

# CRITICAL CARE NURSES' KNOWLEDGE IN PREVENTING NOSOCOMIAL PNEUMONIA

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## ABSTRACT

### **Objective:**

The purpose of this study was to identify knowledge deficits concerning nosocomial pneumonia (NP) prevention among critical care nurses. The study also determined whether NP knowledge was associated with nurse characteristics.

### **Design:**

A survey design using a mailed self-administered questionnaire.

### **Setting:**

New Zealand critical care nurses were identified through the Nursing Council of New Zealand.

### **Subjects:**

134 critical care nurses.

### **Main outcome measures:**

NP prevention knowledge score (the proportion of 24 items answered correctly).

### **Results:**

The NP knowledge score ranged from 21% to 92%. The mean (and median) was 48%. Items related to knowledge about NP risks had the highest mean score (67%) compared to items addressing NP prevention (43%) or the role of devices in the transmission of NP (45%). No nurse demographic or workplace characteristic was associated with NP knowledge.

### **Conclusions:**

Several important deficits in nosocomial pneumonia knowledge were identified indicating a need for critical care nurses to have greater exposure

to nosocomial pneumonia prevention education, guidelines, and research.

## INTRODUCTION

Nosocomial pneumonia (NP), also known as hospital-acquired pneumonia, is a lower respiratory tract infection that was not present or incubating on admission to hospital (American Thoracic Society 2005; UK Comptroller and Auditor General 2000; Tablan et al 1994). NP comprises 15% to 23% of all hospital-acquired infections (Ayliffe et al 1999; Egan et al 1999; Wenzel 1993). In a report of Auckland New Zealand hospitals, NP accounted for 19% of patients with nosocomial infection (n=110) (Nicholls and Morris 1997). Among all nosocomial infections, NP has the highest mortality rate ranging from 13% to over 50% (Liberati et al 2004; Drakulovic et al 1999).

In critical care units (CCUs) NP is the most common nosocomial infection, with prevalence rates ranging from 10% to 70% (Rello et al. 2001; Ibrahim et al. 2000; Nicholls and Morris 1997). Ventilator support is a well known risk factor for NP; the incidence of NP is 6 to 20 times higher in patients treated with continuous ventilatory support (American Thoracic Society 2005). NP develops in mechanically ventilated patients at a rate of one to three percent per day of mechanical ventilation (American Thoracic Society 2005; Ibrahim et al 2001).

Despite the prevalence of NP and its associated high mortality rate, there is little guidance for NP prevention in New Zealand. The Centers for Disease Control and Prevention (CDC) in the United States of America (USA) published a guideline (Part 1) for the prevention of NP in 1994 (Tablan et al 1994), updated in 2003 (Tablan et al 2004). This guideline addresses the common problems encountered by infection control practitioners in NP prevention and control in hospitals. The CDC guideline

had been implemented in 98% of 179 USA hospitals surveyed by Manangan et al (2000). Among these hospitals the NP rate decreased significantly after implementation of the guideline. The CDC Guideline for Prevention of NP can be an important resource for educating health care workers regarding prevention and control of NP and was chosen as the benchmark for this study.

Critical care nurses (CCNs) have an important role in preventing NP by decreasing risk factors, recognising early symptoms, and assisting in diagnosis (Myrianthefs et al 2004; Hixson et al 1998).

## AIM

It is likely that if CCNs have knowledge about NP prevention, as suggested by the CDC guidelines, the rates of NP could be reduced. Reduced NP rates would benefit patients, reduce critical care lengths of stay, and reduce health care costs. The aim of this study was to determine the level of knowledge that CCNs in New Zealand have regarding NP prevention. The study also determined whether knowledge about prevention correlates with certain nurse characteristics such as education level and length of service.

## LITERATURE REVIEW

Numerous potential risk factors and prevention activities for nosocomial pneumonia (NP) have been identified in the literature (figures 1 and 2) (Artigas et al 2001; Ibrahim et al 2001; Rello et al 2001; Leroy et al 1997). Although specific risk factors may differ between study populations, they can be grouped into four categories: host factors, aspiration, inhalation, and cross contamination (Visnegarwala et al 1998).

