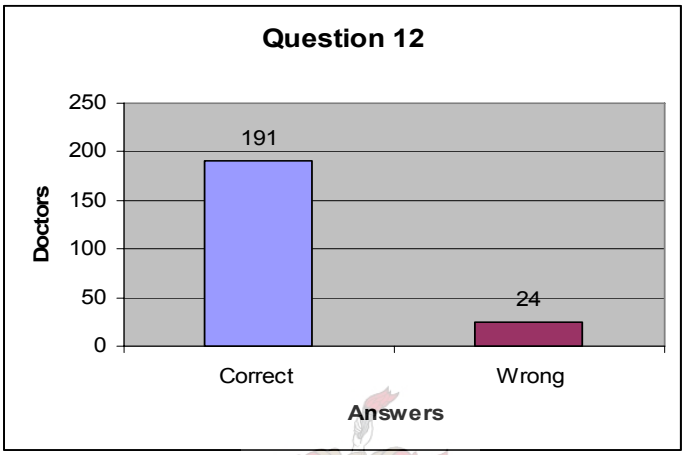


Figure 12.12 Tap water in humidifiers

Figure 12.12 gives a visual presentation of the scores on this question whereas only 88.8% (n= 191) medical staff answered correctly and use sterile water to fill humidifiers which also indicated the $\overline{X}$ score (see Table 12.3). Tap or distilled water can harbour Legionella spp. Only 100% compliance to this question is acceptable therefore the score indicated a knowledge deficit.

Question Thirteen: True or false – Ventilator condensate should always be drained before repositioning the patient?

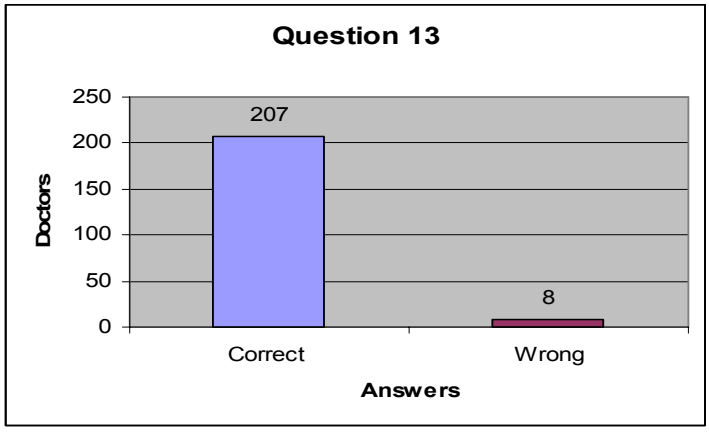


Figure 12.13 Drainage of ventilator condensate

Of the total (n=215) medical staff, 96% (n= 207) answered correctly and said that they would drain ventilator circuit condensate before repositioning their patient. Only 100% compliance to this question is acceptable therefore the $\overline{X}$ score, 96%, indicated a knowledge deficit (see also Figure 12.13).

Question Fourteen: True or false – Patients on ventilators should have the head of the bed elevated to 30 degrees to prevent condensate from draining into the patient?

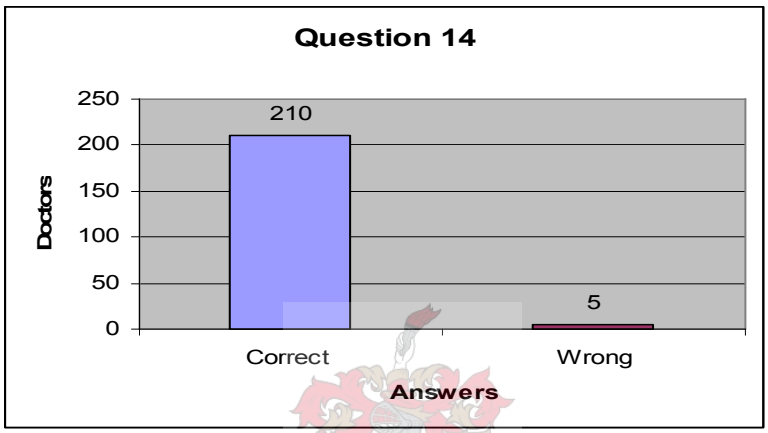


Figure 12.14 Head of bed elevated

97.7% (n= 210), which also represented the $\overline{X}$ scores of the medical staff agreed that they need to place ventilated patients in a semi-recumbent position with the head of the bed elevated 30° as tolerated, even during transport. Only 100% compliance to this question is acceptable therefore the score indicated a slight knowledge deficit (see also Figure 12.14 and Table 12.3).

Question Fifteen: True or false – The nurse should monitor gastric residual volumes before each feeding to prevent aspiration in ventilated patients receiving tube feedings?

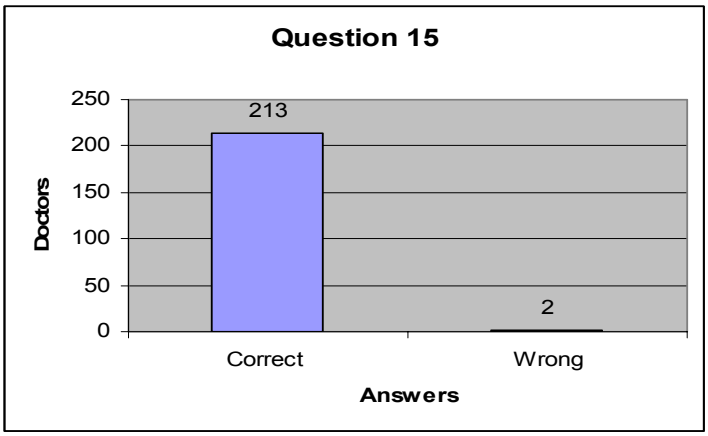


Figure 12.15 Gastric residual volumes

99% (n= 213) of the medical staff answered correctly and confirmed that it is important to monitor gastric residual volumes before feedings to avoid gastric distension. This also represented the $\overline{X}$ score (see also Figure 12.15 and Table 12.3).

Question Sixteen: True or false – A patient has a temperature of 37.2°C, minimal amounts of clear sputum, and a normal chest x-ray. White blood cells are 8k/cm and the sputum culture is positive for *Staphylococcus aureus*. Does the patient have pneumonia and should the patient be treated with antibiotics?

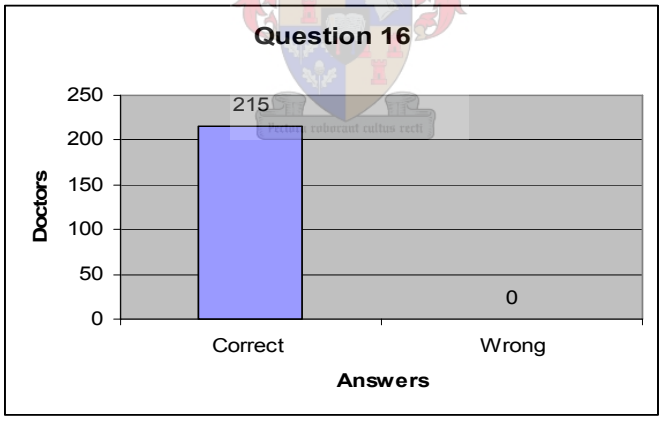


Figure 12.16 Clinical manifestations for pneumonia

100% (n= 215) of the medical staff agreed that there is no evidence of infection or pneumonia, only colonisation. Only 100% compliance to this question is acceptable therefore the score indicated sufficient knowledge for the medical staff (see also figure 12.16).

Question seventeen: After one day that this patient was urgently intubated, this patient's chest x-ray shows consolidation, the patient has a productive cough with yellow sputum, her temperature is 38.9°C and her WBC's are 15,000. The physician orders a broad-spectrum antibiotic. Which of the following is true?

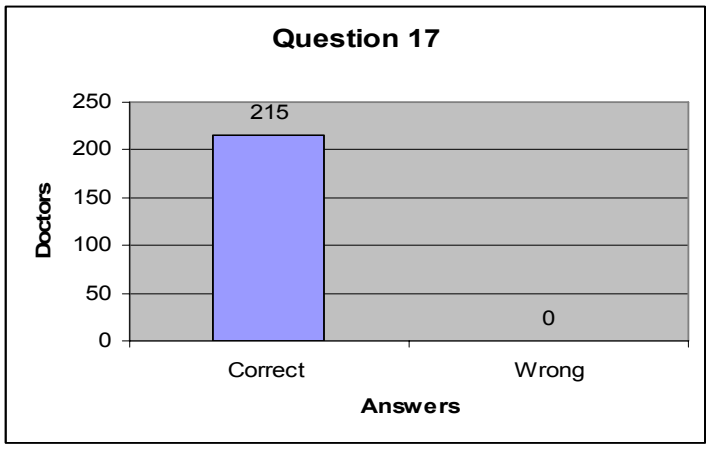


Figure 12.17 Broad spectrum antibiotics

The Centre for Disease Control and Prevention (CDC) (2004) has developed standardised definitions for health-care-associated pneumonia and ventilator-associated infections. Patients with VAI must have had mechanical ventilation for **greater than 48 hours** to fall into this category. 100% (n= 215) of the total (n= 215) medical staff answered this question correct, this also indicated the $\overline{X}$ score. Only 100% compliance to this question is acceptable therefore the score indicated a sufficient knowledge base (see also Figure 12.17 and Table 12.3).

