Nutritional care practice in the patients receiving non-invasive positive pressure ventilation (NIPPV) therapy in an intensive care unit (ICU)

By

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A thesis submitted in partial fulfilment of the requirements for the degree of Master of Nursing

(Coursework/Research)

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Declaration

I certify that this work does not incorporate without acknowledgement any material previously submitted for a degree or diploma in my university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed:

Date:

Acknowledgements

I would like to express my gratitude to all those who gave me the possibility to complete this thesis:

Associate Professor Diane Chamberlain RN BNg BSc MNSc (Critical Care) MPH PhD. Thank you for introducing me to this interesting topic which I really enjoyed studying. I also appreciate your efforts to keep me on the right track and being patience for my slow progression.

Dr. Anita de Bellis RN, DipN SACAE, BN (Man) MN, PhD. Thank you for your kind advice and encouragement and also appreciate your patience with my progression.

Ms. Natalie Sore ICU research RN in the study hospital. Thank you for your help in data collection in the ICU. You were a dedicated research nurse.

Ms. Alice Murray ICU dietitian. Thank you for providing me all nutrition related data required for my study and sharing your concern about nutrition. It helped me think more deeply about the nutrition needs of patients on NIPPV.

My parents, my brother and my sister in law, and all my extended family. Thank you for all your support throughout the whole course of this thesis. You were always there whenever I needed help.

My friends and my previous colleagues; Yeon-Hee, You-Sun, Ji-Young, Kyung-Ah, BoRa, Mi-kyeong, Jung-Ha, Ok-Jin, Eun-Hee, Eun-kyung, Hee-Sun, Sunny, Simon and Jennis,. Thank you for your encouragement and emotional support.

Finally, I would like to express my special thanks to my dear friend Winnie and Winnie's family. I believed I could finish this long journey safely with your help. You are my Australian family and I will never forget your warm heart.

Glossary of Terms & Abbreviations

ABG	Arterial Blood Gas
AEI	(Mean Daily) Actual Energy Intake
API	(Mean Daily) Actual Protein Intake
APACHE II	Acute Physiology and Chronic Health Evaluation II
ARF	Acute Respiratory Failure
BMI	Body Mass Index
COPD	Chronic Obstructive Pulmonary Disease
CPO	Cardiogenic Pulmonary Oedema
CRF	Clinical Recording Form
DNI	Do Not Intubate
DRG	Diagnosis Related Group
EER	Mean Daily Estimated Energy Requirement EER was calculated by multiplying body weight by 25kcal/kg for the patients with a body mass index (BMI) of <30 and 11kcal/kg for the patients with BMI of ≥ 30 (McClave et al. 2009).
EN	Enteral Nutrition
EPR	Mean Daily Estimated Protein Requirement EPR was calculated using 1.2g protein/ kg for patients with BMI <30 (McClave et al. 2009). Ideal body weight (Female: 45 kg for the first 152.4cm plus 0.9kg for each additional cm, Male: 48kg for the first 152.4cm plus 1.1kg for each additional cm) was used for the patients with BMI ≥ 40 (McClave et al. 2009).
GORD	Gastro-oesophageal reflux disease
HBE	Harris-Benedict Equation
ICU	Intensive Care Unit
IMV	Invasive Mechanical Ventilation
IVT	Intra Venous Treatment Fluid
kJ	Kilojoules
LOS	Length of Stay

MNA	Mini Nutrition Assessment
MNA-SF	Short-form MNA
MST	Malnutrition Screening tool MST
MUST	Malnutrition Universal Screening Tool
NHF	Nasal High Flow
NIPPV	Non- Invasive Positive Pressure Ventilation
NPC	Nutrition Panel Calculator
NGT	Nasogastric Tube
NRS-2002	Nutritional Risk Screening
NUTRIC score	NUTrition Risk in the Critically ill score
ON	Oral Nutrition
PN	Parenteral Nutrition
SGA	Subjective Global Assessment
SNAQ	Short Nutrition Assessment Questionnaire
SOFA	Sequential Organ Failure Assessment

Abstract

Background: Non-invasive positive pressure ventilation (NIPPV) is increasingly and widely used for respiratory support in critical care settings around the world. While many studies have examined the effect of NIPPV, there is a paucity of data on nutrition in patients undergoing NIPPV therapy in an intensive care unit (ICU). Adequate nutrition is essential for critically ill patients to improve patients' outcomes such as reducing mortality, morbidity or length of hospital or ICU stay. Despite this, it is challenging for critically ill patients to meet their nutrient requirements. Current nutritional care guidelines for the critically ill exclude NIPPV patients completely as many of them rely on oral nutrition. Aspiration pneumonia is a serious complication, and the fear of aspiration may interrupt nutrient intake of the patients while receiving NIPPV therapy. However, there is a lack of evidence about aspiration or aspiration pneumonia during NIPPV therapy.

Objective: The aim of this study is to explore clinical nutritional care practice in patients undergoing NIPPV therapy and to investigate whether these patients are adequately nourished while in the ICU.

Methods: An exploratory prospective observational study of adult patients (≥ 18yrs) admitted to the study ICU and commenced NIPPV therapy were included. Observational forms consisting of clinical reporting form and food and fluid chart were used to collect nutrition- related data regarding NIPPV therapy. The diagnosis of aspiration pneumonia was confirmed/excluded by reviewing chest x-ray results. Welch's t test was used to investigate whether the patients were adequately nourished in the ICU while comparing the actual energy and protein intakes to estimated requirements. Cross-tabulation analysis was used to identify the differences in variables between patients receiving <50% of energy or protein requirements and the patients receiving ≥ 50% of energy or protein requirements.

Results: Thirty patients were enrolled in the study from December 2014 to February 2015. Eighty-three percent of the patients commenced some type of nutrition including enteral,

parenteral or oral nutrition within 48 hours after the initiation of NIPPV therapy. The most common type of nutrition was oral nutrition (73%). Only eight of 30 patients (27%) had an ICU dietitian consult during NIPPV therapy. Patients seen by an ICU dietitian were more likely to receive estimated protein requirements compared to the patients without a dietitian consult. The most common reasons for not eating were anorexia (57%) and respiratory distress (50%). Ninety-seven percent of the patients did not meet estimated energy or protein requirements. Furthermore, a majority of the patients failed to receive 50% of energy or protein requirements. Patients who were a longer time on NIPPV (BIPAP, CPAP or NHF), a longer time on NHF, less hours for fasting, and starting nutrition within 24hours of the initiation of NIPPV were more likely to consume ≥ 50% of estimated energy requirements. Whereas patients who received parenteral nutrition and the patients who had an ICU dietitian consult were more likely to receive ≥ 50% of estimated protein requirements. All patients were found to be undernourished prior to the NIPPV therapy and according to haematological biomarkers undernourishment became worse during NIPPV therapy. No patients developed aspiration pneumonia during NIPPV therapy although the patients were assessed as an increased risk of aspiration.

Conclusion: The results from this study indicated that patients undergoing NIPPV therapy were inadequately nourished. The clinical nutritional care practice reflected patients' lack of adequate nutritional care during NIPPV therapy and that patients were poorly nourished in ICU. Providing artificial nutrition is an essential component of medical and nursing care of patients on NIPPV yet the practice of when to commence nutrition is highly variable. Nursing and medical staff accept and do not assess the nutritional status of patients prescribed NIPPV just having sips of water for first 24hrs and minimal nutritional intake throughout their ICU admission. This is despite an abundance of robust data supporting the benefits of nutritional screening, need for early nutrition and valid and reliable formulas for calculating and individualising the energy and protein requirements for each patient.

Although the literature suggests that issues related to air leaks and gastric distention should be addressed, the advice for both of these was ambiguous perhaps because solving gastric distension by the insertion of large bore vented naso-gastric tube (NGT) may lead to small air leaks. The literature on resolution of air leaks was supported by research however the management of stomach and abdominal distension caused through insufflation (NIPPV) revealed a lack of evidence and interventions were ambiguous and based on local opinion. Although none of the patients developed aspiration pneumonia, aspiration is a high risk during NIPPV and should be taken into account when providing nutritional care.

Multiple gaps exist in both knowledge and practice related to oral nutrition in patients prescribed NIPPV. Research is required on multiple aspects of the provision of oral nutrition, including the roles, knowledge and attitudes of the interdisciplinary ICU team, development, implementation and research on the clinical efficacy of NIPPV policies and protocols which include attention to nutritional status and clear rationales, prevention of gastric sulfation and the appropriateness of either large vented NGT or small bore NGT in the management of gastric distension and EN.

Key words: NIPPV, nutrition, critically ill patients, aspiration pneumonia, hospital under-nutrition and nutritional barriers

Chapter 1: Introduction

The application of non-invasive positive pressure ventilation (NIPPV) for acute respiratory failure (ARF) is widespread in critical care areas around the world. The relationship suggested in the literature between undernutrition and patients receiving NIPPV therapy in intensive care units (ICUs) although logical was not confirmed by sufficient evidence to support these claims. One reason postulated for undernutrition in patients is the uneasiness of health professionals in ordering oral or enteral nutrition for patients prescribed NIPPV because of a genuine risk of aspiration pneumonia. The chapter goes on to link the importance of nutrition and NIPPV together, identifies problems that can arise in clinical practice, addresses the research questions under investigation, and finally describes the significance of the research project to complete the outline of the thesis.

1.1 Brief background

1.1.1 Non-invasive positive pressure ventilation

Non-invasive positive pressure ventilation (NIPPV) refers to the provision of ventilatory support to a patient through the patient's upper airway using a non-invasive interface such as an oronasal mask, total face mask, nasal mask, mouthpieces, nasal pillows or plugs, or a helmet (Nava & Hill 2009). NIPPV is delivered via a non-invasive interface in the form of either continuous positive airway pressure (CPAP) or biphasic positive airway pressure (BiPAP) (Rose & Gerdtz 2009). A face mask or nasal cannula may be used to employ enhanced pressure ventilatory support via a flow generator (Hill et al. 2007). High-flow oxygen therapy through a nasal cannula is a technique whereby heated and humidified oxygen is delivered to the nose at high flow rates (up to 60 L/min) (Frat et al. 2015; Nishimura 2015). High flow rates generate low levels of positive pressure in the upper airways. The fraction of inspired oxygen (FIO2) is adjusted by changing the fraction of oxygen (Parke et al. 2011; Chanques et al. 2013). Nasal high flow (NHF) therapy will be included in the NIPPV therapies in this study. NIPPV assists breathing in ARF patients by enhancing transpulmonary pressure, inflating the lungs, increasing tidal volume, and unloading fatigued ventilatory muscles to relieve dyspnoea (Bertella & Vitacca 2010).

The main indications for NIPPV are exacerbation of chronic pulmonary disease (COPD), cardiogenic pulmonary oedema, pulmonary infiltrates in immunocompromised patients, and weaning of post-extubation patients (Crimi et al. 2010). NIPPV is also extensively used for postoperative patients with respiratory distress, neurological diseases, and palliation of respiratory distress in the terminally ill or assisting with bronchoscopy (Crimi et al. 2010). The use of NIPPV has steadily increased over the last two decades (Demoule et al. 2006) and has become front-line treatment in the management of patients with acute respiratory failure in ICUs throughout the world (Sanchez et al. 2014). A study conducted in France and Belgium illustrates the increasing usage of NIPPV as a first-line therapy or for patients previously intubated. From a reported 9% in 1997 its use increased to 28% in 2007 and 37% in 2010/11 (Demoule et al. 2016)

Despite the increased use of the NIPPV, nutritional data for patients undergoing NIPPV therapy is rare, as most studies tend to focus on the effectiveness of NIPPV. Adequate nutrition is essential for the critically ill patient to support anabolism, ameliorate uncontrolled catabolism, maintain a competent immune system, and ultimately improve patient outcome (McClave & Heyland 2009). Nutrition support attenuates the metabolic response to stress, limits oxidative cellular injury, and favourably modulates the immune response (Kotzampassi et al. 2009; Gunst et al. 2013). Optimal nutrition also enhances autophagy, a survival mechanism serving to recycle mitochondrial intracellular nutrients and maintain energy homeostasis during nutrient deprivation. Recent evidence suggests that autophagy is essential for the immune response and for functions such as removal of toxic protein aggregates and damaged organelles, and thus is critical for recovery from organ failure (Gunst et al. 2013). Optimal nutritional therapy (calories and protein) in mechanically ventilated critically ill patients was associated with a 50% decrease in 28-day mortality (Weijs et al. 2012).

1.1.2 Malnutrition

Malnutrition is a deficiency or imbalances in an individual's consumption and or body's ability to use energy and/or nutrients including micronutrients and vitamins and minerals (WHO 2000). Signs and symptoms of malnutrition are numerous, based on complex pathogenesis and include: loss of adipose tissue, diminished muscle mass, depression, declined cognitive functioning, delayed healing, heightened risk for infections, risk of hypothermia, decreased white blood cells, reduced immunity, altered skin integrity, and ultimately, extreme metabolic, physiological and anatomical alterations with severe malnutrition (Mitch et al. 2002). Adverse effects of malnutrition on pulmonary functions include: distorted ventilatory drive, reduced ventilatory response to hypoxia, diminished diaphragmatic mass, force, contractility and endurance, reduced respiratory muscle strength, hypercapnia, lowered synthesis of alveolar surfactant, altered humoral and cellular immunity and intensified bacterial adhesion in the lower respiratory tract (Ambrosinoa and Clinib 2004). Allingstrup et al. (2012) demonstrated energy deficits accumulated by underfeeding patients during their ICU stay are rarely overturned and increases the risk of adverse outcomes (Singer et al. 2010; Faisy et al. 2011). Malnutrition is an independent factor of morbidity and mortality, readmission rate, length of ICU or hospital stay, and one that increases hospital costs (Alberda et al. 2009; Agarwal, 2013). Assessment and response to the risk for, or actual nutritional deficits should be an integral component of care from admission through to discharge and beyond.

1.1.3 NIPPV and Nutrition

NIPPV assists in breathing without the need for intubation and patients are able to maintain the ability to speak or consume oral food and fluids during NIPPV therapy. NIPPV Guidelines for Adult Patients with Acute Respiratory Failure (Sanchez et al. 2014), recommend initiating oral intake if the patient is able to tolerate the cessation of NIPPV for short periods. However, oral intake during NIPPV therapy may be problematic. Reeves et al. (2014) reported that patients receiving NIPPV therapy ordered oral nutrition had less nutrient intake compared to patients provided nutrition via enteral or parenteral route.

Patients' lack of energy for chewing and insufficient time for eating due to respiratory distress, resulted in inadequate oral intake (Reeves et al. 2014).

Achieving adequate nutritional intake via enteral nutrition may also be challenging as the nasogastric tube can disrupt the patient-mask interface causing an air leak (Carron et al. 2013). Although not explored in the research literature the risk for Nasogastric Tube (NGT) causing an air leak may be one reason for lack of prescription of enteral feeding (Bambi et al. 2017). In addition, the fear of an air leak may lead to the use of a small bore NGT as recommended by Elliott (2004) rather than a larger bore vented NGT. Another reason given for either not inserting NGT or using a small bore NGT during NIPPV was the risk for increasing the incompetence of the lower oesophageal sphincter and thus risk of gastroesophageal reflux and subsequent aspiration (Bambi et al. 2017). On the other hand, guidelines for enteral nutrition during periods of CPAP/NIPPV, warn of the increased risk of stomach and abdominal distention due to positive pressure, if gastric decompression cannot be achieved through a vented nasogastric tube (Sanchez et al. 2014).

A complication mentioned in NSW guidelines was "abdominal distension due to swallowing of air" (Sanchez et al. 2014 p.20) but the only advice to nursing staff was the ambiguous recommendation that nurses be proactive in taking steps to limit these complications. Thus, there was no explicit recognition that NIPPV is the cause of the "swallowed air" in these 2014 NIPPV Australian Guidelines.

Thus, patients undergoing NIPPV therapy are likely to be undernourished in ICU and will require strategies developed through consultation with the interdisciplinary team early in the patient's admission to improve nutrient intake. The Society of Critical Care Medicine (SCCM), American Society of Parenteral and Enteral Nutrition (ASPEN) guidelines (McClave et al. 2009), Canadian (Heyland et al. 2003; Dhaliwal et al. 2014), European (Kreymann et al. 2006; Preiser & Schneider 2011) and Australian Guidelines (Sanchez et al. 2014) recommend Dietetics and nutritionist assessments, documentation and nutritional plan within 24 hours after initiation of NIPPV therapy and the implementation of enteral feeding within 24 hours where patients are unable to maintain volitional intake.

Sanchez et al's (2014) publication of Non-invasive Ventilation Guidelines for Adult Patients with Acute Respiratory Failure for New South Wales, Australia involved consultation with a committee of 16 health professionals but did include a dietitian. In addition, failure of the literature reviewed by the committee to include research on nutrition or malnutrition perhaps confirms the low status afforded to nutrition in patients prescribed NIPPV. Oral feeding was recommended for patients able to tolerate "small periods" off NIPPV (Sanchez et al. 2104 p.22). No clarification was provided on what constitutes small periods and no mention of the need to calculate whether and to what degree the patient was consuming required nutrients. The advice for referral to a dietitian is also ambiguous for the guidelines states "If patients remain NIV dependent for > 24hrs consider dietitian review" (Sanchez et al. 2104 p.22). Thus, the interpretation could be that if patients are able to tolerate small periods off NIPPV then a dietitian referral is not required.

Despite the plethora of published guidelines recommending the provision of enteral nutrition within 24 hours of ICU admission, data from control arms of clinical trials reveal up to 40% of critically ill patients receive no nutritional support during their ICU admission (Doig et al. 2008). Furthermore, 60% of patients who stay in the ICU at least 3 days remain unfed for 48 hrs or longer (Binnekade et al. 2005), with nutritional goals achieved on only 50% of feeding days (Binnekade et al. 2005; Elke et al. 2008). Nutritional guidelines fail to take into account the patient's clinical progression and nutrient intake prior to ICU admission thus recommendation for addressing nutrition within 48hrs of ventilation may be problematic. In view of the limited research and expert opinion available to guide clinical practice, it suggests the low priority that is possibly afforded to ICU patients in meeting nutritional requirements.

NIPPV is used for patients experiencing an exacerbation of COPD (Crimi et al. 2010). Patients with COPD have swallowing difficulties prior to the use of NIPPV (Gross et al.

2009). While the exact mechanism remains unknown, numerous studies have shown that inspiration and swallowing occur almost simultaneously in patients with respiratory failure, which may induce aspiration (Gross et al. 2009; Carron et al. 2013; Terzi et al. 2014). The epiglottis, arytenoids, and vocal folds and the normal "exhale – swallow – exhale" pattern all work to prevent tracheopulmonary aspiration. Alteration of the swallow-respiratory pattern occurs in the elderly and in cerebrovascular disease, Parkinson's disease, neurological diseases (Matsuoa & Palmer 2009) and COPD and respiratory failure (Gross et al. 2009; Carron et al. 2013; Terzi et al. 2014). Patients prescribed NIPPV may therefore be already at risk for aspiration because of the occurrence of swallowing during inspiration. The fear of aspiration may also interrupt nutrient intake for patients with swallowing difficulties such as patients with COPD and doctors may be reluctant to prescribe nutrition for these patients due to the risk of aspiration. Other than that, mask interface and positive pressure ventilation secondary to gastric insufflation (Asai et al.2002; Miller & Light 2003) may also cause aspiration. Face mask or oronasal mask is a most common type of mask interface when providing NIIPV therapy because it can minimise air leak (Nava & Fanfulla 2014). However, it would be difficult to monitoring aspiration on face mask, contributing the risk of aspiration. Furthermore, patients may also easily aspirate when vomiting while wearing a face mask unless they are able to remove the mask strap quickly. Aspiration pneumonia is a potentially serious complication of NIPPV (Gay 2009; Carron et al. 2013) and clinicians may be reluctant to commence oral nutrition in patients requiring NIPPV.

1.2 Overview of the problem

As use of NIPPV for acute respiratory failure has increased (Demoule et al. 2006), determining how best to provide nutrition care for these patients has become a topic of great clinical relevance. However, there is a paucity of published data and lack of evidence on the provision of nutrition and degree of nourishment provided in patients undergoing NIPPV therapy in ICU. Current nutritional care guidelines for the critically ill fail to incorporate elements addressing specific needs of patients prescribed NIPPV (Singer et al.

2009; Reeves et al. 2014). In order to develop nutritional guidelines to provide good nutritional care to the patients undergoing NIPPV therapy, preliminary research providing fundamental data is required. Aspiration pneumonia is a potentially serious complication of NIPPV. Patients receiving NIPPV therapy have a high risk of aspiration and this may negate doctors prescribing patients' oral nutrient intake. Since there is limited research examining the incidence of aspiration pneumonia during NIPPV further investigation is warranted.

1.3 Purpose of the study

The aims of this study is to explore current clinical nutritional care practice provided to patients undergoing NIPPV therapy and to investigate whether these patients are adequately nourished in ICU. This research also investigated the incidence of aspiration pneumonia during the NIPPV therapy.

1.4 Research Questions

In meeting the aims for this study three questions need to be answered.

Question 1: What is the current clinical practice regarding nutrition care for patients receiving non-invasive positive pressure ventilation (NIPPV) therapy in intensive care unit (ICU)? This first question was broken down into a subset of questions.

- *What is the time to commencement of nutrition after the initiation of NIPPV therapy?*
- *What is the most common type of nutrition in the patients requiring NIPPV therapy?*
- *What are the outcomes for patients who have ICU dietitian consult?*
- *What factors interrupt nutrient intakes in patients while receiving NIPPV therapy?*

Question 2: Are the patients adequately nourished? The second question was also broken down into a number of sub-questions.

a. *Are there significant differences between average daily energy and protein intakes and estimated requirements in the patients requiring NIPPV therapy?*

b. *What are different in variables between the two groups: patients receiving < 50% of estimated energy or protein requirements vs. patients receiving ≥ of estimated energy or protein requirements*

c. *What are the nutritional status of the patients receiving NIPPV therapy?*

Question 3: What is the prevalence of aspiration pneumonia in the patients undergoing NIPPV therapy?

1.5 Significance of the research

Nutrition-related evidence is rare for patients receiving NIPPV therapy. This research will contribute to the development of nutritional guidelines for critically ill patients undergoing NIPPV therapy by providing fundamental evidence on nutrition in this population. This study will also be used to guide future research directions. Although the findings from this research cannot be generalisable due to the small sample size and not using randomise sampling, this research will further contribute to the small body of knowledge on nutrition in critically ill patients requiring NIPPV therapy. Additionally, the evidence from this research may assist in improving clinical outcomes by contributing to the development and implementation of nutritional care plans, protocols and guidelines for patients receiving NIPPV therapy.

1.6 Outline of the thesis

This thesis consists of six chapters. The first chapter provides the introduction of the thesis. Chapter 1 includes a brief background of the study, problem overview, research questions, significant of the research and outline of the thesis.

Chapter 2 provides a review of the literature describing nutrition- related issues for patients receiving NIPPV therapy in ICU as well as presenting evidence of potential risks associated with aspiration pneumonia due to feeding, and identify gaps in the literature where future study is required.

Chapter 3 is the method chapter and explains the methods and methodology used for exploring current clinical nutritional care practice in the patients receiving NIPPV therapy in ICU. Data analysis and ethical considerations are also included in this chapter.

Chapter 4 presents the research findings. Findings are presented as aligned with the research questions.

Chapter 5, the discussion, focuses on answering the research questions, addressing the significance of the findings and identifies the implications for nutritional status or nutritional practice provided to patients requiring NIPPV therapy.

Chapter 6, provides a summary of the main findings, the strengths and limitations of the study, and recommendations for future studies and identifies implications for nursing education, nursing practice and research.

Chapter 2: Literature Review

The present literature review explores current knowledge regarding nutrition, critical illness, and aspiration pneumonia related to the use of NIPPV. Through reviewing current literature, the researcher determines 'what is known' and 'what is unknown' about the topic which assists them in identifying a new areas of investigation (Nieswiadomy 2011). The present literature review describes the framework used to structure the review, the article search and selection processes, a summary of the critical appraisal of studies, and a presentation of the review's findings and implications regarding the studied topic. Additionally, this paper will discuss the main themes in order to deepen understanding of the topic. Finally, the conclusion l summarises the main findings of the literature review and highlight incomplete areas of evidence to inform this study.

2.1 The framework used to structure the review

This literature review used the five-stage integrative literature review method proposed by Whittemore and Knafl (Whittemore & Knafl 2005): (i) problem identification stage, (ii) literature search stage, (iii) data evaluation stage, (iv) data analysis stage, (v) presentation. The integrative review possesses the potential to play a greater role in evidence-based practice for nursing (National Health and Medical Research Council 2015) and allows for examination of diverse methodologies. The author identified major themes based on the study purpose and the major findings obtained from an intense analysis of the literature to develop deeper understanding of the current nutritional practices and issues associated with NIPPV.

2.2 Article search and selection process

The literature search was conducted using four electronic databases: Cumulative Index for Nursing and Allied Health Literature (CINAHL), Google Scholar, MEDLINE, and SCOPUS. An initial strategy consisting of Medical Subject Headings (MeSH) and descriptors were developed for each of the key terms: 'non-invasive ventilation', 'non-invasive positive pressure ventilation', 'Continuous positive airway pressure', 'artificial respiration', 'Biphasic positive airway pressure', and 'nasal or mask high-flow'. These were combined with descriptors such as 'nutrition', 'artificial nutrition', 'enteral nutrition' and 'parenteral nutrition'. However, this initial search did not yield many relevant results. Accordingly, the search keywords were extended to include 'critical illness', 'acute respiratory failure', 'chronic obstructive pulmonary disease (COPD)' and 'cardiogenic pulmonary oedema (CPO)', which appeared frequently in the initial search. Each respiratory distress related search term was combined with descriptors such as 'nutrition' and 'nutrient intake', 'malnutrition', 'hospital malnutrition', 'under-nutrition' and 'nutritional status'. Since there was a paucity of studies on the topic of nutrient intake in patients receiving NIPPV therapy, no restrictions were initially applied to the date of publication. In order to find literature on aspiration pneumonia associated with NIPPV, the following key search terms were used: 'aspiration', 'aspiration pneumonia', 'ventilation associated pneumonia', 'nosocomial infection', and 'hospital infection'. All types of studies were included, in addition to expert opinions and review articles. Reference and citation tracking was performed on included publications and on a published literature review in the field.

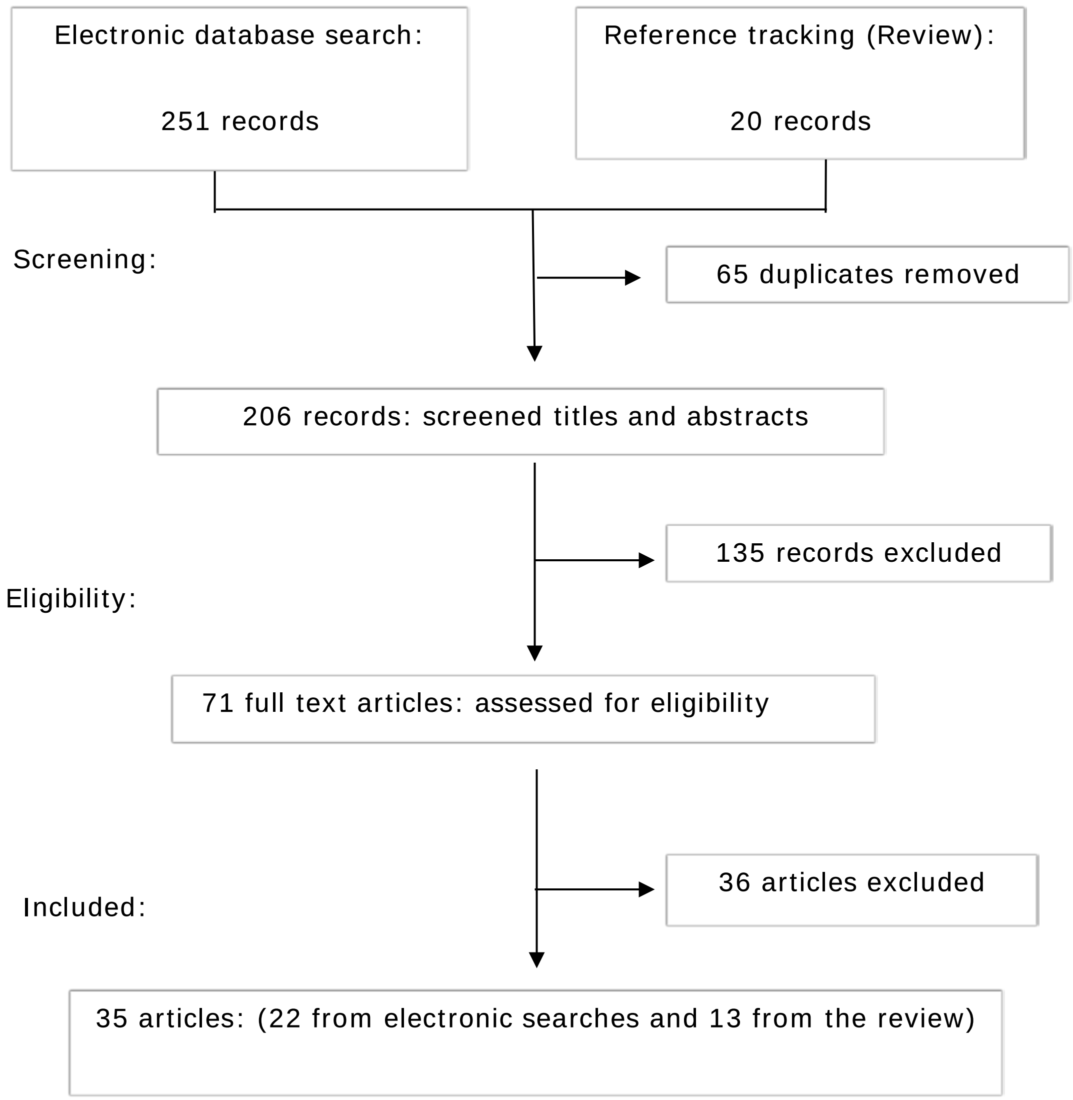
2.3 Selection criteria

The literature review selection criteria included primary research articles, which focused on NIPPV, critically ill patients, nutrition, aspiration, aspiration pneumonia and were published during 2003-2017. The search was restricted to 2003-2017 to take into account 2003-2008, a period where extensive research was conducted on hospital malnutrition, and to also obtain knowledge that was as current as possible by searching the 2017 literature after data collection. However, some older seminal articles were included to provide imperative information about the topic. Additionally, the search was restricted to publications in the English language and primary source articles. Using these criteria, a total of 271 articles were retrieved. Although the abstracts and titles of these initial retrieved articles indicated their relevance to this review, on closer reading 236 of them failed to meet the inclusion criteria. Hence, only 35 research articles were included in this review (Appendix A.1).

2.4 Search results

Figure 2.1 outlines the search and screening strategy and outcome. The electronic database search yielded a total of 251 records. These were imported into EndNote bibliographic management system software (EndNote x7; Thomson Reuters, NY, USA) along with 20 citations included after hand searching the reference list of relevant literature review. After the removal of 65 duplicates, the titles and abstracts of 201 studies were retrieved and screened against the inclusion and exclusion criteria. Full papers were reviewed where the abstract contained insufficient detail. Sixty-six full texts were screened for inclusion in this review, resulting in final selection of 35 relevant research articles.

Figure 2. 1 Flow chart of search strategy and results



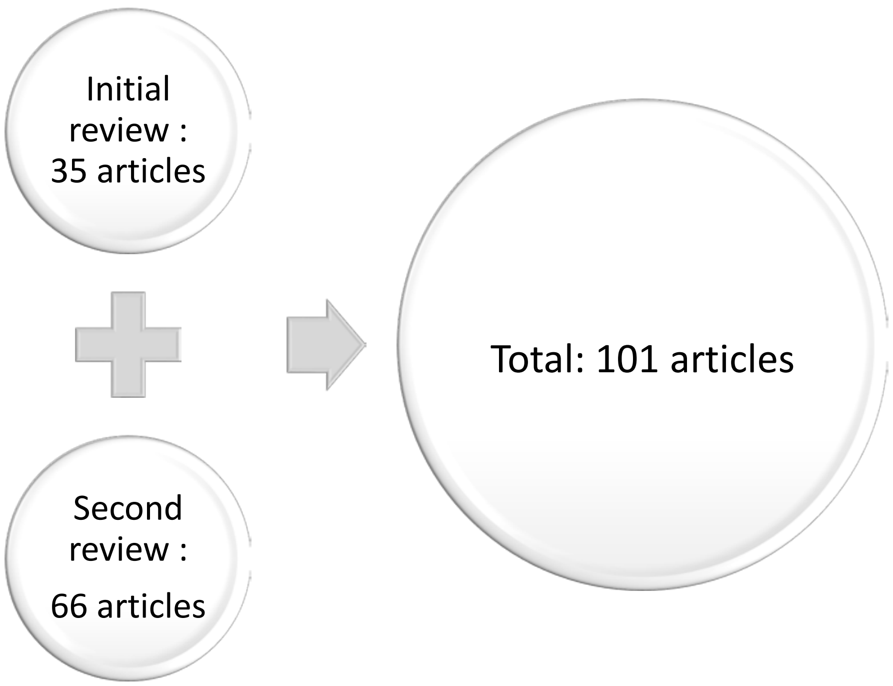
2.5 A summary of the critical appraisal of studies

A total of 35 articles met the selection criteria for this review. Each of the articles selected for this review described quantitative methodology, despite the absence of restrictions on study type. Included were 2 randomised control trials (Arabi et al. 2011; Heidegger et al. 2013) (including one 2X2 factorial, randomized, controlled study (Arabi et al. 2011), 19 cohort studies of which 14 were prospective (Aquilani et al. 2003; Dupertuis et al. 2003; Soler et al. 2004; Schettino et al. 2005; Metheny et al. 2006; Esteban et al. 2008; Alberda et al. 2009; Gross et al. 2009; O'Leary-Kelley et al. 2009; Cahill et al. 2010; Peterson et al. 2010; Heyland et al. 2011; Kim & Choi-Kwon. 201; Reeves et al. 2014) and 5 retrospective (Kohlenberg et al. 2010; Purkey et al. 2009; Walkey & Wiener 2013b). There is no gold standard for evaluating and interpreting the quality of diverse empirical sources (Whittemore & Knafl 2005); therefore, all studies meeting the inclusion criteria, regardless of methodological quality, were retained. Cohort studies and systematic reviews were critically evaluated using appropriate tools from the Critical Appraisal Skills Program (*Critical Appraisal Skills Programme* 2013). Survey studies were appraised using the tool produced by the Centre for Evidence Based Medicine (*Critical Appraisal tools*). Cross-sectional and experimental/quasi-experimental studies were appraised using an evaluation tool for quantitative studies adapted from the University of Salford Evaluation Tool for Quantitative Studies (Long 2002). The included studies were rated using the NHMRC levels of evidence (National Health and Medical Research Council 2015), which places evidence in a hierarchy according to the type of research question and recognises the importance of the appropriate research design for a particular type of question. Clinical impact was also evaluated(National Health and Medical Research Council 2015).

2.6 Literature review on hospital iatrogenic malnutrition

A second review was undertaken using the descriptors of hospital (iatrogenic) malnutrition, barriers to nutritional intake and equation of adequate energy requirement. This was essential in providing data as to the extent of hospital malnutrition internationally, an identification of barriers to nutrition in the general hospital population and calculation of adequate energy requirement not substantiated in research on malnutrition in NIPPV. As over 2000 references were located, a decision was made to include a selection of 66 articles (Appendix A.2) to demonstrate an international perspective on hospital malnutrition, tools used in screening and assessment, overview of barriers to the provision of nutrients in general populations, and determination of equations for adequate energy requirement (See Figure 2-2). These articles included systematic reviews (6), surveys (8), prospective studies (14), cross-sectional design (8), retrospective studies (11), expert opinion – seminal article (5), electronic book (1) and a qualitative semi-structured interview (1) plus NIPPV protocols or policy (12) (Appendix A.3).

Figure 2. 2 A total number of articles reviewed in initial and second search



2.7 A presentation of the review's findings

After data extraction and coding, nine major themes were derived: 1) Use of NIPPV 2) Nutrition In Critically Ill Patients 3) Hospital Under-Nutrition 4) Nutritional Barriers 5) Current Nutritional Practice in ICU 6) NIPPV and Nutrition 7) Enteral Nutrition during NIPPV Therapy 8) 8) Estimation of Energy Requirement 9) Ventilator-Associated Pneumonia (VAP) and Aspiration Pneumonia associated with NIPPV.

2.7.1 Use of NIPPV

Non-invasive positive pressure ventilation (NIPPV) refers to the delivery of mechanical ventilation without the use of an invasive artificial airway (Cross 2012). NIPPV is delivered via a nasal or facial mask in the form of either continuous positive airway pressure (CPAP) or biphasic positive airway pressure (BiPAP) (Rose & Gerdtz 2009). A nasal cannula may be used to apply enhanced pressure ventilatory support from a flow generator (Hill et al.

2007). High-flow oxygen therapy through a nasal cannula is a technique whereby heated and humidified oxygen is delivered to the nose at high flow rates (Frat et al. 2015). These high flow rates generate low levels of positive pressure in the upper airways, and the fraction of inspired oxygen (FIO2) adjusted by changing the fraction of oxygen in the driving gas (Parke et al. 2011; Chanques et al. 2013). Therefore, nasal high flow (NHF) can also be included in NIPPV.

NIPPV assists breathing in acute respiratory failure (ARF) patients by enhancing the transpulmonary pressure, inflating the lungs, increasing tidal volume, and unloading fatigued ventilatory muscles to relieve dyspnoea (Bertella & Vitacca 2010). The use of NIPPV has been fuelled by evidence demonstrating improved outcomes in patients with respiratory failure due to COPD exacerbations, acute cardiogenic pulmonary oedema, or immunocompromised states, and facilitation of extubation in COPD patients with failed spontaneous breathing trials.

The use of NIPPV has become more common as its benefits are increasingly recognized (Demoule et al. 2006; Maheshwari et al. 2006). The increased use of NIPPV in critically ill adults is supported by studies demonstrating its association with reduced hospital mortality (Schettino, Altobelli & Kacmarek 2005; Burns et al. 2009). Burns and colleagues (2009) published a meta-analysis of 12 randomised controlled trials (including one quasi-randomised trial) in which they examined the use of NIPPV to facilitate ventilator weaning. Data from 530 study participants demonstrated a significant association between non-invasive weaning and reduced mortality (relative risk 0.55, 95% confidence interval 0.38 to 0.79) and ventilator associated pneumonia (RR 0.29, 95% CI 0.19 to 0.45) when compared to invasive weaning. The non-invasive approach also resulted in shorter length of stay in hospital and reduced total duration of ventilation (Burns et al. 2009).