Host factors include patient age of more than 65 years and co-morbidities. Ibrahim et al (2001) examined 132 patients with ventilator associated pneumonia. Most of the patients had underlying illnesses such as: congestive heart failure (55%), chronic obstructive pulmonary disease (COPD) (45%), diabetes mellitus (27%), acute renal failure (28%), immuno-compromise (14%), and bacteraemia (9.8%). There are not many things that can be done to alter host factors such as age and co-morbidities. The most promising host factor prevention measure noted in the literature is to maximise nutritional status. Providing adequate nutritional support improves organ function in critical care patients and significantly lowers patients' risk of infection (Marik and Zaloga 2001).

Aspiration is the primary route of transmission of pathogens into the lungs (Porth 1998). Oropharyngeal colonisation, gastric fluid, and enteral feeding are three important factors affecting aspiration. Oropharyngeal colonisation is present in approximately one in four patients on admission to a critical care unit, and by the

10th to 15th day in critical care, approaches 100% (Park 2005; Orgeas et al 1997; Johanson et al 1969).

Among ventilated patients, the endotracheal cuff is likely to increase the risk of NP by allowing oropharyngeal secretions to pool above the cuff, become colonised, and then leak into the airway or be dislodged by suctioning, coughing or movement of the tube. Clearing oropharyngeal secretions before handling an endotracheal tube is an important critical care nurse action to reduce the risk of nosocomial infection. Aspiration of gastric fluid is also implicated as a contributory factor for NP (Park 2005; Safdar et al 2005; Orgeas et al 1997) and is related to alterations in secretion of gastric juice, alkalisation of gastric contents and administration of enteral nutrition.

Adequate nutrition promotes immuno-competence in the critically ill patient, which is important in preventing ventilator-associated pneumonia however it also exposes patients to gastric colonisation and aspiration. Studies have shown that for patients given continuous enteral feeding, 54% develop pneumonia within three days (Jacobs et al 1990). Eighty percent of patients who received either continuous or intermittent enteral feeding had gastric colonisation seven days after the start of feeding in another study (Bonten et al 1996). Both continuous and intermittent enteral feeding increase gastric pH and are associated with gram negative colonisation of the stomach. Critical care nurses must be cautious when caring for a patient receiving enteral feeding and implement preventive actions such as checking gastric tube position, measuring gastric residual, assessing patient intestinal motility, and elevating the head of the bed.

Inhalation is another route of transmission of pathogens into the lungs, most commonly caused by mechanical ventilation and contaminated aerosols (Ball 2005; Lawson 2005; Safdar et al 2005; Visnegarwala et al 1998). Respiratory equipment including ventilators, humidifiers, and nebulizers can form potential reservoirs for infection. In ventilator circuitry the highest colonisation occurs at parts nearest the patients, likely due to retrograde sputum colonisation (Park 2005; Safdar et al 2005; Craven et al 1984). Among humidifiers, heated humidifiers may be associated with a higher rate of pneumonia compared with heat moisture exchangers (Cook et al 1998).

When moving ventilator tubing (such as when suctioning, adjusting ventilator settings, feeding or caring for the patient), caution must be taken to avoid spillage of contaminated condensate fluid into the patient's tracheobronchial tree. Changing humidifier tubing is recommended only when there is gross contamination (Tablan et al 2004; Centers for Disease Control and Prevention 1997; Tablan et al 1994) and changing ventilator circuits is recommended no more frequently than at 48 hour intervals.