Question Eighteen: After a sputum sample of the same patient was obtained, the culture grew *Pseudomonas aeruginosa*. Which of the following is true?

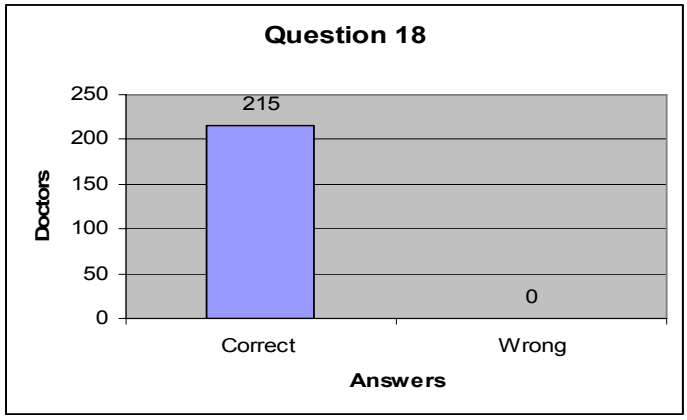


Figure 12.18 *Pseudomonas aeruginosa* indicators

100% (n= 215) of the medical staff answered correctly and knew that a deep suctioned specimen should provide accurate culture results when the patient is symptomatic and VAI is suspected. Figure 12.18 and Table 12.3 and the $\overline{X}$ score of this question, depicts clearly the medical staff' knowledge.

Question Nineteen: A patient, who suffered a cardiac arrest, was admitted to ICU about a week ago. He was intubated and NG-feeds were started. During your shift he spikes a temperature of 39.1°C and you suction copious amounts of thick yellow sputum from his ETT-tube. When you check his gastric residual, it is 250cc. What should you do?

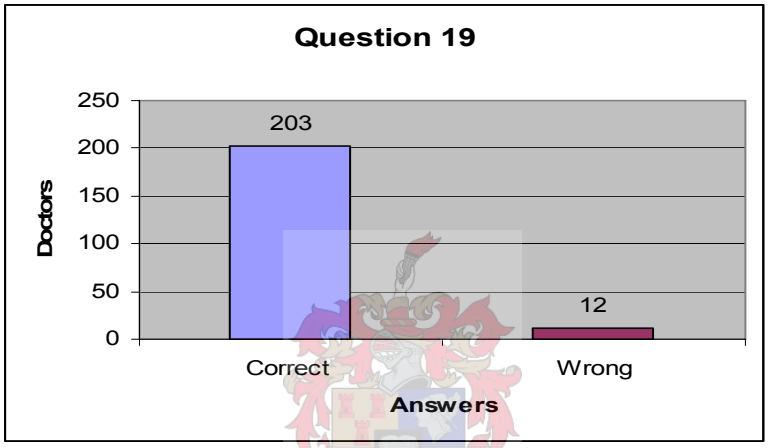


Figure 12.19 Gastric residual

94% (n= 203) of the medical staff answered correctly and said that they would hold the tube feeding. The patient has 250cc still in his stomach and is at risk for aspiration, then remove the HME. Do not use HME's for patients with excessive secretions or haemoptysis. Only 100% compliance to this question is acceptable therefore the $\overline{X}$ score this indicating a knowledge deficit (see also Figure 12.19 and Table 12.3).

Question Twenty: What information should you bring to the physician's attention?

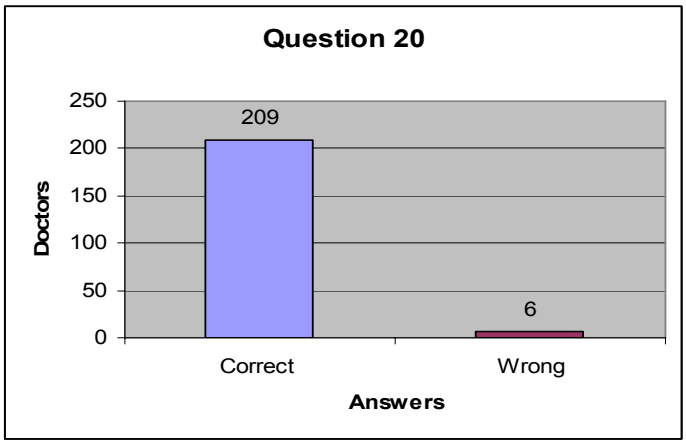


Figure 12.20 Physician information

Figure 12.20 gives a visual presentation of information to be communicated to the physician and 97% (n= 209) of the total (n= 215) medical staff agreed that the following is important to bring to the physician's attention: Oral intubation is preferred over naso-tracheal intubation; and an oral gastric tube should be considered since nasogastric tubes may increase the possibility of aspiration of gastric contents or bacterial migration via the tube from the stomach to the upper airway. Only 100% compliance to this question is acceptable therefore the $\overline{X}$ score indicated a slight knowledge deficit (see Table 12.3).

Conclusion: To pass the pre-test, a minimum score of 80% was required (4 wrong answers only). The overall pass rate in the pre-test was 100% for medical staff, which shows that they have sufficient knowledge regarding ventilator-associated infections.

Table 12.3 Results of the pre-test for medical staff

QUESTION	n =CORRECT ANSWER	n = WRONG ANSWER	MEAN (CORRECT ANSWERS) %
1 - Risk groups	207	8	96
2 - Factors	211	4	98
3 - Suction catheter	203	12	94
4 - Gloves	187	28	87
5 - Circuit condensate	209	6	97
6 - Antibiotics	212	3	99
7 - Suctioning	215	0	100
8- Health-care-associated infection	206	9	96
9 - HME's	201	14	93
10 – Ventilator circuits	198	17	92
11 – Intubation	184	31	86
12 – Humidifiers	191	24	89
13–Ventilator condensate	207	8	96
14 – Elevate head of bed	210	5	98
15 – Aspiration	213	2	99
16 – Pneumonia	215	0	100
17 – VAI	215	0	100
18 – Sputum specimen	215	0	100
19 – NG-feeds	203	12	94
20 – Information	209	6	97

Data gathering and data handling

The data was gathered according to a semi-structured questionnaire after each staff member completed the self-study Learning Programme. The researcher explained the goal of the research and gathered the data by means of ten open-ended questions with a section for comments (see appendix 9). It took each respondent approximately 40 minutes to complete the questionnaire.

To ensure trustworthiness of the responses, respondents could remain anonymous and 107 respondents participated in the completion of the questionnaires. This constituted a saturated sample, as these 107 staff members had done the self-study programme. Staff that had not completed the self-study programme was not included in the final sample. This is the results of the questionnaires received from the medical staff.

Results

Results are described according to completion rates and answers given in the questionnaires.

- **Completion rates of questionnaires**

Overall, for both hospitals, 215 out of 239 medical staff (89.9%) completed the Learning Programme. The staff completion rates at the two individual hospitals for the self-study Learning Programme are shown in Table 12.4.

The high completion rate for the Learning Programme amongst nurses could be due to the fact that the self-study Learning Programme was included in the mandatory competency requirement for nurses. The high completion rate for medical staff may be due to other factors not identified. The results of the pre- and post-test for medical staff are shown in Appendix 12.

Table 12.4 Staff completion rates for the self-study Learning Programme

Hospital infections	Nursing Completion Completion Rate, %	Medical Staff Completion Rate, %	Ventilator-associated Reduction, %
Hospital 1	77.6	98.5	53.3
Hospital 2	82.6	81.3	60.7
Both	80.1	89.9	57.0

❖ **Results: Questionnaires on the evaluation of the Learning Programme**

The responses to the open-ended questionnaire are summarised below. A total of 107 respondents (who completed both the pre-and post-test) filled in the Questionnaire by the given date for collection (see Appendix 9 for the questionnaire). Comments were clustered according to the same responses.