NIPPV has also been investigated as an alternative to invasive ventilation in terminally ill patients with do-not-resuscitate (DNR) or do-not-intubate (DNI) orders (Schettino, Altobelli & Kacmarek 2005). In a prospective observational study of 181 DNI patients with ARF (Schettino, Altobelli & Kacmarek 2005), NIPPV was found to be effective in relieving respiratory distress and preventing hospital mortality, although underlying disease was an important determinant of survival. NIPPV was most successful in patients with a primary diagnosis of COPD or cardiogenic pulmonary oedema (hospital mortality 37.5% and 39%, respectively) but hospital mortality was high in patients with post-extubation respiratory failure (77%), hypoxemic respiratory failure (86%), and end-stage cancer (68%).

Patients presenting with a Glasgow coma scale (GCS) score <10 have also been considered poor candidates for NIPPV (Evans 2001). However, an observational study of ARF patients (Diaz et al. 2005a) found that NIPPV therapy was more successful in coma patients than in conscious patients . Diaz et al. (2005a) performed a single centre observational study of 958 patients with ARF who had NIPPV therapy. Among the 958 patients, 95 patients had hypercapnic coma secondary to ARF with GCS ≤8, and 863 patients were awakening (GCS>8). The researchers found that NIPPV therapy was more successful (p=0.0434) in coma patients with GCS ≤8 (80%) than in conscious patients with GCS > 8 (70%). Successful outcomes of NIPPV included a response to therapy allowing the patient to avoid intubation, plus survival in the ICU and an additional 24hr on ward. In addition, there was no significant difference in the mortality between the two groups while receiving NIPPV treatment (26.3% vs 33.2%, p=0.1706). The incidence of aspiration in coma patients receiving NIPPV was just 1.05% (n=1). This is the first study investigating the effect of NIPPV in coma patients and the researchers concluded that NIPPV can be used even in unconscious patients with good effect.

The use of NIPPV has increased in many critical care areas around the world over the past 20 years (Martin 2007; Chandra et al. 2012; Alves et al. 2014; Demoule et al. 2016; Hicks & Parker 2016). Chandra et al. (2012) analysed over 7.5 million hospital admissions for chronic obstructive pulmonary disease (COPD) exacerbations in the US Healthcare Cost and Utilization Project's Nationwide Inpatient Sample. This work revealed that between 1998 and 2008, NIPPV increased as a percent of all COPD admissions from 1% to 4.5% (Chandra et al. 2012). Alves et al. (2014) analysed 14,515 adult patients admitted with asthma in the Portuguese national hospitalizations database. This study found that the application of NIPPV increased from 1% in 2000 to 3.3% in 2010 in all patients admitted with asthma (Alves et al. 2014). In France and Belgium, only 9% of the patients used NIPPV therapy as a first-line therapy or a weaning procedure after extubation in intensive care units (ICUs) in 1997. This rate significantly increased to 28% in 2007 and 37% in 2010/11 (Demoule et al. 2016). In Australia, the rate of use of NIPPV in critical care areas increased from 15% in 2007 to 18% of ventilation in 2012, with ventilation hours increasing from 9% in 2007 to 11% in 2012 of total ventilation hours and a total proportion of all ICU admission from 7% in 2010/11 to 9% in 2014/15 (Martin et al. 2007; Carter & Hicks 2016). In a prospective survey conducted in 20 countries, overall NIPPV therapy use rose from 4.4% in 1998 to 14% in 2010 (Esteban et al. 2008). This is consistent with the findings of a more recent web-based survey conducted in the USA (Walkey & Wiener 2013) that the use of NIPPV in patients with COPD significantly increased over the 10-year study period from 3.5% in 2000 to 12.3% in 2009 (250% increase). The rate of change was even higher in patients without COPD (1.2% in 2000 to 6.0% in 2009; 400% increase) (Walkey & Wiener 2013). This evidence indicates that the rate and duration of NIPPV is increasing overall.

As discussed above, NIPPV has become a mainstay of treatment for the patients with acute respiratory failure resulting from various conditions. Therefore, customized comprehensive care addressing all activities of daily living (ADLs) for these patients is required in various areas rather than just focusing on respiratory care. Nutrition is therefore an integral need to address when caring for patients with NIPPV. As the proportion of patients receiving NIPPV in the ICU increases, the provision of adequate nutritional care is essential. The consideration of comorbidities of patients with critical illness is crucial when assessing, planning and implementing nutritional care for this cohort. The next theme will discuss the association between critical illness and nutrition.

2.7.2 Nutrition in critically ill patients

Critical illness is a catabolic process with a systemic inflammatory response; it is associated with increased infection, multi-organ dysfunction, prolonged hospitalisation and mortality

(Sharifi et al. 2011). Despite increased metabolic rate, lack of nutrient intake and well-established complications of malnutrition debate continues on whether to provide adequate nutrition or to underfeed. This debate is confusing, as critically ill patients require more than double the regular amount of dietary protein because muscle proteolysis is dramatically increased in the critically ill (Hoffer & Bistrian 2013).

Nutritional support in acute-phase critically ill patients appears to be controversial. While two studies showed favourable clinical outcomes after nutritional support in these patients (Elke et al. 2014; Heidegger et al. 2013), two others supported underfeeding acutely ill ICU patients (Arabi et al. 2011; Heyland, Cahill & Day 2011). A two-centre randomised controlled trial involving 305 patients admitted to mixed medical and surgical ICUs in Switzerland (Heidegger et al. 2013) found that providing close to 100% (mean 103% [SD 18%]) of energy requirements by combining enteral nutrition with parenteral supplementation (SPN group) improved clinical outcomes when compared to patients provided enteral nutrition only (EN group, mean 77% [SD27%] of energy requirements. Fewer patients in the SPN group contracted nosocomial infections than in the EN group (hazard ratio (HR) 0·65, 95% CI 0·43–0·97; p=0.0338), and the SPN group had a lower mean number of nosocomial infections per patient (HR −0·42 [−0·79 to −0·05]; p=0·0248). These results are consistent with the recently published findings of a retrospective analysis of pooled data from the International Nutrition Survey (INS) and baseline data from the Enhanced Protein Energy Provision via the Enteral Route in Critically Ill Patients (PEP uP) study (Elke et al. 2014). Elke et al. (Elke et al. 2014) demonstrated that the provision of energy and protein requirements closer to the calculated daily needs of the patient was associated with a shorter duration of mechanical ventilation and lower mortality in patients diagnosed with sepsis and/or pneumonia. Sixty-day mortality was significantly reduced with each additional 1000kcal/day (adjusted odds ratio (OR) 0.61, 95% CI 0.48 to 0.77) and for each additional 30g of protein per day (adjusted OR 0.76, 95% CI 0.65 to 0.87), and ventilator-free days were increased with increasing energy (adjusted median 2.81 days, 95% CI 0.53 to 5.08) and protein intake (1.92 days, 95% CI

0.58 to 3.27). This finding demonstrates that underfeeding is associated with significantly increase risk of death. Accordingly, adequate nutrient intake is crucial for the critically ill patients and nutrition care should be a part of regular treatment to reduce ICU mortality.

A randomised double-blind placebo controlled study of nutritional supplementation (Gariballa & Forster 2006) examined the effects of the acute-phase response of critical illness on nutritional status and clinical outcome in hospitalised older patients (age ≥65yrs). Using c-reactive protein (CRP) levels as an indicator, this study showed that the acute-phase response (CRP>10mg/L) was associated with significantly lower energy intake, deterioration in nutritional status, and longer hospital stays than observed in patients with CRP≥10mg/L (Gariballa & Forster 2006). Although benefits of nutritional supplementation was noted in patients with CRP>10mg/L statistical significance was not reached, probably due to the low number of participants in each subgroup.

In contrast, there is also evidence that caloric underfeeding during the early acute phase of critical illness is more beneficial than provision of calculated daily energy needs (Arabi et al. 2011; Heyland, Cahill & Day 2011). A single centre randomised controlled trial conducted by Arabi and colleagues (Arabi et al. 2011) compared the provision of 90-100% of the energy target with permissive underfeeding, defined as 60-70% of the caloric goal in 240 critically ill patients receiving EN in the ICU. The study found that the permissive underfeeding group had significantly lower hospital mortality compared to the target feeding group (30.0% and 42.5%, respectively; RR 0.71, 95% CI: 0.50 to 0.99; p=0.04). Dickerson and colleagues (2002) also demonstrated the effect of under-nutrition in a retrospective study involving 40 critically ill obese patients, finding that lower calorie intake (<20 kcal/kg of ideal weight per day) significantly reduced ICU length of stay when compared to ideal calorie intake (≥20 kcal/kg of ideal weight per day) (18.6 ± 9.9 days vs. 28.5 ± 16.1 days, p<0.03) and the duration of antibiotic therapy (16.6 ± 11.7 days vs. 27.4 ± 17.3 days, p<0.03). Prediction of energy requirements for patients with obesity is more complex than for patients with optimal weight. Although Indirect calorimetry studies documented relatively lower energy requirements in obese patients, and SOME clinical guidelines recommend hypocaloric feeding, clinicians target energy intake goals at lower levels in obese than optimal-weight patients (Compher et al. 2014)- failure still exists in identifying and addressing that nutrition entails more than calorific intake.

2.7.3 Hospital under-nutrition

In 1974, Butterworth hypothesised that malnutrition was more prevalent in hospitals than in "rural slums or urban ghettos". He found it unacceptable that "iatrogenic malnutrition" existed despite health professionals' knowledge of its negative affect on increased infection, delayed wound healing, and increased morbidity, mortality and bed occupancy. Hospital malnutrition persists as a highly prevalent, under-diagnosed and under-treated international issue (Gout et al. 2009; Liang et al. 2008; Cederholm et al 2015). Research in the 21st century has so far continued to show that hospital malnutrition remains an international problem not yet resolved (Table 2.1).

Table 2. 1: Research on hospital malnutrition in 21st Century

Country	Author
America	Liang et al. 2008; Corkins et a. 2014
Asia	Liang et al. 2008; Lim et al. 2012
Australia	Middleton et al. 2001; Banks et al. 2007; Gout et al. 2009; Rowell & Jackson 2011; Agarwal et al. 2012; Agarwal et al.2015; Reeves et al. 2014
Brazil	Pasquini et al. 2012
Canada	Rahman et al. 2015
Ecuador	Gallegos et al. 2014.
Europe	Kondrup et al., 2003; Cederholm et al 2015
International study: Austria, Czech Republic, Egypt, Germany, Hungary, Lebanon, Libya, Poland, Romania, Slovakia, Spain and Switzerland	Sorensen et al. 2008
Ireland	Rice & Normand 2012
Italy	Lucchin et al. 2009
Japan	Wakabyashi & Sashika 2014
Latin American Countries	Norman et al. 2008
Netherlands	Bavelaar et al. 2008; Meijers et al. 2009
Portugal	Cansado, Ravasco & Camilo 2009
Scandinavia – Sweden, Denmark and Norway	Mowe et al. 2006
United Kingdom	Stratton et al.2006

The publication of guidelines for the assessment, diagnosis, prevention and management of hospital malnutrition developed through a systematic review and critique of available evidence and extensive stakeholder consultation are available in most countries (Heyland et al. 2003; Kreymann et al. 2006; McClave et al. 2009; Dhaliwal et al. 2014). These guidelines have not however made a significant difference to the identification and management of hospital malnutrition. In Australia in 2009, Evidence Based Practice Guidelines for Nutritional Management of Malnutrition in Adult Patients across the Continuum of Care was published to: increase access health professionals access to evidence based nutritional protocols; increase accuracy in the timely diagnosis of malnutrition; improved referral to dietitians so dietitians can advocate for correct assessment, diagnosis and management of hospital malnutrition (Watterson et al. 2009).

Nutrition risk screening by clinicians at the bedside using a validated tool can be a simple and quick technique to identify patients at risk of malnutrition and promote timely referral to dietitians for appropriate management. Yet, screening for malnutrition is not mandatory in Australia and many countries throughout the world and as a consequence malnutrition is under-reported, not documented, not Diagnosis Related Group (DRG) coded therefore leading to increased morbidity and increased long term health care costs. Screening tools have however been extensively used in research on hospital malnutrition (Table 2.2).

Table 2. 2: Tools used to assess risk of, or actual, malnutrition

Author	**Malnutrition Assessment Tools**
Agarwal et al.2015	BMI, Subjective Global Assessment (SGA).
Banks et al. 2007	BMI (%weight loss), MNA, MUST
Cansado et al., 2009	(BMI, %weight loss) & risk (MNA, MUST),
Cederholm et al. 2015	BMI, unintentional weight loss, Fat Free Mass Index (FFMI)
Duarte et al 2014	Mini Nutrition Assessment (MNA); Mini Nutrition Assessment Short Form (MNA-S); Subjective Global Assessment (ASG); Nutritional Risk Screening (NRS 2002); and Malnutrition Universal Screening Tool (MUST).
Gallegos et al. 2014	SGA
Kim & Choi-Kwon 2011	SGA
Gout et al 2009	SGA
King et al. 2003	Nutritional Risk Screening (NRS 2002); anthropometric and dietary parameters
Kondrup et al., 2003	(BMI, %weight loss) and risk (MNA, MUST),
Kyle et al. 2002	body mass index, serum albumin, Subjective Global Assessment, and 50-kHz bioelectrical impedance analysis
Kruizenga et al., 2005	Short Nutritional Assessment Questionnaire (SNAQ).
Lammel et al 2013	Subjective Global Assessment (SGA).
Lim et al. 2012	BMI
Leandro-Merhi et al. 2009	BMI
Lucchin et al., 2009	Nutritional Risk Screening 2002 (NRS 2002)

Meijers et al. 2009	BMI
Middleton et al. 2001	SGA
Ordonez et al. 2013	subjective global assessment (SGA), body mass index (BMI), triceps skinfold thickness (TST), muscle arm circumference (MAC) and combined tools
Pasquini et al. 2012	subjective global assessment
Rahman et al. 2015	Malnutrition Universal Screening Tool (MUST)
Reeves et al. 2014	SGA
Sorensen et al.2008	nutritional risk screening (NRS-2002)
Stratton et al 2006	Malnutrition Universal Screening Tool (MUST)
Wakabyashi & Sashika 2014	Mini Nutritional Assessment Short Form; Body mass index,
Weng 2008	Serum albumin and haemoglobin
Zanin et al. 2011	subjective global assessment (SGA), body mass index (BMI), triceps skinfold thickness (TST), muscle arm circumference (MAC)

The eight tools used most frequently in research on undernutrition by authors in the table above were: BMI, MNA (Mini Nutrition Assessment), MNA-SF (Short-form MNA), MST (Malnutrition Screening tool MST), MUST (Malnutrition Universal Screening Tool), NRS-2002 (Nutritional Risk Screening), SGA (Subjective Global Assessment) and the SNAQ (Short Nutrition Assessment Questionnaire). Some of these tools are used by themselves whereas others eg., BMI are used as a component of another screening tool. The validity and reliability has been assessed for most tools and literature clearly identifies whether they are best used as a quick or more comprehensive identification of malnutrition.

BMI (Body Mass Index) on admission and throughout hospitalisation facilitates identification of unplanned weight loss/gain and allows a score to be derived to indicate whether nutrition intervention is necessary. MNA (Mini Nutrition Assessment) was developed for use among elderly patients in hospitals, nursing homes and the community. MNA is an 18 item assessment tool incorporating anthropometrical, medical, lifestyle, dietary history and psychosocial factors to determine no nutritional risk, at risk of malnutrition or malnourished (Ferguson et al. 1999; Anthony 2008). Assessment is a lengthy process and possesses low specificity for the screening section in acute populations (Anthony 2008). MNA-SF (Short-form MNA) abridged version of the MNA, using a 2-step nutrition screen (Rubenstein et al. 2001; Kaiser et al. 2009). A comparison of MNA-SF with MNA and clinical nutritional status possessed a sensitivity 97.9%, specificity 100% & diagnostic accuracy 98.7% (Rubenstein et al. 2001). MST (Malnutrition Screening tool

MST) is a simple, 3-question tool assessing recent weight and appetite loss. The scoring system identifies high malnutrition risk and provides a basis for dietetic referrals and interventions. MST, when compared with SGA, possessed sensitivity 93% and specificity 93% (Ferguson et al. 1999; Anthony 2008). MUST (Malnutrition Universal Screening Tool) was designed to detect under-nutrition and obesity in adults in hospitals and nursing homes. In studies evaluating its effectiveness, the tool was shown to consistently provide reliable results (Kyle et al. 2003), possessed face validity, content validity, concurrent validity comparable to MST & NRS (King et al.2003) and predicts mortality risk & increased LOS (Stratton et al 2006). The NRS-2002 (Nutritional Risk Screening) collects data on recent weight loss, decreased BMI and reduced dietary intake and subjective assessment of disease severity to generate a nutrition risk score (Anthony 2008). NRS-2002 predicted higher likelihood of positive outcome from nutrition support and reduced LOS (Kondrup et al. 2003). SGA (Subjective Global Assessment) commonly used nutrition assessment tool; assesses nutrition status using a questionnaire incorporating data on weight change, dietary intake change, gastrointestinal symptoms, changes in functional capacity associated with malnutrition and physical examination of fat and muscle stores and the presence of oedema to categorises patients as: SGA A (well nourished), SGA B (mild-moderate malnutrition) or SGA C (severe malnutrition) (da Silva Fink et al. 2015). Easy to administer, high degree of inter-rater reproducibility and inter-rater reliability, consistently shown to perform similarly or better than usual simple nutritional assessment methods but not with comprehensive nutritional screening methods (da Silva Fink et al. 2015). SNAQ (Short Nutrition Assessment Questionnaire) 4-item questionnaire diagnosing malnutrition in hospitalised patients and data to support dietetic referrals using an easy traffic light system (Kruizenga et al. 2010). Validated for hospital inpatient and outpatient use (Neelemaatet al. 2008; Kruizenga et al. 2010).

Disease-related malnutrition is a common comorbidity at hospital admission which worsens throughout their hospital stay. Large studies using screening tools reported prevalence of 20%–39% (Liang et al. 2008; Norman et al. 2008; Lucchin et al. 2009;

Meijers et al. 2009; Lim et al. 2012) which increased with older age to 32%–58% (Stratton et al 2006, Corkins et al. 2014; Wakabyashi & Sashika 2014). Studies conducted in Australia show prevalence of 37% to 45% (Middleton et al. 2001; Banks et al. 2007; Gout et al 2009). A large survey investigated the prevalence of malnutrition and dietary intake during 24 hr period in patients admitted to acute wards in 56 hospitals in Australia and New Zealand (Agarwal et al. 2012). Agarwal et al. (2012) screened patients at risk of malnutrition using malnutrition screening tool (MST). Out of 3122 patients (mean age: 64.6, ≤18years), 41% of the patients were found to be at risk of malnutrition. The researchers evaluated nutritional status for these patients using subjective global assessment (SGA) tool and revealed that 32 % of the patients were categorised as moderate or severe malnutrition (SGA B or C). This study also investigated dietary intake of these patients and found poor nutrient intake among not only malnourished patients but also well-nourished patients. Fifty-five percent of malnourished patients and 35% of the well-nourished patients consumed only ≤ 50% of the hospital food during the day (Agarwal et al. 2012). However, as this study only included food offered by the hospital and calculate any foods consumed which were brought in by relative it is possible that nutrient intake could be higher.

Despite this, patients' nutritional status worsens throughout admission with the consumption of less than half of the hospital food offered. More than 30% of the well-nourished patients consumed ≤50% of hospital food. If this trend continues during patient's hospital stay even well-nourished patients can become malnourished with patients experiencing *"iatrogenic malnutrition" (Butterworth, 1974)* with ongoing weight loss, increased complications and a slower recovery (Norman et al., 2008; Cansado et al., 2009).

Nutrition plays an important role to improving hospital outcomes. Agarwal et al. (2013) analysed previous data investigating the prevalence of malnutrition and dietary intake to investigate whether malnutrition and poor food intake affect hospital outcomes independently including length of stay (LOS), mortality, and readmission rate. They found that malnourished patients had significantly longer median hospital stay compared to well-nourished patients (15days vs. 10 days. P<0.0001) (Agarwal et al. 2013). Readmission rate was also significantly higher for the malnourished patients compared to the well-nourished patients (Agarwal et al. 2013). Regarding dietary intake, hospital food intakes were recorded by meals and snacks on a five-point scale (0%, 25%, 50%, 75%, and 100%) (Agarwal et al. 2013). Median LOS for the patients receiving ≤25% of the food was significantly higher than those consuming ≤50% (13 days vs. 11 days, p<0.0001) and the odds of 90-day in hospital mortality were significantly higher for the malnourished patients (CI: 1.09-3.34, P=0.023) and patients consuming ≤25% of the hospital food (CI: 1.13-3.51, P=0.017), respectively (Agarwal et al. 2013). These findings implicated that malnutrition and poor dietary intake are an independent factor of clinical outcomes such as LOS, mortality, and readmission rate (Agarwal et al. 2013). Therefore, early nutritional screening and early nutritional care support can maintain or enhance nutritional status for the hospitalised patients.

Undernutrition is an independent factor of morbidity and mortality, and increases hospital costs (Alberda et al. 2009). Approximately 3 million adults in the UK suffer from undernutrition, with treatment annually costing the nation £13 billion (Elia& Russel 2009). An Australian study demonstrated that 36% of the nation's hospitalised patients were undernourished, with the incidence of mortality at almost 30% (Middleton et al. 2001). Evidence demonstrates that improving treatment and identifying malnourished individuals will result in substantial savings to the NHS (*QIPP* 2012). Most importantly, Alberda and colleagues (2009) stated that increased intake of energy and protein may lead to improved clinical outcomes in critically ill patients.

Many studies have documented the prevalence in inadequacy of nutrient intake among hospitalised patients around the world (Dupertuis et al. 2003; O'Leary-Kelley et al. 2005; Alberda et al. 2009; Peterson et al. 2010; Kim & Choi-Kwon 2011). Peterson et al. (2010) examined the intake of 50 ICU patients over 7 days who consumed an oral diet after extubation. They found that for all patients on all 7 days, the average energy and protein intake failed to exceed 50% of the daily requirements. This finding is consistent with an earlier study (Dupertuis et al. 2003) assessing the oral intake of 1,416 hospitalised patients who received three meals a day without artificial nutritional support. The intake for each patient over 24h revealed that, despite being provided with adequate food (actually exceeding patients daily energy and protein requirements), 70% (975/1416) did not meet their recommended energy and/or protein requirements. When evaluating only the acute care unit population, this value increased to 84.5% (327/400).

Providing artificial nutrition to critically ill patients does not result in overall intake reaching recommended energy and/or protein requirements (Alberda et al. 2009; Kim & Choi-Kwon 2011; O'Leary-Kelley et al. 2005). A prospective observational study of mechanically ventilated ICU patients receiving enteral nutrition (O'Leary-Kelley et al. 2005) found a significant difference between the estimated mean energy requirement and the mean daily energy intake (8996 kJ vs 5899 kJ, 95% CI 3297-3787; $P<0.001$). Of the 60 patients, 41 (68.3%) received <90% of their daily energy requirements, and 23 (38%) patients were severely underfed, receiving <50% of their daily energy requirements (O'Leary-Kelley et al. 2005). These findings are consistent with a South Korean study of 34 ICU patients receiving enteral nutrition (Kim & Choi-Kwon 2011) that found that 62% of patients were underfed (<90% of requirements received). An international study that followed 2,772 mechanically ventilated ICU patients (Alberda et al. 2009) calculated that overall patients received 59.2% of their total energy requirements and 56% of their recommended protein intake, even though 94.6% of the patients received some kind of artificial nutrition. This suggests that the prescription of enteral nutrition is not always calculated based on patients' energy and protein requirement and thus demonstrates the inadequacy of nutrition for critically ill ICU patients.

2.7.4 Nutritional barriers

In order to improve nutrient intake for the patient receiving either oral nutrition or enteral nutrition, identifying nutritional barriers are important. With the effort of reducing nutritional barriers, patients could achieve better nutrient intake. This section provide nutritional barriers associated with oral nutrition, enteral nutrition, patients receiving NIPPV therapy, health professionals' knowledge and attitude towards nutrition, and limited dietitian availability.

2.7.4.1 Oral nutrition

Three studies reported nutritional barriers for the patients receiving oral nutrition (Dupertuis et al. 2003; Naithani et al. 2008; Peterson et al. 2010). Dupertuis et al. (2003) reported the most common reason for inadequate eating was' inadequate taste' and 'absence of choice' among hospitalised patients who received oral nutrition. 'Inadequate time' also affected inadequate intake in the same study (Dupertuis et al. 2003). Naithani et al. (2008) conducted a qualitative semi-structured interviews to examine patients' experiences of assess to food in hospital. The nutritional barriers were categorised into three types: organisational barriers, physical barriers, and environmental barriers. Organisational barriers included inadequate serving time and limited choice of menu, physical barriers included uncomfortable eating position, food out of reach, utensils of packaging presenting difficulties for eating. Environmental factors included staff interrupting during mealtimes, noise, or unpleasant smell. This study gives information of not eating from the patients' perspective that nurses or doctors cannot notice. Peterson et al. (2010) investigated the nutritional barriers for the post-extubation patients who had oral nutrition in ICU. This study found that 'poor appetite' was the most common reason for not eating (Peterson et al. 2001). Nausea/vomiting, 'do not like food', difficulty of chewing/swallowing and mental status changes were reported as reasons for inadequate oral consumption (Peterson et al. 2010). While dietary intake in patients in ICU were more likely to be interrupted by factors associated with their clinical conditions, patients in general wards or acute areas were more interrupted by hospital or environment related factors.

An appraisal of ICU NIPPV policies/procedures demonstrated that these very documents that guide nurses and doctors NIPPV practice may constitute a barrier for they fail to provide explicit guidelines on the provision of nutrition and may indeed, result in patients not consuming diet throughout the duration of NIPPV.

2.7.4.2 Enteral nutrition

Two studies investigated nutritional barriers for the patients receiving enteral nutrition in ICU (Kim & Choi-Kwon 2011; Cahill et al. 2012). Kim & Choi-Kwon (2011) reported EN under-prescription and nutritional status at admission as strong predictors of undernutrition. This study found that patients with EN under-prescription were over five times more likely to be undernourished compared to those with either adequately prescribed or over-prescribed (Kim & Choi-Kwon 2011). Indeed, calculation of the volume and constituents of EN were based on the physician's opinion rather than being informed by a specific protocol (Kim & Choi-Kwon 2011). Thus, doctors' knowledge of nutrition is important in the provision of appropriate and timely nutritional support. Patients severely malnourished (SGA C) on admission were more likely to be underfed than those with suspected to be malnourished (SGA B) when evaluating nutritional status using SGA tool. (SGA A: well-nourished, SGA B: suspected being of malnourished, SGA C: severely malnourished) (Kim & Choi-Kwon). This finding supports the need for mandatory nutritional screening test on admission. Early detection of patients with severe or suspected malnutrition possesses the potential for provision of early nutritional support, improved nutrient intake during ICU stay and improved clinical outcomes.

Cahill et al. (2012) conducted a cross-sectional survey from ICU nurses to investigate nutritional barriers for the critically ill patients receiving enteral nutrition and examine whether these barriers differ across centres. The five most important barriers to patients receiving enteral nutrition were other aspects of patient care taking priority over nutrition, not enough feeding pumps, enteral formula not available on the unit, difficulties in obtaining small bowel access in patients not tolerating enteral nutrition and no or not enough dietitian coverage during weekends and holidays (Cahill et al. 2012). The enteral nutritional barriers found in this study were similar across all five ICUs included, meaning that all items were perceived with the same degree of importance. Kim & Choi-Kwon

(2011) and Cahill et al. (2012) demonstrated that nutrition remains a low priority in ICU. With the lack of dietitians' involvement, health professionals' including nurses and doctors require nutritional knowledge to provide good nutritional care.

2.7.4.3 Nutritional barriers for the patients receiving NIPPV therapy

Only one study reported nutritional barriers for the patients undergoing NIPPV therapy. Reeves et al. (2014) reported nutritional barriers for the patients undergoing NIPPV therapy. Consuming food and drink orally, longer time on NIPPV, more severe illness, and higher BMI were associated with poor nutrient intake (Reeves et al. 2014). Better nutritional status on admission and measuring intake closer to hospital discharge date were associated with improve nutritional consumption (Reeves et al. 2014). This result is consistent with Kim & Choi-Kwon's (2011) findings. Kim & Choi-Kwon (2011) also reported the importance of admission nutritional status. Patients with better admission nutritional status had better nutrient intake, suggesting conducting nutritional screening test on admission. With the early detection of patients with malnourished, early nutritional support can be performed, contributing to improving nutrient intake.

2.7.4.4 Health professionals' knowledge and attitude towards nutrition

Health professionals' nutritional knowledge is important in the provision of evidences based nutritional care. Two studies investigated nurses' or doctors' knowledge of nutrition (Mowe et al. 2008; Morphet, Clarke & Bloomer 2016). Morphet, Clarke & Bloomer (2016) conducted a survey to explore Australian ICU nurses' enteral nutrition knowledge and sources of information. Among 1726 nurses, 388 (22.5%) nurses responded but as incomplete questionnaire were excluded, 358 responses were included in this study. Of the 358 respondents, more than 70% of nurses rated their knowledge on enteral nutrition as good (60.1%) or excellent (10.3%). Despite positive knowledge rating, a significant knowledge deficit was reported such as poor understanding of morbidity and mortality associated with malnutrition, and a lack of knowledge relating to basic physiology of the gastro intestinal system (Morphet, Clarke & Bloomer 2016). Morphet, Clarke & Bloomer (2016) also found that a lack of understanding of different types of formulas, types of formulations required for different clinical presentations and calculation of calories were commonly reported. The nurses reported most of their enteral nutrition knowledge was sourced from ICU dietitian and hospital policies and protocols (Morphet, Clarke & Bloomer 2016). The respondents acknowledged that dietitians are primarily responsible for the enteral nutrition regarding determining feeding regime and appropriate enteral formula (Morphet, Clarke & Bloomer 2016).

Mowe et al. (2016) investigated doctors' and nurses' self-reported knowledge in nutritional practice, with focus on ESPEN's guidelines in nutritional screening, assessment and treatment in Denmark, Sweden and Norway. The response rate was similar in all countries around 37% but the nurse showed higher response rate than doctors, 46% and 30% respectively. Lack of nutritional knowledge was the most common cause for insufficient nutritional practice (Mowe et al. 2016). Twenty-five percent of respondents reported difficulties in identifying patients in need of nutritional therapy, thirty-nine percent reported a lack of tools for screening malnourished patients, fifty-three percent had difficulty calculating the patients' energy requirement, and sixty-six percent believed there were lack of national guidelines for clinical nutrition. Only twenty-eight percent of respondents perceived the importance of nutrition and stated that insufficient nutrition practice could lead to complications and prolonged hospital stay. The findings from the studies (Mowe et al. 2008; Morphet, Clarke & Bloomer 2016) suggests more nutritional training for health professionals is required to provide evidenced based, timely nutritional care.

Nutritional training for doctors has inadequate throughout history and this perception has not significantly changed over sixty years (Frantz et al. 2011). A study investigating medical students' perception on nutrition found that medical students became less interested in nutrition during their medical course. Studies showed lower response rate of doctors compared to nurses or dietitian (Thorensen et al. et al. 2008; Morphet, Clarke & Bloomer 2016) which implies that doctors may not perceive nutrition as important part of treatment. Lack of knowledge and less interest in nutrition may lead to reluctance to assess for and respond to nutritional deficits.

2.7.4.5 Limited dietitian availability

Dietitians may provide nutritional care for the patients as well as acting as the nutritional educator for nurses and doctors. Morphet, Clarke & Bloomer (2016) reported that dietitians were the most preferable source of nurses' enteral nutrition information; however, their limited availability affected their efficacy as an information resource. Indeed, a large European survey conducted by Thorensen et al. (2008) revealed that doctors and nurses working at wards where dietitians frequently visited identified undernourished patients more often and nutrition had a higher priority compared to those working at wards where dietitians did not frequently visited. Dietitians are the most preferable source of nutritional information (Morphet, Clarke & Bloomer 2016). Thus, dietitians may play a role in providing not only nutritional care to the patients but also nutritional education to the medical staff. Despite the importance of dietitians, there are still insufficient numbers of dietitians available in hospitals to combat iatrogenic malnutrition. Cahill et al. (2012) reported insufficient dietitian coverage during weekends and holidays was one barrier to the prescription of appropriate EN. As nurses and doctors possess a lack of knowledge on nutrition, more dietitians are required for managing patients' nutritional care and for continuing nutrition education for the doctors and nurses.

2.7.5 Current nutritional practice in ICU

Accumulated evidence shows patients in critical care units are malnourished; however, little is known about current nutritional practices in the ICU setting. In order to improve the patients' nutritional status, it is necessary to know the details of actual nutritional practice currently performed in intensive care units. Thus, this section examines two studies conducted to investigate current nutritional care practice in ICU settings.

Two studies described current nutritional practice in the ICU (Cahill et al. 2010; Sharifi et al. 2011). A prospective observational study involving 2956 invasively ventilated adult patients (Cahill et al. 2010) described the current nutritional practices in 158 ICUs from

20 countries in order to determine the 'best achievable' practice compared to evidence-based Critical Care Nutrition Clinical Practice Guidelines (CPG). Enteral nutrition was provided to more patients than was parenteral nutrition (61.7% and 11.8%, respectively), which is consistent with CPG recommendations for EN for patients with an intact gastrointestinal tract to decrease risk of infection and of stress gastric ulcers (Cahill et al. 2010). The ICUs also adhered well to other recommendations, including avoiding hyperglycemia (mean glucose levels across sites: 7.5mmol/L), the use of arginine-supplemented enteral formulas, and adhering to hospital feeding protocols. However, there were considerable gaps between actual practice and CPG recommendations in other areas. For example, the CPGs recommend EN initiation within 24 to 48 hours of ICU admission, and although the mean time to initiate the EN was within recommended time (46 hours), one site did not commence enteral feeding until 149.1 hours post-ICU admission. CPGs also recommend using small bowel feeding when patients do not tolerate adequate amounts of EN but small bowel feeding was initiated in only 14.7% of patients with gastric residual volumes. The researchers also found that nutritional intake was inadequate, with patients receiving an average energy intake of 59% of the recommended value, and 60.3% of the recommended protein (Cahill et al. 2010).

A telephone survey conducted in the UK addressed nutritional support practice in 245 ICU and high dependency units (HDU) and involved a total of 1,286 patients (Sharifi et al. 2011). A questionnaire was completed over the telephone with a sister-in-charge or nurse manager of the ICU. The nurses were asked to provide general information about nutritional care on their unit and, more specifically, whether an allocated nutritional team was involved in nutrition care for the ICU patients. In this study, nutritional support was defined as all forms of enteral tube feeding (EN) and all forms of parenteral feeding (PN). Use of EN via nasogastric tube was the most common (almost 55%) type of nutrition support with PN accounting for only 11.4%. It is surprising that over 80% of ICUs had no nutritional support team comprising a doctor, nutritionist, a nurse, and an ICU pharmacist. Furthermore, nine of the participating ICUs reported the absence of a dietitian or specialist nutrition nurse. From these outcomes, it can be inferred that patients in the ICUs may not have quality of nutritional care. Finally, a limitation of the study despite its large sample size which may restrain its generalizability was that it was only conducted in the UK. Additionally, the researchers did not state how they recruited the participating hospitals – if the ICUs were participating voluntarily, response bias could exist. However, this research is significant as it addressed ICU present nutritional practice.

In summary, both studies examined current nutritional care practice. They showed that, although nutritional care practice is performed well in some aspects, a considerable percentage of patients did not receive recommended nutrient requirements. Although nutritional guidelines exist for critically ill patients, especially for the patients who are invasively ventilated requiring artificial nutrition such as enteral or parenteral nutrition, the studies showed that nutrition is still a low priority in ICU treatment possibly related to the lack of nutrition team and delayed nutrition start (Cahill et al. 2010; Sharifi et al. 2011). There are however no explicit nutritional care guidelines for the critically ill patients undergoing NIPPV therapy. The existing NIPPV policies/procedures focused on the technical skills required to set-up NIPPV and only provide minimal information about nutrition care (Osteraas & Fuzzard 2001; British Thoracic Society 2002; Pilbeam et al.2006; Barnes 2007; Tamworth Base Hospital 2012; ResMedica 2014; Saskatoon Health Region 2016; ICSN and ICCMU 2017; Lowe 2017). Current NIPPV policies/procedures will be discussed in detail in 2.7.6.1. There are no evidence based nutritional care guidelines to provide adequate nutritional care to the patients requiring NIPPV therapy. In order to improve nutritional care and nutritional status of these patients, specific nutritional care guidelines are required which take into account the nature of the patient's clinical conditions and the complexities of NIPPV.

2.7.6 NIPPV and nutrition

The use of NIPPV is widespread and increasing around the world, yet few guidelines are specific in recommendations for assessment, referral, and implementation of adequate nutrition in this population.

Direct investigations of the provision of adequate nutrition for patients receiving NIPPV are limited in number. In a study primarily designed to examine prevention measures for pressure ulcers formed by NIPPV mask restraints (Weng 2008), nutrition was evaluated by measuring albumin and hemoglobin (Hb) levels. Nutrition support – provided in a variety of ways (parenteral, NG bolus feeding, NG continuous feeding, oral) - was found to be poor in 42.2% of patients, with an average albumin level of 3.07 gm/dl (SD 0.54 gm/dl), and average Hb level of 10.89 gm/dl (SD 1.65 gm/dl). Although this research did not aim to investigate nutritional status in patients requiring NIPPV therapy, these results clearly demonstrate that these patients did not receive adequate nutrition in ICU.

A recent Australian study (Reeves et al. 2014) provided the first direct measurements of nutrient intake in patients receiving NIPPV treatment in the ICU. This prospective observational study revealed that 78% (95% CI 61-90%) of patients consumed less than 80% of their minimum estimated energy requirements, and 75% (95% CI 58-88%) did not reach their estimated minimum protein intakes, thus most patients receiving NIPPV were underfed in ICU. Patients receiving oral nutrition had significantly poorer nutrient intake compared with those fed enterally or parenterally ($p<0.05$) and longer NIPPV duration was also associated with poorer nutrient intake (Reeves et al. 2014).