Figure 1. Nosocomial pneumonia risk factors addressed in the literature

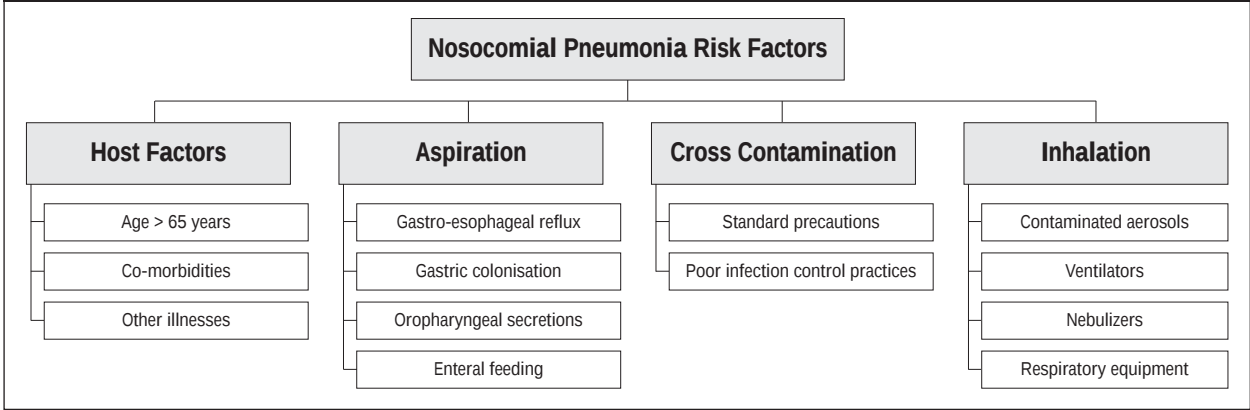
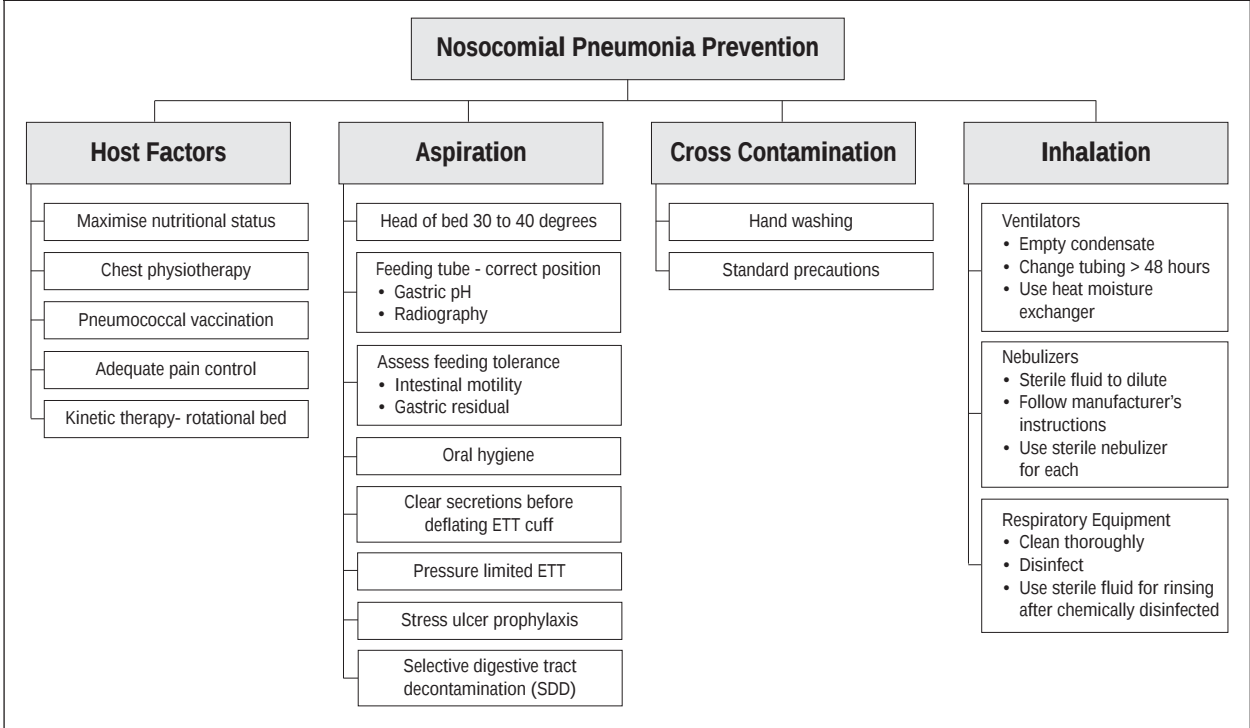