Question One. What is your overall impression of the Learning Programme?

General responses with regard to the overall impression of the Learning Programme were positive. 89% of the respondents (n=95), except 11% (n=12), regarded the programme as very good. The programme was described as “well structured, well thought through, simple but effective and excellent”. After familiarising themselves with the contents of the Learning Programme, the respondents became aware of the importance of the programme and their enthusiasm increased. It can thus be concluded that the Learning Programme left an overall good impression on respondents.

Question Two. What are the positive aspects of the Learning Programme?

Responses on the positive aspects on the Learning Programme were regarding the quality, quantity, timeframe, applicability and other. 44% (n=47) of the respondents commented positively on the quality of the Learning Programme, 59% (n= 63) on the efficient quantity of the programme, 1% (n= 11) on the good timeframe, 7% (n= 8) on the applicability of the programme and 21% (n= 22) had other positive comments regarding the Learning Programme.

Some of the feedback received was as follows:

- The learning programme is a short summary of a lot of information.
- It is straight to the point.
- It allows one to re-assess what you are doing e.g. aseptic technique.
- It ensures that quality care is given to all patients and it supports better patient outcome and survival.

The overwhelming consensus on the positive aspects of the programme as reflected by respondents stated that it would facilitate improvement of patient outcomes and survival.

Question Three. What are the negative aspects of the Learning Programme?

Responses on the negative aspects on the Learning Programme were also regarding the quality, quantity, timeframe, applicability and other /none. Only 8% (n=9) of the respondents gave negative comments on the quality of the Learning Programme, 2% (n= 2) on the quantity of the programme, 69% (n= 74) on the insufficient timeframe, 34% (n= 36) on the applicability of the programme and 17% (n= 18) had no or other comments regarding the Learning Programme.

Some of the feedback received was the following:

- The learning programme takes too long to complete.
- It requires a lot of time and financial resources to implement, which may not necessarily be available.
- Too many projects already in the ICU and
- It is more time spent away for patients.

Most respondents, that is 69% (n= 74), cited time as the main negative factor. It can thus be concluded that the Learning Programme had a few areas to be remediated before implementation to the next group of medical staff.

Question Four. Do you think a Learning Programme similar to this one is appropriate in the current management of ventilated patients?

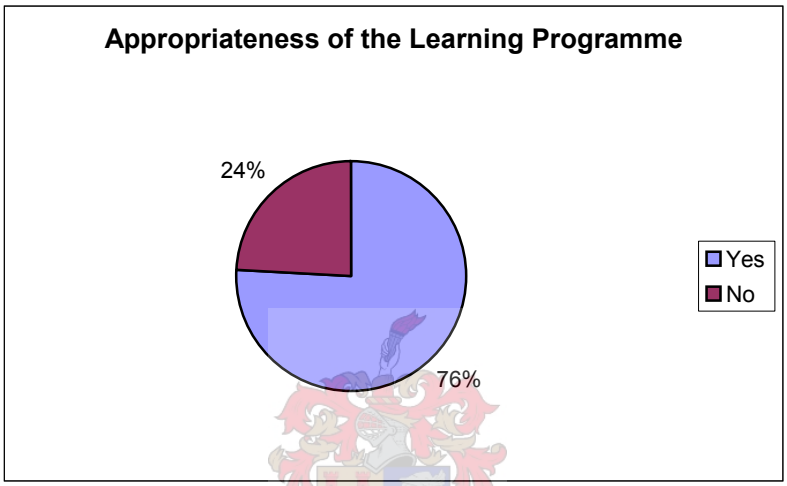


Figure 12.21 Appropriateness of the Learning Programme

Only 24% (n = 26) respondents identified the Learning Programme as inappropriate in the current management of ventilated patients, mainly due to financial constraints and the length of time it takes to implement, therefore the appropriateness of the Learning Programme was established (see figure 12.21).

Question Five. Do you recommend other Learning Programmes, similar to this, covering other infection control subjects, e.g. management and care of central venous catheters, in the future? Please motivate your answer.

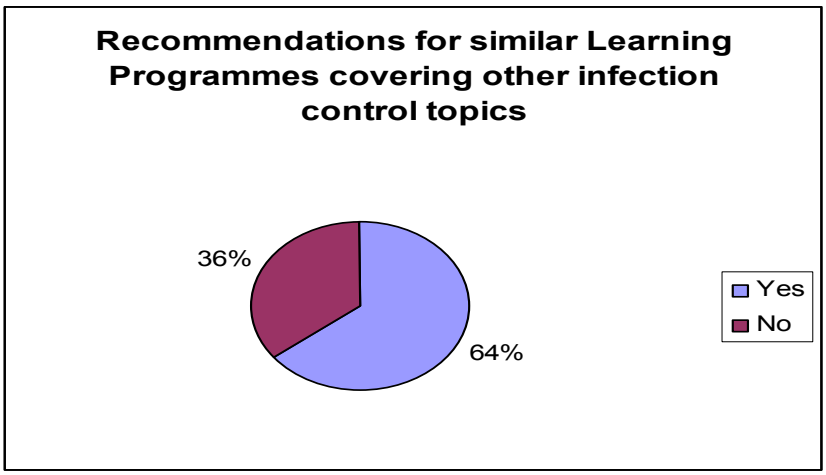


Figure 12.22 Recommendations for other Learning Programmes

General responses on similar learning programmes were (see figure 12.22):

- A positive response was received from 64% (n=69) of the respondents for the implementation of similar programmes on infection control aspects related to critical care nursing.
- Negative responses came from 36% (n = 38) of the respondents.

Comments received were:

- It will help with decreasing infections in the ICU;
- It's an interesting topic to cover during study days;
- It is too time consuming and
- It's really a problem for the medical team to deal with.

More than half, 64% (n= 69) of the respondents recommended the Learning Programme for other infection control topics. It can thus be concluded that similar Learning Programmes will be of value in improving the quality of infection control in ICU.

Question Six. Did you find the self-study Learning Programme helpful and easy to use? Please explain your answer.

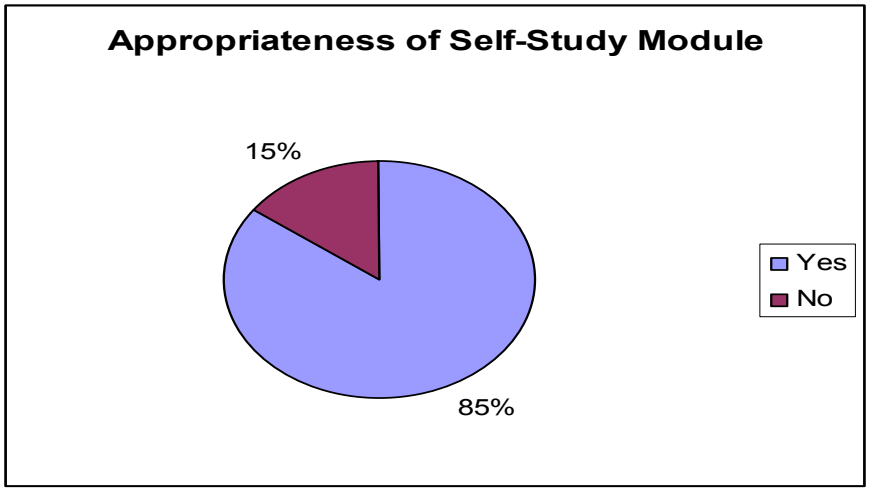


Figure 12.23 Appropriateness of self-study Module

General responses 85 % (n=91) on the appropriateness of the programme were positive and 15% (n=16) were negative.

Comments received were:

- The programme is well structured.
- The Learning Programme is easy to use and understand.
- The Learning Programme has all the relevant information condensed into a few pages.
- The programme was updated with the latest information.

As only 15% (n=16) found the self-study Learning Programme as inappropriate, it can thus be concluded that the self study aspect of the Learning Programme was appropriates for nurses caring for patients being mechanically ventilated (see figure 12.23).

Question Seven. Did you find the in-service provided helpful and of any value? Please motivate your answer.