A possible factor contributing to under-nutrition in NIPPV treatment is air swallowing (Shepherd et al. 2013). Air swallowing into the oesophagus and stomach - known as aerophagia - is a common side effect for patients being treated with NIPPV although the mechanism is not fully understood (Shepherd et al. 2013). With symptoms including gastric insufflation, belching, reduction of appetite, feelings of satiety, diarrhoea, flatulence and stomach noise, patients may be reluctant to eat, contributing to the development of malnutrition.

There is also evidence that prior to ICU admission, poor nutritional status is already likely among patients with conditions treated with NIPPV including COPD (Pirabbasi et al. 2012; Soler et al. 2004) and cardiogenic pulmonary oedema (Aquilani et al. 2003). In addition to the presence of respiratory dysfunction, COPD is recognized as a systemic inflammatory disorder that is associated with weight loss and muscle dysfunction (Pirabbasi et al. 2012). In a study of 178 consecutive outpatients with stable COPD (Soler et al. 2004), 19.1% were found to have low body weight (BMI in bottom quartile of reference population), 17.4% had visceral protein depletion (low albumin and transferrin), and fat depletion was present in 19.1% (body fat at or within bottom quartile of reference population). Malnutrition as assessed by muscle wasting (called muscle-protein malnutrition) was found in 47.2% of all patients, including in 62.9% of patients with normal body weight (Soler et al. 2004).

A recent Malaysian cross-sectional study (Pirabbasi et al. 2012) enrolling outpatients with COPD (moderate to severe) at two medical centres reported malnutrition was significantly more prevalent in severe COPD cases, compared with patients with mild and moderate COPD (52.4% vs. 26.2%, $P<0.05$). Peripheral muscle weakness (as indicated by handgrip strength) provided a measure of protein malnutrition and was demonstrated in 77.9% of patients. Nutritional status was assessed using the fat free mass index (FFMI), which showed that 41.9% of the subjects had depletion of fat-free mass (muscle wasting). It was also noted that 65% of the study participants were undernourished based on food diary evidence (Pirabbasi et al. 2012).

Patients with cardiogenic pulmonary oedema related to Congestive Heart Failure (CHF) have a higher basal metabolic rate than healthy subjects (Aquilani et al. 2003), and higher daily minimum energy requirements. A study of clinically stable CHF outpatients (Aquilani et al. 2003), found that actual energy and nitrogen intakes were not significantly different to those recorded by matched healthy control subjects. However, the CHF group on average consumed less than their daily requirements (−186 ± 305 kcal/day) while the healthy subjects on average consumed more (104.2 ± 273 kcal/day), and this difference was statistically significant ($p < 0.01$). Patients with CHF also had energy availability 41% lower than healthy controls ($p<0.05$). Additionally, patients with CHF had a negative nitrogen balance (−1.7 ± 3.2 g/24 h) in contrast to the positive nitrogen balance measured in healthy subjects (+ 2.2 ± 3.6 g/24 h; $p < 0.01$), indicating hypercatabolic status in CHF patients (Aquilani et al. 2003). Furthermore, patients with CHF had 41% lower energy availability than the control group ($p<0.05$). Hence, the results demonstrate that the metabolic needs of stable CHF patients are not adequately met by their daily calorie and protein intakes; moreover, they have reduced energy availability for physical activities. These findings infer that patients with CHF may already be at risk of nutritional deficiency prior to hospitalisation even if CHF patients receive the same amount of dietary intake as healthy subjects. A further interpretation is that patients with CHF require more nutritional intake in order to maintain calorie balance. Aquilani et al's (2003) study is important because it helps improve health professionals' understanding of mechanisms leading to malnutrition in patients with CHF. As NIPPV is one of the main treatments for patients with acute cardiogenic pulmonary oedema, nutritional issues in these patients need to be carefully considered.

2.7.6.1 Analysis of Nutritional related concepts in NIPPV ICU policies/procedures

Intensivist and intensive care nurses continued reluctance to commence oral or enteral nutrition in patients prescribed NIPPV is not without short term and long term consequences (Artinian et al. 2006; Terzi et al. 2014). A reason for not commencing oral or enteral nutrition and documentation of where ICU health professionals obtain information concerning oral or enteral nutrition, management of gastric distention and insertion and type of NGT was difficult to locate. Knowledge that the practice of ICU nurses and medical staff guide by ICU policies and procedures led to a search of the World Wide Web (WWW) and an analysis of ICU NIPPV policies/procedures for recommendations for the commencement of oral or enteral nutrition, management of gastric distention and insertion and type of NGT (Appendix A. 3).

Prerequisites for the initiation of NIPPV are Nil by mouth (Tamworth Base Hospital 2012) or no oral or NG intake (Thomas 2016). Due to the nature of the illness and NIPPV the patient is unlikely to be able to maintain an adequate oral intake (Lowe 2017). Oral food and fluids can commence after a few hours, or if later when the patient can maintain a patent airway and utilise a nasal mask or nasal prongs (Tamworth Base Hospital 2012).

The patient will be NPO for the first 24hrs of NIPPV (Saskatoon Health Region 2016). After 24hrs, decisions regarding nutritional and oral intake will be made according to patient stability and likelihood of intubation (Saskatoon Health Region 2016). Closely monitor fluid balance and if indicated, commence IV fluids and consider a fine bore nasogastric feeding tube (Lowe 2017). After 24hrs decisions to commence oral intake is made in consultation with the physician (Saskatoon Health Region 2016) or dietitian (ICSN and ICCMU 2017).

Once NIPPV is commenced many policies state that the patient should remain nil orally throughout NIPPV (Western Health 2016). Other NIPPV policies/procedures indicate that frequent breaks from NIPPV should be allowed for the consumption of food and fluids (British Thoracic Society 2002; Barnes 2007; ResMedica 2014; Saskatoon Health Region 2016; ICSN and ICCMU 2017) if the patient tolerates small periods off NIPPV. ICU health professionals are however warned that repeated removal and re-application of the mask for oral nutrition contributes to a loss of seal and increased risk for aspiration (Saskatoon Health Region 2016).

Complications of NIPPV are listed in NIPPV policies/procedures as Aerophagia, gastric distension, aspiration (Osteraas & Fuzzard 2001; Pilbeam et al. 2006; Thomas 2016). Causes of the above complications include air swallowing, poor fitting mask, excessive air pressure, eating and drinking prior to NIPPV commencement (Osteraas & Fuzzard 2001; Tamworth Base Hospital 2012). Interventions: Delay starting NIPPV for 2/3 hours after a meal (Osteraas & Fuzzard 2001; Tamworth Base Hospital 2012); Nil by mouth (Tamworth Base Hospital 2012), NPO for the first 24 hours of NIPPV (Saskatoon Health Region 2016), discourage eating and drinking during NIPPV (Osteraas & Fuzzard 2001); use of pressures less than 20 to 25 cm H_2O (Pilbeam et al.2006; Royal College of Physicians 2008); administer antiemetics (Pilbeam et al.2006; Tamworth Base Hospital 2012; Lowe 2017); administer simethicone (anti-flatulent) agent (Osteraas & Fuzzard 2001; Pilbeam et al.2006) and consider NGT insertion (Tamworth Base Hospital 2012). Although Western Health (2016) advise that routine gastric decompression is unnecessary, Lowe (2017) stated that a naso-gastric tube on free drainage and aspirated every 4 hours will reduce the risk of aspiration for patients with gastric distension and nausea.

Use of nasogastric tubes to remove gastric distension is contentious as the NGT can increase air leaks and block nares (Pilbeam et al. 2006). Philbeam (2006) recommends the use of an interface (nasogastric tube guard) between the NGT and the skin and mask to prevent air leaks (Pilbeam et al. 2006; Royal College of Physicians 2008) whilst Royal College of Physicians (2008) and Lowe (2017) consider a fine bore nasogastric feeding tube to minimize air leaks (Lowe 2017). Small leak should not cause a problem (Royal College of Physicians 2008). Lowe (2017) advises that the Boussignac CPAP valve system allows vomit to pass through and decreases the risk for aspiration (Lowe 2017).

As mentioned above, current policies on NIPPV therapy provide only either very simple information on nutritional care or ambiguous recommendations. Without the clear nutritional protocols or guidelines, it is not expected that patients undergoing NIPPV therapy are adequately fed in ICU. Further nutritional research is required to develop evidence based nutritional care guidelines specifically for patients receiving NIPPV therapy and the main points and reference to such guidelines are incorporated into ICU NIPPV policies/procedures so that ICU nurses can provide adequate nutritional care and contribute to improving patients' nutrient intake and nutritional status as well.

2.7.7 Enteral nutrition during NIPPV therapy

Non-invasive Ventilation Guidelines for Adult Patients with Acute Respiratory Failure recommend initiating oral nutrition if the patients are guaranteed with adequate pause periods from NIPPV treatment (Sanchez et al. 2014). However, if these patients are not able to consume oral nutrition due to severe respiratory distress or some medical conditions required artificial nutrition, enteral nutrition should be provided via nasogastric tube (NGT) (unless there is a clear indication for parenteral nutrition) (Bambi et al. 2017). The most widely used type of mask interface when providing NIPPV therapy for the critically ill patients is oronasal mask which covers both nose and mouth (Nava & Fanfulla 2014). Providing enteral feeding through a NG tube would be a challenge due to a risk of air leaks. The use of a small bore NGT to decrease air leak rather than a large bore vented NGT to decrease risk of aspiration requires further research and the development of guidelines with well-articulated evidence based rationales.

A paucity of evidence exists concerning EN in patients receiving NIPPV therapy. A retrospective study conducted by Kogo et al. (2016) investigated the relationship between enteral nutrition and airway complications for the patients with acute respiratory failure receiving NIPPV therapy. More than half (56%) of the patients were provided enteral nutrition during NIPPV therapy (Kogo et al. 2016). This study found that patients with enteral nutrition had significantly higher percentage of airway complications compared to those without enteral nutrition (53% vs. 32%, $p=0.03$) (Kogo et al. 2016). In this study airway complications were defined as the total number of episodes of vomiting, followed by desaturation, mucus plug, and aspiration pneumonia (Kogo et al. 2016). In addition, the median length of NIPPV therapy was significantly longer for the patients with EN therapy in comparison with those without (16 days vs. 8 days, $p=0.02$) (Kogo et al. 2016). Although this study did not present that air leakage resulted from the NGT used to provide enteral nutrition, it demonstrated enteral nutrition increased the risk of aspiration during NIPPV therapy.

Naso-gastric tube insertion for patients prescribed NIPPV is however a controversial issue. The NGT helps to remove air from the stomach therefore reduces aerophagia (Bambi et al. 2017). Aserophagia is a common complication of NIPPV therapy, causes increased gastric distension and may lead to aspiration (Gay 2009). Thus, some doctors prefer to insert NG tube when initiating NIPPV therapy to minimise the risk of aspiration (Gay 2009). Although the relationship between insertion of NGT, small air leaks and effectiveness of NIPPV has not been explored in the research literature the risk for NGT causing an air leak may be one reason for lack of prescription of enteral feeding. In addition, the fear of an air leak may lead to the use of a small bore NGT (Elliott 2004) rather than a larger bore vented NGT required to reduce aerophagia and aspiration. Guidelines for enteral nutrition during periods of CPAP/NIV warn of the increased risk of gastric distension due to positive pressure and therefore the need gastric decompression achieved through a vented nasogastric tube (Sanchez et al. 2014). In addition, masks are available which enable a NGT to be insitu without causing risk for air leaks. Although it is logical to assume that patients undergoing NIPPV would be sitting upright, very few authors comment on patient position whilst enteral nutrition is in progress (Drakulovic et al. 1999; Elliott 2004; Weinstein et al. 2004). Weinstein et al. (2004) stated that supine patient positioning may increase risk of aspiration and this risk can be decreased by semi-recumbent positioning. A randomised contrail trial researching the most efficacious position for mechanically ventilated patients prescribed EN found that the semi-recumbent position achieved a 3-fold reduction in the incidence of VAP (Drakulovic et al. 1999).

A meta-analysis analysed of 19 randomised controlled trials with 1394 critically ill patients compared small bowel feeding with gastric feeding on the prevalence of pneumonia and other clinical outcomes (Alhazzani et al. 2013). Alhazzani et al. (2013) found that patients with small bowel feeding had significantly lower risk of pneumonia (RR= 0.70, 95% CI: 0.55-0.90, p=0.004) and lower risk of ventilator associated pneumonia (RR= 0.68, 95% CI: 0.53-0.89, p=0.005) compared to the patients with gastric feeding. A retrospective study by Metheny et al. (2011) demonstrated that the risk of aspiration was 11.6% lower when feeding tubes placed in first portion of the duodenum, 13.2% lower in the second/third portions of the duodenum, and 18.0% lower when in the fourth portion of the duodenum when compared with gastric feeding (all significant at P < .001) .

There were however, no significant differences in mortality, length of ICU stay, duration of mechanical ventilation, aspiration and vomiting. Six RCTs with 472 patients reported the incidence of aspiration and there was no significant difference between both groups (RR=0.92, 95% CI: 0.52-1.56, p=0.79). This study did not state if this sample included patients receiving NIPPV therapy. Therefore, the result from this study could not be generalised for critically ill patients undergoing NIPPV therapy. In addition, the initiation of small bowel feeding does not take into account the need to decrease aerophagia achieved using a large bore vented NGT. In order to choose the optimal position for the administration of EN, future studies investigating the incidence of aspiration between the two groups: patients receiving gastric feeding and those receiving small bowel feeding during NIPPV therapy are required.

A lack of evidence exists on enteral nutrition during NIPPV therapy. Although the insertion of a large bore vented NG tube can reduce aerophagia and the risk of aspiration the insertion of a small bore NGT (thus no vent) for the administration of EN increases the risk of aspiration in patients with concurrent NIPPV. Small bowel feeding may not also be the best way to provide nutrition to decrease the risk of aspiration. More research is required to identify the best option to provide enteral nutrition to the patients undergoing NIPPV therapy.

2.7.8 Estimation of energy requirement

Providing adequate energy intake is important for critically ill patients. Indirect calorimetry (IC) is the most accurate method for estimating daily optimal energy requirements, but it is not commonly used in clinical practice area as it is costly and requires trained personnel (O'Leary-Kelley et al. 2005). Instead, there are many published simpler and less costly equations to predict energy requirement. Three studies examined the accuracy of predictive equations (Frankenfield 2007; Kross et al. 2012; Compher et al. 2014). Kross et al.'s (2012) retrospective study compared resting energy expenditure (REE) measured by using IC to published formulas including Harris-Benedict, Owen, Mifflin, Ireton-Jones, and weight based equation recommended by American College of Chest Physicians (ACCP) guidelines in mechanically ventilated, critically ill patients. Although a total of 1519 IC measurements were made on 971 patients during the reviewed period, no equations were found which predicted REE as accurate as REE measured by IC. Frankenfield et al. (2007) conducted a systematic review to report the accuracy of REE calculated using published equations including Fick Method, Harris-Benedict equation without added factors, Harris-Benedict with stress factors, Swinamer equation, and Ireton-Jones equations. The review also found that no equations perfectly predict energy expenditure to prescribe energy requirement for these patients (Frankenfield et al. 2007). Frankenfield (2007) and Kross et al. (2012) suggested developing improved predictive equations to assess energy needs in order to ensure nutritional interventions provide adequate energy requirement.

On the other hand, Compher et al. (2014) analysed the secondary data of Improving Nutrition Practices in the Critically Ill international Nutrition Survey database from 2007 to 2009. The researchers compared the clinical outcomes including mortality and time to discharge alive in patients who consumed energy calculated using complex equations (Harris-Benedict equation, Ireton-Jones equation, and Mifflin-St Jeor equation) to patients who received energy predicted using weight-based simple equation (Compher et al. 2014). The study found that no difference in mortality between the use of complex and weight-based equations (OR, 0.90; 95% ci, 0.86-1.15) while time to discharge alive was shorter in patients nourished using weight-only based equations (hazard ratio, [HR], 1.11; 95% CI, 1.01-1.23) although the statistical significance is marginal (P=0.04). Although weight based simple equations are not the most accurate of tools to calculate adequate energy requirements, they have a positive effect on clinical outcomes and are appropriate to be used by medical staff at the bedside in the clinical setting. The use of a simple weight based equation has a high probability for the calculation of more accurate prescription of energy intake and is certainly preferable to energy intake prescribed by doctors' personal opinion as exists in many clinical setting (Kim & Choi-Kwon 2011).

2.7.9 VAP and aspiration pneumonia associated with NIPPV

Ventilator (including NIPPV) Associated Pneumonia is the aspiration of gastric or oropharyngeal contents, colonized with enteric gram-negative bacteria (EGB) and Pseudomonadaceae, into the respiratory tract (Weinstein et al. 2004). With the absence of an invasive artificial airway, NIPPV has been shown to result in fewer cases of ventilator-associated pneumonia (VAP) (Burns et al. 2009; Kohlenberg et al. 2010; Carron et al. 2013; Carron et al. 2014). In a retrospective review of patient records from 400 German ICUs (Kohlenberg et al. 2010), the use of NIPPV was associated with a lower incidence of VAP (mean 1.58 cases per 1000 ventilator days) compared to invasive ventilation (5.44 cases per 1000 ventilator days). Carron et al. (2014) evaluated the efficacy of NIPPV delivered by helmet (H-NIPPV) as a ventilation weaning approach in patients admitted to the ICU with ARF by comparing this method with the conventional weaning procedure. This research showed VAP was significantly lower in the H-NIPPV weaning group (1/32 patients) in comparison with the conventional invasive ventilation group (10/32 patients; $p=0.018$) (Carron et al. 2014). These findings are supported by two meta-analyses (Burns et al. 2009; Carron et al. 2013). A meta-analysis of 12 RCTs involving 530 ICU patients (Burns et al. 2009) showed significance of the non-invasive approach for weaning compared to conventional invasive ventilation, demonstrated by a reduction in VAP (RR 0.29; 95% CI 0.19-0.45). A more recent meta-analysis of 62 RCTs (Carron et al. 2013) also showed that NIPPV considerably reduced VAP compared with tracheal intubation for ventilator support weaning (RR 0.79; 95% CI 0.71-0.88, $p<0.0001$).

Although resulting in lower VAP rates (0.5% to 5.7%) than seen in patients treated with invasive ventilation, NIPPV does increase the risk of pneumonia when compared to no ventilation (Burns et al. 2009; Kohlenberg et al. 2010; Carron et al. 2013; Carron et al. 2014). Kohlenberg et al. (2010) showed the mean pneumonia incidence associated with NIPPV was almost three times higher than that of pneumonia not associated with ventilation (1.58 and 0.58 per 1000 ventilator days, respectively). This study also demonstrated that clinical outcomes from pneumonia associated with NIPPV are as serious as those from pneumonia associated with invasive mechanical ventilation (IMV), with no significant differences in rates of secondary sepsis (NIPPV 6.2%, IMV 6.1%) or mortality (21.3%, 18%) (Kohlenberg et al. 2010). However, Carron et al. (2013) noted that reporting the incidence of pneumonia associated with NIPPV is uncommon because most research was retrospective and it is difficult to characterise NIPPV-associated pneumonia. This potential for under-reporting has been suggested previously (Kohlenberg et al. 2010). These studies suggest that NIPPV has a strong benefit in terms of lower risk of VAP. However, the risk for aspiration pneumonia should be considered when prescribing NIPPV because patients requiring NIPPV therapy has a potential risk of aspiration.

Pneumonia in patients prescribed NIPPV may be caused by pulmonary aspiration related to the complications of aerophagia and gastric insufflation (Carron et al. 2013; Shepherd, Hillman & Eastwood 2013). In addition, patients prescribed enteral nutrition and NIPPV are highly at risk for aspiration as NGT causes incompetence of epiglottic function and of cardiac sphincter (Matsuoa & Palmer 2009; Asai et al.2002; Miller & Light 2003).

An experimental study conducted in a French ICU demonstrated that patients receiving conventional NIPPV experience gastric insufflation after swallowing small volumes of water (5mL and 10mL) (Terzi et al. 2014). Terzi et al. (2014) investigated breathing-swallowing interactions in a small group of patients (n = 8) requiring NIPPV treatment for exacerbation of COPD and found that swallowing induced pressure support triggering followed by auto-triggering, causing patient-ventilator asynchrony and contributing to the development of insufflation. This finding logically assumed that patients with exacerbation of COPD had aerophagia during NIPPV therapy that caused gastric distension. Although no patients experienced overt signs of aspiration during the study, this result demonstrated that patients have a risk of aspiration with air swallowing during NIPPV therapy.

Two studies reported that silent aspiration is more common than symptomatic aspiration (Daniels et al. 1998; Metheny et al. 2006). A case series involving 55 stroke patients with neurologic deficit (Daniels et al. 1998) reported that 38% (21/55) of the patients experienced aspiration during the 5-day study period. Overt signs of aspiration were present in only 7 of the 21 (33%), and the remaining 14 (67%) were defined as silent aspiration (Daniels et al. 1998). This finding is consistent with a more recent prospective study (Metheny et al. 2006) that enrolled 360 patients being treated with mechanical ventilation and receiving enteral feeding in five ICUs in American university hospitals. At least one aspiration event was recorded in 88.9% (320/360) of the patients but less than 1% (3/360) experienced at least one aspiration with witnessed clinical signs. Metheny et al. (2006) noted that silent aspirations are likely to be under-diagnosed because bedside testing to detect silent aspirations is currently unavailable.

Aspiration could also result from swallowing difficulty, particularly in patients with COPD who may have a disrupted swallow-respiration pattern (Gross et al. 2009). In a prospective repeated measures study, healthy individuals showed an exhale-swallow-exhale pattern while patients with COPD had a significantly higher rate of swallowing during inhalation ($p = 0.002$) and inhaling after swallowing semi-solid material ($p < 0.001$) (Gross et al. 2009). The researchers suggested that prandial aspiration may be a factor that contributes to an exacerbation of COPD, and that an exacerbation of COPD may provoke aspiration, generating a vicious cycle (Gross et al. 2009).

Although this mechanism has not been studied in humans, evidence from a study of the swallowing reflex in animal studies (Nishino et al. 1986) suggests that hypoxia may also disrupt swallowing. Ten healthy animals were anaesthetized, vagotomized, paralysed and artificially ventilated, and the swallowing reflex induced by electrical stimulation of the superior laryngeal nerve. Graded hypoxia resulted in a graded inhibition of the swallowing reflex while graded hypercapnea had no effect on swallowing (Nishino et al. 1986). A direct depressant effect of hypoxia on the central nervous system may contribute to the depression of the swallowing reflex during alveolar hypoxia experienced by patients in acute respiratory failure, enhancing the chance of aspiration of regurgitation material.

Two studies agreed that the risk of aspiration pneumonia is high in patients who frequently aspirated due to swallowing disorder (Metheny et al. 2006; Purkey et al. 2009). Metheny et al. (2006) reported the mean percentage of pepsin-positive tracheal secretions (used to indicate aspiration of stomach contents) was twice as high for patients with pneumonia on the final study day than for those without (42.4 ± 25.1% vs. 21.1 ± 18.2%, respectively; $p < .001$). Tracheobronchial aspiration was also found to be significantly associated with the development of pneumonia (OR 5.0; 95% CI 1.2 to 20.5; $p = 0.025$), in patients with head and neck cancer who were treated with radiotherapy (Purkey et al. 2009). Other independent risk factors for pneumonia in critically ill patients included smoking history (OR 1.04 per pack-year; 95% CI 1.01 to 1.07; $p = 0.011$) and malnutrition (OR 4.4; 95% CI 1.3 to 14.7; $p = 0.018$) (Purkey et al. 2009). Malnutrition was also suggested as a predictor of aspiration pneumonia in a systematic review conducted by van der Maarel-Wierink et al. (2011). Eleven other possible predictors were also listed, namely: age, male gender, lung diseases, dysphagia, diabetes mellitus, severe dementia, angiotensin I-converting enzyme deletion/deletion genotype, bad oral health, Parkinson's disease, and the use of antipsychotic drugs, proton pump inhibitors, and angiotension-converting enzyme inhibitors.

Aspiration pneumonitis is caused by aspirated material causing a chemical insult and inflammation and potentially causes aspiration pneumonia and is a risk for patients prescribed NIPPV. Plain chest radiography is the most commonly used imaging to diagnose aspiration pneumonia and possesses moderate to good specificity and sensitivity (Marom et al. 1999; Franquet et al. 2000 Gossner & Nau 2013). Although Chest x-ray findings of aspiration pneumonitis are usually visible within 2 hours of aspiration sometimes diagnostic opacities develop days later (Gossner & Nau 2013). Diagnostic difficulty also exists as aspiration may be clinically silent for both diagnostic clinical and radiographic features of patchy, bilateral airspace consolidations with perihilar and basilar distribution are contingent on the aspirated volume, pH, and chronicity (Kim et al. 2008).

The studies discussed above demonstrated that NIPPV has a positive effect on reducing VAP, however, NIPPV also increases the risk of pneumonia when compared to patients who do not require respiratory support or receive only simple oxygen therapy. Pneumonia associated with NIPPV is as serious as VAP; studies showed that there were no significant differences in mortality and hospital stay between pneumonia associated with NIPPV and VAP. Patients receiving NIPPV therapy have an increased risk of aspiration, however, the reporting of the incidence of aspiration pneumonia associated with NIPPV is rare. Most studies investigating the incidence of pneumonia are conducted using retrospective data analysis and are unable to identify the type of pneumonia. Thus, aspiration pneumonia associated with NIPPV therapy needs to be investigated prospectively. Interventional evidence based strategies are required to avoid aspiration throughout NIPPV therapy whilst maintaining appropriate nutritional intake. Malnutrition itself is a possible cause of aspiration pneumonia. Thus, it is also worth investigating the incidence of aspiration pneumonia when conducting nutrition studies for patients requiring NIPPV therapy.

2.8 Discussion

The purpose of this review was to explore current knowledge on nutrition regarding patients undergoing NIPPV therapy in ICU. It is clear from the literature review that nutrition is a low priority in patients' care in hospital and hospital malnutrition persists as a highly prevalent, under-diagnosed and under-treated international issue (Liang et al. 2008; Gout et al. 2009; Cederholm et al 2015) despite of the crucial role of the nutrition in positive clinical outcomes. Literature demonstrated that malnutrition is associated with increased mortality, length of hospital / ICU stay, less ventilator free time and increased readmission rates and nosocomial infections (Garibala & Forster 2006; Sharifi et al. 2011; Hoffer & Bristrain 2013; Elke et al. 2014). Evidence also indicates that the provision of evidenced based nutritional care and early detection of malnourished patients will result in substantial savings to the health care system (*QIPP* 2012).

NIPPV is now widely and increasingly used around the world with the proven benefit of reducing mortality, ventilator associated pneumonia, length of hospital stay, and total duration of ventilation compared to invasive ventilation (Schettino et al 2005; Burns et al. 2009). NIPPV has become a first-line of therapy for the patients with acute respiratory failure in ICU (Demoule et al. 2006; Sanchez et al. 2014), replacing invasive ventilation. Therefore, tailored care covering everything for these patients is required in various areas rather than just focusing on respiratory care. Nutrition is therefore an integral component to address when caring for patients undergoing NIPPV therapy.

There is lack of direct evidence on nutrition in patients requiring NIPPV therapy in the current literature. However, evidence from reviewed articles reflect this cohort of patients have neither good nutritional status on admission nor adequate nutrient intake throughout hospitalisation. Patients related issues that can cause poor nutritional status or inadequate nutrient intake include critical illness, respiratory distress, and current comorbidity. During critical illness, metabolic rate and proteolysis are dramatically increased (Hoffer & Bistrian 2013). Gariballa & Forster (2006) reported that patients had significantly less energy intake during acute phase of critical illness and were therefore at a high risk for iatrogenic malnutrition.

Despite all the associated risks of malnutrition debate continues on whether providing permissive underfeeding (Arabi et al. 2011; Heyland, Cahill & Day 2011) or adequate nutrition (Heidegger et al. 2013; Elke et al. 2014) for the patients with acute phase of critical illness leads to positive clinical outcomes. Respiratory distress could also lead to poor nutrient intake for the patients undergoing NIPPV therapy if the patients cannot tolerated removal of the mask interface during NIPPV therapy. Reeves et al. (2014) found that patients prescribed NIPPV and ordered only oral nutrition had significantly less nutrient intake compared to those with either EN or PN. This they suggest is due to insufficient time to eat due to respiratory distress thus inability to eat adequate amounts and or tolerate time without NIPPV.

Acute respiratory failure resulting from exacerbation of COPD and CHF are the most common indications for NIPPV therapy. COPD is recognised as a systemic inflammatory disorder that is associated with weight loss and muscle dysfunction (Pirabbasi et al. 2012). Pirabbasi et al. (2012) reported that 41.9% of the outpatients with COPD were diagnosed with malnutrition while 65% of the patients consumed inadequate nutrient intake. On the other hand, patients with CHF have a higher basal metabolic rate and lower energy availability than healthy subjects (Aquilani et al. 2003). Accordingly, these patients are likely to be undernourished even when in a stable condition.

With respect to NIPPV therapy, aerophagia, risk of aspiration, and time on NIPPV therapy is related to decrease nutrient intake. Aerophagia is a common complication of NIPPV therapy (Gay 2009). Aerophagia can lead to gastric distension, which may lower patients' appetite because air in stomach gives patients a sense of fullness. Aerophagia can also lead to vomiting that also negatively affects nutrient intake. Although aspiration pneumonia is a rarely reported complication associated with NIPPV therapy, doctors may be reluctant to commence oral or EN nutrition to avoid aspiration because aspiration pneumonia is as fatal condition with high mortality (Gay 2009). Reeves et al. (2014) revealed that patients who had a longer time on NIPPV therapy had significantly less nutrient intake, due to patients skipping meals or insufficient time to eat due to respiratory distress and inability to tolerate removal of the NIPPV mask.

The literature review demonstrated the importance of early detection of malnutrition. Studies showed that patients with better nutritional status on admission had enhanced nutrient intake during the hospital stay (Reeves et al. 2014) while patients with severe malnutrition on admission were more likely to be underfed during hospitalisation (Kim & Choi-Kown 2011). From these findings, it can be assumed that patients' nutritional status worsens throughout the hospital stay particularly where patients were undernourished on admission. Therefore, early detection of malnutrition is crucial to provide adequate nutritional support. However, nutritional screening is not routinely performed in many hospitals and many patients malnutrition remains undiagnosed and untreated during their hospital stay, worsening nutritional status causing negative hospital outcomes and increased long-term morbidity.

The reviewed articles showed that several simple and validated nutrition screening tools have been published (Kondrup et al. 2003; Kyle et al. 2002; King et al. 2003; Kruizenga et al., 2005; Banks et al. 2007; Cansado et al. 2009; Gout et al 2009; Leandro-Merhi et al. 2009; Lucchin et al., 2009 Meijers et al. 2009; Kim & Choi-Kwon 2011; Lim et al. 2012; Pasquini et al. 2012; Lammel et al 2013; Ordonez et al. 2013; Duarte et al 2014; Gallegos et al. 2014; Agarwal et al.2015; Cederholm et al. 2015; Rahman et al. 2015). Studies revealed health professional's lack of knowledge on nutritional care (Mowe et al. 2008; Morphet, Clarke & Bloomer 2016). In a large Scandinavian nutritional survey, a quarter of doctors' and nurses' working in ICUs reported difficulties with identifying patients requiring nutritional therapy and almost 40% reported the lack of tools for screening (Mowe et al. 2016), despite the plethora of published articles on simple nutritional screening tools. If doctors or nurses evaluate patients' nutritional status at the bedside using a simple nutritional screening tool, early detection of the patients with malnutrition or at risk of malnutrition will be possible. This will increase dietitian referral so that the patients can receive early nutritional care support.

Doctors and nurses had insufficient training for nutritional care during their undergraduate degrees resulting in a lack of knowledge of nutrition and understanding of the association between malnutrition and negative hospital outcomes (Morphet, Clarke & Bloomer 2016). Nurses prefer to obtain nutritional information from dietitians rather than other sources such as internet, book, or training sessions, and many nurses believe dietitians are primarily responsible for the nutritional care (Morphet, Clarke & Bloomer 2016) but rely on medical staff to refer. A survey reported a limited availability of dietitians was a barrier of nutritional care practice (Cahill et al. 2012). Nutrition is still, particularly in ICU, low priority in caring for patients and dietitian may not be closely involved in patients care in many ICUs. In this circumstances, using a simple nutritional screening tools will help bedside nurses or doctors detect patients with malnutrition of risk of malnutrition early, probably on admission. Also, more dietitian involvement needs to be encouraged. Dietitian can play an important role to provide nutritional care support and educate health professionals regarding nutritional intervention.

Determining nutrient requirement is important to provide adequate amount of nutrition. In many clinical areas, nutritional prescription is often based on physicians' personal opinion without following a nutritional protocol or nutritional guideline (Kim & Choi-Kwon 2011). Kim & Choi-Kown (2011) reported patients with under-prescription by physician were over five times more likely to be undernourished than those with either adequately prescribed or over-prescribed. Indirect Calorimetry is known to be the gold standard of calculating energy expenditure for patients, however, it is also known to be not practical in current practice area because it is costly and requires trained personnel (O'Leary-Kelley et al. 2005). There are many predicted equations to calculate energy requirements, but studies showed there is no equation which estimates energy requirement for critically ill patients as accurate as indirect calorimetry (Frankenfield 2007; Kross et al. 2012;

Compher et al. 2014). A weight based simple equation was found to have a positive effect compared to other complicated equations (Compher et al. 2014). Using simple equation will help doctors prescribe adequate energy requirement although more studies on predicting adequate energy requirements.

Current clinical nutrition practice demonstrated that patients are poorly nourished in ICU despite presented nutritional care guidelines for critically ill patients (Cahill et al. 2010; Sharifi et al. 2011). Even without the nutritional care guidelines to follow for the patients undergoing NIPPV therapy, it is not expected that these patients have good nutritional care practice and also have good nutritional status. NIPPV does not require sedation and patients are able to have oral nutrition (Nava & Hill 2009). However, as discussed above, respiratory distress and risk of aspiration can interrupt nutrient intake. Thus, developing nutritional care guidelines tailored for these patients to minimise aspiration during oral nutrition is essential. The risk of aspiration can also interrupt enteral nutrition. A study showed the higher risk of aspiration in the patients receiving enteral nutrition during NIPPV therapy. Large bore NG tubes are used for decompression to avoid aspiration but this can lead to air leakage. Future studies are required to determine what type of nutrition is the best option for this population. There is lack of evidence on nutritional barriers in the patients receiving NIPPV therapy, thus, studies investigating nutritional barriers for these patients are required to improve nutritional care.

Patients undergoing NIPPV therapy are considered as a high risk of aspiration, however, prevalence of aspiration pneumonia is rarely reported (Gay 2009). This may be because silent aspiration is more common than overt symptoms of aspiration (Daniels et al. 1998; Metheny et al. 2006) and as most studies investigating aspiration pneumonia use a retrospective design which may not capture and categorise aspiration pneumonia (Daniels et al. 1998; Metheny et al. 2006). Thus, prospective studies investigating incidence of aspiration pneumonia associated with NIPPV use are required.

2.9 Implications for Research

A lack of evidence exists regarding whether or not patients treated with NIPPV are adequately nourished in critical care setting. Nutrition is closely related to hospital outcomes including mortality, length of hospital stay and infection rate (Hoffer & Bistrian 2013; Elke et al. 2014). As the number of patients requiring NIPPV therapy in ICU has been significantly increasing worldwide, nutrition care for these patients needs to be addressed.

This review found a lack of specific nutritional guidelines or protocols for critically ill patients undergoing NIPPV treatment. With the absence of published nutrition care guidelines for the patients using NIPPV device, it is hard to expect provision of individualised nutrition care during patients' ICU stay. Although direct evidence is lacking, the literature presented in this review implies patients requiring NIPPV therapy are poorly nourished due to critical illness, respiratory distress, and underlying diseases as well as NIPPV associated factors such as difficulty feedings on NIPPV, symptoms of aerophagia, and the risk of aspiration. Only one study (Reeves et al. 2014) demonstrated nutrient intakes in patients receiving NIPPV and that most of the patients did not meet their nutrient needs. Nutrition support to acute phase critically ill patients is still a controversial issue, however, nutrition care guidelines for the patients receiving NIPPV therapy needs to be established to direct the initiation and provision of appropriate nutritional care. In order to develop evidence-based nutrition care guidelines for patients requiring NIPPV therapy, further studies are required to provide direct evidence on nutrient intakes and demonstrate actual clinical nutrition care practices. In addition, the risk of aspiration and aspiration pneumonia, known as a serious side effect of NIPPV, in patients treated with NIPPV, also needs investigating as the literature suggests potential factors increasing the risk of aspiration in these populations. Aspiration pneumonia has high mortality and requires serious consideration when patients are prescribed NIPPV.

2.10 Conclusion

This literature review confirmed that evidence on nutrient intake in patients requiring NIPPV in the critical care setting is lacking and required further investigation. The literature also suggests that patients receiving NIPPV have potential risk factors of aspiration causing aspiration pneumonia. There is minimal research investigating the incidence of aspiration pneumonia in the patients receiving NIPPV and future exploration is required to investigate the relationship between aspiration pneumonia, EN, type of NGT and NIPPV therapy. The next chapter will discuss the methods used in this study.

Chapter 3: Methods

This chapter discusses the methodology underpinning this study and the methods used including the research design, study population and setting, data collection, the instruments used, and data analysis. The ethical considerations for this study are also outlined prior to a summary of discussions in this chapter.

3.1 Research design

This research employs an exploratory prospective observational study design. An exploratory study is regarded as a preliminary stage of research to establish baseline information for future studies (Sekaran 2003). Exploratory studies are conducted when there is few or no previous research on the identified research problem (Nieswiadomy 2011). As presented in the previous chapter, only a few published studies are available to date on nutrition for patients prescribed NIPPV therapy and very little is known about this topic area; thus, an exploratory study is warranted at this time. This research explored the current nutritional care practice provided to patients requiring NIPPV therapy in a critical care setting. It also examined if this population were adequately nourished, and investigated the prevalence of aspiration pneumonia among the study population.

In medical research, non-experimental studies are referred to as observational studies (Polit & Beck 2012). The current study used simple observational forms and collected data prospectively. There were no interventions or extra tests conducted for this study. Even though an exploratory prospective observational study produces weak evidence, it is a method informing clinicians and researchers of current practices and factors influencing these practices and can be used to expand knowledge of a specific area and form the basis for the development of larger random control trials in the future (Kermode & Roberts 2006).