Figure 2. Nosocomial pneumonia preventive measures addressed in the literature



Hospitalised patients are commonly exposed to potentially large inocula of bacteria from a number of sources (American Thoracic Society 2005). In one study, 38% of all nosocomial infections occurring in critical care were attributed to cross contamination (Weist et al 2002). Hand washing is important to avoid cross contamination and is consistently seen to be most effective in preventing NP (Lawson 2005; Boyce and Pittet 2002). Nurses traditionally show high compliance with infection control policy, including hand washing, and respond positively to education (Pittet et al 2000). In contrast to hand washing, the routine culturing of patients, equipment and devices used for respiratory therapy is not necessary (Glupeczynski 2001), particularly if the results are not used to improve infection control (Tablan et al 2004; Ayliffe et al 1999).

NP strikes many patients in CCUs. Although this is the second most common nosocomial infection, ranking after urinary tract infection, it is by far the most deadly. The ability to identify NP risk factors could help CCNs to plan better care for susceptible patients in the unit.

METHODS

A survey study was conducted using a self-administered questionnaire to determine whether nurses working in critical care units (CCUs) in New Zealand are knowledgeable about the prevention of nosocomial pneumonia (NP) as indicated in the literature and the Centers for Disease Control and Prevention (CDC) guideline (Centers for Disease Control and Prevention

1997). The questionnaire was designed to highlight areas of knowledge that, if were improved, might reduce the rate of NP. The study protocol was approved by the Auckland University of Technology Ethics Committee.

## Sample

The target population included CCNs working with ventilated patients in New Zealand. The sampling frame was provided by the Nursing Council of New Zealand (NCNZ). The Nursing Council of New Zealand database included 1599 nurses working in critical care in 2003. Of these, 781 had agreed to receive mailings inviting them to participate in research. A sample size calculation for a dichotomous independent variable such as full time versus part time employment indicated that 128 participants would be required to demonstrate a difference in mean knowledge scores between 15 and 18 ( $\alpha = 0.05$ , power = 0.80). It was decided to post the questionnaire to all 781 nurses to allow for non response.

## Instrument

A multiple-choice questionnaire (MCQ) was selected for this study because it is a method suitable for testing knowledge (Burton et al 1991) and has high reliability related to consistent and objective scoring (Gronlund 2003; McMillan 2001). The first draft of the multiple-choice questionnaire (MCQ) for this study was developed by the researcher (KLS).

The questionnaire was formatted into three sections. In section one the nurses were asked whether or not they nursed patients on a ventilator. If they did not nurse a ventilated patient, they did not have to proceed with the survey. Section two contained 24 MCQ items testing NP prevention knowledge. Twenty-one of the items were based on the CDC guideline (Visnegarwala et al 1998; Centers for Disease Control and Prevention 1997; Tablan et al 1994); three of the items were adapted from the pulmonary disease board review manual (Balk 1998); and one item was formulated based on a study by Young et al (1999). Each item had only one correct answer. All items had a 'don't know' response option. Section three contained 19 questions about demographic and nurse characteristics. Nurse characteristic items were selected from the Nursing Council of New Zealand Annual Practicing form.

The initial draft questionnaire was sent to clinical critical care and infection control experts ( $n=10$ ) who assisted in the process of refining the questionnaire. Numerous questionnaire improvements were made based on their feedback. A pilot study in one CCU was then carried out to obtain information regarding clarity of the wording and presentation of the revised questionnaire. No further alterations were needed; the pilot data were therefore included with the posted questionnaire data. All participants in the pilot study were informed not to answer the questionnaire again if they received mailing from NZNC.