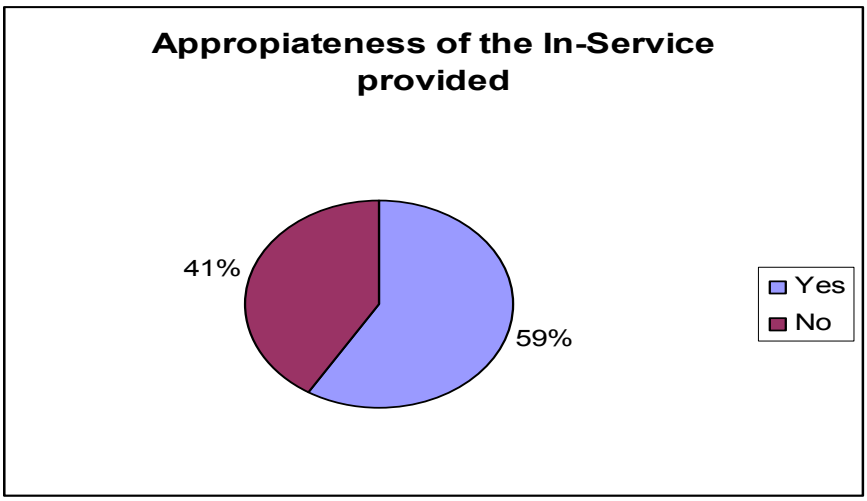


Figure 12.24 Appropriateness of in-service

General responses 59% (n=63) on the appropriateness of the in-service were positive and 41% (n=44) were negative. Comments received were:

- The in-service sessions were interesting.
- It was quality time spent away from the patient (wasn't a waste of time).
- The speakers where experts in their field of practice.
- Some of the sessions took too long.

It can thus be concluded that the in-service provided was appropriate to the needs of medical staff working in an intensive care unit (see also figure 12.24).

Question Eight. Were the fact sheets and posters of any value/ significance? Please motivate your answer.

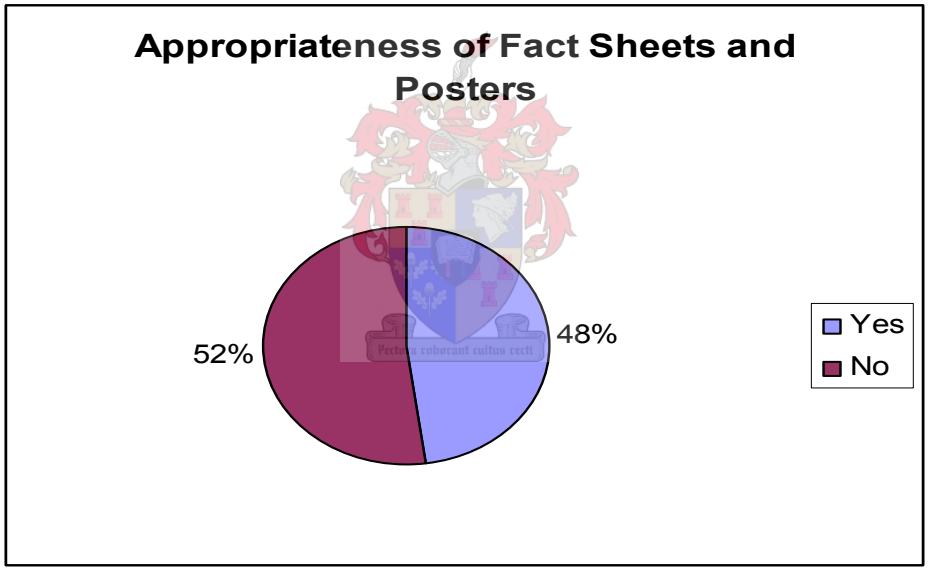


Figure 12.25 Appropriateness of fact sheets and posters

General responses 48% (n=51) on the appropriateness of the fact sheets and posters were positive and 52% (n=56) were negative (see figure 12.25).

Comments received were clustered and were:

- The fact sheets and posters complete the programme.
- It served as good reminders.
- It wasn't as useful as the in-service.
- The posters were more effective and of more value than the fact sheets.

- A lot of the fact sheets got lost.
- The fact sheets didn't get read.

Almost half the staff 42% (n=152) who filled out the questionnaire didn't find the fact sheets and posters as useful and effective as the self-study Learning Programme and the in-service sessions.

Question Nine. Were senior members of staff available and able to answer questions regarding this Learning Programme?

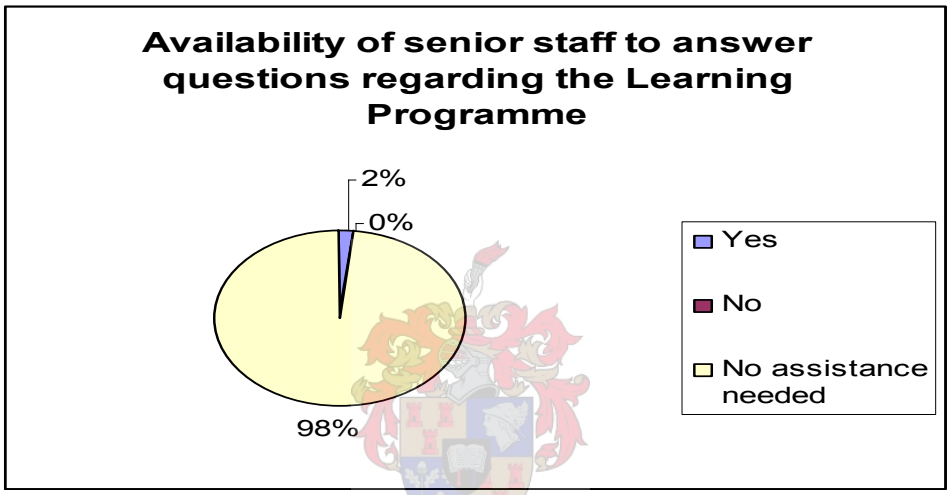


Figure 12.26 Availability of senior staff

Only 2 medical staff members had a query regarding an aspect of the study and managed to found a consultant to clarify the issue (see also figure 12.26). The majority of medical staff, 98% (n=105) didn't have any questions regarding the programme.

It can thus be concluded that overall senior members of staff were available to answers questions with regard to the Learning Programme.

Question Ten. What suggestions do you have for future upgrading of the Learning Programme?

No suggestions were forthcoming from 79% (n=84) of the respondents with regard to future upgrading of the Learning Programme. Other suggestions were the following:

- 4% (n= 4) commented to integrate the programme in the ICU course

- 19% (n= 20) suggested to publish articles regarding the success of the Learning Programme in medical journals
- 16% (n= 17) suggested that we should continue to keep track of infection rates to make sure that the learning programme is still effective
- 8% (n= 9) suggested that staff should be given incentives for participating in the programme

Any other comments included the following:

86% (n= 92) of the respondents made no further comments on the Learning Programme. 11% (n= 12) of the respondents commented that the programme is very time consuming and takes a long time to implement successfully. 8% (n= 4) of the respondents felt that it were also not a good idea considering the staff shortages in the ICU and 13% (n= 14) of the respondents congratulated the researcher on the quality of the programme and the way it was managed.

Results of the post-test for medical staff caring for patients attached to mechanical ventilators

The results were analysed by a statistician who used the Sign-Rank test to compare the results. In Table 12.3 the results of the pre-test are summarised and in Table 12.5the results of the pre-test and post-test are compared. The results for medical staff are summarised in Appendix 12.

Question One: Which of the mentioned groups are at risk for VAI?

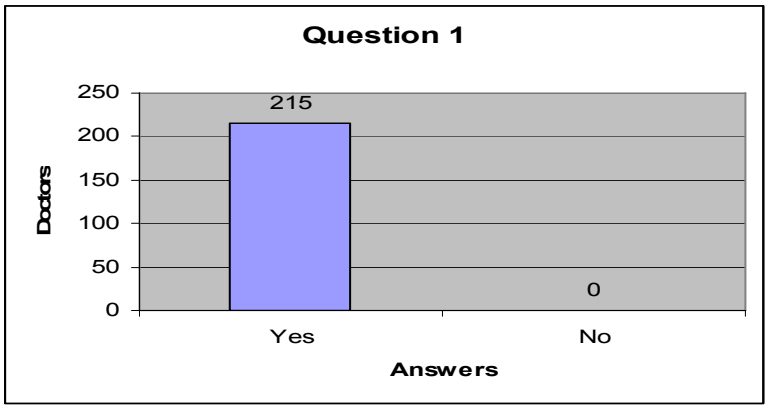


Figure 12.27 groups at risk for VAI

Of the total (n= 215) number of medical staff only 96% (n=207) knew the correct answer in the pre-test, where as in the post-test 100% (n= 215), also indicating the $\overline{X}$ score, knew the correct answer thus giving a statistically significant p-value = 0.0078 which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.27 and Table 12.5).

Question Two: Which two factors may lead to the development of VAI?