3.2 Study population

All adult patients (age ≥18) consecutively admitted to the ICU and prescribed NIPPV therapy were included in this study. It was initially planned to exclude patients who stayed at the ICU for less than 24 hours. However, due to the difficulty of recruitment, it was necessary to include all the patients admitted to the ICU; the minimum ICU stay was therefore 6hours. The study hospital ICU had 11 out of 20 beds during the data collection period due to the remodelling of the hospital. It was also the summer season known to have less patients admitted to ICU with respiratory disorder requiring ventilation support (Donaldson & Wedzicha 2014). It was beyond the scope of the study to collect data for an extended period of time. Data was collected until cessation of NIPPV, ICU discharge or death. The participants were followed up until hospital discharge or hospital death to evaluate hospital mortality.

3.3 Sample size

Given the nature of an exploratory study, a power analysis was not conducted to determine an appropriate sample size. An exploratory study sample size is usually based on the pragmatics of recruitment and the necessities for examining feasibility (Leon, Davis & Kraemer 2011). This researcher aimed to enrol 30 consecutive eligible patients in the study ICU with 11 beds. Based on the size of the ICU, seasonal limitation, and the limited time frame for this research project, the recruitment of more than 30 participants was not achievable. External validity refers to how well the study results are able to be generalised (Schneider, Whitehead & Elliott 2016). The upmost goal of quantitative research is to generalise knowledge by interpreting numbers (Polit & Beck 2012). As this is an exploratory study, the results from this study will not be able to generalise in the true sense, but will lay the foundation for future larger studies and inform subsequent power calculations (Leon, Davis & Kraemer 2011).

3.4 Study site

This study was conducted in an ICU at a tertiary hospital in South Australia. There were initially 20 beds in the ICU in the study hospital, but only 11 beds were available during the data collection period due to the remodelling of the hospital. The data collection was conducted from 27th November 2014 to 28th February 2015.

3.5 Data collection

A simple observational form was used for data collection. This form consisted of a Clinical Recording Form (CRF) (see Appendix B.1 and Appendix B.2) and Food and Fluid Chart (see Appendix C.1 and Appendix C.2). The observational form was initially used in a pilot study investigating nutrient intake for patients undergoing NIPPV therapy in ICU in an Australian tertiary hospital. Appropriateness of data to be collected using this form was examined and the form trialled by an ICU nurse working in the study ICU prior to the commencement of data collection. The observational sheet was modified after the pre-test by this researcher and confirmed by the researcher's supervisor.

3.5.1 Data collected using CRF

The CRF was used to collect data, from patients' medical notes and ICU database, associated with patients' demographics, clinical characteristics, information about NIPPV and information about nutrition. Chest x-ray results were reviewed to confirm/exclude a diagnosis of aspiration pneumonia.

Demographic information included age, gender and admission body weight and height. Patients' body weight and height were obtained from patients' medical notes. Although this researcher expected to use the patients' actual body weight or height measured on ICU admission, most of the ICU patients were bedridden and scales to weigh the patients were not commonly used in the ICU. Patients who transferred to ICU from a general ward had body weight and height measured and recorded in an admission note in patients' medical notes as a part of the routine assessment on admission. ICU dietitians recorded patients' body weight and height in the patients' medical notes to assess nutritional status when requested to consult a patient. If no body weight and height was recorded in the patients' medical notes, self-reported body weight and height was used. ICU bedside nurses were requested to ask patients or the relatives of the patients' recent body weight and height and record them on the CRF.

Although the body weight and height used in this research may lead to bias in estimates of adequate nutrient requirements, given the nature of observational study, any extra procedures or tests could not be performed. Body mass index (BMI) was calculated as weight in kilogram divided by height in metres squared and categorised as underweight (BMI < 18.5), healthy weight (18.5 ≤ BMI <24.9), overweight (25 ≤ BMI < 29.9), and obese (BMI ≥ 30 kg/m^2) (World Health Organisation 2006).

Clinical characteristics included chronic comorbidities, disease severity, length of ICU and hospital stay and discharge status. The Acute Physiology and Chronic Health Evaluation (APACHE) II and Sequential Organ Failure Assessment (SOFA) scores were used to identify disease severity. The APACHE II scoring system assesses disease severity and predicts mortality in the ICU setting (Knaus et al. 1985). It generates scores of 0-71 based on considerations of age, underlying health condition and 12 acute physiological variables – temperature, mean arterial pressure, heart rate, respiratory rate, oxygenation, arterial pH, serum sodium, serum potassium, serum creatinine, haematocrit, white blood count, and itemised Glasgow Coma Scale score (Knaus et al. 1985). Each variable is weighted from 0 to 4, with higher scores indicating more severe illness (Knaus et al. 1985). The APACHE II is a valid, reliable instrument used worldwide to assess disease severity in ICUs (Vincent & Moreno 2010). The APACHE II scores for this study used the worst value of each of the parameter during the first 24-hour period in the ICU for all ICU patients; The SOFA score is a validated scoring system to estimate the severity of organ dysfunction /failure in critically ill patients (Vincent et al. 1996; Moreno et al. 1999). The SOFA score is composed of scores from six organ systems including respiratory, cardiovascular, renal, coagulation, liver and neurological system, graded from 0 (normal) to 4 (most abnormal), and calculated using the worst values of the day (Vincent et al. 1996). In the current study, the researcher calculated SOFA scores of each participant within 24 hours of ICU admission using the worst value of the day by reviewing the ICU flow chart and ICU laboratory database. Discharge status was recorded as discharge home, transfer to other ward / hospital or ICU death.

Information about NIPPV included time to commencement of NIPPV, reason for NIPPV therapy, mode of NIPPV such as BIPAP, CPAP, or NHF, type of interface such as nasal mask, oro-nasal mask or helmet, and total hours on NIPPV.

Information about nutrition included time to commencement of nutrition, type of nutrition such as oral nutrition (ON), enteral nutrition (EN) or parenteral nutrition (PN), dietitian consult, and routine haematological results related to nutritional status including serum haemoglobin (Hb) and serum albumin levels. The nutrient intake from artificial nutrition including EN or PN were sourced from the ICU flow chart in the section of fluid intake and medication chart. The brand, type, volume, route and rate of EN were recorded on the CRF. For PN, the type, brand, volume, site and rate were recorded. Bedside nurses recorded reasons for either stopping of skipping EN or PN. Patients' medical notes were reviewed daily to check if they had a dietitian consult and their assessment and recommendations. Chest x-ray results on ICU admission and during NIPPV therapy were checked to confirm/exclude the diagnosis of aspiration pneumonia.

3.5.2 Data collected from food and fluid chart

The Food and Fluid Chart was used to measure actual nutrient intake consumed orally and investigate issues regarding oral nutrition. The ICU bedside nurses were asked to visually estimate (ml, teaspoon, cup, serve, packet or slice) and record the type and amount of food and fluid consumed orally at each regular hospital meal including three main meals (breakfast, lunch, and dinner) and three mid meals (morning tea, afternoon tea, and supper) on the food and fluid intake chart. A space was available for nurses' documentation of the type, amount and brand of extra food other than hospital meals that patients consumed. Group of foods such as main meal, dessert and drinks were listed on the form with space to record the particular food and fluid consumed.

Although there may be a bias towards approximation, it could be minimised by carefully trained experienced observers (Shatenstein, Claveau & Ferland 2002). Although a training session to demonstrate how to accurately record the amount of food and fluid consumed by patients was initially planned for all ICU nurses prior to the commencement of data collection this was infeasible because the 60 plus nursing staff were employed over 24 hours, 7 days per week on irregular shifts in the ICU. Instead, an explanation sheet (See Appendix D.1) together with a sample food and fluid chart were attached to the observational file for each patient so that the nurses could use them as a reference. It was also considered that documenting food and fluid intake may be a usual practice for nurses and therefore any bias amongst the nurses might be small.

3.5.3 Estimation of actual nutrient intake

Adequacies of nutrient intakes were estimated comparing actual nutrient intakes to estimated requirements. Nutrient intakes obtained from either EN or PN were recorded in kilojoules (kJ), while nutrient intakes from ON was recorded in various units, such as grams (g), millilitres (ml), and serves. The total daily oral nutrient intake (as measured and calculated by bedside nurses) were converted to kJ using the nutrition information of the hospital menu calculated by an ICU dietitian for hospital meals while the nutrient file from the Nutrition Panel Calculator (NPC) database (FSANZ 2011) was used for any extra food. The NPC database files provide nutrient data for 2,520 foods/ingredients in terms of energy and six mandatory nutrients, with nutrient data available on a per 100g edible portion food basis (FSANZ 2011). The total daily energy and protein (in kilojoules - kJ) received via oral, enteral, and parenteral nutrition by patients undergoing NIPPV therapy were compared with the estimated daily nutrient requirements of critically ill patients.

3.5.4 Estimated energy and protein requirements

Patients' daily energy requirements were estimated using 25 kcal/kg for patients with a body mass index (BMI) of < 30 and 11 kcal/kg for patients with a BMI of ≥ 30 (McClave et al. 2009). Daily protein requirements were estimated using 1.2g protein/kg for patients with BMI <30 and 2g protein/ ideal body weight for patients with a BMI between 30 and

40, and 2.5g/kg ideal body weight for patients with class III (BMI ≥ 40) (McClave et al. 2009). Ideal body weight was calculated using Harmwi formula (Harmwi 1964).

Female: 45 kg for the first 152.4cm plus 0.9kg for each additional cm

Male: 48kg for the first 152.4cm plus 1.1kg for each additional cm

3.5.5 Data collection and management

Data was collected or managed on a daily basis by the researcher. Food and fluid charts were completed by bedside ICU nurses while CRF was completed by the researcher by reviewing ICU flow charts and patients' medical notes. Laboratory results were obtained from the ICU database. A dedicated research nurse assisted with the data collection. The research nurse took the researcher's place when the researcher could not visit the hospital. The research nurse telephoned the ICU every morning to check for new patients admitted requiring NIPPV therapy and then texted or emailed the researcher with this information. On patient discharged from ICU, the ward clerk filed the observational sheets in a confidential folder for the researcher. The time to discharge from the ICU and hospital was confirmed with the ward clerk using ICU database to calculate the length of ICU and hospital stay. Figure 3.1 briefly shows the data collection and management.

Figure 3. 1 Data Collection and Management

Data Collection and Management	
Researcher or research RN identification of new patients prescribed NIPPV	
On Admission Data Collection	BMI calculated as weight in kilogram divided by height in metres squared.
	Ideal body weight calculated using Harmwi formula for males and females pts classified as: • underweight (BMI < 18.5) • healthy weight (18.5 ≤ BMI <24.9) • overweight (25 ≤ BMI < 29.9) • obese (BMI ≥ 30 kg/m2)
	APACHE II score – calculated by research RN
	SOFA score- calculated by researcher
	Completion of CRF by researcher through analysis of patient medical notes and ICU database NIPPV data ON or EN or PN or IVT
	Estimation of actual nutrient intake • CRF Nutrients consumed converted to kJ using nutrition information from hospital menu calculated by the researcher. • Nutrients from extra food calculated using Nutrition Panel Calculator (NPC) database
	Estimation of daily energy requirements – estimated using: • 25 kcal/kg for patients with a body mass index (BMI) of < 30 • 11 kcal/kg for patients with a BMI of ≥ 30
	Estimation of daily protein requirements: • 1.2g protein/kg for patients with BMI <30 • 2g protein/ ideal body weight for patients with a BMI between 30 and 40 • 2.5g/kg ideal body weight for patients with class III
	Calculation of difference between: • Actual and required energy requirement • Actual and required protein requirements
Data Entry	SPSS
Statistical analysis	Categorical variables - frequencies and percentages • frequencies 5 or more than 5 examined using Chi-square test, • frequencies less than 5 analysed using Fisher's exact test. • Mean difference between the actual intakes and estimated adequate requirements were analysed using Welch's t-test
	Continuous variables- SD, median and range. • normal distribution analysed using independent t-test • non-normal distribution analysed using Mann Whitney U-test presented as median, range, mean and SD. • Distribution of continuous variables checked using box plots, histograms, normal probability plots, and Shapiro-Wilk test.
	NB: P values < 0.05 considered to be statistically significant

APACHE II: Acute Physiology and Chronic Health Evaluation, BMI: Body Mass Index, CRF: Clinical Recording Form, EN: Enteral Nutrition, ICU: Intensive Care Unit, IVT: Intra Venous Treatment Fluid, ON: Oral Nutrition, PN: Parenteral Nutrition, RN: Registered Nurse, SD: Standard Deviation, SOFA: Sequential Organ Failure Assessment

3.6 Data Analysis

All statistical analysis for this study were performed using a software package called Statistical Package for Social Science (SPSS Version 22.0. Armonk, NY: IBM Corp.) and STATA version 14 (Stata Corp), which are widely used to calculate statistics. Demographics and clinical characteristics were stratified by APACHE II scores for disease severity. Patients with APACHE II score less than 21 belong to 'less severe group' and patients with APACHE II score 21 or more than 21 were categorised into 'more severe group'. Cross tabulation analysis was used to examine the association between disease severity and demographics/ clinical characteristics. Potential variables associated consuming < 50 percentage or 50% ≥ of energy and protein requirements were analysed using cross tabulation. Categorical variables were presented with frequencies and percentages while continuous variables were presented with mean, standard deviation (SD), median and range.

Categorical variables for frequencies 5 or more than 5 were examined using Chi-square test, those with frequencies less than 5 were analysed using Fisher's exact test. Continuous variables with normal distribution were analysed using independent t-test whereas those with non-normal distribution were analysed using Mann Whitney U-test presented as median, range, mean and SD. The distribution of continuous variables was checked using box plots, histograms, normal probability plots, and Shapiro-Wilk test. The mean difference between the actual intakes and estimated adequate requirements were analysed using Welch's t-test as there were unequal variances between the actual intakes and estimated requirements. Welch's t-test does not assume equal variance. P values less than 0.05 were considered to be statistically significant, for the entire statistical test employed

3.7 Ethical considerations

Ethical approval to conduct this study was obtained from the Flinders University Social and Behavioural Research Ethics Committee (project number 6457) (see Appendix E.1), the study hospital ethics committee (permission letter) (see Appendix E.2), and the South Australian Human Research Ethics Committee (HREC reference number: HREC/14/TQEHLMH/155) (see Appendix 15).

This research design complied with the ethical standards established by the National Health and Medical Research Council for the conduct of research in humans (National Health & Medical Research Council 2015). The principle of beneficence requires that the risk of harm and discomfort is minimised for all patients (National Health & Medical Research Council 2015). All the test procedures used in this study were part of standard assessment and routine monitoring of people admitted in ICU. The exception to this was recording oral intake on food and fluid charts. The ICU nurses recorded the food and fluid intake thus the patients had no discomfort while filling in the chart.

The present research is a prospective exploratory observational study which uses de-identified data in order to respect the autonomy of the patient. The participating patients continued to receive the necessary treatment and care that would be provided normally; their routine care was not affected in any way. Research data was collected only for the study's stated purposes and stored in a locked office or password-protected computer. All data reporting forms were stored in an ICU research nurses' locked office in folders ordered by study number. The collected data was not accessible to any unauthorised persons; only this researcher and the ICU research nurse had access to the data. In addition, all identifiable patient information (i.e., name, address, date of birth and the name of hospital) was protected by concealing all names and identities in the final report. On completion of the study the data was securely stored for seven years at the health service (National Health & Medical Research Council 2015).

Therefore, the present research bears no additional risks of harm, discomfort, or inconvenience to the participants. Finally, evidence from this study will increase knowledge and understanding of current nutritional practices and improve its future management in this patient population.

3.8 Issue of rigor

Reliability and validity are two important criteria that demonstrate the rigor of a quantitative study (Polit & Beck 2012). Reliability refers to the extent of a measure's consistency for every repetition of the tests (Kermode & Roberts 2006). Indeed, reliability is achieved when "the results of tests carried out by different individuals or by the same individual at different times remain unchanged" (Craig & Smith 2012, p.158). 'Reliability is strongly associated with the methods used to measure variables (Polit & Beck 2012). The nurses used the structured same observational forms, thus achieving the reliability of this study. At the same time, reliability can be threatened by the person being measured (Belan 2013). Since informed consents are not ethically required due to the nature of this observational clinical audit, the study participants will not be aware of being observed. Therefore, any changes in patients' dietary intakes will be unrelated to this study. Moreover, the amount of nutritional intake for patients receiving enteral or parenteral feeding will not be influenced even if the subjects are aware of being observed.

In turn, the validity question is associated with whether the methods are really measuring what they purport to measure (Kermode & Roberts 2006). Indeed, validity comprises both internal and external validity. Internal validity refers to the accuracy of inferences, interpretations, or actions made on the basis of quantitative data (Schneider, Whitehead & Elliott 2016). In this manner, the validity of this study is achieved by using a clinical reporting form that has been tested and found to be consistent in what it measures. Meanwhile, external validity refers to the generalisability of results (Schneider, Whitehead & Elliott 2016). As this is a pilot study, it will not be generalisable in the true sense, but will instead provide information that will lead to the next study with similar attributes.

3.9 Summary

In summary, this exploratory prospective observational study aimed to explore nutritional care practices to investigate whether patients are adequately nourished in ICU during NIPPV therapy as well as to investigate the incidence of aspiration pneumonia. This study used observational forms consisting of a CRF and a fluid and food chart. The next chapter will present the results, analysis and interpretation of the data.

Chapter 4: Results

This chapter presents the findings of data collected, analysed and interpreted in response to the study aims ‘to explore current nutritional care practice provided to the patients receiving NIPPV therapy in ICU’ and ‘to investigate the incidence of developing aspiration pneumonia in patients during NIPPV therapy’. Over 14 weeks, 30 adult patients aged 18 years or older admitted to the ICU, who met eligibility criteria, were enrolled in the study. All data obtained from the CRF, designed for investigating nutrient intakes in patients receiving NIPPV therapy in ICU, was entered into SPSS for statistical analysis.

This chapter is divided into five sections. Section one describes general information of study participants including demographics and clinical characteristics. Demographics include age, gender, body mass index (BMI), and body weight category based on BMI. Clinical characteristics include chronic comorbidity, reason for ICU admission, Sequential Organ Failure Assessment (SOFA) score, length of stay, discharge status, and mortality. Section 2 presents information of NIPPV and nutrition. The information about NIPPV includes the reason for NIPPV therapy, type of NIPPV and mask interface used, and the total time the patients were placed on NIPPV. The information about nutrition comprises time to commencement of nutrition after the initiation of NIPPV therapy, type of nutrition, ICU dietitian consult, total hours for fasting, and nutritional barriers. Section 3 contains information on nutritional adequacy of the study participants by comparing the patients' mean daily actual energy and protein received with their estimated minimum requirements. Section 4 investigates differences in variables between two groups (patients receiving <50% or estimated energy requirements vs. patients receiving ≥ 50% energy requirements). Section 5 investigates differences in variables between two groups (patients receiving <50% or estimated protein requirements vs. patients receiving ≥ 50% protein requirements). Section 6 describes nutritional status of the study participants evaluated by BMI and haematological results. Section 7 examines the incidence of aspiration pneumonia in the cohort. The eighth and final section summarises the study findings.

4.1 Demographic data

Patients' demographics in Table 4.1 included age, gender, BMI, and weight category based on BMI. The study population included 16 females and 14 males between the ages of 29 and 90. The mean age was 62.6 (SD 13.9) and the median age was 62.5. The mean BMI of 29.5 (SD 8.0) ranged from 16.4 to 43.3. Body weight was further categorised by calculating body mass index (BMI) and classifying this as: underweight (BMI < 18.5), healthy weight (18.5 ≤ BMI <24.9), overweight (25 ≤ BMI < 29.9), and obese (BMI ≥ 30 kg/m2) (WHO 2006) The majority of patients (n = 21, 70%) were classified as either overweight (n=8, 27%) or obese (n=13, 43%) whilst only two (7%) patients were underweight. All demographic data including age, gender, BMI, and weight categories based on BMI had no significant difference between "less severe (APACHE II <21)" and "more severe (APACHE II ≥ 21)" groups.

Table 4. 1 Demographics of the cohort by APACHE II categories

Patients' variables		Total	APACHE II Groups		p-value
			APACHE II < 21	APACHE II ≥21	
Total, n (%)		30 (100)	13 (43)	17 (57)	
‡Age in years, mean (SD)		62.6 (14.0)	61.23 (10.7)	63.6(16.0)	0.675
	Female	16 (53)	6 (20)	10 (33)	
	Male	14 (47)	7 (23)	7 (23)	
‡ BMI, kg/m^2, mean (SD)		29.5 (8.0)	29.6 (7.5)	29.4 (8.6)	0.867
†BMI category, n (%)					
	Yes	2 (7)	0 (0)	2 (7)	
	No	28 (93)	13 (43)	15 (50)	
	Yes	7 (21)	3 (10)	4(13)	
	No	23 (77)	10 (33)	14 (47)	
	Yes	8 (27)	5 (17)	3(10)	
	No	22 (73)	8 (27)	14 (47)	
	Yes	13 (43)	5 (17)	8 (27)	
	No	17 (57)	8 (27)	9 (30)	

*Significant differences were set at p<.05, p- values were **bolded** if they were significant.
† Categorical data were presented as n (%), and p-values were obtained using Chi-square test if cell frequencies were larger than 5, else Fisher's exact probability test were used, the percentages have been rounded to the nearest figure.
‡ Continuous data with normal distribution was presented as Mean ± SD, and p-values were obtained using independent t-test.
‡‡ Continuous data with non-normal distribution was presented as median and range, and p-values were obtained using Mann-Whitney U-test.
APACHE II: Acute Physiology and Chronic Health Evaluation II BMI: body mass index

4.2 Clinical characteristics

Table 4.2 presents the clinical characteristics using APACHE II categories. Clinical characteristics include chronic comorbidity, reason for ICU admission, Sequential Organ Failure Assessment (SOFA) score, length of stay, discharge status, and mortality.

4.2.1 Chronic comorbidity, reason for ICU admission, and SOFA score

All study participants had more than one chronic condition presented below in order of frequency. Chronic respiratory disorder was the most frequent chronic comorbidity (n = 16), diabetes (n = 9), cardiovascular disease (n = 7), cerebrovascular disease (n = 5), gastro-oesophageal reflux disease (GORD) (n = 5), depression (n = 5) and cancer (n = 4). More than half of the participants (53%) already had a chronic alteration in respiratory status prior to admission to the ICU and the initiation of NIPPV therapy. There was no significant difference between APACHE II categories and the various chronic comorbidities.

The most common reason for ICU admission of the study population was respiratory failure, which occurred in 17 patients (57%). Patients were also admitted to the ICU with the diagnosis of sepsis (n = 3), cardiovascular disease (n = 3), renal failure (n = 2), neurological disease (n = 2), metabolic disease (n = 1), tumour lysis syndrome (n = 1) and drug overdose (n = 1). There was also no significant difference between the APACHE II groups with the reason for ICU admission.

Organ failure was calculated using the Sequential Organ Failure (SOFA) score. The SOFA score was recorded within 24 hours of the ICU admission and the mean (SD) SOFA score was 5.2 (SD 3.0). This indicates the study population already had some organ failure, in addition to respiratory failure, before the initiation of NIPPV therapy.

SOFA score was significantly higher in the "more severe" patients group (APACHE II ≥ 21) as compared with those who were "less severe" group (APACHE II <21) (median 6.4 vs. 3.3, p=.010; Mann-Whitney U test). This means that patients who were more seriously ill had more organ failures.

4.2.2 Length of stay, discharge status, and mortality

The length of ICU stay ranged from 0.6 to 23.9 days with a mean of 5.7 days and a median of 4.4 days. Only 2 patients were discharged home, whilst 28 patients were transferred to other wards or other hospitals. Of the four patients classified as ‘do not resuscitate’ (DNR): one patient transferred to the palliative care unit whereas the remaining three patients were treated in the ICU but not referred to, or managed by, the palliative care team.

One person died in the ICU whereas eight patients died in hospital. No significant difference was demonstrated between the APACHE II groups in the length of ICU/ hospital stay, discharge status, or mortality. Although there was no significant difference in mortality between APACHE II groups, the number of patients died in both ICU (APACHE II < 21: n= 0 vs. APACHE II ≥ 21: n=1, p=0.433) and hospital (APACHE II < 21: n= 3 vs. APACHE II ≥ 21: n=5, p=1.00) was higher in the “more severe” group (APACHE II ≥ 21) than”less severe” group (APACHE II <21).

Table 4. 2 Clinical characteristics of the cohort by APACHE II categories

Patients' variables		Total	APACHE II Groups		p-value
			APACHE II < 21	APACHE II ≥21	
Total, n (%)		30 (100)	13 (43)	17 (57)	
Chronic comorbidity, n (%)					
	Yes	7 (23)	4 (13)	3 (10)	
	No	23 (77)	9 (30)	14 (47)	
	Yes	5 (17)	1 (3)	4 (13)	
	No	25 (83)	12 (40)	13 (43)	
	Yes	16 (53)	6 (20)	10 (33)	
	No	14 (47)	7 (23)	7 (23)	
	Yes	1 (3)	1 (3)	0 (0)	
	No	29 (97)	12 (40)	17 (57)	
	Yes	9 (30)	5 (17)	4 (13)	
	No	21 (70)	8 (27)	13 (43)	
	Yes	5 (17)	3 (10)	2(7)	
	No	25 (83)	10 (33)	15 (50)	
	Yes	4 (13)	2 (7)	2 (7)	
	No	26 (87)	11(37)	15 (50)	
	Yes	12 (40)	6 (20)	6 (20)	
	No	18 (60)	7 (23)	11 (37)	
	Yes	1 (3)	1 (3)	0 (0)	
	No	29 (97)	12 (40)	17 (57)	
†Reason for ICU admission, n (%)					
	Yes	17 (57)	8 (27)	9 (30)	
	No	13 (43)	5 (17)	(27)	
	Yes	3 (10)	0 (0)	3 (10)	
	No	27 (90)	13 (43)	14 (47)	
	Yes	2 (7)	0 (0)	2 (7)	
	No	28 (93)	13 (43)	15 (50)	
	Yes	3 (10)	2 (7)	1 (3)	
	No	27 (90)	11 (37)	16 (53)	
	Yes	1 (3)	1 (3)	0 (0)	
	No	29 (97)	12 (40)	17 (57)	

*Significant differences were set at p<.05, p- values were **bolded** if they were significant.

† Categorical data were presented as n (%), and p-values were obtained using Chi-square test if cell frequencies were larger than 5, else Fisher's exact probability test were used, the percentages have been rounded to the nearest figure.
‡ Continuous data with normal distribution was presented as Mean ± SD, and p-values were obtained using independent t-test.
‡‡ Continuous data with non-normal distribution was presented as median and range, and p-values were obtained using Mann-Whitney U-test.
APACHE II: Acute Physiology and Chronic Health Evaluation II, GORD: Gastro-oesophageal reflux disease, SOFA: Sequential Organ Failure Assessment.

4.3 Information of NIPPV and nutrition

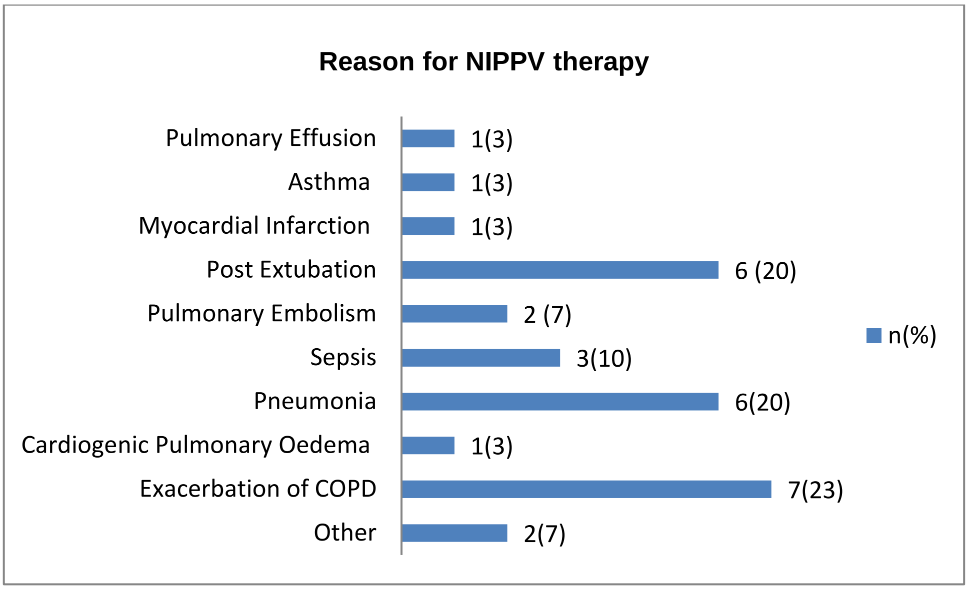
4.3.1 Information about NIPPV

The background information about NIPPV includes the reason for NIPPV therapy, type of NIPPV and mask interface used, and the total time the patients were placed on NIPPV.

4.3.1.1 Reasons for NIPPV therapy

Although respiratory disorders were the main reason for the use of NIPPV, the findings showed that NIPPV was widely used for various clinical indications (Figure 4.1). The majority of the patients (n = 17, 57%) received NIPPV therapy with respiratory disorders including exacerbation of COPD (n = 7), pneumonia (n = 6), pulmonary embolism (n = 2), asthma (n = 1), and pulmonary effusion (n = 1). Non-invasive positive pressure ventilation was also used as a weaning process in patients post-extubation (n = 6, 20%), which represents the second most common reason for NIPPV therapy in the study participants. Sepsis (n = 3), myocardial infarction (n = 1), cardiogenic pulmonary oedema (n = 1), acute respiratory failure resulting from tumour lysis syndrome (n = 1) and hypercapnia due to drug overdose (n = 1) were identified as reasons for initiation of NIPPV.

Figure 4. 1 Reasons for NIPPV

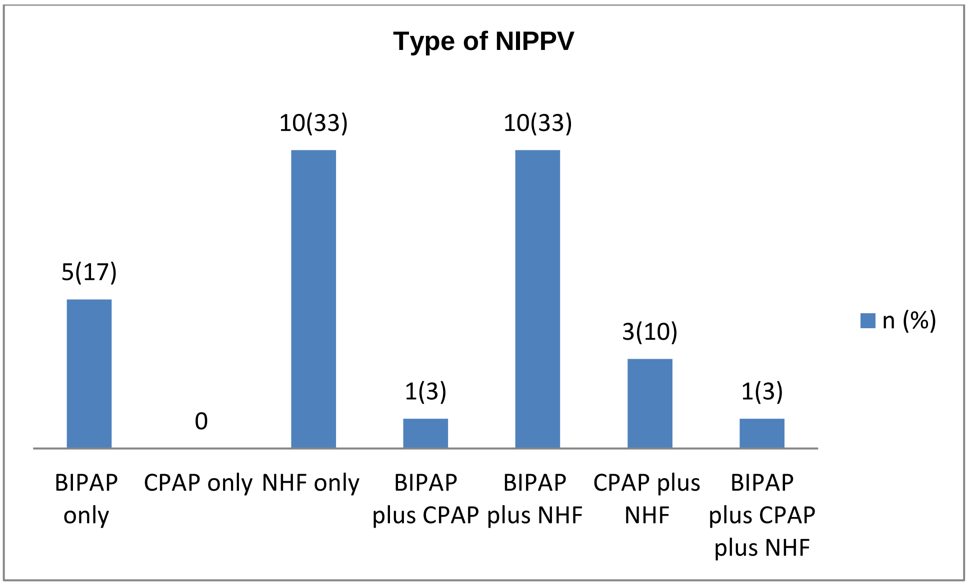


**NIPPV: Non-invasive positive pressure ventilation, COPD: Chronic obstructive pulmonary disease*
**The percentages have been rounded to the nearest figure.*

4.3.1.2 Type of NIPPV

Half of the patients (n = 15) used only one type of NIPPV while the remaining half used more than one type of NIPPV (See Figure 4.2). Nasal high flow (NHF) was the most commonly used type of NIPPV when used either alone or in combination with CPAP or BIPAP. Ten patients were only prescribed NHF, 5 patients received only BIPAP, whilst CPAP was never prescribed without a combination with another NIPPV. BIPAP with NHF were the most commonly used form of NIPPV (n = 10), with BIPAP, NHF and CPAP (n = 1) the least used combination therapy. An oro-nasal mask was used as the interface for all patients receiving BIPAP or CPAP.

Figure 4. 2 Types of NIPPV prescribed

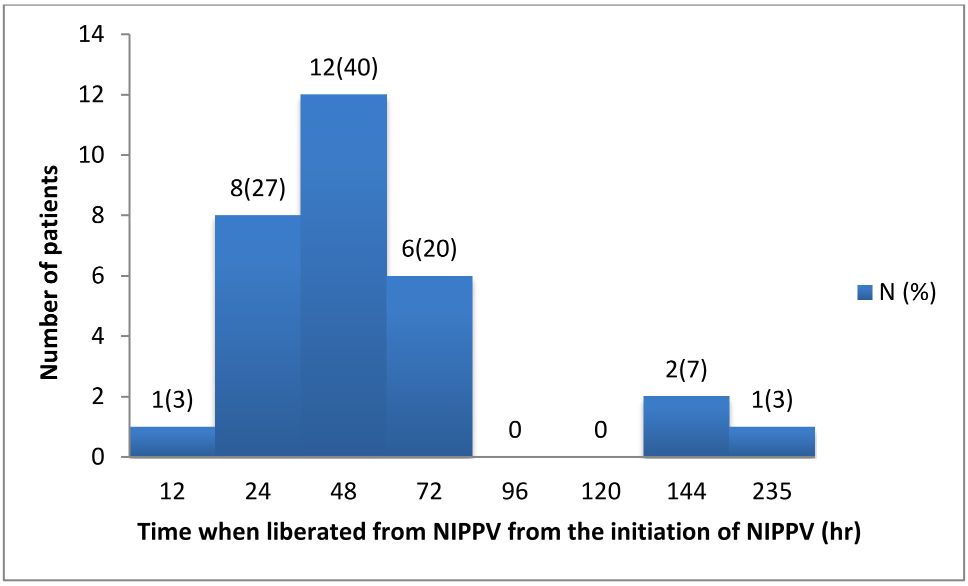


**The percentages have been rounded to the nearest figure.*
**NIPPV: Non-Invasive Positive Pressure Ventilation, BIPAP: Biphasic Positive Airway Pressure, CPAP: Continuous Positive Airway Pressure, NHF: Nasal High Flow*

4.3.1.3 Total time on NIPPV

The mean total hours on NIPPV were 45.1 (SD 47.5) and ranged from 6.0 to 235 hours (See Figure 4.3: Frequency distribution for the total hours on NIPPV). Among the three types of NIPPV, the mean total hours on NHF (36.3 (SD 50.2) hours) were much longer than those on BIPAP (7.8 (SD 8.6) hours) or CPAP (1 (SD 2.9) hour). The majority of the patients (n = 27, 90%) were on NIPPV for less than 72 hours. The study participants were prescribed NIPPV for an average of 62% per day of the total days used to calculate nutritional requirements during this study. This indicates patients had at least one main meal while receiving NIPPV.

Figure 4. 3 Frequency distribution for the total hours on NIPPV



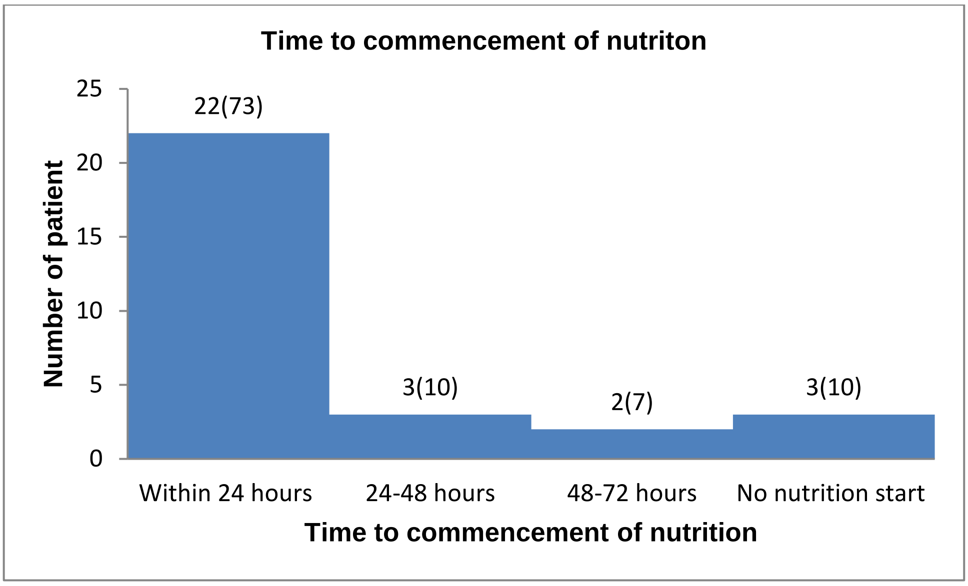
4.3.2 Information about nutrition

This section includes background information about nutrition in the patients receiving NIPPV therapy including time to commencement of nutrition after the initiation of NIPPV therapy, type of nutrition, ICU dietitian consult, total hours for fasting, and nutritional barriers.

4.3.2.1 Time to commencement of nutrition after the initiation of NIPPV

The majority of the patients (n = 22, 73%) commenced nutrition within 24 hours after the initiation of NIPPV therapy, three patients (10%) were provided nutrition between 24 and 48 hours, and two patients (7%) nutrition was delayed for between 48 and 72 hours (See Figure 4.4 for time to commencement of nutrition after the initiation of NIPPV therapy). Three patients did not commence any type of nutrition during NIPPV treatment. Of the three patients, two patients were provided energy through intravenous fluid (IV) containing dextrose (4% or 5% dextrose). These two patients were unable to have oral nutrition because one was sedated due to drug overdose, and another had no appetite associated with ICU admission. The remaining patient was fasting during NIPPV therapy due to ascites and duodenal obstruction and was given IV fluid only containing electrolyte. All of these three patients were on NIPPV less than 24hours (range: 6 to 12hrs).