Unaddressed mailing packages were provided to Nursing Council of New Zealand (NCNZ) that contained: a cover letter, participant information sheet, the questionnaire, a tea bag (in thanks for completing the questionnaire), and a self-addressed stamped return envelope (to KLS). The NCNZ addressed and posted the survey to all nurses who identified themselves as working in critical care and willing to accept mailings ( $n=781$ ).

## Data analysis

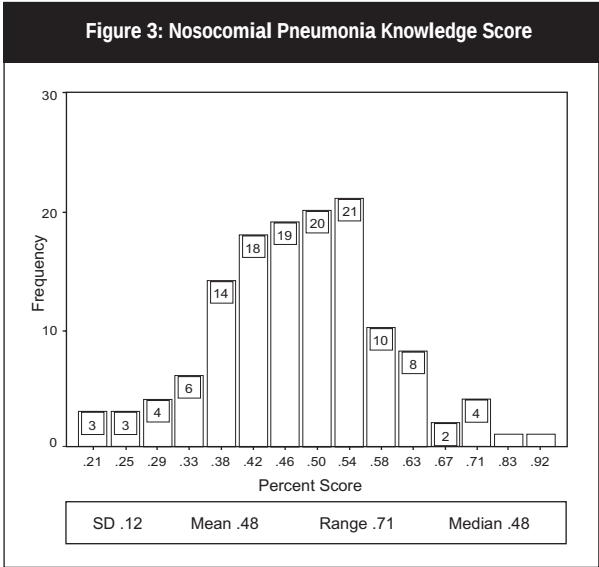
Response rate and sample characteristics were analysed using descriptive statistics. The number of correct NP prevention knowledge answers (out of 24) was standardised by dividing the number of correct answers by the total possible (24) and multiplying by 100. This resulted in NP knowledge score as a proportion of correct responses, ranging from 0% to 100%. The 24 knowledge items were also divided into three domains: knowledge about risks of NP (4 items), knowledge about prevention of NP (8 items) and knowledge about devices (12 items). Overall NP knowledge and domain scores are reported. Students' *t*-test was used to determine whether NP prevention knowledge score was associated with demographic or nurse characteristic variables that were dichotomous (eg. full-time versus part-time), otherwise Analysis of Variance (ANOVA) was used.

## RESULTS

Two hundred fifty-two questionnaires were returned, 135 indicated non-eligibility (103 nurses did not nurse patients with ventilators, 20 did not complete the questionnaire, 12 lived outside New Zealand). One hundred and seventeen completed returned questionnaires, in addition to the 17 completed pilot questionnaires, provided a final sample of 134 New Zealand Critical Care Nurses (CCNs) whose practice included caring for patients with ventilators. Among the 134 participants, most were firstly qualified as diploma or hospital based registered nurses (39% and 44% respectively). When asked whether their work setting had an infection control policy for ventilator-associated NP, 32% responded affirmatively. In the prior 12 months, 35% of participants reported having read one or more articles about ventilator-associated pneumonia and 54% had attended infection control education in the prior 12 months.

The NP knowledge score ranged from 21% to 92%. The mean (and median) was 48% (see figure 3).

The middle 50% of scores (inter-quartile range) were between 42% and 54%. Among individual items, 13 (54%) items had 30% to 80% correct responses (see table 1). The individual item most often answered correctly (92%) was that development of ventilator associated pneumonia in a critically ill patient can result in increased mortality, increased length of stay, and increased cost of care. The item least often answered correctly (4.5%) was that the routine sterilisation or



disinfection of the internal machinery of mechanical ventilators was unnecessary (84% of nurses thought the internal machinery needed care ‘between patients’). The ‘don’t know’ response was typically used infrequently (<10% of responses to items), however, 58% of nurses responded that they did not know which type of endotracheal tube was associated with the lowest risk of NP (pressure limited cuff).

Examining scores across the three domains, knowledge about risks of NP had the highest mean score (67%), compared with knowledge about prevention (43%) or knowledge about devices (45%). No nurse demographic or workplace characteristic was associated with NP knowledge (see table 2).