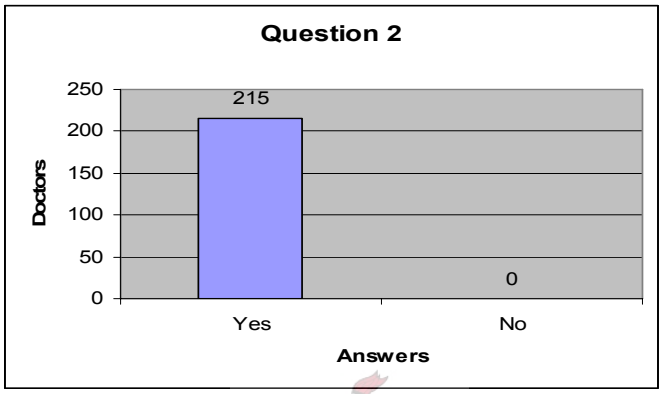


Figure 12.28 Factors leading to VAI

The two factors that frequently lead to VAI development are bacterial colonisation of the aero-digestive tract and aspiration of the contaminated secretions. Of the total number of medical staff (n= 215), 98% of them answered correctly (n=211) in the pre-test. In the post-test, 100% (n= 215) also indicating the $\overline{X}$ score, answered correctly thus giving a statistically significant p-value = 0.1250 which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.28 and Table 12.5).

Question Three: Where should oral suction catheters be stored?

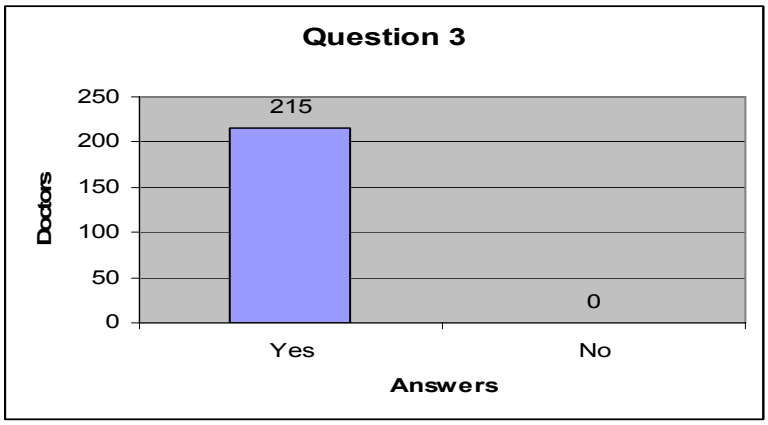


Figure 12.29 Storage of suction catheters

Of the 215 medical staff, 94% (n= 203) knew to store the oral suction catheter in the correct manner when doing the pre-test, as to 100% (n= 215) medical staff when undergoing the post-test, also indicating the $\overline{X}$ score, thus giving a statistically significant p-value = 0.0005 which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.29 and Table 12.5).

Question Four: While emptying your patient's Foley bag, you look up and realise that the condensate in the ventilator tubing needs to be drained. Your patient starts to cough, what do you do?

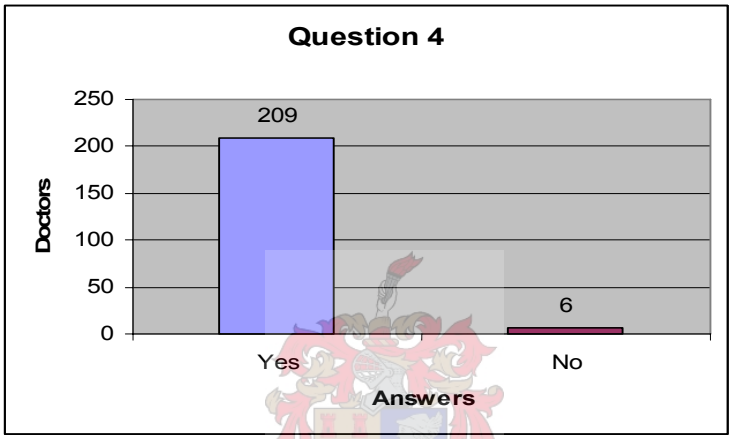


Figure 12.30 Prioritising infection control nursing actions

Of the total 87% of the medical staff (n=187) knew to always remove their gloves and wash their hands or use a waterless hand antiseptic after completing a "dirty" task when undergoing the pre-test. After completing the learning programme and taking the post-test, 97% (n= 209) of medical staff answered correctly also indicating the $\overline{X}$ score, thus giving a statistically significant p-value = <.0001, which indicated an overall improvement in the medical staff knowledge (For a visual presentation see Figure 12.30 and Table 12.5).

Question Five: Which is the proper procedure for draining ventilator circuit condensate?

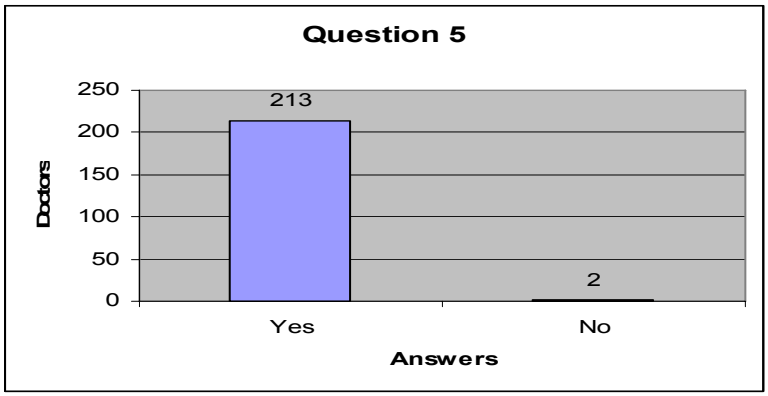


Figure 12.31 Procedure for ventilator circuit drainage

97% (n=209) of the total (n = 215) medical staff answered correctly in the pre-test, that you do not need sterile gloves or a sterile container for this procedure. You also need to carry and empty the condensate into a hopper and not into a trashcan or sink. After taking the post-test, 99% (n= 213) also indicating the $\overline{X}$ score of the medical staff answered correctly thus giving a statistically significant p-value = 0.1250. This indicated an overall improvement in the medical staff' knowledge (for a visual presentation see Figure 12.31 and Table 12.5).

Question Six: True or False – The use of multiple antibiotics increases a patient's risk of developing VAI?

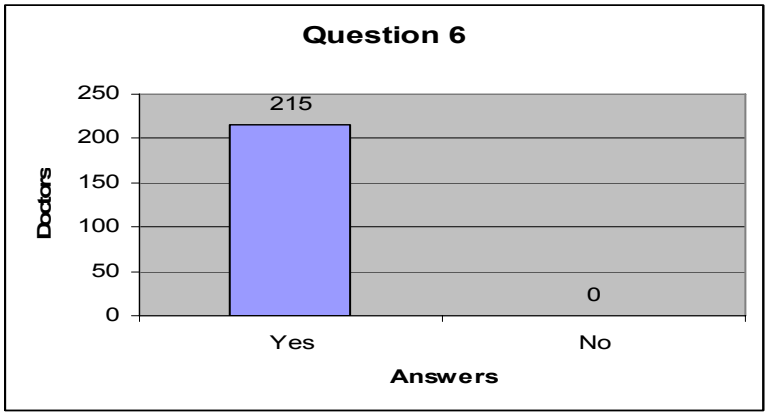


Figure 12.32 Antibiotics as a risk factor for VAI

Of the total (n= 215) medical staff taking the pre-test, 99% (n= 212) knew that multiple use of antibiotics, especially when used for empiric treatment, increase the risk for developing resistant organisms that can cause infection. After completing the learning programme

and after taking the post-test, 100% (n= 215), also indicating the $\overline{X}$ score, of medical staff answered the question correct thus giving a statistically significant p-value = 0.2500, which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.32 and Table 12.5)

Question Seven: True or false – Frequent suctioning of the patient is the single best way to prevent VAI?

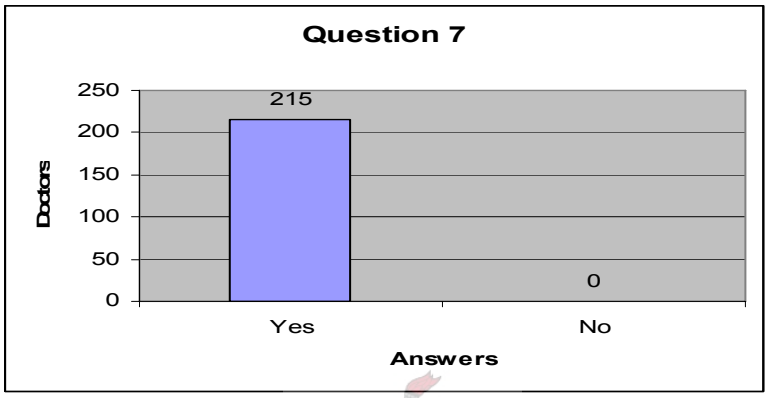


Figure 12.33 Frequent suctioning

In the pre-test, 100% (n=215) medical staff said that the statement is false, which is correct and that the patient only needs suctioning when necessary. Frequent unnecessary suctioning may introduce organisms into the lower respiratory tract. In the post-test, 100% (n= 215) also indicating the $\overline{X}$ score, medical staff answered correctly, thus no changes in their knowledge base was observed.