Figure 4. 4 Time to commencement of nutrition after the initiation of NIPPV



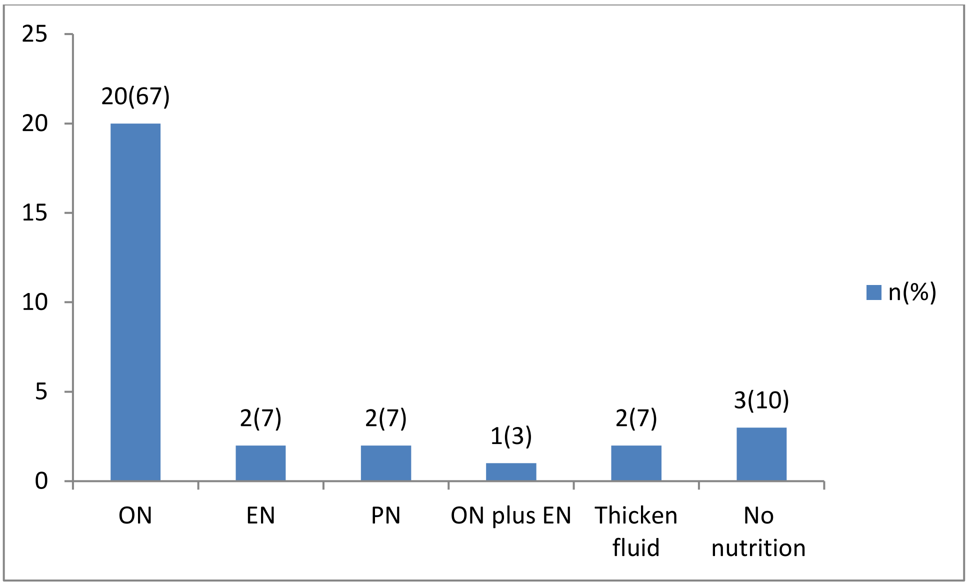
The percentages have been rounded to the nearest figure.

4.3.2.2 Type of nutrition and ICU dietitian consult

Oral nutrition (ON) was the most common type of nutrition (n=20, 67%) (See Figure 4.5 for type of nutrition). Two patients (7%) were only allowed thickened fluid due to swallowing difficulty associated with shortness of breath, and risk of aspiration post extubation. Thickened fluid was regarded as nutrition in this study because thickened fluid (e.g. soup, supplement drink, and juice etc.) provides some energy and protein. Enteral nutrition (EN) was commenced in two patients (7%). Of the two patients, one was suffering from dysphagia due to previous stroke and was given EN through Percutaneous Endoscopic Gastrostomy (PEG) feeding tube. The other patient was prescribed EN through nasogastric tube (NGT) due to risk for aspiration from oral intake post extubation. Two patients (7%) were prescribed total parenteral nutrition (TPN) because of malfunction of gastro-intestinal (GI) tract secondary to abdominal compartment syndrome (n = 1) and enterocutaneous fistula (n = 1). One patient was prescribed ON in combined with 80% of nutrition to be provided EN as this patient was unable to tolerate an adequate oral intake due to dysphagia post extubation, fatigue and anorexia.

Although a dietitian was attached to the study ICU there was no ICU nutrition team. A total of 8 (27%) out of 30 study participants were assessed by ICU dietitian and provided nutritional intervention (See Figure 4.5 for type of nutrition). Among the eight patients, three had ON, two were prescribed EN, two prescribed PN and one patient ordered a combination of ON and EN. Not all NIPPV patients had ICU dietitian consult and no protocol existed for referral of patients to ICU dietitian.

Figure 4. 5 Nutrition prescribed during NIPPV



ON: oral nutrition, EN: enteral nutrition, PN: parenteral nutrition
The percentages have been rounded to the nearest figure

4.3.2.3 Total hours for fasting and nutritional barriers

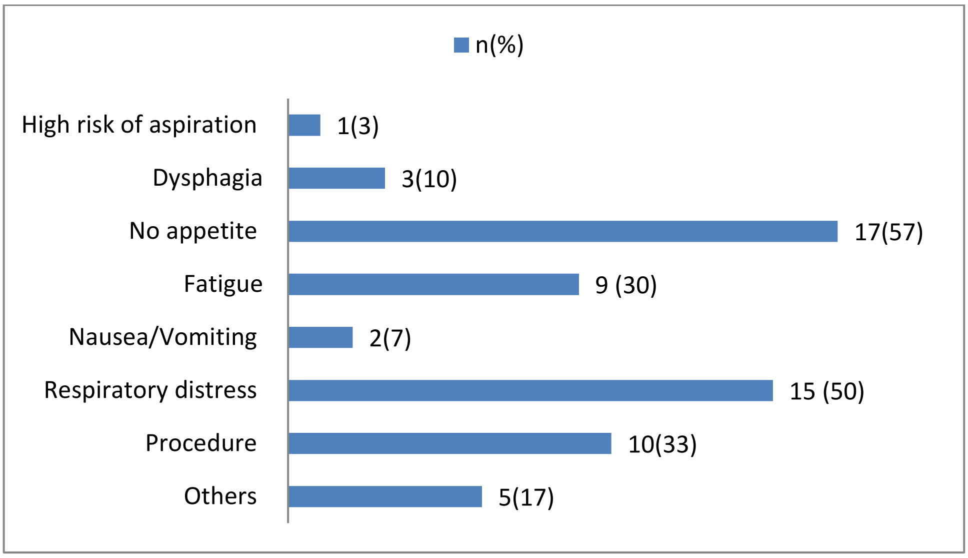
The mean total hours for fasting over the eligible nutrition days were 15.3 hours (SD 13.6) ranged from 0 to 59 hours in the study participants.

The majority of the study participants (n = 25, 83.3%) had more than one nutritional barrier (See Figure 4.6 for the reasons for lack of nutrition). Seventeen patients (57%) refused to eat due to poor appetite while nine (30%) did not eat due to fatigue. Breathing difficulties such as shortness of breath was the second most common reason for not eating for 15 patients (50%). Of the 15 patients, 12 patients (40%) were receiving NIPPV through

BIPAP or CPAP. It was observed that there was a difference in nutrition between patients with BIPAP or CPAP and patients with NHF. Patients were not allowed to have oral nutrition while receiving BIPAP or CPAP whereas patients were allowed to eat while on NHF. Patients were only allowed to have sips of water on BIPAP or CPAP in the ICU. This reflects nutrient intakes could be negatively affected in patients using BIPAP or CPAP.

Ten patients (33%) skipped nutrition associated with ICU procedures. While three (10%) patients were unable to eat properly due to dysphagia, one patient (3.3%) stopped enteral feeding once with the high risk of aspiration because PEG tube was dislocated, meaning enteral nutrition could enter the respiratory tract not stomach causing aspiration. Other reasons included: 'TPN was not ordered for the next connection', 'tea trolley did not come up', and 'diet was not ordered for the patient'. This suggests that nutritional requirements were not provided with a high priority for patients undergoing NIPPV. Patients' clinical condition was also the reason for lack of nourishment such as 'suspicious gastric bleeding' and 'duodenal obstruction'.

Figure 4. 6 Reasons for lack of nutrition



The percentages have been rounded to the nearest figure

4.4 Nutritional adequacy

This section incorporates the information on nutritional adequacy of the study participants by comparing the patients' mean daily actual energy and protein received with their estimated minimum requirements. In addition, variables associated with 50% consumption of minimum energy and protein requirements, and haematological data reflecting the patients' nutritional status are also included in this section.

4.4.1 Actual energy and protein intakes vs. estimated requirements

Actual mean daily energy and protein intakes for the 30 patients during NIPPV therapy were 2277 ± 1776 kJ (= 544 ± 424 kcal) and 29 ± 32 g protein while estimated minimum mean daily energy and protein requirements were 6126 ± 1801 kJ (= 1464 ± 430 kcal) and 103 ± 33 g protein. The mean daily actual intakes (AI) and the minimum mean daily estimated requirements (ER) had unequal variance. In order to compare the mean differences between AI and ER, Welch's t-test was used as Welch's t-test is not assumed equal variance. Welch's t-test is more robust than Student's t-test and maintains type I error rates *close to nominal for unequal variances and for unequal sample sizes*. A significant mean difference was demonstrated between the mean daily actual energy intake (AEI) and the mean daily estimated energy requirement (EER). The result showed AEI was significantly lower than EER (Mean difference = -3849 kJ, 95% CI: -4773, -2925), t (59) = -8.3332 ($p<.001$) (Table 4.3). Similarly, there was also statistically significant mean difference between the mean daily actual protein intake (API) and the minimum mean daily estimated protein requirement (EPR). The result showed API was significantly lower than EPR (Mean difference = -73 g, 95% CI: -90, -57), t (59) = -8.7119 ($p<.001$) (Table 4.4).

The findings of the Welch's t-test indicates that patients' mean energy and protein intakes did not meet their requirements, and that patients were undernourished during NIPPV therapy in the ICU.

Table 4. 3 The mean difference between AEI and EER

```
. ttest DEI == EER, unpaired unequal welch
```

Two-sample t test with unequal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
DEI	30	2277.054	324.3275	1776.415	1613.729	2940.378
EER	30	6125.934	328.8434	1801.15	5453.374	6798.494
combined	60	4201.494	339.4088	2629.049	3522.338	4880.649
diff		-3848.88	461.8726		-4772.767	-2924.994

```
    diff = mean(DEI) - mean(EER)                                  t =  -8.3332
Ho: diff = 0                              Welch's degrees of freedom =  59.9881

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
```

API: mean daily actual protein intake, EPR: mean daily estimated protein requirement

Level of significance: p< .05

Table 4. 4 The mean difference between API and EPR

```
. ttest DPI_EPR_P == EPR, unpaired unequal welch
```

Two-sample t test with unequal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
DPI_EP~P	30	29.12842	5.846822	32.02436	17.17032	41.08651
EPR	30	102.587	6.075639	33.27765	90.16092	115.0131
combined	60	65.85771	6.351261	49.19666	53.14886	78.56655
diff		-73.45858	8.432006		-90.32564	-56.59153

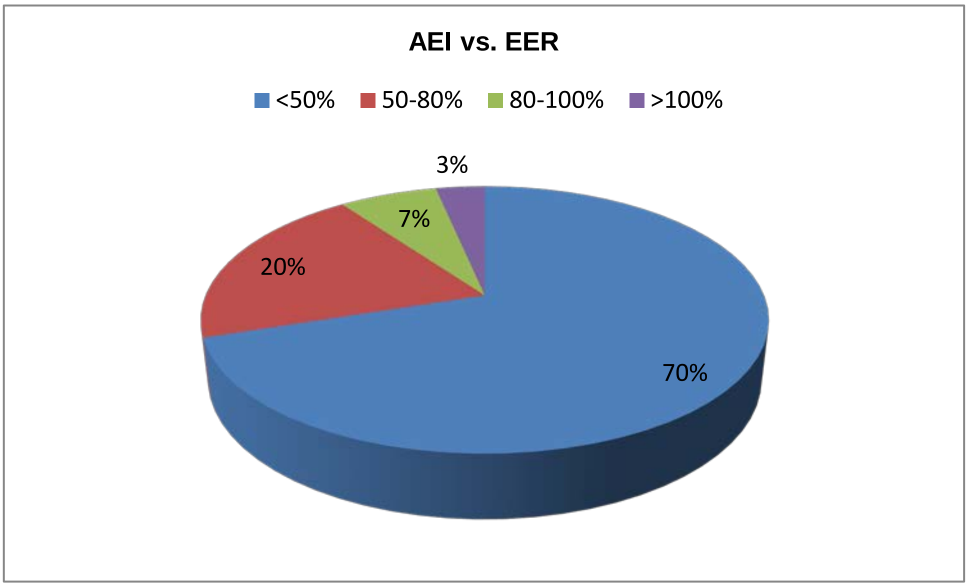
```
    diff = mean(DPI_EPR_P) - mean(EPR)                            t =  -8.7119
Ho: diff = 0                              Welch's degrees of freedom =  59.9089

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
```

API: (mean daily) actual protein intakes, EPR: (minimum mean daily) estimated protein requirements

Level of significance: p< .05

Figure 4.7 presents the percentage of AEI on EER. The majority of the patients (n = 21, 70%) failed to meet 50% of EER while only one patient consumed more than 100% of the EER. This patient was prescribed parenteral nutrition (PN) by ICU dietitian. Six patients (20%) consumed energy between 50% and 80 % of EER and two patients (7%) were between 80% and 100%. All these results indicate that patients receiving NIPPV were not adequately nourished and seriously undernourished in terms of fulfilling energy requirements.

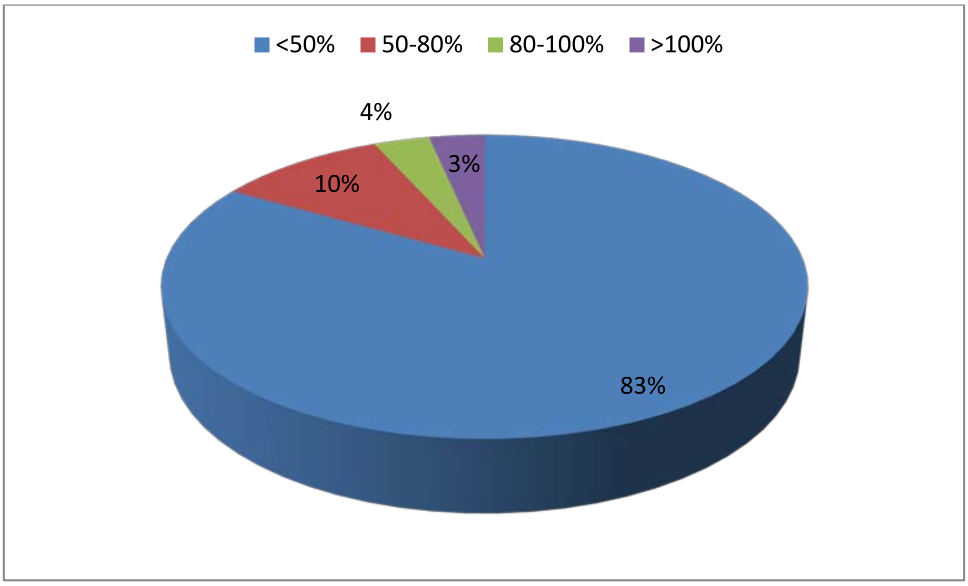
Figure 4. 7 AEI vs. EER



AEI: mean daily actual energy intake, EER: mean daily estimated energy requirement

The percentages have been rounded to the nearest figure.

Figure 4. 8 API vs. EPR



API: Actual mean daily Protein Intake, EPR: Estimated mean daily protein requirement

The percentages have been rounded to the nearest figure.

Figure 4.8 presents the percentage of API on EPR. The majority of the patients (n=25, 83%) failed to meet 50% of EPR while only one patient consumed more than 100% of EPR. This patient was the same patient who had more than 100% energy requirements. Three patients (10%) consumed protein between 50% and 80% of EPR and one patient was between 80% and 100%. All these results indicate that patients receiving NIPPV were not adequately nourished and seriously undernourished in terms of protein as well as energy.

Energy and protein consumption were divided into two groups depending on the percent of consumption of estimated mean daily energy and protein requirements: less than 50% consumption of estimated requirement and 50% or more than 50% consumption of estimated requirement.

Categorical variables were presented as frequencies (n) and percentages (%) and analysed using Chi-square test if cell frequencies were larger than 5, else Fisher's exact probability test were used. Continuous variables were summarised with means (M) and standard deviations (SD) for variables with normal distribution and analysed using independent t-test. Variables not normally distributed including SOFA, APACHE II score, and the length of stay were presented as median and range, and analysed using Mann-Whitney U-test. P values less than .05 were considered to be statistically significant, for the entire statistical test employed.

4.5 Differences in variables between the two groups (patients consuming < 50% of energy requirements vs. ≥ 50% of energy requirements)

Differences in variables consuming 50% of minimum mean daily estimated energy requirement (EER) comprised demographics including age, gender, BMI, and clinical characteristics including APACHE II and SOFA scores, chronic comorbidity, and length of stay. Information about NIPPV including type of NIPPV, total time on NIPPV as well as information about nutrition including time to commencement of nutrition after initiation of NIPPV therapy, type of nutrition, nutritional barriers, dietitian consult, and total hours for fasting were also used as the variables. Twenty patients had less than 50% of EER whilst 10 patients consumed 50% or more than 50% of EER.

4.5.1 Differences in demographics

Patient demographics and clinical characteristics, including age, gender, BMI, current chronic comorbidity, SOFA score, the length of ICU and hospital stay, were not associated with consuming 50% of energy requirements ($p>.05$). However, there was a trend towards higher APACHE II score in patients received less energy intake (<50% of EER), although not statistically significant (median 23 vs. 18, $p=.098$; Mann-Whitney U test).This indicates patients with more severe disease tended to have lower energy intake. See table 4.5 for demographics and clinical characteristic variables by energy groups.

Table 4. 5 Demographics and clinical characteristic variables by energy group

Patients' variables		Total	Energy Groups		p-value
			< 50% EER	≥ 50% EER	
Total, n (%)		30 (100)	20 (67)	10 (33)	
Age in years, mean ± SD‡		63 ± 13.9	64 ± 15.5	60 ± 9.3	0.571
	Female n (%)	16 (53)	10 (33)	6 (20)	
	Male, n (%)	14 (47)	10 (33)	4 (13)	
BMI, mean (SD)†		29 ± 8.0	29 ± 8.6	31 ± 7.0	0.634
SOFA, median (range)‡‡		5 (1-12)	4.5 (1-12)	4.7 (2-9)	0.982
APACHE II, median (range)‡‡		21 (5-38)	22.7 (15-38)	18.3 (5-38)	0.098
Chronic comorbidity, n (%) †					
	Yes	7 (23)	6(20)	1 (3)	
	No	23 (77)	14(47)	9 (30)	
	Yes	5(17)	4(13)	1(3)	
	No	25(83)	16(53)	9 (30)	
	Yes	16(53)	10(33)	6(20)	
	No	14(47)	10(33)	4(13)	
	Yes	1 (3)	1 (3)	0 (0)	
	No	29(97)	19(63)	10(33)	
	Yes	5(17)	3(10)	2(6)	
	No	25(83)	17 (57)	8(27)	
	Yes	9 (30)	6 (20)	3 (10)	
	No	21 (70)	14(47)	7 (23)	
	Yes	5(17)	3(10)	2(7)	
	No	25(83)	17 (57)	8(27)	
	Yes	4(13)	4(13)	0 (0)	
	No	26 (87)	16(53)	10(33)	
	Yes	12 (40)	7 (23)	5(17)	
	No	18 (60)	13 (43)	5(17)	

Table 4. 5 Demographics and clinical characteristic variables by energy group

Table 4. 5 Demographics and clinical characteristic variables by energy group

		Energy Groups		
		< 50% EER	**≥ 50% EER**	
Total, n (%)	30 (100)	20 (67)	10 (33)	
‡‡Length of hospital stay, in days, median (range)	4.4 (0.6-23.9)	4.3 (0.6-23.9)	6.2 (1.9-13.2)	0.402
‡‡Length of hospital stay, in days, median (range)	10.1 (3.9-137.5)	10.0 (3.9-51.6)	11.8 (5.9-137.5)	0.572

*Significant differences were set at p<.05, p- values were **bolded** if they were significant.
† Categorical data were presented as n (%), and p-values were obtained using Chi-square test if cell frequencies were larger than 5, else Fisher's exact probability test were used.
‡ Continuous data with normal distribution was presented as Mean ± SD, and p-values were obtained using independent t-test.
‡‡ Continuous data with non-normal distribution was presented as median and range, and p-values were obtained using Mann-Whitney U-test
EER: estimated mean daily energy requirement, BMI: body mass index, SOFA: Sequential Organ Failure Assessment, APACHE II: Acute Physiology and Chronic Health Evaluation II, GORD: Gastro-oesophageal reflux disease

4.5.2 Differences in type of NIPPV

Type of NIPPV used including BIPAP, CPAP, and NHF were not significantly associated with consuming 50% of EER whereas there were significant differences in the time on NIPPV between the energy groups. Total hours on NHF were significantly lower in patients who consumed < 50% of EER as compared with those who had ≥ 50% of EER (median 15.7 vs.32, p=.039; Mann-Whitney U test). Similarly, total hours on NIPPV, including BIPAP, CPAP, and NHF, were significantly lower in patients who consumed < 50% of EER as compared with those who had ≥ 50% of EER (median 25.3 vs.40, p=.017; Mann-Whitney U test). There were not significant differences between the energy categories in total hours on BIPAP and total hours on CPAP with the small sample. See table 4.6 for NIPPV variables by energy groups.

Table 4. 6 NIPPV variables by energy groups

Patients' variables		Total	Energy Groups		p-value
			< 50% EER	≥ 50% EER	
Total n (%)		30(100)	20 (67)	10 (33)	
†Type of NIPPV, n (%)					
	Yes	17 (57)	12 (40)	5 (17)	
	No	13 (43)	9(30)	4(13)	
	Yes	5(17)	5(17)	0(0)	
	No	25(83)	16(53)	9(30)	
	Yes	24(80)	15(50)	9(30)	
	No	6(20)	6(20)	0(0)	
‡‡Total time on NIPPV, hours, median (range)					
BIPAP		7 (0-26.5)	7.3 (0-26.5)	6 (0-25)	0.887
CPAP		0 (0-14)	0.8 (0-14)	0 (0-0)	0.117
NHF		17.5 (0-235)	15.7 (0-69.7)	32 (9-235)	**0.039**
NIPPV (including BIPAP, CPAP, NHF)		26.8 (6-235)	25.3 (6-69.7)	40 (24-235)	**0.017**

*Significant differences were set at p<.05, p- values were **bolded** if they were significant.

† Categorical data were presented as n (%), and p-values were obtained using Chi-square test if cell frequencies were larger than 5, else Fisher's exact probability test were used.

‡ Continuous data with normal distribution was presented as Mean ± SD, and p-values were obtained using independent t-test. ‡‡ Continuous data with non-normal distribution was presented as median and range, and p-values were obtained using Mann-Whitney U-test

EER: estimated mean daily energy requirement, NIPPV: non-invasive positive pressure ventilation, BIPAP: Biphasic Positive Airway Pressure, CPAP: Continuous Positive Airway Pressure, NHF: Nasal High Flow.

4.5.3 Differences in nutrition

Time to commencement of nutrition within 24 hours from the initiation of NIPPV had a trend towards receiving less energy intake (<50% EER), although not statistically significant (p=.067). Type of nutrition, including oral nutrition (ON), enteral nutrition (EN), parenteral nutrition (PN), ON plus EN, thicken fluid only and no nutrition, was not significantly associated with consuming 50% of EER (p>.05). The reasons for not having nutrition either ON or artificial nutrition including EN or PN were not significantly associated with consuming 50% of EER ($p > .05$). Also, having ICU dietitian consult had no significant difference between the two energy groups ($p = .384$). In contrast, the total hours for fasting during NIPPV therapy were significantly higher for < 50% EER group compared to ≥ 50% EER group (median 16.5 vs. 5.3, $p = .035$; Mann-Whitney U test). See table 4.7 for nutrition variables by energy groups.

Table 4. 7 Nutrition variables by energy groups

Patients' variables		Total	Energy Groups		p-value
			< 50% EER	≥ 50% EER	
Total, n (%)		30 (100)	20 (67)	10 (33)	
†Time to commencement of nutrition, n (%)					
	Yes	22 (73)	13 (43)	9 (30)	
	No	8 (27)	8 (27)	0 (0)	
	Yes	3 (10)	3 (10)	0 (0)	
	No	27 (90)	18 (60)	9 (30)	
	Yes	2 (7)	2(7)	0 (0)	
	No	28 (93)	19 (63)	9 (30)	
	Yes	3 (10)	0(0)	3 (10)	
	No	27 (90)	18 (60)	9 (30)	
†Type of nutrition, n (%)					
	Yes	20 (67)	13 (43)	7 (23)	
	No	10 (33)	8 (27)	10 (33)	
	Yes	2 (7)	1 (3)	1 (3)	
	No	28 (93)	20 (67)	8 (27)	
	Yes	2(7)	1 (3)	1 (3)	
	No	28 (93)	20 (67)	8 (27)	
	Yes	1 (3)	1 (3)	0 (0)	
	No	29 (97)	20 (67)	9 (30)	
	Yes	2 (7)	2 (7)	0 (0)	
	No	28 (93)	19 (63)	9 (30)	
	Yes	3 (10)	3 (10)	0 (0)	
	No	27 (90)	18 (60)	9 (30)	

Table 4.7 Nutrition variables by energy groups

			Energy Groups		
			< 50% EER	≥ 50% EER	
Total, n (%)		30 (100)	20 (67)	10 (33)	
†Reason for not eating/ nourished, n (%)					
	Yes	10 (33)	6 (20)	4 (13)	
	No	20 (67)	14 (47)	6 (20)	
	Yes	15 (50)	11 (37)	4 (13)	
	No	15 (50)	9 (30)	6 (20)	
	Yes	2 (7)	1(3)	1(3)	
	No	28 (93)	19 (63)	9 (30)	
	Yes	17 (57)	11 (37)	6 (20)	
	No	13 (43)	9 (30)	4 (13)	
	Yes	9 (30)	4 (13)	5 (17)	
	No	21 (70)	16 (53)	5 (17)	
	Yes	3 (10)	3 (10)	0 (0)	
	No	27 (90)	17 (57)	10 (33)	
	Yes	8 (27)	4 (13)	4 (13)	
	No	22 (73)	16 (53)	6 (20)	
Total hours for fasting, median (range)		11.5 (0-59)	16.5 (0-59)	5.3 (0-22.5)	**0.035**
	Yes	1 (3)	1 (3)	0 (0)	
	No	29 (97)	20 (67)	9 (30)	
	Yes	2 (7)	2 (7)	0 (0)	
	No	28 (93)	19 (63)	9 (30)	
	Yes	3 (10)	3 (10)	0 (0)	
	No	27 (90)	18 (60)	9 (30)	

*Significant differences were set at p<.05, p- values were bolded if they were significant.
† Categorical data were presented as n (%), and p-values were obtained using Chi-square test if cell frequencies were larger than 5, else Fisher's exact probability test were used, the percentages have been rounded to the nearest figure.
‡ Continuous data with normal distribution was presented as Mean ± SD, and p-values were obtained using independent t-test.
‡‡ Continuous data with non-normal distribution was presented as median and range, and p-values were obtained using Mann-Whitney U-test
EER: estimated mean daily energy requirement, ON: oral nutrition, EN: enteral nutrition, PN: parenteral nutrition, SOB: shortness of breath, ICU: intensive care unit, SD: standard deviation.

4.6 Differences in variables between the two groups (patients consuming < 50% of protein requirements vs. ≥ 50% of protein requirements)

Variables associated with 50% consumption of minimum mean daily protein estimated requirement (EPR) were summarised below. Twenty-six patients (87%) had less than 50% of EPR whilst only four patients (13%) consumed 50% or more than 50% of EPR.

4.6.1 Demographics and clinical characteristics

Patient demographics and clinical characteristics, including gender, current chronic comorbidity, SOFA and APACHE II scores, and the length of ICU, were not significantly associated with consuming 50% of EPR ($p>.05$). There was a trend towards the older and increasing BMI were more likely to have < 50% EPR with the p value of .082 and .078 respectively. In addition, there was also a trend for longer hospital stay the patients had, the more the patients received ≥50% of EPR (median 9.8 days vs. 13.9 days, $p=.080$; Mann-Whitney U test). See Table 4.8 for demographics and clinical characteristic variables by protein groups.

Table 4. 8 Demographics and clinical characteristic variables by protein groups

Patients' variables		Total	Protein Groups		p-value
			< 50% EPR	≥ 50% EPR	
Total, n (%)		30 (100)	26 (87)	4 (13)	
Age in years, mean ± SD‡		63 ± 13.9	64 ± 12.9	53 ± 17.6	0.082
	Female	16 (53)	14 (47)	2 (7)	
	Male	14(47)	12(40)	2 (7)	
BMI, mean (SD)†		29 ± 8.0	31 ± 7.8	21 ± 3.1	0.078
SOFA, median (range)‡‡		5 (1-12)	4.3 (1-11)	7 (2-12)	0.249
APACHE II, median (range)‡‡		21 (5-38)	21.4 (5-38)	19 (14-30)	0.357
Chronic comorbidity, n (%) †					
	Yes	7 (23)	6 (20)	1 (3)	
	No	23 (77)	20 (67)	3(10)	
	Yes	5(17)	5 (17)	0 (0)	
	No	25(83)	21 (70)	4 (13)	
	Yes	16(53)	14 (47)	2 (7)	
	No	14(47)	12 (40)	2 (7)	
	Yes	1 (3)	1 (3)	0 (0)	
	No	29(97)	25 (83)	4 (13)	
	Yes	5(17)	3 (10)	2 (7)	
	No	25(83)	23 (77)	2 (7)	
	Yes	9 (30)	9 (30)	0 (0)	
	No	21 (70)	17 (57)	4 (13)	
	Yes	5(17)	5	0 (0)	
	No	25(83)	21 (70)	4 (13)	
	Yes	4(13)	3 (10)	1 (3)	
	No	26 (87)	23 (77)	3 (10)	
	Yes	12 (40)	10 (33)	2 (7)	
	28 (93)	16 (53)	2 (7)	28 (93)	

Table 4.8 Demographics and clinical characteristic variables by protein group

		Protein Groups		
		< 50% EPR	**≥ 50% EPR**	
Total, n (%)	30 (100)	26 (87)	4 (13)	
‡‡Length of hospital stay, in days, median (range)	4.4 (0.6-23.9)	4.3 (0.6-13.2)	4.9 (1.9-23.9)	0.452
‡‡Length of hospital stay, in days, median (range)	10.1 (3.9-137.5)	9.8 (3.9-34.1)	13.9 (7.5-137.5)	0.080

*Significant differences were set at $p<.05$, p- values were **bolded** if they were significant.

† Categorical data were presented as n (%), and p-values were obtained using Chi-square test if cell frequencies were larger than 5, else Fisher's exact probability test were used.

‡ Continuous data were presented as Mean ± SD, and p-values were obtained using Mann-Whitney U test. EPR: estimated mean protein daily requirement, BMI: body mass index, SOFA: Sequential Organ Failure Assessment, APACHE II: Acute Physiology and Chronic Health Evaluation II, GORD: Gastro-oesophageal reflux disease

4.6.2 Differences in NIPPV (PROTEIN)

The type of NIPPV including BIPAP, CPAP, and NHF were not significantly associated with consuming either greater or less than 50% of EPR. Similarly, total hours on NIPPV were also not statistically significantly associated with 50% of EPR. See table 4.9 for NIPPV variables by protein groups.

Table 4. 9NIPPV variables by protein groups

Patients' variables		Total	Protein Groups		p-value
			< 50% EPR	≥ 50% EPR	
Total, n (%)		30 (100)	26(87)	4(13)	
†Type of NIPPV, n (%)					
	Yes	17 (57)	16 (53)	1 (3)	
	No	13 (43)	9 (30)	4 (13)	
	Yes	5(17)	0 (0)	5 (17)	
	No	25(83)	20 (67)	5 (17)	
	Yes	24(80)	5 (17)	19 (63)	
	No	6(20)	0 (0)	6 (20)	
‡‡Total time on NIPPV, hours, median (range)					
BIPAP		7 (0-26.5)	7.8 (0-26.5)	5 (0-25)	0.223
CPAP		0 (0-14)	0.7 (0-14)	0 (0-0)	0.284
NHF		17.5 (0-235)	16.3 (0-132)	27 (9-235)	0.172
NIPPV (including BIPAP, CPAP, NHF)		26.8 (6-235)	26.2(6-142)	34 (24-235)	0.172

*Significant differences were set at p<.05, p- values were **bolded** if they were significant.

† Categorical data were presented as n (%), and p-values were obtained using Chi-square test if cell frequencies were larger than 5, else Fisher's exact probability test were used.

‡ Continuous data were presented as Mean ± SD, and p-values were obtained using Mann-Whitney U test. EPR: estimated mean daily protein requirement, NIPPV: non-invasive positive pressure ventilation, BIPAP: Biphasic Positive Airway Pressure, CPAP: Continuous Positive Airway Pressure, NHF: Nasal High Flow.

4.6.3 Differences in nutrition (Protein)

Time to commencement of nutrition was not significantly associated with consuming 50% of EPR. Of the type of nutrition examined for this study, only PN was found to be associated with consuming 50% of EPR. All the patients who had PN (n=2) received significantly more protein (≥ 50% EPR) ($p=.023$). There were no statistically significant differences in the reasons for not having nutrition between <50% EPR group and ≥ 50% EPR group. Total hours for fasting were also not significantly associated with consuming 50% of EPR ($p=.139$). However, dietitian consult was made significant difference in protein consumption. Patients with dietitian consult were more likely to have greater EPR (>50% EPR) ($p=.011$). See table 4.10 for nutrition variables by protein groups. See table 11 for nutrition variables by protein groups. That means that a consult with a Dietitian would have a greater intake of protein.

Table 4. 10 Nutrition variables by protein groups

Patients' variables		Total	Protein Groups		p-value
			< 50% EPR	≥ 50% EPR	
Total, n (%)		30 (100)	26(87)	4(13)	
†Time to commencement of nutrition, n (%)					
	Yes	22 (73)	18 (60)	4 (13)	
	No	8 (27)	7 (23)	1(3)	
	Yes	3 (10)	2 (7)	1(3)	
	No	27 (90)	23 (77)	4 (13)	
	Yes	2 (7)	2 (7)	0 (0)	
	No	27 (90)	22 (73)	5 (17)	
	Yes	3 (10)	3 (10)	0 (0)	
	No	27(90)	23 (77)	4(13)	
†Type of nutrition, n (%)					
	Yes	20 (67)	18 (60)	2 (7)	
	No	10 (33)	7 (23)	3 (10)	
	Yes	2 (7)	2 (7)	0 (0)	
	No	28 (93)	23 (77)	5 (17)	
	Yes	2 (7)	0 (0)	2 (7)	
	No	28 (93)	25 (83)	3 (10)	
	Yes	1 (3)	0 (0)	1(3)	
	No	29 (97)	25 (83)	4 (13)	
	Yes	2 (7)	2 (7)	0 (0)	
	No	28 (93)	23 (77)	5 (17)	
	Yes	3 (10)	3 (10)	0 (0)	
	No	27 (90)	22 (73)	5 (17)	

Table 4.10 Nutrition variables by protein groups

			Protein Groups		
			< 50% EPR	≥ 50% EPR	
Total, n (%)		30 (100)	26(87)	4(13)	
†Reason for not eating/ nourished, n (%)					
	Yes	10 (33)	8 (27)	2 (7)	
	No	20 (67)	18 (60)	2 (7)	
	Yes	20 (67)	14 (47)	1 (3)	
	No	20 (67)	12 (40)	3 (10)	
	Yes	20 (67)	1 (3)	1 (3)	
	No	20 (67)	25 (83)	3 (10)	
	Yes	17 (57)	16 (53)	1(3)	
	No	13 (43)	10 (33)	3 (10)	
	Yes	9 (30)	8(27)	1 (3)	
	No	21 (70)	18 (60)	3 (10)	
	Yes	3 (10)	3 (10)	0 (0)	
	No	27 (90)	23 (77)	4 (13)	
	Yes	8 (27)	4(13)	4(13)	
	No	22 (73)	21(70)	1 (3)	
Total hours for fasting, median (range)		11.5 (0-59)	14 (0-59)	6.3 (0-20)	0.139

*Significant differences were set at p<.05, p- values were bolded if they were significant.
† Categorical data were presented as n (%), and p-values were obtained using Chi-square test if cell frequencies were larger than 5, else Fisher's exact probability test were used, the percentages have been rounded to the nearest figure.
‡ Continuous data with normal distribution was presented as Mean ± SD, and p-values were obtained using independent t-test.
‡‡ Continuous data with non-normal distribution was presented as median and range, and p-values were obtained using Mann-Whitney U-test
EPR: estimated mean daily protein requirement, ON: oral nutrition, EN: enteral nutrition, PN: parenteral nutrition, SOB: shortness of breath, ICU: intensive care unit, SD: standard deviation.

4.7 Nutritional status evaluated by BMI and biomarkers

Plasma albumin and haemoglobin (Hb) levels were obtained on the day of initiation of NIPPV (D1) and the day of NIPPV (D2) cessation. The mean albumin level on D1 was 29.1g/L (SD 6.3) while the mean albumin level on D2 was 27.2g/L (SD 3.7). Patients' mean plasma albumin levels were lower than normal (normal range 32-45g/L) on both D1 and D2. The mean Hb level on D1 was 110.1 g/L (SD 22) and the mean Hb level on D2 was 105.1 g/L (SD 20.9). Patients' mean Hb levels were also lower than normal (normal range- female: 115-165 g/L, male: 130-180 g/L) on both D1 and D2. See table 4.11 for the level of albumin and haemoglobin on the initiation and cessation of NIPPV. Patients were already undernourished when they were admitted to the ICU and their nutritional status became worse according to the haematology results during NIPPV therapy depending.

Table 4. 11 The level of albumin and haemoglobin on the initiation and cessation of NIPPV

		Mean ± SD	Minimum	Maximum
	Albumin (g/l)	29 ± 6	21	43
	Hb (g/l)	110 ± 22	65	157
	Albumin (g/l)	27 ± 4	20	36
	Hb (g/l)	105 ± 21	68	148

4.8 Incidence of aspiration pneumonia

Chest X-ray findings were reviewed by this researcher to determine if the study participants developed aspiration pneumonia during NIPPV therapy. There were no patients who developed aspiration pneumonia over the 14 weeks study period. Chest X-ray was not routinely checked for all the study participants that it was not able to check all the patients' chest x-ray results after the initiation of NIPPV therapy. One patient was admitted to the ICU with suspicious aspiration pneumonia due to dislocation of percutaneous endoscopic gastrostomy (PEG). This patient was on nil by mouth for 59 hours then initiated PEG feeding again. During the fasting, 5% dextrose IV fluid was administered. No overt symptoms of aspiration had been observed in this patient during NIPPV therapy in the ICU.

4.9 Summary

In summary of the findings, this study demonstrated current nutritional care practice provided to the patients receiving NIPPV therapy in the ICU. The results showed that the majority of study participants (n = 22, 73%) started nutrition within 24 hours from the initiation of NIPPV therapy and the most common type of nutrition was oral nutrition (n = 20, 67%). The most common reason for not having nutrition either oral or artificial nutrition, including enteral nutrition or parenteral nutrition, was poor appetite (n = 17, 57%), followed by breathing difficulties (n = 15, 50%), fatigue (n = 9, 30%), ICU procedure (n = 10, 33%), dysphagia (n = 3, 10%), and high risk of aspiration (n = 1, 3%). The study ICU had access to the services of an ICU dietitian but only eight patients were assessed by ICU dietitians and provided nutritional intervention.

There were significant differences between the mean daily actual energy and protein intakes and the minimum mean daily estimated requirements. The majority of the patients failed to meet their energy and protein requirements during the NIPPV therapy in the ICU, 70% and 83%, respectively.