DISCUSSION

The typical score (48%) indicated that critical care nurses working in New Zealand have some nosocomial pneumonia (NP) knowledge. Knowledge about risk factors for NP was greater than for NP prevention or the role of devices in the transmission of NP. Two of the device items (types of endotracheal tubes and disinfection of ventilator internal machinery) had correct scores less than 10%. These two items however relate to knowledge and practices which involve collaboration with other health care team members such as the physician and respiratory therapist.

The knowledge deficit about NP prevention is of concern because this relates to an important role for critical care nurses (CCNs); though this component can be addressed through education. However our finding that 46% of CCNs had not had infection control education in the prior 12 months is cause for concern. A National Health Service report of hospital acquired infection similarly identified ‘important gaps in the extent to which education and training in infection control is provided to key health care staff’, with less than two thirds receiving annual updates’ (Comptroller and Auditor General 2000).

| Table 1: Individual Nosocomial Pneumonia Item Responses By Domain   |                      |                |                    |
|---------------------------------------------------------------------|----------------------|----------------|--------------------|
| Item                                                                | Incorrect Choice (%) | Don't Know (%) | Correct Choice (%) |
| Nosocomial Pneumonia Risk Factors                                   |                      |                |                    |
| Consequences of ventilator associated pneumonia                     | 8.2                  | Nil            | 92.8               |
| Nosocomial pneumonia risk factors                                   | 16.4                 | .07            | 82.8               |
| Risk factors for nosocomial pneumonia associated death              | 21.6                 | 3.7            | 74.6               |
| Bacteria most often responsible for ventilator associated pneumonia | 76.8                 | 5.2            | 17.9               |
| Nosocomial Pneumonia Prevention                                     |                      |                |                    |
| Interventions to prevent nosocomial pneumonia                       | 35.8                 | .07            | 63.4               |
| Tracheostomy care                                                   | 37.3                 | 1.5            | 61.2               |
| Effective nosocomial pneumonia prevention                           | 44.0                 | 3.7            | 52.2               |
| Unit policies to reduce hospital acquired pneumonia                 | 40.2                 | 9.7            | 50.0               |
| Nursing actions to prevent aspiration                               | 52.2                 | 1.5            | 46.3               |
| Interventions to reduce nosocomial pneumonia in the elderly         | 56.7                 | 3.7            | 39.6               |
| Feeding related interventions for reducing nosocomial pneumonia     | 68.6                 | 10.4           | 20.9               |
| Infection control practices to reduce nosocomial pneumonia          | 86.6                 | Nil            | 13.4               |
| Devices Related to Nosocomial Pneumonia                             |                      |                |                    |
| Oxygen therapy devices                                              | 11.2                 | Nil            | 88.8               |
| Care of reusable respiratory devices                                | 19.4                 | Nil            | 80.6               |
| Processing of single use and reusable respiratory devices           | 21.6                 | 0.7            | 77.6               |
| Positioning of the head of bed                                      | 25.3                 | 10.4           | 64.2               |
| Nebulizer care                                                      | 38.0                 | 1.5            | 60.4               |
| Ventilator circuit care                                             | 44.0                 | 5.2            | 50.7               |
| Rinsing solution for devices                                        | 50.0                 | 17.9           | 32.1               |
| Mechanical ventilator maintenance                                   | 70.1                 | Nil            | 29.9               |
| Heat moisture exchanger                                             | 76.1                 | 3.7            | 20.1               |
| Suction catheter care                                               | 75.3                 | 6.7            | 17.9               |
| Types of endotracheal tubes                                         | 34.3                 | 58.2           | 7.5                |
| Disinfection of ventilator internal machinery                       | 88.8                 | 6.7            | 4.5                |