Question Eight: True or false – In ICU's, VAI is the leading cause of health-care-associated infection, accounting for 60% of all deaths attributable to health-care-associated infections?

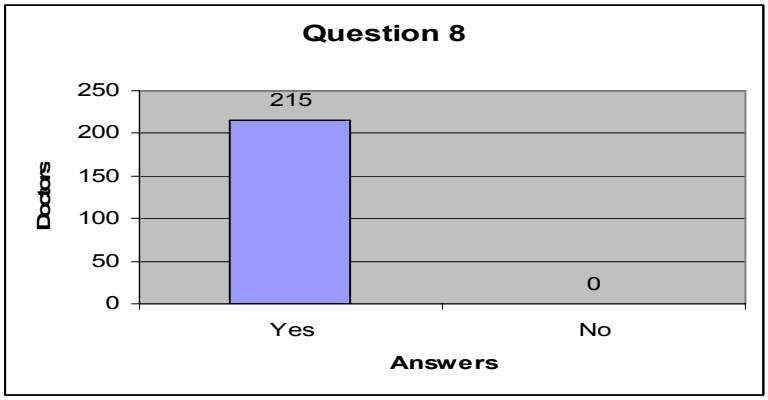


Figure 12.34 VAI as the leading course of health-care-associated infections

Of the all the medical staff (n= 215), 96% (n=206) answered correctly and realised that VAI is responsible for 60% of all deaths attributable to health-care-associated infections. However, after doing the Learning Programme, 100% (n= 215) also representing the $\overline{X}$ score, of the medical staff answered correctly when undergoing the post-test thus giving a statistically significant p-value = 0.0039, which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.34 and Table 12.5).

Question Nine: True of false – HME's (heat & moisture exchangers) should be changed every 24 hours to maintain proper function?

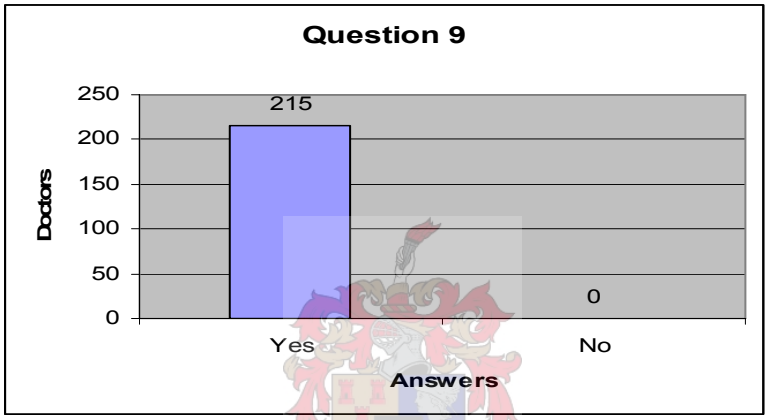


Figure 12.35 Changing of HME's

93% (n=201) of the medical staff during the pre-test knew that heat and moisture exchangers (HME's) cannot maintain proper function if not changed according to manufacturer's instructions and may be a risk factor for VAI development. In the post-test, 100% (n= 215) of the medical staff also representing the $\overline{X}$ score, knew the correct answer thus giving a statistically significant p-value = 0.0001 which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.35 and Table 12.5).

Question Ten: True or false – Ventilator circuits and in-line suction catheters should be changed every 7 days while the patient is in an ICU?

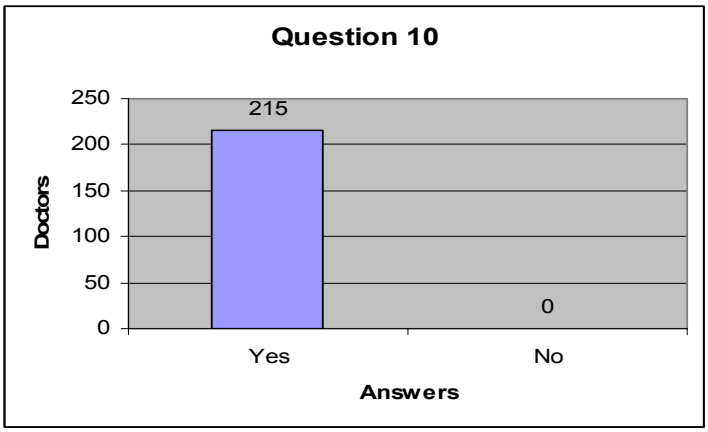


Figure 12.36 Changing regimen for ventilator circuits

92% (n= 198) of the total (n= 215) medical staff in the pre-test answered correctly and knew that data from studies shows an increase in VAI when the circuit was changed every seven (7) days compared to not changing the circuit unless it is soiled or malfunctioning. Of the medical staff, 100 % (n= 215) also indicating the $\overline{X}$ score answered correctly in the post-test thus giving a statistically significant p-value = <.0001, which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.36 and Table 12.5).

Question Eleven: True of false – Nasal intubation is preferred whenever possible to prevent aspiration of the oral secretions?

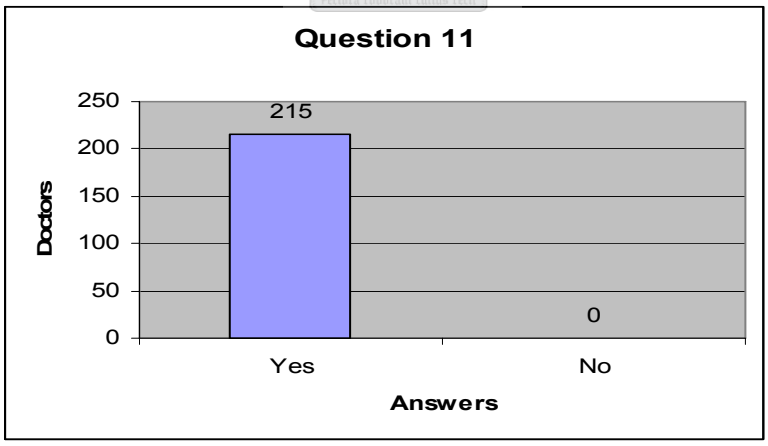


Figure 12.37 Nasal intubation as a risk factor

86% (n= 184) of the medical staff undergoing the pre-test knew that nasal intubation is associated with sinusitis and increases the risk for VAI. After completing the post-test, it was calculated that 100% (n= 215) also indicating the $\overline{X}$ score answered correctly, giving

a statistically significant p-value = <.0001 for the post-test and indicated an overall improvement in the medical staff knowledge (see Figure 12.37 and Table 12.5).

Question Twelve: True of false – Tap water should be used in humidifiers?

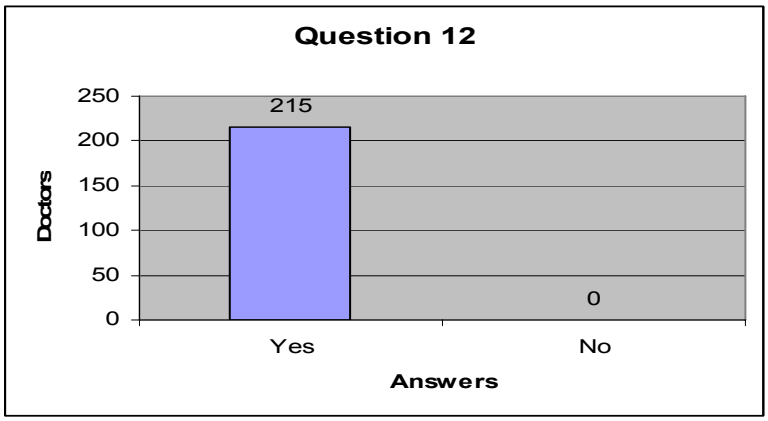


Figure 12.38 Use of tap water

Of the medical staff 89% (n= 191) answered correctly in the pre-test and use sterile water to fill humidifiers. In the post-test, 100% (n= 215) also indicating the $\overline{X}$ score, of the medical staff agreed that the use of sterile water was the correct answer thus giving a statistically significant p-value = <.0001 which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.38 and Table 12.5).