The variables associated with consuming 50% of EER and consuming 50% of EPR were different. While receiving 50% of EER were significantly associated with total time on NIPPV, total time on NHF, total hours for fasting, and the time to commencement of nutrition after the initiation of NIPPV therapy, consuming 50% of EPR were statistically significantly associated with type of nutrition and ICU dietitian consult. The shorter time on NIPPV, the shorter time on NHF, and the longer hours for fasting the patients were the more the patients likely to receive < 50% of EER. In addition, patients who started nutrition within 24 hours from the initiation of NIPPV therapy tended to have < 50% of energy requirements ($p=.067$). On the other hand, patients with PN were significantly more likely to receive ≥ 50% of EPR. There were significantly more patients in the <50% EPR group among the patients who did not have ICU dietitian consult. Some variables showed a trend although there was no statistically significant association. There was a trend towards consuming < 50% of EER in the patients with higher APACHE II score ($p=.098$). This indicates patients with more severe disease were more likely to have lower energy intakes. In relation to protein consumption, there was a trend for older and increasing BMI the patients were, the more the patients received <50% of EPR.

Nutritional status was evaluated using plasma albumin and haemoglobin levels. The levels of albumin and haemoglobin both on the day of initiation of NIPPV therapy and the cessation of NIPPV were lower than normal indicating a degree of malnutrition.

This study also investigated the incidence of aspiration pneumonia and no patient developed aspiration pneumonia during the NIPPV therapy.

The next chapter discusses the main findings of this study with the findings of current similar studies using the research questions as a guide.

Chapter 5: Discussion

Although a plethora of studies on hospital (Iatrogenic) malnutrition exist, including those on malnutrition in ICU, this study is amongst a few to examine nutritional practices in ICU patients prescribed NIPPV. Both the literature reviewed and the results of this study confirm the ongoing high prevalence and suboptimal management of malnutrition in ICU.

In particular, findings of this study demonstrated that not only were patients malnourished on admission but that this worsened throughout admission. This was related to the finding that the oral consumption of nutrients for patients prescribed NIPPV therapy in the ICU failed to meet the required daily allowance for either energy or protein intake. Some of the multiple barriers to the provision of adequate nutrition were specific to this patient population and related to age, diagnose and the very nature of NIPPV. Other barriers corresponded with previously reported barriers to malnutrition in the general hospital population. One major barrier was a reliance on expert opinion and thus a lack of scientific rationale for not ordering oral or enteral nutrition. Although many patients in this study, who were prescribed NIPPV and ordered oral or enteral nutrition, were at risk for aspiration, no cases of aspiration were confirmed by clinical signs and symptoms or chest x-rays. This chapter uses the study's findings and the literature to critically respond to the research questions in the order they were presented in Chapter 1 and Chapter 4.

5.1 Demographics (summary of characteristics)

The mean age of patients in this study was similar to most studies of iatrogenic malnutrition, with a range from 57 to 76 (O'Leary-Kelley et al. 2005; Weng 2008; Peterson et al. 2010; Kim & Choi, 2011; Reeves et al. 2014). However, the current study participants' had slightly higher mean BMI (29.5 kg/m^2) than those in O'Leary-Kelly et al's (2005) study and Peterson et al's (2010) study with 26.9 kg/m^2 and 28.7 kg/m^2 respectively. It is found that the patients in this study were more severely ill according to APACHE II scores (23.1) compared to the patients in Peterson's et al's (2010) study (APACHE II: 28.7) and those in Reeves et al.'s (2014) study (APACHE II: 17.7). Most common reason for ICU admission in the current study patients was respiratory disease with 57%, which is the same as the other study participants. Kim & Choi (2011), O'Leary-Kelley et al. (2005) and Reeves et al. (2014) also reported the most common reason for ICU admission was respiratory disease with 18.8%, 31.7% and 66.6% respectively.

5.2 What is the current clinical practice regarding nutrition care for patients receiving non-invasive positive pressure ventilation (NIPPV) therapy in intensive care unit (ICU)? This first question was broken down into a subset of questions.

5.2.1 What is the time to commencement of nutrition after the initiation of NIPPV therapy?

This study investigated the time to commencement of nutrition after the initiation of NIPPV therapy. Early nutrition in this study described the commencement of any type of the nutrition within 48 hours after the initiation of NIPPV therapy. This pragmatic definition is consistent with that used in studies (Artinian, Krayem & DiGiovine 2006; Reignier et al. 2015) of mechanically ill patients and also in accordance with International nutritional care guidelines for critically ill patients which recommend early enteral nutrition or parenteral nutrition within 24-48 hours after the admission of the ICU namely, The Society of Critical Care Medicine (SCCM); American Society of Parenteral and Enteral Nutrition (ASPEN) guidelines (McClave et al. 2009); Canadian (Heyland et al. 2003; Dhaliwal et al. 2014); European (Kreymann et al. 2006; Preiser & Schneider 2011) and Australian Guidelines (Sanchez et al. 2014). Recommendations for early nutrition within 24-48 hrs fail to take into account the patient's diagnosis and length of illness, thus nutritional deficits, prior to admission to ICU/hospital. Thus, the current ritualistic definitions of early nutrition and recommendations for practice may be delaying the commencement of nutrition, which for some patients, should begin as soon as possible after admission.

In the current study, most patients (n = 25, 83%) commenced oral, enteral or parenteral nutrition within 48hours of the initiation of NIPPV therapy (<24hours: 73%, 24-48hours: 10%). This finding is different from others studies where doctors were reluctant to start nutrition due to the fear of aspiration (Macht et al. 2013; Bambi et al 2017). Although three patients did not start any type of nutrition during NIPPV therapy in this study, all of these patients stayed in the ICU less than 48hours. Considering this, the majority of the study patients undergoing NIPPV therapy received early nutrition in ICU. Although there are two studies on nutrition in NIPPV therapy, neither study included data on the time from ICU admission or commencement of NIPPV to when nutrition was commenced. A decision was therefore made, to compare this study's finding on time to commencement of nutrition with studies on mechanically ventilated patients.

Studies investigating the time to start of nutrition for mechanically ventilated patients found that the majority of patients commenced nutrition within 48 hours (Cahill et al. 2010; Kozeniecki et al. 2016; Stewart, Biddle & Thomas 2017). Cahill et al. (2010) conducted an international, prospective, observational, cohort study of mechanically ventilated adults' across 20 countries including Latin America, the UK, the U.S., Europe and Asia. The average time to the start of enteral nutrition was 46.5 hours which the authors stated adhered to nutritional guidelines. Stewart, Biddle & Thomas (2017) conducted a retrospective chart audit, on mechanically ventilated patients to evaluate the current state of enteral nutrition in a medical centre in the U.S. They utilised a 10% random sample of patients admitted to the ICU for around one year and audited a total of 69 charts. The study found that almost 70% of the patients commenced enteral nutrition within48 hours of the ICU admission. The median time to EN initiation was 32 hours (IQR, 18.5–75 hours) after ICU admission (Kozeniecki et al. 2016).

The time to start nutrition for ventilated patients appears to be different depending on the ICUs despite early nutrition has been proven to be beneficial to critically ill patients. Prior research revealed an association between early nutrition and reduced mortality (Artinian, Krayem & DiGiovine 2006; Reignier et al. 2015) and positive health related outcomes (Kotzampassi et al. 2009; McClave & Heyland 2009; Gunst et al. 2013) in critically ill patients.

A large retrospective multicentre study of 4,049 non-surgical patients admitted to ICUs receiving invasive mechanical ventilation (IMV) therapy showed that the 'early feeding group', started early enteral nutrition within 48hours after the initiation of IMV, had a lower ICU and hospital mortality compared to 'late feeding group' where enteral nutrition was commenced after 48hours of IMV onset (Artinian, Krayem & DiGiovine 2006). These results are consistent with a multicentre cohort study of 3,032 patients with shock receiving IMV therapy in ICUs (Reignier et al.2015). Reignier et al's (2015) study found that the patients who received early enteral nutrition or parenteral nutrition within 48 hours after intubation, had significantly lower risk of mortality compared to the patients who received nutrition late, 48hours after intubation.

Although the majority of patients receiving NIPPV therapy in the current study in a small ICU commenced early nutrition, further large studies should be conducted to confirm the extend of early nutrition in this population. In addition, research is required to retrospectively explore patients nutritional intake over the week prior to admission to determine and address reasons for malnutrition on admission and ensure that polices take into account. Patients' admission nutritional intake are more likely to be prescribed EN or PN.

Patients undergoing NIPPV therapy in the current study mainly received oral nutrition rather than EN or PN while invasively ventilated patients are not able to have oral intake. Further research is required to investigate the time to commencement of nutrition as well as the role of early nutrition in prescribed oral feeding for the critically ill patients undergoing NIPPV therapy.

5.2.2 What is the most common type of nutrition in the patients requiring NIPPV therapy?

In this study, the most common type of nutrition was oral nutrition.

Patients undergoing NIPPV therapy were mainly prescribed oral nutrition (n = 22, 73%) in the study ICU. However, not all patients were able to eat properly during NIPPV therapy. Patients who received NHF therapy were more able to have oral nutrition, whereas patients who received BIPAP or CPAP were less able to have oral nutrition despite facilitating oral feeding with a change to a nasal mask during mealtime. The patients who received BIPAP or CPAP therapy did not receive meals or “solids’ and only had sips of water. NIPPV guideline for critically ill adult patients with acute respiratory failure recommended not commencing oral nutrition if the patient has respiratory distress and unable to be off NIPPV (Sanchez et al. 2014). The guideline highlights maintaining strict fluid balance but does not mention monitoring or recording nutrient intake (Sanchez et al. 2014). The medical or nursing staff in the study ICU did not seem to be concerned about patients not eating during BIPAP or CPAP therapy. This could be related to their ICU NIPPV Policy/Procedures recommendation for the prerequisite of “No oral or NG intake” and no guidelines for nutrition throughout NIPPV (Thomas 2016). Ambiguous and conflicting recommendations were also found in all ICU NIPPV policies/procedures (Osteraas & Fuzzard 2001; British Thoracic Society 2002; Pilbeam et al.2006; Barnes 2007; Tamworth Base Hospital 2012; ResMedica 2014; Saskatoon Health Region 2016; ICSN and ICCMU 2017; Lowe 2017). Thus, patients will hardly achieve adequate nutrient intake if they are prescribed oral nutrition during BIPAP or CPAP without staff ensuring the adequacy of energy and protein intake and monitoring and responding to alterations in nutritional status.

In the study ICU, it was observed that patients receiving enteral or parenteral nutrition were automatically referred to ICU dietitians that these patients received nutritional intervention by the dietitian. Invasively ventilated patients only can receive artificial nutrition such as enteral or parenteral nutrition that all these patients have nutritional care by dietitian. However, the study ICU dietitians reported that there was no principle of dietitian referral for the patients receiving NIPPV therapy who prescribed oral nutrition and they were also concerned about nutritional status in patients receiving NIPPV therapy who had oral nutrition. In the study ICU, nutritional screening test was not performed as a routine ICU procedure. This implies that patients prescribing oral nutrition have a less chance to have dietitian consult even if they were already malnourished prior to ICU admission and their nutritional status is more likely to be worse. Previous studies have revealed that a considerable number of patients were malnourished or at risk of malnutrition on ICU admission (Kim & Choi-Kwon 2011; Reeves at all. 2014). Studies have also shown that patients with poor nutritional status on admission were more likely to be undernourished throughout the hospital stay (Kim & Choi-Kwon 2011) and their nutrient intake got worse (Reeves at all. 2014).

As oral nutrition is the first option that should be considered for patients requiring NIPPV therapy, the development of nutritional guidelines or protocols on how this should be evaluated are urgently required to ensure nutritional interventions are adequate.

5.2.3 What are the outcomes for patients who have ICU dietitian consult?

In the current study, patients who had an ICU dietitian consult were more likely to consume more than 50% of estimated protein requirements compared to those without a consult. Adequate protein requirements were calculated using 1.2g protein/ kg for patients with BMI <30 and ideal body weight (Female: 45 kg for the first 152.4cm plus 0.9kg for each additional cm, Male: 48kg for the first 152.4cm plus 1.1kg for each additional cm) for the patients with BMI ≥ 40 (McClave et al. 2009). The dietitian prescribed protein supplements such as protein powder or drinks containing high protein such as “sustagen’ thus ensuring a higher protein intake.

Despite the availability of a consult, the study did not closely involve the ICU dietitian in identifying and planning the nutritional needs of patients. While patients who had enteral nutrition or parenteral nutrition were expected to have dietitian consult according to international guidelines (Heyland et al. 2003; Kreymann et al. 2006; McClave et al. 2009; Preiser & Schneider 2011; Dhaliwal et al. 2014), only a small proportion of patients receiving oral nutrition were referred to ICU dietitians in this study. In the present study, only three patients who received oral nutrition were referred to the ICU dietitian during the NIPPV therapy. Considering most of the patients undergoing NIPPV therapy received oral nutrition (n= 25, 82%), a lack of dietitian involvement existed in the nutritional care for this population. This could be related, in part, to a deficit in ICU NIPPV policies/procedures in including explicit recommendation for dietitian referrals (Osteraas & Fuzzard 2001; British Thoracic Society 2002; Pilbeam et al.2006; Barnes 2007;

Tamworth Base Hospital 2012; ResMedica 2014; Saskatoon Health Region 2016; ICSN and ICCMU 2017; Lowe 2017).

Studies revealed that nurses lacked knowledge on nutritional care such as identifying patients with malnutrition or at risk of malnutrition, calculating adequate nutrient requirement, or proper type of nutrition regarding patients' condition (Mowe et al. 2008; Morphet, Clarke & Bloomer 2016). Furthermore, failure of many ICU medical staff to identify poor nutritional status does not confirm an awareness of negative clinical outcomes caused by malnutrition (Morphet, Clarke & Bloomer 2016). ICU nurses tend to rely on input from a dietitian when providing nutritional care (Morphet, Clarke & Bloomer 2016). However, nutritional care involving a dietitian is not a routine part of ICU practice.

The lack of routine dietitian consultation is also highlighted in a large prospective cohort study in 18 Canadian medical surgical wards. Of 750 randomly selected patients receiving oral nutrition, only 23% of the patients were referred to clinical dietitians (Keller et al. 2015). Kellet et al's (2015) study screened patients using subjective global assessment (SGA) tool and found that 75% of patients who were mildly or moderately malnourished (SGA B), and 60% of severely malnourished patients (SGA C) did not have dietitian consult during the hospital stay. Surprisingly, the patients with poor nutrient intake, consuming less than 50% of adequate requirements, were less likely to have dietitian consult (Keller et al. 2015). This finding reflects that there is no clear standard of dietitian referral and nutritional status for the patients with under-nutrition on admission are more likely to be worse during hospital stay.

Results of this study and other studies imply that patients are not provided adequate nutritional care even if they are malnourished on admission and the expected nutrient intake whilst on NIPPV will be minimal. This showed that patients receiving oral nutrition in hospital could be seriously undernourished. The current study participants and indeed any ICU patients prescribed NIPPV, would be at greater risk of being seriously undernourished compared to the patients in a general ward due to critical illness, the ICU environment, and acute respiratory failure. ICU NIPPV policies/ procedures for caring for patients with acute respiratory failure requiring NIPPV therapy (Sanchez et al. 2014) exist in every ICU, however, none of these policies/procedures adequately cover nutritional care required for this cohort of patients. There majority of these ICU NIPPV policies/procedures only recommended initiating oral nutrition if patients can tolerable time off NIPPV (British Thoracic Society 2002; Barnes 2007; ResMedica 2014; Saskatoon Health Region 2016; ICSN and ICCMU 2017) and others state to fast patients during NIPPV (Western Health 2016). There is no mention about nutrient intake but some highlight maintaining a strict fluid balance (Sanchez et al. 2014). Lack of dietitian involvement and no guidelines to direct nutritional care can certainly mean that patients' nutritional status are more likely worsen during NIPPV therapy.

As there was limited information for health professionals to access on screening, assessment and responding to nutritional needs in this population a review was undertaken of policies/procedures for NIPPV in ICUs to investigate if this also included information on medical and nursing staffs need to address nutrition. Although a policy/procedure on NIPPV existed in the study, it focused on the technical skills required to set-up NIPPV (British Thoracic Society 2002; Barnes 2007; ResMedica 2014; Saskatoon Health Region 2016; Thomas 2016; Western Health 2016; ICSN and ICCMU 2017). The ICU policies/procedures for NIPPV also mention 'No oral or NG intake' as a Prerequisite for commencing NIPPV (Tamworth Base Hospital 2012; Thomas 2016) and none mention the importance of providing adequate nutrient intake. In addition, very few NIPPV policies/procedures recommend referral to a dietitian. Only one policy states that dietitian assessments should be undertaken after 24 hours on NIPPV (ICSN and ICCMU 2017). Information in these ICU policies/procedures will also affect nurses' practice in that ensuring patients are be fasted during CPAP or BIPAP therapy.

According to a large European survey, wards with more frequently visits by dietitians were associated with doctors and nurses identifying undernourished patients more often and clinical patient focused nutrition had a higher priority (Thorensen et al. 2008). It can therefore be concluded that the more frequent consultations with dietitians, the higher the awareness of the importance of nutrition to doctors and nurses. This will contribute to early detection of patients with malnutrition or high risk of malnutrition and further interventions to improve nutritional status of the patients.

5.2.4 What factors interrupt nutrient intakes in patients while receiving NIPPV therapy?

5.2.4.1 Patients related reasons

The most common reasons for insufficient intake in the patients requiring NIPPV therapy in the current study were ‘no appetite’ (n= 17, 57%) and ‘respiratory distress’ (n=15, 50%). The bedside ICU nurses documented the reason for not eating on the food and fluid charts and wrote that more than half of the patients refused to eat due to the lack of appetite. This could indeed be a possibility but nurses documented reasons for patients’ lack of oral intake did not take into account the multi-factor reason for not eating. The cause of anorexia is multifaceted. For example, patients may develop anorexia during hospital stay due to an underlying disease, medical treatment, pre-existing psychological disease such as depression, social isolation and advanced age (Schütz et al.2014).One of the possible reasons for ‘poor appetite’ would also be associated with elevations in leptin (a protein secreted by adipocytes) during critical illness (Fantuzzi 2009). Leptin has been reported to act on the central nervous system and regulate appetite to satisfy hunger (Fantuzzi 2009) and the elevated levels of leptin may be an underlying factor in the poor appetite reported by many ICU patients (Peterson, Sheean, & Braunschweig 2011). Peterson et al. (2010) also reported that "anorexia" was the most common reason for not eating in a study of 50 patients’ post-extubation and weaned from mechanical ventilation.

5.2.4.2 NIPPV related reasons

Regarding the use of NIPPV, aerophagia can also cause a 'low appetite'. Aerophagia is a common side effect of NIPPV therapy, and about half of the patients experience these symptoms during NIPPV therapy (Gay 2009; Hemmink et al. 2009; Shepherd, Hillman & Eastwood 2013; Bambi et al. 2017). The symptoms of aerophagia includes abdominal distension, flatulence, excessive belching, diarrhoea, decreased appetite, and stomach gurgling (Hemmink et al. 2009; Shepherd, Hillman & Eastwood 2013). Therefore, patients may experience anorexia related to the use of NIPPV. Future research is required to investigate the relationship between aerophagia and nutrient intake of patients receiving NIPPV therapy to determine whether this complication is associated with a lack of nutrient intake and can be ameliorated.

Respiratory distress was the second most common reason for not eating (50%, n=15). Twelve out of the fifteen patients were provided respiratory support using BIPAP or CPAP. According to clinical observations, these patients were actually fasting while using BIPAP or CPAP. No patient in this study had oral nutrition during BIPAP or CPAP but had sips of water. They could not remove the mask due to difficulty breathing or replace the oro-nasal mask with the nasal mask; however, it was unclear whether there were any efforts to provide any nutrition to these patients. ICU nurses suggested that it was unsafe to provide oral nutrition during BIPAP or CPAP due to the risk of aspiration. Studies also addressed that some doctors were reluctant to commence nutrition for the fear of aspiration (Macht et al. 2013; Bambi et al. 2017). This was despite the lack of nutritional protocol or guideline for these patients in the study ICU. It appeared to be routine practice in both this and other ICUs for allowing patients to fast during BIPAP or CPAP therapy (Sanchez et al. 2014). In order to understand this practice a qualitative study is required to investigate nurses and doctors' perception and knowledge of the importance of nutritional needs of patients receiving NIPPV therapy, especially for the patients using BIPAP or CPAP, and their clinical nutritional care practice for this population in ICU.

5.2.4.3 Hospital related reasons

Missed meals was another reason for inadequate nutrition. The patients skipped at least one meal or snack with the reasons such as medical procedure (33%), fatigue (30%), dysphagia (10%), nausea/vomiting (7%), high risk of aspiration (3%), and other reasons (17%). Other reasons include 'diet was not ordered', 'tea trolley did not come up'. For a patient who received parenteral nutrition this was stopped because total parenteral nutrition (TPN) order for the next 24 hrs was not written. These results indicate nutritional care remains a low priority and nutrition appears to be considered as supportive care only and not part of routine therapy in the ICU. Because nutrition plays an important role in improving clinical outcomes (Singer et al. 2010; Faisy et al. 2011; Heidegger et al. 2013; Elke et al. 2014;), more attention should be paid to the nutritional care of patients treated in ICU.

Protein supplements prescribed by the dietitian were often milk protein based with flavouring. One patient refused to drink a protein supplement drink prescribed because she or he did not like the colour. Naithani et al. (2008) conducted qualitative semi-structured interviews on patients' reasons for not eating. They reported three barriers, including organisational barriers, physical barriers, and environmental factors. Organisational barriers include "unsuitable serving time, menu not enabling informed decision about what food met their needs, and inflexible ordering systems". Physical barriers include "not in a comfortable position to eat, food out of reach, utensils or packaging presenting difficulties for eating". Environmental factors included "staff interrupting during mealtimes, disruptive and noisy behaviour of other patients, repetitive sounds or unpleasant smells".

The roles of members of the health care team in identifying and responding to risks for or actual alteration in nutrition are not only poorly defined but health professionals are unware of their own and the roles of other members of the multidisciplinary team. Clearly, this constitutes a major barrier to the provision of timely and appropriate nutritional care. Several studies demonstrated that it was not health professionals' knowledge per se but the application of such nutritional knowledge in practice (references). Despite education on nutritional practice, there was no guarantee for improved nutritional screening or interventions.

Few patients in this study were screened for malnutrition by doctors or nurses nor were the results of any nutritional screening documented. This may be understandable in the first instance as the priority for medical and nursing staff was to address respiratory needs.

In addition, no tool was recommended or available for use by doctors or nurses in the study ICU. Bambi et al. (2017) indicated that because medical and nursing staff in ICU have to address all physiological needs the recommendation of a simple nutritional screen tool which can identify patients at risk and lead to a dietitian referral is warranted. A tool as simple as assessing BMI (kg/m2) and unintentional weight loss can be used as a criteria of malnutrition. A BMI of 18,5 kg/m^2 in the adult population is associated with increased mortality whereas a BMI 20 kg/m^2 is more appropriate in the elderly. Both the MST and SNAQ are also considered to be quick and easy tools for clinician use at the bedside (Ferguson et al. 1999; Anthony 2008; Neelemaat et al. 2008; Kruizenga et al. 2010). A caveat is however required when using quick and easy tools for although they are able to identify patents at risk for malnutrition it is essential that a more detailed nutrition assessment needs to be completed by the dietitian once a risk has been identified (Reeves et al. 2014; Bambi et al. 2017).

There is insufficient data on the barriers to inadequate oral intake in patients in ICU. Further research in the patients undergoing NIPPV therapy is required to better understand the personal patient variables for an inadequate food intake in this population. In this section, nutritional issues were discussed including early nutrition, type of nutrition, effect of dietitian consult and factors interrupting nutrient intake. What is also essential is knowledge of the degree of adequacy in whether nutritional interventions achieved clearly energy and protein requirements in ICU.

5.3 Are the patients adequately nourished? The second question was also broken down into a number of sub-questions.

This study and other studies on nutrition and NIPPV (Weng 2008; Reeves et al. 2014) found that patients were seriously undernourished during NIPPV therapy. Twenty-nine out of 30 patients were not adequately nourished comparing their actual energy or protein intakes to calculated energy or protein requirements.

5.3.1 Are there significant differences between average daily energy and protein intakes and estimated requirements in the patients requiring NIPPV therapy?

There were large differences between actual energy and protein consumption and estimated requirements. Daily estimated energy requirement (EER) was calculated by multiplying body weight by 25kcal/kg for the patients with a body mass index (BMI) of <30 and 11kcal/kg for the patients with BMI of ≥ 30 (McClave et al. 2009). Patients' daily estimated protein requirement (EPR) was calculated using 1.2g protein/ kg for patients with BMI <30 (McClave et al. 2009). Ideal body weight (Female: 45 kg for the first 152.4cm plus 0.9kg for each additional cm, Male: 48kg for the first 152.4cm plus 1.1kg for each additional cm) for the patients with BMI ≥ 40 (McClave et al. 2009). The present study found that the 30 adult patients (≥ 18yr) (53% female, 63±14 years, mean APACHE II score: 23.1 ± 7.92, and mean BMI 29.5 ± 8 kg/m2) who required NIPPV therapy in the ICU consumed a daily average of 544 ± 424 kcal and 29 ± 32 g protein. In this study, 29 (97%) patients did not reach adequate energy and protein requirements. Furthermore, 70% of the patients failed to receive 50% of energy requirements while 83% of the patients did not reach 50% of protein requirements (see figure 8 and figure 9 in chapter 4).

Intakes in the current study were significantly lower than those reported by Reeves et al. (2014). A prospective observational intake study conducted by Reeves et al. (2014) found that 36 adult respiratory patients (67% female, 65 ± 9 years, BMI: 31.6± 12.0, APACHE II scores: 17.7±5.4) who received NIPPV therapy consumed on average 1434 ± 627 kcal and 63 ± 29 g protein daily. Patients in Reeves et al.'s (2014) study were however less severely ill compared to those in current study according to APACHE II score, 17.7 and 23.1 respectively. Patients in Reeves et al's (2014) study includes not only the patients with acute respiratory failure admitted to the ICU but also patient admitted to respiratory ward with obstructive sleep apnoea (OSA), they would have had more sufficient time to off the mask during meal time with less serious illness. Evidence also demonstrated that acute phase patients had significantly lower nutrient intake compared to those with less seriously illness (reference). Reeves et al. (2014) found that three quarters of these patients consumed less than 80% of energy and protein requirements and reported consuming food and drink orally was associated with poor nutrient intake in the patients requiring NIPPV therapy (Reeves et al. 2014).

The average energy and protein intakes in Peterson et al's (2010) study (54% female, 59.1±14.5years, mean APACHE II score: 21.9±7.0, and mean BMI 28.7±7.2 kg/m^2) was similar to findings in current study. Over the 7 days included in the analysis, patients' daily average energy and protein intakes were 509-767kcal and 22-34g respectively (Peterson et al. 2010). The average actual energy and protein consumption did not reach adequate energy and protein requirements over the 7days, consuming only 33-55% of energy requirements and 23-37% protein requirements (Peterson et al. 2010). It is challenging for critically ill patients to meet nutrient requirements, especially for the patients who received nutrition through oral nutrition alone (Peterson, Sheean, & Braunschweig 2011; McClave et al. 2014). As the most common route of nutrition for the patients requiring NIPPV therapy is oral nutrition, strategies to improve the nutritional content of oral nutrition for this population should be established.

There is also the risk for considerable morbidity if oral nutrition is designated by medical staff as the optimal route for this population if food intake is not available during NIPPV therapy using BIPAP or CPAP in ICU. A nutritional guideline for critically ill patients recommends commencing enteral nutrition within three days of ICU admission if patients do not receive adequate nutrition via oral route (Kreymann et al. 2006). The current study revealed that patients were not able to eat while using BIPAP or CPAP due to respiratory distress or probably due to the risk of aspiration. Evidence showed that enteral nutrition using small bowel route helps to reduce the risk of aspiration or aspiration pneumonia in the patients with IMV (Invasive mechanical ventilation) (Methney et al. 2006). Eating is not just for providing nutrition but a source of pleasure, enhancing the quality of life. Encouraging oral nutrition is important if available, however, if patients are not able to have oral nutrition, other options should be explored. Small bowel feeding may help to nutrient intake for the patients receiving NIPPV therapy however patients will still real risk for aspiration so large bore vented NGT may be required to decrease air insufflation. Further studies are required to determine the optimal type of nutrition for the patients requiring NIPPV therapy.

Decision making concerning the optimal nutritional intake is also clouded by evidence that permissive caloric underfeeding during the early acute phase of critical illness (Arabi at al. 2011; Heyland et al. 2011) and with critically ill obese patients (Dickerson et al. 2002) is beneficial in significantly lowering hospital mortality and length of hospital stay. It is however essential that obesity is not considered as reason for permissive underfeeding. On the other hand, Elke et al. (2014) demonstrated that the provision of energy and protein requirements closer to the calculated daily needs was associated with a shorter duration of mechanical ventilation and lower sixty-day mortality with each additional 1000kcal/day and additional 30g of protein per day.

What is also problematic in calculation of appropriate nutrition in both this and previous studies is lack of knowledge concerning the severity of the patients' illness and patient nutritional history prior to admission to ICU. What is highly likely is that these patients are chronically undernourished prior to hospital admission and that implementing a gold standard of commencing nutrition replacement therapy within 48 hrs of ICU admission will be insufficient to correct the ongoing negative effects of chronic undernourishment.

5.3.2 What are different in variables between the two groups: patients receiving < 50% of estimated energy or protein requirements vs. patients receiving ≥ of estimated energy or protein requirements

In this study, patients who had a longer time on NIPPV (BIPAP, CPAP or NHF), longer time on NHF, less hours for fasting, and start nutrition within 24hours of the initiation of NIPPV were more likely to consume ≥ 50% of EER (See table 4-6 and table 4-7). A nutritional guideline for critically ill patients recommends providing at least 50-65% of energy requirement through enteral nutrition to achieve optimal therapeutic clinical benefits

(McClave et al. 2009). There were significant differences in the median time on NIPPV between the patients receiving <50% of EER and the patients receiving ≥ 50% of EER, at 25.3 hours and 40 hours respectively ($p=0.017$). Patients who received ≥ 50% EER were also significantly increased median time on NHF compared to those who received <50% EER, at 32 hours and 15.7 hours respectively ($p=0.039$). Although it is difficult to explain why the patients who were longer time on NIPPV or NHF received more energy intake, it can be assumed that the patients may become accustomed to eating while receiving NIPPV therapy as time in ICU increases. Unlike total time on NHF, total time on BIPAP or CPAP were not significantly different between the two groups (>50% EER and ≥ 50% EER). Compared to BIPAP or CPAP, patients in this study were much longer time on NHF (mean BIPAP hours: 7.9 ± 8.6 h, mean CPAP hours: 1.0 ± 2.9 h, mean NHF hours: 36.3 ± 50.2h); thus, patients would be more time on NHF rather than BIPAP or CPAP during a mealtime while receiving NIPPV therapy.

As discussed above, patients were less able to eat during BIPAP or CPAP while patients were more able to eat during NHF. The finding of this study is not consistent with the previous study finding conducted by Reeves et al. (2014). Reeves et al. (2014) found that insufficient energy for chewing, lack of appetite, not enough time between food consumption and mask application, and longer time on NIPPV were associated with poor oral intake. Reeves et al. (2014) did not present the type of NIPPV prescribed however, from the description of the research it is more likely to be a mask rather than NHF which does not require removing the mask for eating. However, the researchers reported the patients' nutrient intakes improved close to discharge. There was no explanation about this; however, it is possible that the patients could get used to eating on NIPPV as time goes by or have more time off NIPPV as their respiratory status improves. Peterson et al. (2010)'s intake study of patients who received oral nutrition after extubation reported that energy and protein intakes increased by around 10% on the 2nd day of oral nutrition compared to the first day of oral nutrition after extubation. The energy and protein consumptions remained almost same although there were little fluctuations in the nutrient intakes from day 2 to day 7.

Patients who were fasted longer were more likely to receive less than 50% of EER in this study. The mean total hours for fasting was 15.3 ± 13.6 hours and there was significant difference in the median fasting time between consuming <50% of EER group and ≥ 50% of EER group, at 16.5 hours and 5.3 hours respectively ($p=0.035$). It is not surprising that fasting longer determined patients received less energy intake. As previously discussed, the most common reason for not eating in this cohort as identified by ICU nurses were anorexia and respiratory distress. There are several studies investigating the fasting in critically ill patients in ICU. Common reasons for interruptions to enteral nutrition were fasting for diagnostic procedures, surgery and airway management (Segaran, Barkera & Hartle 2016).

5.3.3 What are the nutritional status of the patients receiving NIPPV therapy?

The majority of patients in the sample were classified as either overweight (34.8%) or obese (37.7%). Despite a high BMI, which may contribute to a “false sense’’ of nutrient adequacy, many patients were at nutritional risk due to delayed initiation of any type of feeding.

In this study, serum albumin and haemoglobin levels were used as indicators of nutritional status. The mean albumin and haemoglobin levels on the first day of NIPPV therapy were lower than normal value, 29 ± 6 g/l and 110 ± 22 g/l respectively. These levels decreased on the last day of NIPPV therapy with the mean albumin level of 27 ± 4 g/l and the mean haemoglobin level of 105 ± 21 g/l (See Table 4.11 in Chapter 4). According to the serum albumin and haemoglobin levels, the patients were already undernourished prior to the use of NIPPV therapy and their nutritional status deteriorated on the last day of NIPPV treatment. Serum albumin and haemoglobin are however not considered to be reliable biomarkers for assessing nutritional status in critical illness (Ridley, Gantner & Pellegrino 2015) because hypoalbuminemia and anaemia are common in critically ill patients especially in the acute phase of critical illness (Vincent et al.2014; Ridley, Gantner &

Pellegrino 2015). During the acute phase of critical illness, serum albumin often dramatically decreases due to biochemical diversity as a result of underlying disease (Nicholson, Wolmarans & Park 2000). Low haemoglobin is common in critically ill patients due to excessive blood loss or haemodilution. Critically ill patients often develop intravascular hypovolaemia requiring fluid resuscitation and therefore haemodilution, or have hypervolaemia which contributes to reducing haemoglobin concentration during the acute phase of critical illness (Walsh & Saleh 2006). Despite this, many studies still use serum albumin and haemoglobin levels as nutritional markers (Brugler et al. 2005; Flancbaum et al. 2006; Weng et al. 2008; Gout, Barker & Crowe 2009; Kim & Choi-Kwon 2011). Because of the nature of the observational studies, only data from the routine test results were available for this study and further testing was not available. Although serum albumin and haemoglobin levels cannot accurately represent nutritional status of this population, these results support the findings of a poor nutrient intake or energy requirement of these patients.

Previous studies showed that patients' initial nutritional status were significantly associated with either nutritional status or nutrient intake during hospitalisation (Kim & Choi-Kwon 2011; Reeves et al. 2014). Kim and Choi-Kwon (2011) found that patient's nutritional status deteriorated more in the patients with severe malnutrition than in the patients with mild or moderate malnutrition during ICU stay. Reeves et al. (2014) reported that better nutritional status was associated with improved nutrient intake in the patients receiving NIPPV therapy. These results indicate that early detection of malnutrition is important. Patients with serious malnutrition would benefit more from early nutritional support – on admission rather than within 48hrs of commencement of NIPPV. Guidelines therefore need to stress the need to take into account the severity of the patient's illness and history of nutrient intake prior to hospitalisation let alone the commencement of NIPPV. Future studies are required to evaluate initial nutritional status and nutritional status changes in patients undergoing NIPPV therapy using an accurate valid tool such as SGA or NUTRIC score to investigate the association between the two.

Nutritional status of the patients were poor, presenting low level of serum albumin and haemoglobin level, prior to use NIPPV therapy which worsened during NIPPV therapy. Although the biomarkers used in this study are not that reliable, when combined with history of poor nutrient intake and decreases in BMI they were sufficient to diagnose an alteration in nutritional status and malnutrition. In order to determine nutritional status of these populations, further studies comparing the validity and reliability of simple and easy bedside tools and use of these by nurses and doctors soon after admission.

5.4 What is the prevalence of aspiration pneumonia in the patients undergoing NIPPV therapy?

In this study, no patients developed aspiration pneumonia during NIPPV treatment. However, the results generated from this study implicate that patients undergoing NIPPV therapy have an increased risk of aspiration. In this study, more than half (53%) of the study participants had COPD, and the most common reason for NIPPV therapy was exacerbation of COPD (23%). As discussed in the literature review, patients with COPD are at increased risk of aspiration due to abnormal breathing and swallowing pattern. Gross et al. (2009) found that patients with stable COPD had disrupted coordination of the respiratory cycle with deglutition. For instance, while healthy individuals showed an exhale-swallow-exhale pattern, patients with COPD demonstrated an inhale-swallow-inhale pattern that increased the risk of prandial aspiration (Gross et al. 2009). Despite this, not every patient with COPD had a swallowing test in the study ICU. In this study, only few patients with serious dysphasia had a speech therapist consult and were prescribed a therapeutic diet called ‘smooth pureed diet’ to prevent aspiration. A careful assessment of the ability to swallow and cough before the commencement of oral nutrition must be a high priority to minimise the incidence of aspiration.

A mask interface can also contribute to aspiration pneumonia. All patients in this study used an oro-nasal mask when using BIPAP or CPAP. If the patient was vomiting and the patient was unable to release the mask strap quickly in this situation, he or she can aspirate the vomitus. Aerophagia, a common complication of NIPPV therapy, can cause abdominal insufflations (Hemmink et al. 2009; Shepherd, Hillman & Eastwood 2013). Although there may be differences depending on the degree of abdominal bloating, it can cause vomiting and this can be a risk factor for aspiration.

Studies showed that silent aspiration is a more common occurrence than overt symptoms of aspiration such as reflexive cough (Metheny et al. 2006; Macht et al. 2013). A prospective descriptive study of mechanically ventilated adults (n = 360) receiving naso-gastric tube feeding reported that 320 patients experienced more than one aspiration event. Among the 320 patients, only three patients had overt aspiration while the remaining showed silent aspiration (Metheny et al. 2006). Metheny and colleagues (2006) found a strong relationship between aspiration and subsequent pneumonia.

There is limited evidence describing NIPPV patients and aspiration. Aerophagia is a common complication of NIPPV (Gay 2009). Although prevalence of aspiration pneumonia is rare, aspiration is potentially more serious complication during NIPPV therapy (Gay 2009). Therefore, some doctors inserted NG tube when initiating NIPPV therapy in order to remove air from the stomach so that reduce aerophagia (Gay 2009). If reduced aerophagia, abdominal distension will decrease, contributing to reducing risk of aspiration (Bambi et al. 2017). However, Gay (2009) did not mention about type of NG tube: small bore or larger bore. This is a limitation for fails to provide sufficient information and rationale to guide professional practice. There is a dilemma using small or large bore NG tube for patients undergoing NIPPV therapy. In order to minimise air leak, using fine bore NG tube is recommended for enteral formula, but large bore vented NG tube will be preferable as can be used to administer EN and to decrease gastric insufflation and avoid risk of aspiration. Developing evidence based guidelines to provide adequate energy and protein requirement to minimise a risk of aspiration for the patients undergoing NIPPV therapy.