Table 2: Nosocomial Pneumonia Knowledge and Nurse Demographics and Workplace Characteristics

|                                      | (n =134) | Mean Knowledge Score | p   |
|--------------------------------------|----------|----------------------|-----|
| <b>Nursing Qualification</b>         |          |                      | .44 |
| Hospital Based – registered nurse    | 58       | .47                  |     |
| Hospital Based – enrolled nurse      | 2        | .39                  |     |
| Diploma in Nursing – comprehensive   | 52       | .47                  |     |
| Degree in Nursing                    | 21       | .50                  |     |
| <b>Highest Nursing Qualification</b> |          |                      | .54 |
| Masters                              | 5        | .46                  |     |
| Bachelor                             | 41       | .48                  |     |
| Postgraduate Diploma                 | 3        | .55                  |     |
| Postgraduate Certificate             | 17       | .45                  |     |
| Diploma in Nursing                   | 28       | .50                  |     |
| Hospital based – Registered Nurse    | 33       | .46                  |     |
| Other                                | 2        | .58                  |     |
| <b>Length of Service</b>             |          |                      | .44 |
| 1 –5 years                           | 8        | .52                  |     |
| 6 –10 years                          | 36       | .46                  |     |
| 11 –15 years                         | 29       | .46                  |     |
| Over 15 years                        | 60       | .49                  |     |
| <b>Workplace Number of Beds</b>      |          |                      | .74 |
| < 5 beds                             | 44.0     | .48                  |     |
| 5 – 8 beds                           | 50.0     | .46                  |     |
| 9 –16 beds                           | 70.1     | .48                  |     |
| > 17 or more beds                    | 76.1     | .51                  |     |

There is a growing body of literature to inform critical care nursing in preventing NP among ventilated patients (Myrianthefs et al 2004; Harris and Miller 2000). Strong evidence indicates that elevating the head of the bed reduces both the frequency and severity of pulmonary aspiration (Dodek et al 2004; Tablan et al 2004). Regular monitoring of gastric residual in enteral feeding patients is important because persistent high gastric volume predisposes patients to regurgitation and pulmonary aspiration.

Other educational topics include the use and monitoring of heat moisture exchanger (HME), how to identify early signs of pneumonia, when culturing is necessary, and the NP risks associated with suctioning. Finally, education and reinforcement about handwashing is vital. Pittet et al (2000) observed hand-washing compliance before and after implementation of a hand hygiene campaign in Geneva hospital; hand-washing compliance improved from 48% to 66% and the nosocomial infection rate decreased from 17% to 10%.

As well as the growing body of literature identifying evidenced based nosocomial infection prevention activities, numerous internet sites are available to support infection control learning, such as the New Zealand Nurses Organisation National Division of Infection Control Nurses: <http://www.infectioncontrol.co.nz/files/home.asp>).

LIMITATIONS

There are three important limitations to this study. Firstly, the investigator-developed multiple choice questionnaire (MCQ) was likely to include significant measurement error. Despite having had clinical experts review the MCQ, some distractors were perhaps not well chosen. It is easy to develop one or two good distractors, but developing the third and fourth distractors was significantly more difficult. Educational experts suggest avoiding the use of complex multiple-choice formats such as ‘all the above’, ‘none of the above’, or ‘A and B’ (Haladyna 2004; Kehoe 1995). Inclusion of ‘all the above’ also made it possible to answer an item on the basis of partial information (Gronlund 1993). Questionnaire improvements, in collaboration with educational experts, would be recommended prior to further use.

Secondly, only 30% of CCNs responded to the questionnaire, only 15% meeting entry criteria (working in a New Zealand CCU, nursing patients who are mechanically ventilated). According to Nachmias and Nachmias (1992) a typical response rate for a mail survey without follow up is between 20% and 40%. A higher response rate would be able to more accurately reflect the knowledge level of CCNs in New Zealand. And finally, the researchers had no control over the respondent environment; we do not know for example, whether participants answered the questionnaire individually or as a group.

CONCLUSION

This study’s purpose was descriptive not explanatory and thus has described gaps in critical care nurses’ knowledge regarding nosocomial pneumonia and its prevention. It is hoped that this study raises nurses’ awareness of nosocomial pneumonia risk factors and nursing prevention activities. With increasing awareness and knowledge, nurses can intervene to reduce nosocomial pneumonia infection rates, accompanied by reduced nosocomial pneumonia related mortality, reduced critical care length of stays, and reduced health care costs.

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