Question Thirteen: True or false – Ventilator condensate should always be drained before repositioning the patient?

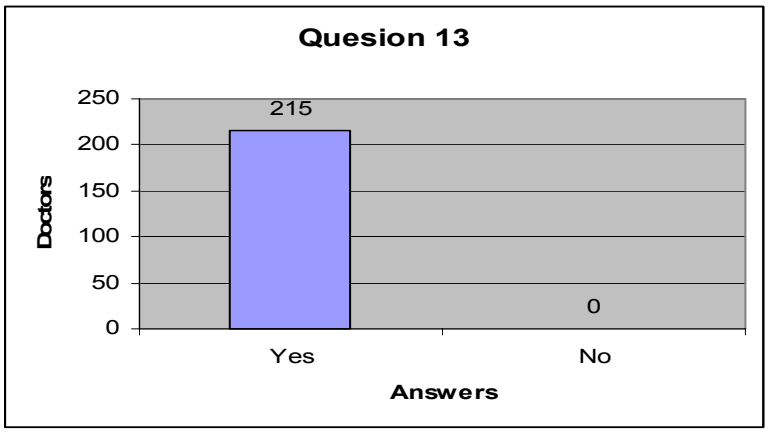


Figure 12.39 Draining of ventilator condensate

Of the total (n= 215) medical staff, 96% (n= 207) answered correctly in the pre-test and said that they would drain ventilator circuit condensate before repositioning their patient.

When answering the same question in the post-test, 100% (n=215) also indicating the $\overline{X}$ score, of the medical staff answered correctly giving a statistically significant p-value = 0.0078 which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.39 and Table 12.5).

Question Fourteen: True or false – Patients on ventilators should have the head of the bed elevated to 30 degrees to prevent condensate from draining into the patient?

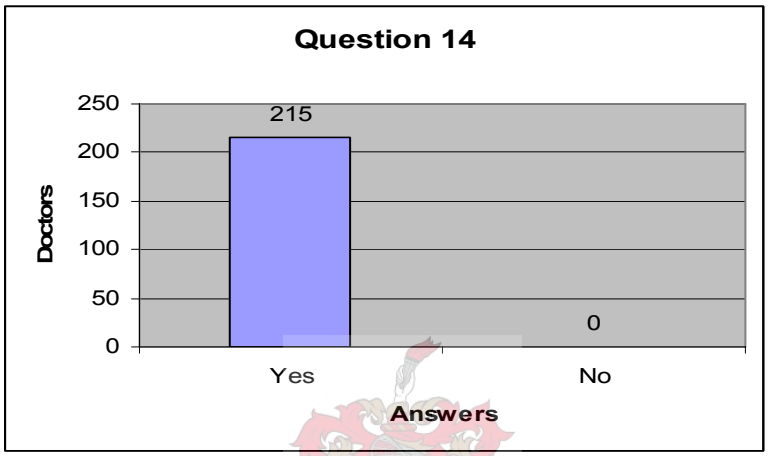


Figure 12.40 Elevation of head of bed

98% (n= 210) of the medical staff taking the pre-test, agreed that they need to place ventilated patients in a semi-recumbent position with the head of the bed elevated 30° as tolerated, even during transport. In the post-test, 100% (n= 215) also indicating the $\overline{X}$ score, of the medical staff agreed to elevate the head of the bed 30° giving a statistically significant p-value = 0.0625 which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.40 and Table 12.5).

Question Fifteen: True or false – The nurse should monitor gastric residual volumes before each feeding to prevent aspiration in ventilated patients receiving tube feedings?

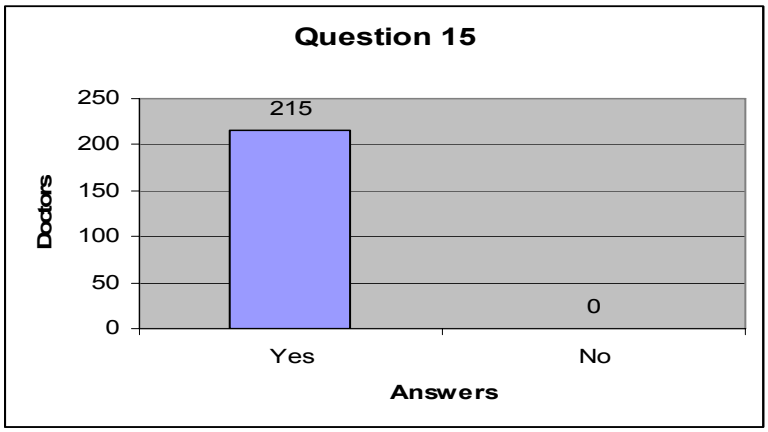


Figure 12.41Monitoring of gastric residual volume

Of the medical staff 99% (n= 213) in the pre-test answered correctly and confirmed that it is important to monitor gastric residual volumes before feedings to avoid gastric distension. In the post-test, 100% (n= 215) also indicating the $\overline{X}$ score, of the medical staff correctly answered this question giving a statistically significant p-value = 0.5000 which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.41 and Table 12.5).

Question Sixteen: True or false – A patient has a temperature of 37.2°C, minimal amounts of clear sputum, and a normal chest x-ray. White blood cells are 8k/cm and the sputum culture is positive for *Staphylococcus aureus*. Does the patient have pneumonia and should the patient be treated with antibiotics?

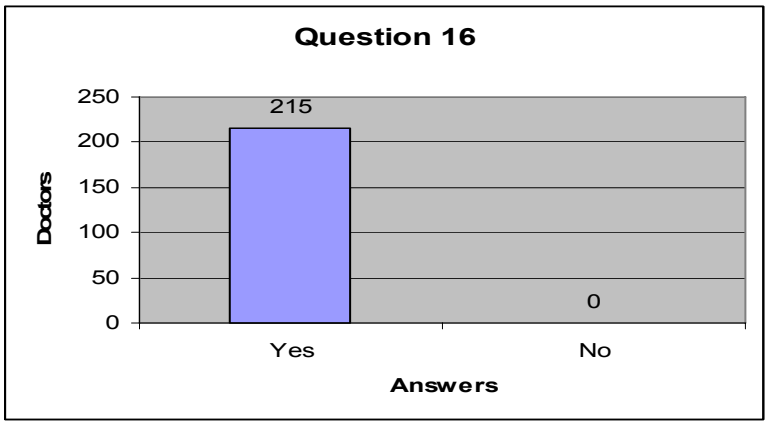


Figure 12.42 Criteria for pneumonia

In the pre-test 100% (n= 215) of the medical staff agreed that there is no evidence of infection or pneumonia, only colonisation. In the post-test, again 100% (n= 215) as indicated in the $\overline{X}$ score (for a visual presentation see Figure 12.42 and Table 12.5).

Question Seventeen: After one day that this patient was urgently intubated, this patient's chest x-ray shows consolidation, the patient has a productive cough with yellow sputum, her temperature is 38.9°C and her WBC's are 15,000. The physician orders a broad-spectrum antibiotic. Which of the following is true?

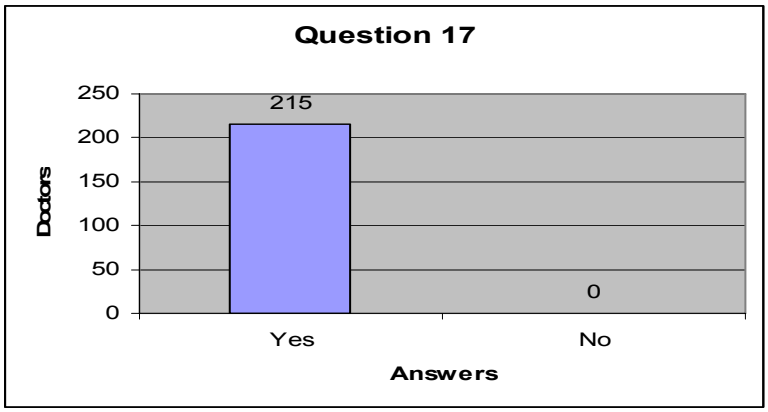


Figure 12.43 Definition for health-care-associated pneumonia

The Centre for Disease Control and Prevention (CDC) (2004) has developed standardised definitions for health-care-associated pneumonia and ventilator-associated infections. Patients with VAI must have mechanical ventilation for **greater than 48 hours**. 100% (n= 215) of the total (n= 215) medical staff answered his question correct in the pre-test. When asked the same question in the post-test, 100% (n= 215) of the medical staff answered correctly again, also representing the $\overline{X}$ score (for a visual presentation see Figure 12.43 and Table 12.5).