The literature raises several issues which are not adequately explored in recommendations or addressed in guidelines for the prevention of aspiration pneumonia. Firstly, type of NGT and rationale and secondly, position of patients ordered EN or oral intake with NIPPV. In respect to air leaks and NGT insertion advice is more weighted on the prevention of small air leaks than decreasing gastric insufflation and risk of aspiration by the insertion of a large bore vented NGT. The literature is however uncertain of the importance of small air leaks (Gay 2009; Bambi et al. 2017) and some authors consider these as less detrimental than initially thought and that decreasing air in the stomach by insertion of a large bore vented NGT was of equal import (Elliott 2004). Clearly, there is a lack of available evidence and current practice is based on local knowledge or expert opinion (Bambi et al 2017).

Although no patients developed aspiration pneumonia in the current study, these patients may possibly experience frequent silent aspiration, contributing to development of aspiration pneumonia. In addition, not all patients were ordered chest x-rays throughout their ICU stay. It is also important to note that although chest x-rays are the most commonly used diagnostic tool for identifying aspiration pneumonia that results indicative of aspiration pneumonitis may not develop until days later (Gossner & Nau 2013). More efforts to prevent aspiration should be made in this population. Effective strategies to minimise the risk of aspiration should be proposed and more attention should be given to aspiration prevention while caring for the patients undergoing NIPPV therapy despite none of the patients exhibiting aspiration in this study.

5.5 Conclusion

In conclusion, this chapter discussed the major findings of the current study in conjunction with the literature under the research questions. This study and a critical analysis of the literature revealed that the provision of adequate nutrition in patients with NIPPV continues to be problematic. Patients undergoing NIPPV therapy were at risk for serious undernourishment as they failed to consume even 50% of calculated energy or protein requirements. Despite this, nutrition still seems to be considered as supportive care and not included as a daily routine ICU care. Patients requiring NIPPV therapy commonly received oral nutrition, however, oral nutrition was challenging for these patients with anorexia, respiratory distress or a perceived risk of aspiration. Enteral nutrition will also be a problematic when providing nutrition with the ambiguous issues of type of NG tube.

With the lack of evidence on the effect of air leak for using large bore NG tube and risk of aspiration using fine bore NG tube. Although there are some nutritional recommendations in NIPPV policies/procedures for critically ill patients (see Appendix A.3), the guidelines very briefly mention nutritional care for these patients. Such advice includes nil by mouth prior to implementation of NIPPV (Tamworth Base Hospital 2012; Thomas 2016), commencement of oral food and fluids after a few hours on NIPPV if patients can maintain a patent airway for short periods of time (British Thoracic Society 2002; Barnes 2007; Tamworth Base Hospital 2012; ResMedica 2014; Saskatoon Health Region 2016; ICSN and ICCMU 2017)), nil by mouth for first 24hrs of NIPPV (Saskatoon Health Region 2016) nil orally throughout NIPPV (Western Health 2016), and referral to physician (Saskatoon Health Region 2016) or dietitian (ICSN and ICCMU 2017) after 24hrs decisions regarding nutritional and oral intake.

Patients undergoing NIPPV were therefore not afforded the opportunity for timely and appropriate nutritional care based on the best available evidence. In order to improve nutritional status or nutrient intake of this population, customised nutritional care guidelines for critically ill patients receiving NIPPV therapy should be developed for every critical care area. For this, more research on the nutrition of this population should be undertaken. The following chapter will provide conclusion of this study.

Chapter 6: Conclusion

In 1974 Butterworth was convinced that "iatrogenic malnutrition" was significant factor in determining illness outcomes and that malnutrition occurred more frequently in hospitals than in "rural slums or urban ghettos". Disappointedly, this current research project and the critical review of historical, international and current literature did not provided any evidence that disputes Butterworth's 1974 conviction. Indeed, patients admitted to ICU are already undernourished which worsens throughout hospitalisation. Furthermore, patients with acute respiratory distress who are prescribed NIPPV may not commence oral, Enteral or Parenteral nutrition until 48hours after admission.

This chapter presents the conclusion of this study in several sections and follows on from the discussion which explored similarities and differences between the research findings, the literature and research questions. The first section summarises the main research findings in relation to the research objectives. The second section discusses the strength of this study while the third section highlights the limitations of the study. The last section puts forward recommendations for future research directions as addresses the implication for health professionals' clinical nutritional practices and recommendations for the improvement of tertiary and continuing education.

6.1 Summary of main findings

The findings generated from this study indicate that patients receiving NIPPV therapy were not adequately nourished in ICU. The majority of the patients (97%) failed to meet adequate energy or protein requirements, and more than 70% consumed less than 50% of both energy and protein requirements. Critically ill patients usually receive EN or PN; however, this research revealed that patients undergoing NIPPV therapy were mostly prescribed but consumed little oral nutrition in ICU, contributing to a lower nutrient intake. An analysis of the literature suggested that the initial high positive pressure associated with NIPPV was a reason for not commencing oral nutrition in the first 24hrs. Anorexia was found to be the most common reason documented by RNs in this study for patients skipping meals. Anorexia was likely due to critical illness and aerophagia. Although it was not investigated in this study, 'aerophagia', a common complication of NIPPV, may lead to anorexia, contributing to undernutrition. Respiratory distress was reported by RNs as the second common reason for not eating meals. Patients using BIPAP or CPAP were not able to remove the mask for eating while those using NHF could eat whilst remaining on NHF. Although all nurses recorded the reason for not eating during BIPAP or CPAP was respiratory distress, some nurses when interviewed stated that eating food was not allowed for the patients due to the risk of aspiration. An analysis of the ICU policy/procedure for NIPPV on this ward (Thomas 2016) and other documented NIPPV policies (see Appendix A.3) located in a search of the World Wide Web provided support for the nurses' interpretation of the need for fasting for patients prescribed NIPPV. None of these documents used to guide NIPPV set-up, ongoing assessment and nursing care of patients prescribed NIPPV provided an evidenced based rationale for the need for patients to fast, or length of time fasting was required or recommendations for nutrition in this population. Nurses and medical staff decisions may be based on the ICU NIPPV policies/procedure which have minimal information on nurses or medical staff role in nutrition and recommendations are not based on best available evidence. Accordingly, nutrition support for these patients appeared to be inadequate.

Dietitians were not adequately involved in nutritional care for the patients who received oral nutrition. This research found a positive association between dietitian consult and consuming ≥ 50% protein requirements (The research found patients who had ICU dietitian consult were more likely to consume ≥ 50% protein requirements.) Parenteral nutrition was also positively associated with consuming ≥ 50% protein requirements. Total hours for NIPPV were significantly associated with consuming ≥ 50% energy while total hours for fasting was negatively associated with consuming <50% energy consumption. The majority of patients received NIPPV using NHF had increase energy intake. Serum albumin and Hb levels revealed that this population were already undernourished prior to the use of NIPPV therapy and the nutritional status deteriorated on the last day of NIPPV treatment. Although patients undergoing NIPPV therapy were commenced early nutrition, this did not result in them achieving expected energy or protein requirements.

This study indicated that nutrition was placed as a low priority in patients undergoing NIPPV therapy in ICU. This was confirmed by the absence of nutritional screening on ICU admission, a lack of ICU dietitian involvement, and no nutritional care protocol or nutritional care guidelines in place for this population. As nutrition plays a key role in improving clinical outcomes, strategies should be established to enhance nutritional care for these patients.

An analysis of clinical signs and symptoms and the results of chest x-rays showed that no patient developed aspiration pneumonia during NIPPV treatment. It must however be acknowledged that patients did not have daily chest x-rays and that radiographical signs of aspiration pneumonia may not appear for 2days post aspiration. Patients receiving NIPPV therapy do however have a higher risk of aspiration, which can cause aspiration pneumonia. Efforts to avoid aspiration should be ongoing, as frequent aspiration is a great risk factor of aspiration pneumonia. In addition, aspiration is closely related to nutrient intake, especially oral nutrition, and therefore, the relationship between oral/EN intake, NIPPV and risk for aspiration should be considered when studying nutrition in patients undergoing NIIPPV therapy. The advice regarding strategies to decreasing risk for aspiration for patients prescribed EN whilst on NIPPV is both confusing and ambiguous with some authors advising large bore vented NGT to decrease gastric distention whilst others a small bore for EN to decrease the risk for small air leaks.

It is unknown whether NIPPV use adversely affects patients' nutritional status or nutrient intake directly, however, the findings from this study demonstrated that patients have nutritional deficits, are malnourished on admission and have iatrogenic malnutrition.

6.2 Strength of the study

A strength of this study was that it demonstrated the overall nutritional care practice of the patients undergoing NIPPV therapy in ICU. To this researcher's knowledge, this study is the second study on nutrition in patients undergoing NIPPV therapy. While a previous study included patients admitted to the ICU or a respiratory ward (Reeves et al. 2014), this study enrolled patients only from ICU to explore the current clinical nutritional care practice given to the patients requiring NIPPV therapy, particularly treated in a critical care setting. This researcher accessed all possible resources, such as fluid intake chart, ICU flow chart, dietitian and medical notes, to ensure completeness of nutritional intake data, assessment and recommendations for interventions. This study also considered all sources of energy and protein such as supplements, snacks, extra food intakes that were not provided by the hospital and which may provide a significant source of energy or protein. This study is an observational study and the ICU nurses recorded patients' nutrient intakes. The study participants would consume the food without being conscious of their food intake being observed, therefore, participant bias was eliminated. The variables associated with consuming 50% energy and protein requirements found in this study would be useful for the future larger study to investigate causal relationship between the variables and nutrient intake.

6.3 Limitations of the study

There are several limitations of this study, and the results should therefore be interpreted cautiously. Average daily energy and protein intakes were calculated using total energy and protein intakes from the initiation of NIPPV until cessation of NIPPV therapy. Patients' intake, particularly, oral intake may have improved once the acute phase of their illness resolved or the patients became used to hospital meals. Reeves et al. (2014) found that patients' nutrient intake increased closer to discharge. Regarding the food and fluid chart completed by ICU nurses, there may be a bias towards approximation; however, this is an inherent limitation to this methodology, which may have been somewhat reduced by providing the completed sample food and fluid charts as references to ICU nurses. In this study, a simple predictive equation for critically ill patients was used to determine adequate energy requirements.

Ideally, using indirect calorimetry is the most accurate method for measuring energy requirements (Strachan & Friend 2016). However, this is not always possible in the clinical setting because it is costly and requires trained personnel (O'Leary-Kelley et al. 2005; Marino 2014). To date, there are no equations available to estimate energy needs for patients requiring NIPPV therapy, so the adequate energy requirement calculated in this study will not be as accurate as the energy requirement calculated by indirect calorimetry. Nutritional status was evaluated using haematology results including serum albumin and haemoglobin levels, known to be unreliable biomarkers for evaluating nutritional status. However, due to the nature of the observational studies, further testing to assess nutritional status was not possible.

The purpose of a quantitative study is to generalise results (Polit & Beck 2012). Due to the small sample size and not using random sampling, the patients in this study may not be representative of the general population undergoing NIPPV in ICU. There were several difficulties recruiting participants. The study ICU was small with only 11 beds and data collection occurred during the summer season when historically the number of patients admitted to ICU with respiratory disease requiring ventilator support is lower than in winter months (Donaldson & Wedzicha 2014). For these reasons, it was not possible to recruit more than 30 patients. However, the data obtained from this study will lay the foundation for future lager studies and inform subsequent power calculations (Leon, Davis & Kraemer 2011).

6.4 Recommendations for practice and future research directions

This section takes the opportunity to express how this study findings support recommendations for research, policies, practice and education. It will explore additional research required and outline possible measures to guide future researchers, health care organisations, educational organisations and health care professionals.

6.4.1 Nutritional protocols/procedures or guidelines

Patients undergoing NIPPV therapy were poorly nourished and were not provided evidence-based nutritional care in ICU. Although an ICU policy/procedure on NIPPV existed in the study, it focused on the technical skills required to set-up NIPPV while not adequately covered nutritional care required for this cohort of patients. The majority of existing NIPPV policies/procedures provide insufficient recommendations to ensure evidenced based nutritional care. For example, 'initiating nutrition when patients are tolerable to remove NIPPV' or 'fast patients either during NIPPV therapy or prior to NIPPV therapy, as a prerequisite for commencing NIPPV' are ambiguous and insufficient to guide nutritional care. ICU NIPPV policy/procedures for patients with acute respiratory failure only highlights the need for strict fluid balance which is an instruction for a need for timely documentation of fluid rather than explicit guidelines for ensure fluid balance. No policies/procedures or guidelines which provide a link to, or reference to National Nutritional Guidelines for patients admitted to ICU or possess the potential to guide ICU doctors and nurses in the provision of timely, evidenced based practice were located. Nurses and medical staff decisions may be based on the ICU NIPPV policies/procedure which were founds to have minimal information on nurses or medical staff role in nutrition and recommendations were ambiguous, contradictory and not based on best available evidence. With the lack of practice based nutritional care guidelines, it is not expected that patients would receive nutritional care which maintained or improved nutritional status during NIPPV therapy in ICU.

Recommendation

- The appointment of a Multidisciplinary national team including ICU medical and nursing staff, dietitians and pharmacists to develop nutritional protocols or nutritional guidelines tailored for patients undergoing NIPPV therapy especially for the patients receiving oral or enteral nutrition in ICU and to provide evidenced based rationale for recommendations.

- A multi-site randomised control trial to investigate the effect of fasting during or prior to NIPPV therapy (eg. incidence of aspiration pneumonia; changes in nutritional status) and total hours for fasting.

- A multi-site randomise control trial to investigate the optimal time of initiation of nutrition for the patients receiving NIPPV therapy which takes into account patients dietary history prior to admission and nutritional status on admission.
- A multi-site national randomise control trial to investigate the effect of the timing of the commencement of oral or enteral on patients', receiving NIPPV therapy, nutritional status and health care outcomes. In developing this study the research team would need to further examine the definition of early nutrition as that provided in first 48hrs after commencement of NIPPV/ or admission to ICU in order to address the nutritional requirements for patients who are already malnourished on admission. It would be advantageous if the study above compared nutritional outcomes for the provision of: (1) nutrition on ICU admission, (2) early nutrition (within 24hrs of admission to ICU), (3) intermediate nutrition (within 48hrs of admission to ICU) and (4) late nutrition (after 48hrs of admission to ICU).

6.4.2 Health professional knowledge

Lack of knowledge was found to be a significant factor that interrupts the provision of adequate nutritional care. Doctors reported they did not feel comfortable when they advised on nutritional issue. Doctors and nurses have insufficient training for nutritional care during their undergraduate course. Despite the fact that doctors in many critical areas prescribe nutrition this is often dependent on their personal opinion and experience. Nurses have a role to provide direct nutritional care at the bedside but at this stage are not fulfilling this role in ensuring adequate nutrition for patient prescribed NIPPV. Dietitians were the most preferable human or material resource for nurses for any inquiries about nutrition however there was inadequate referral to dietitians and therefore unsatisfactory dietitian involvement in the nutritional assessment and management of patients receiving NIPPV treatment. In this circumstance, ICU health professionals will rely on NIPPV policies/procedures. However, the existing NIPPV policies/procedures provide minimal information on nutritional care such as timing the initiation of oral nutrition or prerequisite for commencing nutrition or the provision of any recommendations on nutrient intake. Thus, evidence based guidelines for caring for patients receiving NIPPV therapy or nutritional education programmes for the ICU nurses and medical staff is required if patients prescribed NIPPV are to be provided nutritional care throughout their admission which meets required energy and protein requirements.

Recommendation

- Development, piloting, implementing and evaluating a case-based nutritional training program for doctors and nurses conducted by dietitian either face-to-face or using interactive on line learning.
- Development and implementation of a ICU NIPPV policy/procedure by MDT which include a dietitian which includes explicit reference and rationales to guide nurses and doctors assessment, provision of timely nutritional care, referral to dietitian as an integral component of routine ICU NIPPV practice.
- Research to investigate nurses and doctors' knowledge on nutritional care for patients prescribed NIPPV treatment.
- Research to investigate medical and nursing students' exposure to nutritional practices while on clinical practice and submit a report to universities which incorporates suggestions to improve student exposure.

6.4.3 Health professionals' nutritional practice

Critically ill patients are already likely to be have deficits in nutritional status prior to ICU admission. However, for many of them nutritional deficits are undiagnosed and remained untreated with malnutrition and nutritional status worsening during hospitalisation. Nutritional screening is not performed as a routine practice in ICU and studies showed that nurses had difficulties with detecting patients with malnutrition or at risk of malnutrition despite many simple nutritional screening tools published. On admission nutritional status affects nutrient intake and nutritional status throughout the whole hospital stay, thus early detection and early treatment of malnutrition is important.

Recommendation

- Research on ICU nurses and doctors' experiences of using a simple nutritional screening tool as routine practice including the appropriateness of subsequent nutritional interventions.

- Implementing a hospital policy that early referral to dietitian for patients screened as malnutrition or at risk of malnutrition on admission so that the patients provide early nutritional care.

6.4.4 Nutritional barriers

Patients receiving NIPPV therapy are not required sedation; thus, oral nutrition seems to be the currently most common type of nutrition for these patients. A paucity of studies have investigated factors interrupting oral intake for critically ill patients or investigating nutritional barriers for patients receiving NIPPV therapy. In order to improve oral intake of these patients, in-depth qualitative studies for both patients and nurses are required.

Recommendations

- Conducting semi-structured qualitative studies to obtain real experiences and patients' perceptions regarding oral nutrition in ICU.
- Conducting semi-structured qualitative studies to obtain doctors', nurses' and ICU dietitians' perceptions regarding nutritional care for the patients receiving oral nutrition in ICU.
- Conducting randomised control trial to investigate causal relationship between the variables obtained from this study, which were related to consuming < 50% or ≥ 50% of energy or protein requirement, and nutrient intake to determine the predictors interrupting adequate nutrient intakes during NIPPV therapy (eg. time on NIPPV therapy, dietitian consult, time to commencement of nutrition etc.)

6.4.5 Prevention of aspiration

Aspiration is a serious complication of NIPPV therapy and doctors tend to be unwilling to start nutrition for these patients. NIPPV guidelines for the patient with acute respiratory failure treated in ICU provide insufficient evidence for the nutritional care and more focus on preventing aspiration, advising no nutrition prior to NIPPV therapy and only highlighting strict fluid balance without mention of nutrient intake. However, there is no published evidence to show the prevalence of aspiration pneumonia in patients receiving NIPPV therapy.

There is a dilemma using either small bore or larger bore vented NG tube during EN. Using large bore vented NG tube for decompression and feeding has the potential to decrease risk of aspiration but also can contribute to small air leaks. Using fine bore NG tube can minimise air leakage but not able to decompress the stomach. Optimal type of enteral nutrition and amount over time needs to be investigated and also the effect of air leakage and degree of gastric insufflation gastric while using large bore vented NG tube versus small bore feeding tubes.

Recommendation

- Developing nutritional guidelines or protocols to minimise the risk of aspiration for the patients receiving oral or enteral nutrition while undergoing NIPPV therapy.
- Investigating the prevalence of aspiration pneumonia during NIPPV therapy with prospective approach.
- Research is required to compare the effect of large bore vented NG tube and small bore regarding air leakage and degree of gastric distension
- Investigating optimal type of nutrition for the patients receiving NIPPV therapy.

6.5 Summary / Conclusion

This thesis demonstrates that malnutrition in patients admitted to ICU for NIPPV is consistent with findings of numerous studies of the unacceptable prevalence of iatrogenic malnutrition for hospitalised patients including those admitted to ICU. It also confirmed that nutritional assessment and interventions including referral to dietitians for patients who were often also malnourished on admission was not routine practice. The appropriateness of recommendations for assessment of nutritional risk to be performed within 24 to 48 hours was also questioned for this population of patients established to be at high risk for malnutrition based on evidence of malnutrition on admission, disease severity based on APACHE II and SOFA scores and treatment with NIPPV. Consideration should therefore be made for nutritional assessment by dietitians as soon as feasible after initial resuscitative interventions. Further research and expert consultation was recommended in the development of more visible guidelines for the commencement of oral or enteral nutrition in patients admitted to ICU and prescribed NIPPV. Such guidelines should more clearly articulate rationales for nursing and medical interventions including reasons for recommending fasting whilst patients on NIPPV, reasons for use of either large bore vented NGT or small bore feeding tubes for patients commenced enteral nutrition and referral to dietitians.

Nutrition should not be considered as an either adjunctive or supportive care when caring for critically ill patients but as an integral and regular part of ICU care if substantial short and long term outcomes are to be achieved. Developing nutritional care guidelines based on evidence-based practice and implementing nutritional care protocols is urgent for the patients receiving NIPPV therapy in ICU. Although this study was a small exploratory study, the findings from this research will contribute to providing background knowledge on nutrition in patients receiving NIPPV therapy in ICU.

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APPENDICES

Appendix A. 1 Summary of reviewed articles

Author(s)	Year	Study details	Major findings	Weakness/strength	Theme/ significance	Level of evidence/ clinical impact
Alberda et al.	2009	167 ICUs in 21 countries Prospective observational study to examine the relationship between the amount of energy and protein administered to critically ill mechanically ventilated adult patients (>18yo) and clinical outcomes, and the extent to which pre-morbid nutritional status influenced this relationship 2,772 Patients were followed prospectively to determine 60-day mortality and number of VFDs. Patient demographics and the type /amount of nutrition received were	Average energy intake was 1,034 kcal/ day Average protein intake was 47.1 g/ day Increased energy intake (+1,000 kcal/day) significantly decreased 60-day mortality (OR=0.76, 95% CI: 0.61-0.95, P=0.014) and increased VFDs (3.5 VFDs, 95% CI:1.2–5.9, p = 0.003). The effect of increased calories associated with lower mortality was observed only in patients with a BMI<25 or >35 with no benefit observed for patients with a 25 <BMI <35	**Weakness** Study design cannot prove causality BMI inadequate as the only tool to define nutritional reserve. **Strength** The large number of subjects enrolled from multiple critical care units across five different continents enhances the generalisability of the findings		II Moderate

		recorded daily for a maximum of 12 days Nutritional status was measured using BMI (kg/ m2).				
Aquilani et al.	2003	Italy Prospective observational study to investigate the nutritional adequacy and energy availability for physical activity in free-living, clinically stable patients with CHF. Total energy expenditure (TEE), calorie intake (kcalI), and nitrogen intake (NI) recorded using a seven-day food diary by non-obese patients with CHF (52 males and 5 females), and matched with 49 healthy subjects (39 males and 10 females) Total nitrogen excretion (TNE), and energy availability (EA = kcalI − resting energy expenditure) also calculated	kcalI and NI were similar between groups. CHF kcalI was <TEE (−186 ± 305 kcal/day vs. + 104.2 ± 273 kcal/day of controls; $p < 0.01$). Nitrogen balance was negative in CHF patients (−1.7 ± 3.2 g/24 h vs. + 2.2 ± 3.6 g/24 h in controls; $p < 0.01$) Energy availability in CHF patients was 41% lower than in controls ($p < 0.05$).	**Weakness** Food diary inaccurate; Small sample size **Strength** Very detailed description of methods (reliable)	Utilisation of NIPPV and NIPPV-associated pneumonia are under-reported. Although the incidence of pneumonia associated with NIV was significantly low compared to invasive ventilation, severity of the disease was the same.	II Moderate
Arabi et al.	2011	Saudi Arabia	Twenty-eight-day all-cause mortality was lower in the	**Weakness:** Single centre study		II Moderate

		A 2X2 factorial, randomized, controlled study to examine the effect of permissive underfeeding (60-70% of calculated needs) compared with that of target feeding (90-100% of calculated needs) and of intensive insulin therapy (IIT) compared with that of conventional insulin therapy (CIT) on the outcomes of critically ill patients.	permissive underfeeding group (18.3%) than in the target feeding group (23.3%; RR 0.79; 95% CI 0.48, 1.29; p = 0.34) Hospital mortality was lower in the permissive underfeeding group (30%) than in the target group (42.5%; RR 0.71; 95% CI 0.50, 0.99; p = 0.04). No significant differences in outcomes between the IIT and CIT groups	Researcher' bias (blinding was not achieved) **Strength:** RCT Small sample size but power analysis The first RCT to compare permissive underfeeding to target feeding with EN		
Burns et al.	2009	Systematic review and meta-analysis of randomised and quasi-randomised controlled trials to summarise the evidence for early extubation with immediate application of non-invasive ventilation compared with continued invasive weaning on important outcomes (mortality, VAP, hospital/ICU length of stay, ventilation days) in intubated adults with respiratory failure	12 trials enrolling 530 participants, mostly with COPD Compared with invasive weaning, non-invasive weaning was significantly associated with reduced mortality (relative risk 0.55, 95% confidence interval 0.38 to 0.79), ventilator associated pneumonia (RR 0.29, 95% CI 0.19 to 0.45), length of stay in intensive care unit (weighted mean difference -6.27 days, -8.77 to -3.78) and hospital (WMD -7.19 days, -10.80 to -	**Weakness** Publication bias **Strength** Robust methodology	Malnutrition contributes to pneumonia risk in patients with high rates of aspiration.	I Substantial

			3.58), total duration of ventilation, and duration of invasive ventilation. Non-invasive weaning had no effect on weaning failures or weaning time.			
Cahill et al.	2010	158 ICUs in 20 countries Prospective observational study to describe current nutrition practices in intensive care units and determine “best achievable” practice relative to evidence-based CPGs Demographics, diagnosis and nutritional data collected for 2,946 patients treated with invasive mechanical ventilation Participating ICUs provided information describing the characteristics of their hospital and ICU and general aspects of nutrition practice (e.g., use of feeding protocol or algorithms).	High adherence to CPGs recommendations regarding use of EN in preference to PN, glycemic control, lack of utilization of arginine-enriched enteral formulas, delivery of hypocaloric parenteral nutrition, and the presence of a feeding protocol Large gaps between CPG recommendations and current practice included: Long average time to start of EN (46.6h; site average range, 8.2 – 149.1 hours); Low utilisation of motility agents (58.7%) and small bowel feeding (14.7%) as strategies to optimize EN in patients with high gastric residuals; Low average nutritional adequacy for energy (59%) and protein (60.3%)	**Weakness** NIPPV patients were not included Participants were voluntary; thus, potential for response bias. Uses Critical Care Nutrition CPGs developed in Canada; these recommendations may not represent the standard of care for all ICUs around the world participating in this survey. **Strength** The observation of actual nutrition practices compared with evidence-based recommendations in a large sample of ICUs across 20 countries.	Lack of nutritional teams indicates nutrition is a low priority in ICU/HDU in UK	II Moderate

Carron et al.	2013	Systematic review and meta-analysis of 62 RCTs (total 5870 adult patients) published between January 1990 and August 2012 and conducted in clinical setting Aim: To comprehensively review the published literature on the pathophysiology and the management of complications associated with NIV	Major NIV complications: pneumonia, Barotrauma, haemodynamic effects Air pressure and flow-related complications: Air leaks, nasal or oral dryness and nasal congestion, airway dryness, gastric insufflations and aerophagia	**Weakness** Publication bias **Strength** Robust methodology		I Substantial
Carron et al.	2014	Italy Prospective randomized study to investigate the effectiveness of NIPPV using helmet interface (H-NIPPV) as a weaning approach (n=32) in ICU patients with ARF compared to conventional invasive weaning procedure (n=32).	Significant reduction in mean duration of IMV (by 8days, p<.0001) in the H-NIPPV group Incidence of VAP: IMV group-10/32 (31%), H-NIPPV group-1/32 (3%) (p=0.018) No statistically significant difference in ICU or hospital survival between groups	**Weakness** Small sample size Risk of systematic bias (H-NIPPV conducted by a specially trained skilled team) Risk of researchers or assessors' bias: no blinding **Strength** RCT Small sample size but power analysis	This article demonstrates all possible complications when using NIV; thus, it provides some information that could be related to nutrition in patients receiving NIV, such as gastro insufflations and aerophagia.	II Moderate
Crimi et al.	2010	Europe (25 countries) Web-based survey of 530 selected physicians to identify the pattern of NIPPV	51.3% response rate (272/530) A significantly higher proportion of pulmonologists (52.9%) reported > 20% of	**Weakness:** Selection bias; Location bias/differences **Strength:**	Small sample numbers in individual studies but evidence consistently indicates positive	IV Not rated for clinical significance

		utilisation and the reasons for choosing a specific ventilator and interface type	patients treated with NIPPV per year compared to intensivists /anaesthesiologists (34.3%) or other practitioners (12.6%) (p<0.05). The most common indications of NIPPV were acute hypercapnic respiratory failure (AHRF) and cardiogenic pulmonary oedema (CPO) Oro-nasal mask was the most frequently used NIPPV interface overall (p<0.01).	Pilot testing increased reliability; Relatively high response rate	effects of NIPPV on hospital mortality and VAP rates	
Daniels et al.	1988	USA Case series to determine the frequency and clinical predictors of aspiration within 5 days of acute stroke Assessed swallowing, dysphagia and aspiration in 55 consecutive adult male stroke patients with a new neurologic deficit in a tertiary care centre.	Aspiration in 21/55 patients (38%); 7/21 (33%) overt aspiration and 14/21 (67%) silent aspiration Predictors of silent aspiration (chi-square analyses) included dysphonia, dysarthria, abnormal gag reflex, abnormal volitional cough, cough after swallow, and voice change after swallow Logistic regression showed abnormal volitional cough in conjunction with cough with swallow predicted aspiration with 78% accuracy 1/55 (1.8%) developed aspiration pneumonia during the course of hospitalisation	**Weakness** Selection bias Small sample size Outdated **Strength** Use of sensitive swallowing test		IV Moderate

Diaz et al.	2005	Spain Prospective, open, non-controlled study to (1) evaluate the safety and effectiveness of NIPPV in patients with ARF and severe neurologic deterioration (coma; GCS ≤ 8) compared to those with GCS > 8 (without coma), and (2) determine the variables that predict the lack of response to NIPPV therapy in patients presenting with coma Included 958 consecutive patients (GCS ≤ 8: n = 95; GCS > 8: n = 863) presenting with ARF and treated with NIPPV in ICU NIPPV success defined as response to therapy allowing patient to avoid intubation, and survival in ICU plus an additional 24h on ward	NIPPV more successful in coma patients (80%) than in patients without coma (70.1%); p = 0.0434 Hospital mortality rate was not significantly different (26.3% and 33.2%, respectively; p = 0.1706). COPD was the most common disease underlying ARF in coma patients (66/95; 69.4 %) Complications associated with NIPPV in coma patients included: skin ulceration (n=23), gastric distension (n=5), vomiting (n=3), and pulmonary aspiration (n=1) Lack of response occurred in patients with higher acuity of illness and organ failure scores Improvements in GCS score, pH, $PaCo_2$, and PaO_2/FiO_2 ratio within the first hour of NIPPV therapy correlated with response to therapy	**Weakness** Selection bias: mostly hypercapnic coma so generalisation to all coma patients not possible **Strength** Large sample size		III-2 Moderate
Dickerson et al.	2002	USA Retrospective analysis to compare the nutritional and clinical efficacies of eucaloric	Hypocaloric group had a shorter stay in the ICU (18.6 +/- 9.9 d versus 28.5 +/- 16.1 d, P < 0.03) and decreased duration of antibiotic therapy	**Weakness:** Small sample size Selection bias Only enrolled critically ill obese patients, the		III-2 Moderate

		(≥20kcal/kg of ideal body weight per day) and hypocaloric (<20kcal/kg of ideal body weight per day) enteral feedings in 40 critically ill, obese patients (>125% ideal body weight) admitted to the trauma or surgical ICU.	days (16.6 +/- 11.7 d versus 27.4 +/- 17.3 d, P < 0.03)	results might not the same as critically ill patients with healthy weight/underweight **Strength:** Homogenous sample Provide evidence on effective amount of feeding for critically ill obese patients		
Dupertuis et al.	2003	Switzerland Prospective observational study to assess the ability of the hospital meal service to meet patients' nutritional needs Included 1,416 patients in a University hospital who received 3 meals/day without artificial nutritional support Food provided, eaten and wasted monitored over 24h then compared to minimum needs (Harris–Benedict formula for energy, and 0.8 g of protein/kg of body weight/day) and recommended needs (110%	Less than 10% of the patients considered hospital meals to be unacceptable Most common reasons for inadequate eating were inadequate taste and absence of choice Inadequate time also contributed to inadequate intake, especially for patients treated in acute care setting Under-nutrition calculated for 45% of patients when assessing minimum needs 70% of patients were undernourished when assessing recommended needs	**Weakness** Short study period **Strength** Large sample size Investigating the reasons of inadequate food intake in clinical staff's point of view as well as patients' opinion.	Managing barriers to oral intake in early days post-extubation may reduce under-nutrition	II Moderate

		Harris–Benedict formula for energy and 1.2 or 1.0 g of protein/kg of body weight/day for patients < or ≥65 years old, respectively) Patients evaluated meal quality on scale of 0-10 Reasons for insufficient food intake were investigated using questionnaire by patients and nursing staff	The food intake of 572 (59%) of these underfed patients was not affected by disease/illness			
Elke et al.	2014	737 ICUs in 33 countries Retrospective analysis of pooled data from the International Nutrition Survey (INS) and baseline data from the Enhanced Protein-Energy Provision via the Enteral Route in Critically Ill Patients (PEP uP) study to evaluate the effect of energy and protein amount given by EN on clinical outcomes in a large cohort of critically ill patients with an ICU admission diagnosis of pneumonia and sepsis (n = 2,270).	An increase in energy intake of 1,000 kcal per day was associated with reduced 60-day mortality (OR 0.61; 95% CI 0.48 to 0.77, p <0.001) and more ventilator-free days (2.81 days, 95% CI 0.53 to 5.08, P = 0.02) An increase in protein intake of 30g per day was also associated with reduced 60-day mortality (OR 0.76; 95% CI 0.65 to 0.87, p <0.001) and more ventilator-free days (1.92 days, 95% CI 0.58 to 3.27, p = 0.005)	**Weakness:** Selection bias **Strength** Large sample size; Multi-centre study Long study period		III-2 Moderate

		Patient intake evaluated over first 12 days in ICU.				
Esteban et al.	2008	349 ICUs in 23 countries Prospective international observational cohort study to (1) describe current mechanical ventilation practices (2004), (2) compare 2004 data with those collected in 1998, and (3) judge the concordance of practice change with interval reports of randomized trials Consecutive sampling over a 1-month period; study included 4,968 patients receiving mechanical ventilation for at least 12 hours after admission	The use of NIPPV was significantly greater in the 2004 cohort. Acute exacerbations of COPD: 17% in 1998 to 44% in 2004, p<0.001 Other causes of ARF: 4% in 1998 to 10% in 2004, p <0.001	**Weakness** Design not suitable for studying effects of these changes on patient outcomes **Strength** Design ideal for describing changes in usual practice; large sample size		II Not rated for clinical significance
Gariballa & Forster	2006	UK Randomised double-blind placebo controlled trial of nutritional supplementation to measure the effects of acute-phase (CRP > 10mg/L)	Subjects with acute phase response were significantly more disabled and had higher fasting plasma glucose levels.	**Weakness** Selection bias: extensive exclusion criteria **Strength** Large sample size;	Food intake might be improved by hospitals' effort: food quality, meal choice, adequate time for meals	II Moderate

		response on nutritional status and clinical outcome in hospitalised, acutely ill older patients (≥65yo). Supplement group (n=199) received 2 nutritional supplement drinks per day in addition to meals, providing 995 kcal and 100% of the reference vitamin and mineral intakes for a healthy older person. Control group (n=204) received 2 drinks visually identical to those used for supplement group but containing only 60kcal and no additional nutrients. Supplementation over 6 weeks with actual intake calculated using food diaries and weighing of meals. Nutritional status measured at baseline, 6 weeks and 6 months using anthropometric, hematologic, and biochemical data	Energy intake was significantly higher in those with CRP ≤ 10mg/L The effect of supplements on nutritional status most evident among patients with acute-phase response	Double blind		
Gross et al.	2009	USA	Logistic regression showed that participants with COPD	**Weakness** Small sample size.		II Moderate

		Prospective repeated measures design to test the hypothesis that persons with moderate to severe COPD (n=25; all male) would show disordered coordination of breathing and swallowing during oral intake when compared with a matched, healthy control group (n=25; 12 male) Respiratory inductance plethysmography and nasal thermistry were used simultaneously to track respiratory signals. Submental surface EMG was used to mark the presence of each swallow within the respiratory cycle. Data were recorded while participants randomly and spontaneously swallowed solids and semi-solids.	swallowed solid food during inhalation more frequently than normal subjects (P= 0.002) and had a significantly higher rate of inhaling after swallowing semi-solid material (P< 0.001).	Control group was not matched with gender (selection bias). **Strength** Exclusion of patients with dysphagia to minimise confounding factors		
Heidegger et al.	2013	Switzerland Randomised, controlled trial to assess whether delivery of 100% of the energy target from days 4 to 8 in the ICU with EN plus supplemental parenteral nutrition (SPN)	Between days 9 and 28, 27% (41/153) of patients in the SPN group had a nosocomial infection compared with 38% (58/152) of patients in the EN group (hazard ratio 0·65, 95% CI 0·43–0·97; p=0·0338)	**Weakness:** Risk of sponsorship or funding bias Risk of researcher's bias (not double-blinded) **Strength:** RCT		II Moderate

		could reduce the incidence of nosocomial infection (followed to day 28). Patients enrolled on day 3 in ICU if receiving <60% of their energy target from EN alone. Randomised to continue with EN alone (n = 152) or receive SPN (n = 153).	SPN group had a lower mean number of nosocomial infections per patient (−0·42, 95% CI −0·79 to −0·05; p=0·0248)	Avoid selection bias by achieving allocation concealment Very detailed description of methods (reliable) No significant difference between the two groups regarding demographics and clinical characteristics		
Heyland, Cahill and Day	2011	352 ICUs in 33 countries Prospective audit to examine the relationship between calories administered to mechanically ventilated, critically ill patients and 60-day hospital mortality.	Association between caloric intake and mortality varied depending on the statistical method used. With adjustments for important covariates, patients who received more than two-thirds of their caloric prescription were less likely to die than those receiving less than one-third of their prescription (OR: 0.67; 95% CI 0.56-0.79; p < .0001). When treated as a continuous variable, increasing calories was associated with decreasing mortality (p < .0001)	**Weakness:** Indication bias (confounding) large variation in prescribing calories **Strength:** Large sample size; Multi-centre study		II Moderate
Kim & Choi-Kwon	2011	South Korea Prospective cohort study to	A total of 48 patients (mean age, 57.2 years; 70.8% male)	**Weakness** Small sample size.	Energy deficiency (calorie and protein) is consistent with other studies	II Moderate