Question Eighteen: After a sputum sample of the same patient was obtained, the culture grew *Pseudomonas aeruginosa*. Which of the following is true?

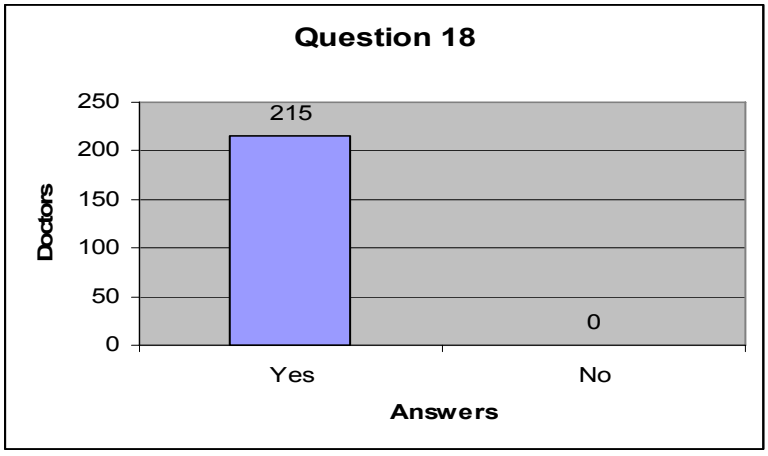


Figure 12.44 Indicators for *Pseudomonas aeruginosa*

All, 100% (n= 215), of the medical staff in the pre-test answered correctly and knew that a deep suctioned specimen should provide accurate culture results when the patient is symptomatic and VAI is suspected. In the post-test 100% (n= 215) of the medical staff answered correctly, which indicated that the medical staff knowledge stayed consistent with the results of the pre-test (for a visual presentation see Figure 12.44 and Table 12.5 for the $\overline{X}$ scores).

Question Nineteen: A patient, whom suffered a cardiac arrest, was admitted to ICU about a week ago. He was intubated and NG-feeds were started. During your shift he spikes a temperature of 39.1°C and you suction copious amounts of thick yellow sputum from his endotracheal (ET) tube. When you check his gastric residual, it is 250cc. What should you do?

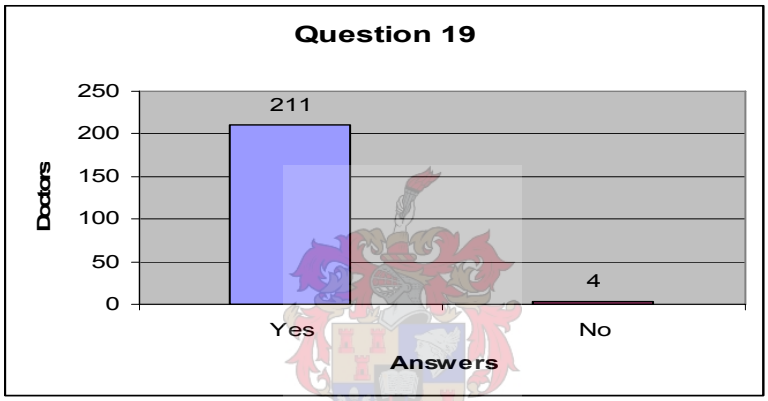


Figure 12.45 Gastric feeding

Again, 94% (n= 203) of the medical staff answered correctly in the pre-test and said that they would start by holding the tube feeding and then remove the HME. The mean score which indicated 98% (n= 211) of the medical staff answered correctly in the post-test, giving a statistically significant p-value = 0.0078 which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.45 and Table 12.5).

Question Twenty: What information should you bring to the physician's attention?

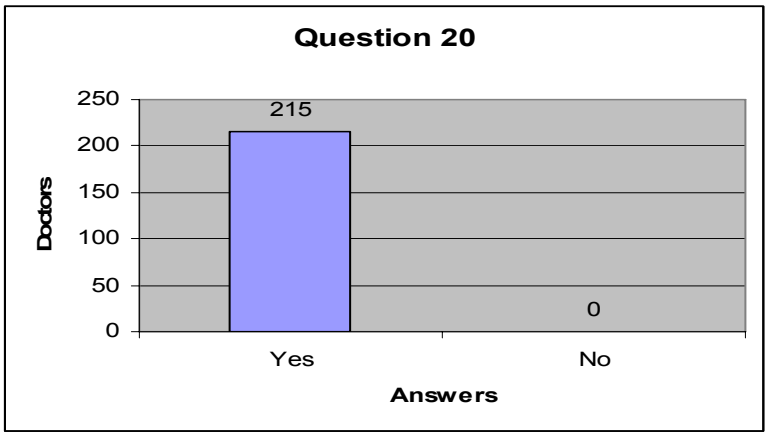


Figure 12.46 Physician information

Of the total (n= 215), 97% (n=209) medical staff agreed that the following is important to bring to the physician's attention when tested during the pre-test:

- Oral intubation is preferred over naso-tracheal intubation;
- An oral gastric tube should be considered since NG tubes may increase the possibility of aspiration of gastric contents or bacterial migration via the tube from the stomach to the upper airway.

After completing the post-test, it was evident that 100% (n= 215) the $\overline{X}$ score, of the medical staff identified the correct information to bring to the physician's attention thus giving a statistically significant p-value = 0.0313 which indicated an overall improvement in the medical staff knowledge (for a visual presentation see Figure 12.46 and Table 12.5).

General conclusion

To pass the test, a minimum of 80% was required (4 wrong answers only). The overall pass rate for the post-test was 100 % (n= 215), similar to the 100% (n=215) in the pre-test. In Table 12.5 a comparison of the results of the pre- and post-tests are given.

Due to the large number of participants, a valid outcome was established and a statistical significance was seen in all questions after the Learning Programme was initiated. The null hypothesis, there is no difference in the knowledge base of medical staff following the implementation of the Learning Programme, is thus rejected and the alternative hypothesis, there is a difference in the knowledge base of medical staff following the implementation of the Learning Programme, is supported.

The realisation of the following two objectives are described in Appendix 12 as this was done on special request by the medical staff:

- *To implement and evaluate the implemented Learning Programme for Medical staff (This was done as a special request from the medical staff.*
- *To post-test medical staff' knowledge with regard to ventilator-associated infections and the prevention thereof*

Table 12.5 A comparison of the results of the pre and post-test for medical staff

QUESTION	n = CORRECT ANSWER		n = WRONG ANSWER		MEAN (CORRECT ANSWERS) %		T-test Value(p-value)	Sign Rank-test (Difference between the pre- and post-tests) p-values
	Pre	Post	Pre	Post	Pre	Post		
1 – Risk groups	207	215	8	0	96	100	.0102	0.0078
2 – Factors	211	215	4	0	98	100	.0008	0.1250
3 - Suction catheter	203	215	12	0	94	100	1.000	0.0005
4 – Gloves	187	209	28	6	87	97	.3820	<.0001
5–Circuit condensate	209	213	6	2	97	99	.6525	0.1250
6 – Antibiotics	212	215	3	0	99	100	.3125	0.2500
7 – Suctioning	215	215	0	0	100	100	.1218	-
8– Health-care-associated infection	206	215	9	0	96	100	1.000	0.0039
9 – HME's	201	215	14	0	93	100	.0979	0.0001
10 – Ventilator circuits	198	215	17	0	92	100	.0279	<.0001
11 – Intubation	184	215	31	0	86	100	.0002	<.0001
12 – Humidifiers	191	215	24	0	89	100	.0279	<.0001
13 – Ventilator condensate	207	215	8	0	96	100	.0421	0.0078
14 – Elevate head of bed	210	215	5	0	98	100	1.000	0.0625
15 – Aspiration	213	215	2	0	99	100	1.000	0.5000
16 – Pneumonia	215	215	0	0	100	100	.4099	-
17 – VAI	215	215	0	0	100	100	.0056	-
18 – Sputum specimen	215	215	0	0	100	100	.2432	-
19 – NG-feeds	203	211	12	4	94	98	.3741	0.0078
20 – Information	209	215	6	0	97	100	.0021	0.0313

Appendix 13: Statistician declaration

Contents:

This is to certify that I performed statistical analysis for Juliana van der Merwe.

Dr Michael Bailey PhD, MSc(statistics), BSc(hons)
Statistical Consultant/Senior Research Fellow
Department of Epidemiology & Preventive Medicine Monash University
The Alfred Hospital (3rd floor, Burnet Building)
89 Commercial Road
Melbourne VIC 3004
Australia
Tel +61 (0)3 9903 0574
Fax +61 (0)3 9903 0556