		(1) evaluate the adequacy of energy and protein intake, and (2) investigate the factors that impact adequate intake in 34 adult patients (≥18) admitted to ICU who were expected to receive enteral feeding for at least four days Total energy intake included energy provided via enteral nutrition or combined enteral/parentral nutrition, plus dextrose (due to medication such as antibiotics) Energy requirements were calculated using the HBE Protein requirements were calculated using the American Dietetic Association's equation	75% of patients severely malnourished at admission; and nutritional status worsened in all malnourished and suspected malnourished patients 62% of patients were underfed (received <90% of requirements) 29% were adequately fed (received ±10% of requirements) 9% were overfed (received >110% of requirements) Adequate protein intake recorded in 44% of patients; 56% underfed for protein Factors associated with underfeeding included: Time to initiation of enteral nutrition (OR: 0.01, 95% CI: 0.00-0.77), Under-prescription (OR: 16, 95% CI: 1.75-146.66), and Interruption time of enteral nutrition (OR: 1.01, 95% CI: 1.00-1.02)	The result of under-prescription is not reliable because of a wide range of 95% CI (1.75-146.66); very small sample size may lead to this outcome. **Strength** Homogenous group		

Kohlenberg et al.	2010	474 ICUs in Germany Retrospective observational study (1) to determine the utilization of IMV and NIV and the associated incidence densities (IDs) of pneumonia, and (2) to compare the characteristics of pneumonia cases and the spectrum of associated pathogens. Pooled data covering 779,500 admitted patients over three years (2005-2007)	400 ICUs (84.4%) performed NIV Of 6,869 cases of pneumonia, 84.6% were associated with IMV and 2.3% with NIV The mean pneumonia IDs were 1.58 vs 5.44 cases per 1,000 ventilator days for NIV and IMV, respectively. The mean ID of pneumonia not associated with ventilation was lower with 0.58 cases per 1,000 patient days without ventilation. Pneumonia cases associated with IMV and NIV had a higher proportion of secondary sepsis and death than in non-ventilation associated pneumonia, and the proportion of cases with bacterial confirmation was significantly different between the three groups (IMV group had highest rates of pathogen recovery).	**Weakness** Lacks data about underlying diseases, disease severity or other known risk factors for nosocomial pneumonia, including reason for ventilation **Strength** Using homogenous definitions, methods and criteria for devices and nosocomial infections Large sample size/ long study period		III-2 Moderate
Metheny et al.	2006	USA	320/360 (88.9%) patients had at least one aspiration event	**Weakness**		II Substantial

		Prospective descriptive study to describe (1) the frequency of pepsin-positive tracheal secretions, (2) the outcomes associated with aspiration, and (3) the risk factors associated with aspiration and pneumonia Included 360 adult patients receiving mechanical ventilation and tube feeding from 5 ICUs in a University hospital over 2 years Tracheal sputum specimens collected by bedside nurses while suctioning. Vomiting episodes and frequency of gastric suction also recorded.	Less than 1% (3/360) of the patients had overt aspiration events, the remaining aspirations were clinically silent Of 6,000 tested tracheal sputum specimens, 31.3% were pepsin-positive and patients who had pneumonia on day 4 had a significantly higher percentage of pepsin-positive specimens than did those who did not have pneumonia (42.2% vs. 21.1%, respectively; $p < .001$) 75% of patients who had an aspiration event developed pneumonia, while only 17.5% patients developed pneumonia without aspiration. Low backrest elevation a risk factor for both aspiration ($p=0.024$) and pneumonia ($p=0.018$)	VAP may have been over-estimated; Nutritional status was not evaluated **Strength** Large sample size; Multiple observations of risk factors		
Nishino et al.	1986	Japan Experimental study examining the effects of changes in $PaCO_2$ and PaO_2	Graded hypoxia resulted in a graded inhibition of the swallowing reflex In contrast, graded hypercapnia had no effect on	**Weakness** Animal study; Anaesthesia could also affect swallowing reflex; Outdated		III-2 Slight or restricted

		on the swallowing reflex in cats 10 healthy animals were anaesthetized, vagotomized, paralysed and artificially ventilated; the swallowing reflex was induced by electrical stimulation of the superior laryngeal nerve	the swallowing reflex, although graded hypercapnia and hypoxia similarly increased the spontaneous respiratory activity Swallowing reflex is independent of the background level of respiratory activity	**Strength** There are no clinical trials on humans investigating whether hypoxia affects swallowing		
O'Leary-Kelley et al.	2005	USA Prospective descriptive study to examine the adequacy of enteral nutritional intake and the factors that affect its delivery in patients receiving mechanical ventilation in 3 ICUs in 2 hospitals Energy requirements were determined by using Harris-Benedict equation(HBE) for 60 adult patients (≥18) Resting energy expenditure (REE) was measured by using indirect calorimetry for 25/60 patients Energy received via enteral feeding was recorded, along with reasons for and	68.3% of patients were significantly underfed (received <90% of requirements) 30% of patients received within ±10% or requirements 1 patient (1.7%) was overfed (received >110% requirements) ICU tests and procedures were the most common cause of interruptions in tube feeding (p<0.001). *there is no significant difference between the adequate energy requirement calculated by HBE and indirect calorimetry	**Weakness** Small sample size; Sample bias (percentage of men and women significantly different between two hospitals (P<0.001)) **Strength** Tube feeding intake was examined only after the target infusion rate had been achieved in order to separate gastrointestinal intolerance (minimise confounding factors).	Well-nourished patients have fewer complications and better clinical outcomes. Patients being cared for in ICUs worldwide are underfed, receiving just fewer than 60% of recommended nutritional requirements.	II Moderate

		duration of interruptions in feeding				
Peterson et al.	2010	USA Prospective observational study to examine the adequacy of oral intake and to identify predictors of oral intake after ICU (medical or surgical) patients were removed from invasive mechanical ventilation 50 adult patients (≥18yo) who required mechanical ventilation for at least 24h and advanced to an oral diet post-extubation (no artificial nutrition) First 7 days of oral intake after extubation was assessed using 24h-recall by patient and hospital meal menu, discussed and clarified by researcher Barriers to oral nutrition also noted Nutritional status on admission assessed using	Inadequate energy intake (oral intake <75% of daily requirements) calculated for over 70% of participants on all 7 days On admission, malnutrition or suspected malnutrition (based on SGA) determined in 44% of participants; Severe malnutrition in 2% Barriers to oral intake included: No appetite (n=19, 38%), Nausea/vomiting (n=13, 26%), Does not like food (n=5, 10%), Difficulty chewing/swallowing (n=2, 4%), Mental status changes (n=2, 4%)	**Weakness** Short study duration; Subjective data; Diet technician visited patients at least once a day which may influence patients' response; No evaluation of SGA after the study **Strength** Observational study design appropriate	Artificial nutrition does not protect patients from under-nutrition due to frequent interruptions in feeding.	II Moderate

		Subjective Global Assessment				
Pirabbasi et al.	2012	Malaysia Cross-sectional study to determine the prevalence of malnutrition, along with nutritional status and factors associated with nutritional status at two medical centres Data was collected for 149 adult male outpatients with COPD, including anthropormophic measures and electronic body composition for nutritional status and food diaries for oral intake. Blood samples were also taken for biochemical analysis.	Malnutrition was more prevalent in patients in severe stages of COPD (52.4%) than in mild and moderate COPD (26.2%), food intake in all groups was below the recommended levels for energy, protein and micronutrients Fat-free mass depletion (assessed using FFMI) was recorded in 41.9% of participants Plasma vitamin A and FEV1 were predictors of FFMI	**Weakness** Selection bias due to convenience sampling; Food diaries inaccurate; Only male patients **Strength** Investigated the relationship between disease severity and nutritional status	Patients with COPD are malnourished.	IV Moderate
Purkey et al.	2009	USA Retrospective observational study to identify clinical variables associated with the diagnosis of aspiration pneumonia Reviewed records of 52 patients (39 males) referred for modified video	28 episodes of pneumonia in 20 patients in the 6 months before and after MVBS study 18 patients were classified as malnourished and 11 of these developed at least one episode of pneumonia	**Weakness** Small sample size **Strength** Homogeneous sample		III-2 Moderate

		fluoroscopic barium swallow (MVBS) testing (for clinical symptoms of dysphagia) following radiation for head and neck cancer (HNC)	Independent risk factors for the development of pneumonia were (1) tracheobronchial aspiration on MVBS testing (odds ratio [OR], 5.0; 95% confidence interval [CI], 1.2 to 20.5; p = 0.025), (2) malnutrition (OR, 4.4; 95% CI, 1.3 to 14.7; p = 0.018), and (3) smoking history (OR, 1.04 per pack-year; 95% CI, 1.01 to 1.07; p = 0.011)			
Reeves at al.	2014	Australia Prospective observational study to (1) measure energy and protein intake of 36 adult ARF patients requiring NIPPV and standard hospital nutritional care in the ICU, and (2) describe factors associated with level of nutritional intake	78% of patients consumed less than 80% of the minimum estimated energy and protein intakes Factors associated with consuming enough to me/.,et minimum energy and protein requirements included consuming food and drink orally, longer time on NIPPV, higher APACHE Ⅱ score Higher BMI was associated with poorer nutrient intakes	**Weakness** Small sample size **Strength** Minimisation of observers' bias	Although this study was undertaken among OSA patients (not critically ill patients receiving NIPPV in ICU setting), this study supports that positive pressure via NIV (CPAP) might affect patient nutrition.	II Moderate
Schettino, Altobelli & Kacmarek	2005	USA Prospective observational study to determine	NIPPV is most successful in reversing ARF and preventing hospital mortality in DNI patients with a primary	**Weakness** Albumin levels were not checked in all participants.	Implication: NIPPV may enhance the quality of life for DNI patients by reducing	III-2 Moderate

		outcomes of the use of NIPPV in “do-not intubate” (DNI) patients with ARF. Included 131 adult patients (>18yo) treated in University-affiliated large medical centre (emergency room, intensive care unit, or regular medical/surgical unit) over 1 year. Facial masks (94.7%) and nasal masks (5.3%) were used.	diagnosis of COPD or cardiogenic pulmonary edema (Hospital mortality 37.5% and 39%, respectively). Hospital mortality was high in patients with post-extubation respiratory failure (77%), hypoxemic respiratory failure (86%), and end-stage cancer (Non-COPD hypercapnic respiratory failure: 68%). Serum albumin and SAPS II were independently related to hospital outcome, with wide confidence intervals (95% CI 3.72-33.00 and 1.11- 8.34, respectively). One patient experienced gastric distension ion and vomiting.	Study did not evaluate the impact of NIPPV in quality of life **Strength** Identified underlying diseases contributing to ARF and indications for NIPPV	dyspnea and allowing conversation and oral nutrition.	
Sharifi et al.	2011	245 ICUs and HDUs in 196 hospitals in the UK Survey to evaluate current nutrition support practice in ICUs and HDUs Conducted by telephone over 72h period	Total of 1,286 patients in ICU/HDU Nasogastirc feeding: 703 patients (54.6%) Gastrotomy tube feeding: 2(1.5%) Nasojejunal feeding: 2(1.5%) PN: 147 (11.4%)	**Weakness** Response bias unclear; Drop-out rate 22.4%; Oral feeding excluded **Strengths** Multi-centre study; generalizable in the UK.	Although this study was not conducted to investigate the nutritional status of NIPPV patients, it demonstrates that over 40% of patients receiving NIPPV were malnourished. This result provides some evidence that NIPPV may, to some	IV Moderate

		Nutrition support defined as all forms of EN and PN	Nutritional support team not available in 158 ICUs (83.1%) No dietitian or specialist nutrition nurse in 9 (4.7%) hospitals		extent, affect nutrition in these patients.	
Shepherd et al.	2013	Australia Survey study to determine (1) the prevalence of aerophagia symptoms in a group of OSA patients on CPAP therapy, and (2) whether aerophagia symptoms are related to an increase in prevalence of GER symptoms Complete data collected for 259 (203 male) adult patients undergoing in-laboratory polysomnography and CPAP titration	Participants with aerophagia symptoms (n=130) had a greater prevalence of frequent GER symptoms than those without (day time: 29% vs. 10%, p<0.05; night time: 9% vs. 2%, p<0.05) Participants with night time GER symptoms (n=27) had a greater prevalence of aerophagia symptoms than those without (63% vs. 23%, p<0.05).	**Weakness** Design cannot prove causality **Strength** Relatively high response rate		IV Moderate
Soler et al.	2004	Spain Prospective study to determine the prevalence of malnutrition in 178	Low body weight in 19.1% of patients, muscle wasting in 47.2%, visceral protein depletion in 17.4%, fat depletion in 19.1%	**Weakness** Small sample size **Strength** Precise results, controlled confounding factors		II Not rated for clinical significance

		outpatients with stable COPD	In patients with normal weight, muscle wasting was detected in 62.9% Reduced BMI and muscle wasting significantly associated with increased bronchial obstruction (P <.001 and P=.015, respectively).			
Terzi et al.	2014	France Prospective, open-label, interventional study to (1) investigate breathing-swallowing interactions in patients with COPD requiring NIPPV, and (2) develop a technical modification of the ventilator designed to eliminate ventilator insufflations during swallowing Study included 15 adult patient in a University hospital Medical ICU with acute COPD exacerbations requiring NIPPV (nasal mask)	Abnormal breathing-swallowing and dyspnea in patients improved with NIPPV but use of the standard device set-up resulted in patient/ventilator asynchrony as swallowing induced ventilator triggering followed by autotriggering (responsible for 100% of insufflations following swallows in seven patients) With Modified NIPPV (on/off switch for swallowing) there was no swallowing-induced ventilator triggering or post swallow autotriggering, and no clinical signs of aspiration	**Weakness** Small sample size Selection bias Researcher bias Publication bias Interest Only liquid (not solid food) Do not measure of microaspiration **Strength** Only study to investigate the casual relationship between the use of NIPPV (positive pressure) and swallowing/gastric insufflation	Patients receiving NIPPV could also experience more silent aspiration than overt aspiration. Implication: Nurses need to perceive predictors of silent aspiration to avoid them to develop aspiration pneumonia Future study: nurses' knowledge about the symptoms of aspiration or silent aspiration	III-2 moderate

van der Maarel-Wierink et al.	2011	Systematic literature review to examine the risks for aspiration pneumonia in frail older people (≥60yo)	21 publications included Evidence level 2a (systematic review with homogeneity of cohort studies) was found for a positive relationship between aspiration pneumonia and age, male gender, lung diseases, dysphagia, and diabetes mellitus; 2b (individual cohort study) for severe dementia, angiotensin I-converting enzyme deletion/deletion genotype, and bad oral health; 3a (systematic review with homogeneity of case-control studies) for malnutrition; 3b (individual case-control study) for Parkinson's disease and the use of antipsychotic drugs, proton pump inhibitors, and angiotensin-converting enzyme inhibitors.	**Weakness** Lack of RCTs; Publication bias **Strength** Carefully considered grading of evidence		II Moderate
Walkey & Wiener	2013	USA Retrospective study to compare utilization trends and outcomes associated	The proportion of COPD patients who received NIPPV increased from 3.5% in 2000 to 12.3% in 2009 (250% increase)	**Weakness** Use of ICD-9-CM diagnosis codes may have lower sensitivity to identify diagnoses of		III-3 Moderate

		with NIPPV in patients with and without COPD Records covered a 10- year period taken from Nationwide Inpatient Sample (including 994 hospitals in 28 states in 2000 and 1,050 hospitals in 44 states in 2009) Sample included adult patients (≥18yo) with ARF (various aetiology) n=11,659,668	In non-COPD patients, 1.2% received NIPPV in 2000 compared with 6.0% in 2009 (400% increase) The risk of NIPPV failure was greater in patients without COPD (multivariable adjusted OR, 1.19; 95% CI, 1.15–1.22; p<0.0001), and patients with NIPPV failure had greater hospital mortality (multivariable adjusted OR, 1.14; 95% CI, 1.11–1.17; p<0.0001).	interest but have high specificity, thus underestimating disease prevalence or incidence. Uncertainty: severity of disease, location of care setting, causal relationship between the use of NIPPV and outcomes such as mortality (observational study). **Strength** Nationally representative sample		
Weng 2008	2008	Taiwan Quasi-experimental study to compare the efficacy of protective dressings and of using no materials for pressure ulcer prevention Measurement of nutritional status: level of albumin, sodium, potassium and haemoglobin in 90 adult patients receiving NIPPV in MICU and CCU	42.2% of patients did not have good nutrition support (albumin: 3.047gm/dl, Hb: 10.89 gm/dl) Nutrition support included parenteral, NG bolus feeding, NG continuous feeding, and oral	**Weakness** Small sample size. Not designed to investigate nutritional status in patients receiving NIPPV. Not controlled for confounding factors **Strength** Nutritional status in patients receiving NIPPV	This is the only study directly investigating nutrient intakes in patients receiving NIPPV	III-2 Moderate

Appendix A. 2 Summary of reviewed articles: Hospital under-nutrition/ barriers

Author(s)	Year	Study details	Major findings	Weakness/strength	Theme/ significance	Level of evidence/ clinical impact
Alhazzani et al.	2014	Systematic review To evaluate the effect of small bowel feeding compared with gastric feeding in critically ill patients.	19 trials with 1394 patients Small bowel feeding was associated with reduced risk of pneumonia in comparison with gastric feeding (risk ratio [RR] 0.70; 95% CI, 0.55, 0.90; P = 0.004; I 2 = 0%) and ventilator-associated pneumonia (RR 0.68; 95% CI 0.53, 0.89; P = 0.005; I_2 = 0%). No difference in mortality (RR 1.08; 95% CI 0.90, 1.29; P = 0.43; I_2 = 0%), length of ICU stay (95%CI -1.79, 0.66; P = 0.37; I_2 = 0%), duration of mechanical ventilation (95%CI -3.37, 1.35; P = 0.40; I_2 = 17%), gastrointestinal bleeding (RR 0.89; 95% CI 0.56, 1.42; P = 0.64; I_2 = 0%), aspiration (RR 0.92; 95% CI 0.52, 1.65; P = 0.79; I_2 = 0%), and vomiting (RR 0.91; 95% CI 0.53, 1.54; P = 0.72; I_2 = 57%)	_Weakness:_ Included all critically ill patients in ICU; did not present how many patients were invasively or non-invasively ventilated. The included trials were small in size that could have biased the overall estimate of treatment effect. The definition of pneumonia and VAP were not consistent across trials. _Strength:_ comprehensive search strategy, multiple clinically important outcomes, inclusion of non-English trials	*Enteral Nutrition during NIPPV Therapy*	I Substantial
Anthony	2008	Expert opinion – seminal article	Screening tools which have been validated in a variety of care settings and patient populations include the Malnutrition Universal Screening Tool, Nutritional Risk Screening 2002, Mini Nutritional Assessment, Short Nutritional	_Weakness:_ Low level of evidence _Strength:_ Highlighted the importance of nutritional screening test	*Nutrition Screening Tool*	V Not rated for clinical significance

			Assessment Questionnaire, Malnutrition Screening Tool, and the Subjective Global Assessment need. Clinicians understand how the tools were validated and for which population and care setting to determine if the tool appropriate.			
Agarwal et al.	2012	Survey Australian & New Zealand To determine the nutritional status and dietary intake of acute care hospital patients. Malnutrition Screening Tool (MST): to evaluate a risk of malnutrition Fifty-six hospitals (acute care units) Nutritional assessment using by Subjective Global Assessment (SGA) tool: for the patients with a risk of malnutrition, further evaluate the level of malnutrition Dietary Intake: Percentage of meals and snacks consumed by the participants via visual evaluation (0%, 25%, 50%, 75%, and 100%)	Sample size: 3122 (mean age: 64.6 ± 18 years) “At risk” of malnutrition: 41% Overall malnutrition prevalence: 32%. Fifty-five percent of malnourished participants and 35% of well-nourished participants consumed ≤50% of the food during the 24-h audit. “Not hungry” was the most common reason for not consuming everything offered during the audit.	*Weakness:* Only acute wards thus results not generalizable for ICU. Only included hospital food and excluded foods brought in by family or relatives which would affect total nutrient intake. Food intake only recorded for 24 hours thus failed to recognise. Increased nutrient intake over time. *Strength:* Large sample size and consistent methodology in defining malnutrition. Increased inter-rater reliability to check food intake training and providing written instructions to the dietitians from the study hospitals	*Hospital Under-Nutrition: Nutrition Screening Tool* The first study to provide a snapshot of malnutrition in Australia and New Zeeland. Well-nourished patients could become malnourished in hospital (35% of well-nourished patients had poor nutrient intake (≤50%).	IV Moderate
Agarwal et al.	2013	Survey Australian and New Zealand Survey which investigated if malnutrition and poor food intake are independent risk factors for health-related outcomes Acute care setting in 56 hospitals	Malnourished patients (SGA B or C) had greater median length of stay (LOS) (15 days vs. 10days, p < 0.0001); readmissions rates (36% vs. 30%, p = 0.001). Median LOS for patients consuming ≤25% of the food was higher than those consuming ≤ 50% (13 vs. 11 days, p < 0.0001).	*Weakness*: Only acute wards thus results not generalizable for the patients in ICU *Strength:* Investigate the relationship between malnutrition or poor nutrient intake and clinical outcomes after controlling for various confounders	*Hospital Under-Nutrition* Highlighted the independent association of malnutrition and poor food intake	IV Moderate

			The odds of 90-day in-hospital mortality were twice greater for malnourished patients (CI: 1.09-3.34, p= 0.023) and those consuming ≤ 25% of the offered food (CI: 1.13-3.51, p = 0.017), respectively.	including disease type and severity.		
Agarwal et al.	2015	Prospective cohort study Australian & New Zealand To evaluate malnutrition prevalence in acute units and assign malnutrition-related codes according to ICD-10-AM. Patients (n=2976) from 56 hospitals. Dietitians evaluated nutritional status - BMI and SGA. 3 months later coding results for participants identified as malnourished reviewed.	Malnutrition prevalent in 30% (n = 869). A significantly small number coded for malnutrition (n = 162, 19%, P < 0.001). No coding for malnutrition in 21 hospitals	*Weakness:* It is also likely that the screening process may have missed some malnourished patients *Strength:* Participating hospitals represent 20% of Australian acute care hospitals, and 38% of acute care hospitals in NZ (with >60 beds). Provides insight into malnutrition coding practices in public and private hospitals in this region.	*Hospital Under-Nutrition* Provides a snapshot of deficits in malnutrition coding in Australian and New Zealand hospitals, which could potentially result in significant loss of casemix-related revenue for hospitals.	II Moderate
Bambi et al.	2017	Expert opinion – seminal article To provide an update about the “hot topics” of nursing research in NIPPV	Time spent off from NIPPV should be used to provide adequate rest t, suitable feeding and hydration, and to handle other adverse effects related to NIPPV; airways dryness, nasal congestion, noise, and nose-sinus-ear pain. Patient unable to tolerate oral feed, provide nutrients via through a NGT is mandatory (unless clear indication for PN). Reason to insert NGT is to evacuate the ingested air during NIPPV, preventing gastric	*Weakness:* Review article, low level of evidence *Strength:* Provide evidence on nutrition during NIPPV therapy	*Enteral Nutrition during NIPPV*	V Not rated for clinical significance

			distension, and risk of vomit and aspiration. Avoiding gastric distension improves diaphragmatic function, thoracic expansion and gas exchange			
Banks et al.	2007	Cross-sectional study Australia To determine prevalence of malnutrition in Queensland acute & residential care and explore effects of variables associated with malnutrition. Dietitians conducted single-day nutritional status audits of 2208 acute & 839 aged care subjects using SGA.	Mean 34.7-± 4.0% &31.4 ± 9.5% of acute subjects and median 50.0% & 49.2% of residents of aged care malnourished. Variables significantly associated risk of malnutrition: older age, male (residential care), metropolitan location and oncology & critical care.	***Weakness:*** One state; Large differences in population between acute and residential care Data collected only one day ***Strength:*** Demonstrates malnutrition across health care system	*Hospital Under-Nutrition/ Nutrition Screening Tool*	IV Moderate
Bavelaar et al.	2008	Prospective study To describe current practice in diagnosing and treating malnutrition by Drs, medical students and RNs prior, during and after hospitalisation.	Patients (n = 395) aged 19–96yrs prevalence of malnutrition 31.9%. Referrals did not include nutritional status. Nutritional assessment: Drs 15.3%, medical students 52.8%, RNS 29.9%. Intervention low. Discharge follow-up: 1.2%.	***Weakness:*** Documentation of nutritional status by the GP in referral letters to the specialist was inadequate or absent for the majority of patients. ***Strength:*** This study gained insight into the current practice of diagnosing, treating and communication on malnutrition related to hospital stay by medical doctors, medical students and nurses.	*Hospital Under-Nutrition*	II Moderate
Butterworth	1974	Expert opinion – seminal article	Iatrogenic malnutrition" was significant factor in determining illness outcomes. Hypothesised malnutrition occurring more in hospitals that in "rural slums or urban ghettos".	***Weakness:*** Expert opinion, low level of evidence ***Strength:***	*Hospital Under-Nutrition*	V Not rated for clinical significance

			Found it tragic and unacceptable that malnutrition in hospitals still existed despite health professionals' knowledge of its negative affect on health outcomes such as increased infection.	Raising awareness of nutritional importance of medical staff		
Cahill et al.	2012	Survey Denmark, Sweden and Norway To study doctors and nurses' self-reported knowledge in nutritional practice, with focus on ESPEN's guidelines in nutritional screening, assessment and treatment.	The most common cause for insufficient nutritional practice was lack of nutritional knowledge: found it difficult to identify patient in need of nutritional therapy (25%), lacked techniques for identifying malnourished patients (39%), found it difficult to calculate the patients' energy requirement (53%), and lacked national guidelines for clinical nutrition (66%). Twenty-eight percent answered that insufficient nutrition practice could lead to complications and prolonged hospital stay. Those that answered that their nutritional knowledge was good had also a better nutritional practice.	*Weakness:* Low response rate by medical staff *Strength:* Multi-national study	*Nutrient Intake Barriers: lack of knowledge* Health professionals' knowledge and attitude towards nutrition/ doctors' perception on nutrition Response rate: nurses (46%) vs. doctors (30%), reflecting doctors had less interest in nutrition	IV Moderate
Cansado, Ravasco & Camilo	2009	Prospective study Finland To explore the best method to identify undernutrition risk in hospitalized elderly (n = 531) using four validated methods. Data collection <48hrs of admission &24hrs <discharge: clinical data, nutritional status (BMI, %weight loss) & risk (MNA, MUST), energy requirements, diet.	Significant changes from admission to discharge in risk or prevalence. Undernutrition not shown by BMI (≈17% vs 22%), ≥5% weight loss (≈53% vs ≈56%) or MNA 83% vs ≈81%. Admission, 93% "MUST" high risk declining to ≈47% (p=0.001) at discharge. Percent weight loss linked to nutritional progression. Admission ≥5% weight loss and MNA&MUST high risk scores predictive of longer LOS.	*Weakness:* Only included surgical and medical elderly patients, do not represent ICU patients *Strength:* Results from this study fully support nutritional guidelines, given the deterioration observed in elderly patients' nutritional parameters and the lack of awareness or	*Nutrition Screening Tool*	II Moderate

			No significance mean energy requirements admission /discharge: ≈1400kcal intake lower than calculted≈2128kcal.	appropriateness of nutritional support. Use multiple screening tools		
Cederholm et al	2015	Prospective study Europe To provide a consensus-based minimum set of criteria for the diagnosis of malnutrition A group of clinical scientists performed modified Delphi process, encompassing e-mail communications, face-to-face meetings, in group questionnaires and ballots, a ballot for the ESPEN membership.	ESPEN recommends subjects at risk of malnutrition assessed and treated using validated screening tools. Risk of malnutrition own ICD Code. Unanimous consensus advocated for diagnosis of malnutrition. by BMI, kg/m2) <18.5 to define malnutrition and combining finding of unintentional weight loss (mandatory) and one of either reduced BMI or low fat free mass index (FFMI). Weight loss: either >10% of habitual weight indefinite of time, or >5% over 3 months. Reduced BMI is younger <20 or older<22 kg/m2. Low FFMI <15 females, <17 kg/m2 males	*Weakness:* No validation of diagnostic criteria in practice *Strength:* Range of research methods to confirm concensus for diagnostic criteria for malnutrition	*Nutrition Screening Tool*	II Moderate
Compher et al.	2014	Retrospective data analysis Secondary analysis used the Improving Nutrition Practices in the Critically Ill International Nutrition Surveys database from 2007–2009 International study (353 ICUs in 33 countries) Evaluated whether mortality or time to discharge was related to use of complex energy prediction equations vs weight only equation Monitoring: mortality and ICU length of stay (LOS) for 60 days after ICU admission Harris-Benedict vs. Ireton-Jones vs. Mifflin–St Jeor	5672 patients ICU) ≥4 days and a subset of 3356 in the ICU ≥12 days. No difference in mortality between the use of complex and weight-only equations (odds ratio [OR], 0.90; 95% confidence interval [CI], 0.86–1.15), but obesity (OR, 0.83; 95% CI, 0.71–0.96) and higher energy intake (OR, 0.65; 95% CI, 0.56–0.76) had lower odds of mortality. Time to discharge alive was shorter in patients fed using weight-only equations (hazard ratio [HR], 1.11; 95% CI, 1.01–1.23) in patients staying ≥4 days and with greater energy intake (HR, 1.19; 95% CI, 1.06–1.34) in patients in the ICU ≥12 days.	*Weakness:* no comparison of all the energy requirement equations *Strength*: large data base, generalizable the results for patients in ICU	*Equation of Adequate Energy Requirement* Optimal amount of energy intake for critically ill patients is still unclear.	III-2 Moderate

		Weight based calorie requirements: <20 kcal/kg, :25–29 kcal/kg:30–35 kcal/kg	Conclusion: These data suggest that higher energy intake is important to survival and time to discharge alive			
Corkins et al.	2014	Retrospective data analysis USA To examine data from the 2010 Healthcare Cost and Utilization Project (HCUP), describing U.S. hospital discharges. Using ICD-9 codes, constructed a composite variable indicating a diagnosis of malnutrition	3.2% of all U.S. hospital discharged diagnosis of malnutrition. These pts older, longer LOS, higher health care costs, more likely to have 27 of 29 comorbidities assessed in HCUP. Discharge to home care twice as common among malnourished patients, and endpoint of death >5 times as common.	*Weakness:* Retrospective study: subject to confounding *Strength:* Large sample size The first nationally-representative profile of hospitalized patients with a coded diagnosis of malnutrition	*Hospital Under-Nutrition* Patients discharged with malnutrition are older, sicker and care more expensive. Question this % because of the number who are not diagnosed with malnutrition	III-2 Moderate
da Silva Fink et al.	2015	Systematic review To update knowledge on the performance of SGA as a method for the assessment of the nutritional status of hospitalized adults. PubMed data base - search term "subjective global assessment". Studies published in English, Portuguese or Spanish, between 2002 and 2012 with samples>30, age>18yrs. hospitalized populations. Excluded if used modified version of the SGA.	454 eligible studies, 110 met eligibility; 21 selected after applying exclusion criteria =6 surgical patients, 7 clinical patients, and 8 with both. SGA performance similar or better than usual assessment methods for nutritional status, such as anthropometry and laboratory data, but the same result was not found when comparing SGA and nutritional screening methods.	*Weakness:* Publication bias, not including not published study *Strength:* Large sample size High level of evidence	*Nutrition Screening Tool* SGA a valid tool for nutritional diagnosis of hospitalized clinical and surgical patients, and in early detection of malnutrition.	I Substantial
Duarte et al.	2014	Cross-sectional study To assess prevalence of nutritional risk in hospitalized subjects and the agreement in nutritional diagnosis between five nutritional screening protocols. Nutritional screening protocols applied <48 hours of admission: MNA; MNA-S; ASG; NRS 2002;	100 patients at nutritional risk: MNA protocol (49%); MNA-SF (53%); MUST (23%); NRS (7%); ASG. (4%). MNA-SF, MUST and NRS, showed a higher nutritional risk in patients over 60 years (p equal or less than 0.05). MNA and MNA-SF obtained better agreement (Kappa coefficient = 0.760, p less than 0.001).	*Weakness:* Small sample size Lack of homogeneity across the samples *Strength:* Assessed nutritional risk using various tools	*Nutrition Screening Tool* Good agreement between MNA and MNA-SF. MNA-SF ranked the highest percentage of patients at nutritional risk; less nutritional risk was detected by ASG.	IV Moderate

		MUST. The protocols consist of questions related to weight loss, body mass index, functional capacity, food appetite and gastrointestinal disturbances. Subjects were classified into two levels: well-nourished and malnourished.				
Elliott	2004	Expert opinion – seminal article To provide practical guidelines for NIPPV intervention	Practical guidelines for caring for patients undergoing NIPPV therapy	*Weakness:* Low level of evidence *Strength:* Demonstrated small evidence enteral nutrition during NIPPV therapy	*EN during NIPPV Therapy*	V Not rated for clinical significance
Ferguson et al.	1999	Prospective cohort study Australia To develop a simple, reliable and valid malnutrition screening tool that could be used at hospital admission to identify adult acute patients at risk of malnutrition. The sample population included 408 patients admitted to an Australian hospital. The ability of various nutrition screening questions to predict subjective global assessment (SGA) were examined in contingency tables. The combination of nutrition screening questions with the highest sensitivity and specificity at predicting SGA was termed the malnutrition screening tool (MST), and consisted of two questions regarding appetite and recent unintentional weight loss.	Subjects who were at risk of malnutrition according to the MST had significantly lower mean values for the objective nutrition parameters (except immunologic parameters) and longer LOS than subjects who were not at malnutrition risk. Convergent and predictive validity of MST established. Interrater reliability of MST was high (93-97%).	*Weakness:* Out-dated article *Strength:* The interrater reliability of the malnutrition screening tool was high	Nutritional Screening Tool The MST simple, quick, valid, and reliable tool to identify patients at risk of malnutrition.	II Moderate

Frankenfield et al.	2007	Systematic review	Reported the results of an evidence analysis of the accuracy of metabolic rate calculation methods Fick Method, Harris-Benedict Equation, Harris-Benedict Equation without Added Factors, Harris-Benedict with Factors, Swinamer Equation, Ireton-Jones Equation, Ireton-Jones (1992), Ireton-Jones (1997), Penn State Equation (1998, 2003), Mifflin-St Jeor Equation	***Weakness:*** Publication bias ***Strength:*** High evidence level	*Equation for adequate energy requirement* No equations perfectly predict energy expenditure, which helps to prescribe energy intake for the patients.	I Substantial
Frantz et al.	2011	Expert opinion – seminal article USA To present a brief historical overview of the perception of medical education training, and conclude with some ideas on how to implement change	Medical students still do not have adequate nutritional training Decreased interest in nutrition during the medical course among the medical students	***Weakness:*** Review article, low level of evidence ***Strength:*** Present historical overview of the medical students' perception on nutritional care	*Nutrient Intake Barriers: Lack Of Knowledge* Physicians' perception and knowledge on nutrition	V Not rated for clinical significance
Gallegos et al.	2014	Survey Ecuador To estimate current frequency of malnutrition among patients admitted to Ecuadorian public hospitals. Conducted Nov 2011 - June2012. 5,355 patients (Women: 37.5%; Ages ≥ 60 years: 35.1%; Length of stay ≤ 15 days: 91.2%) admitted to 36 public hospitals. Malnutrition estimated by Subjective Global Assessment survey.	5,355 patients (Women: 37.5%; Ages ≥ 60 years: 35.1%; Length of stay ≤ 15 days: 91.2%) admitted to 36 public hospitals. Malnutrition estimated by Subjective Global Assessment survey. Malnutrition 37.1%, dependent upon patient's age and education level; presence of cancer, sepsis, and chronic organic failure. Health condition leading to hospital admission influenced malnutrition. Malnutrition increased LOS.	***Weakness:*** Low response rate Response bias ***Strength:*** Large sample size	*Nutritional Screening Tool*	IV Moderate
Gout et al.	2009	Retrospective study Australia To determine prevalence, diagnosis, documentation and referral rates for malnutrition in	Malnutrition Prevalence 23%. Malnourished patients significantly longer LOS 4.5 days compared with well-nourished patients ($P < 0.001$). 15% malnourishment	***Weakness:*** Small sample size ***Strength:*** Random sampling	Hospital Under-Nutrition/ *Nutritional Screening Tool*	III-2 Moderate

		hospitalised patients and to determine potential shortfalls in financial reimbursement to a hospital as a result of malnutrition misdiagnosis. The Subjective Global Assessment tool assess nutritional status of 275 randomly selected inpatients on admission over 5weeks in acute care wards. Retrospective audit of malnourished patients' medical histories to assess diagnosis, documentation and dietetic referral rates. Determine recoding of DRG if malnutrition identified during hospitalisation, and payment allocated for admission.	correctly identified and documented in the medical histories. Dietitian involved in 45% of malnutrition cases, but only documented 29% of such cases as malnourished. 91% had no DRG code for malnutrition - shortfall of AU$27,617 to hospital in reimbursements, and AU$1,850,540 when extrapolated across financial year.		Malnutrition highly prevalent, poor identification and documentation. Lack of referred to dietitian compromising clinical outcomes.	
Kaiser et al.	2009	Retrospective data analysis Pooled analysis of recent, previously collected data Validate a revision of the Mini Nutritional Assessment short-form (MNA®-SF) against full MNA. Literature search identified studies where MNA used for nutritional screening geriatric patients. Various combinations of the MNA-SF questions were tested through combination analysis and ROC based derivation of classification thresholds	Twenty-seven datasets (n=6257 participants) initially processed. 12 used in current analysis of 2032 participants (mean age 82.3y). The revised MNA-SF included calf circumference (CC) instead of BMI and CC performed equally well. A revised 3-category scoring classification using BMI and/or CC, possessed good sensitivity compared to the full MNA.	*__Weakness:__* Lack of homogeneity across the samples *__Strength:__* Large sample size: used large international datasets	*Nutritional Screening Tool* The revised MNA-SF increased the applicability of this rapid screening tool in clinical practice. Validate a revision of the Mini Nutritional Assessment short-form (MNA®-SF) against full MNA.	III-2 Moderate
King et al.	2003	Cross sectional study 1) To assess nutritional status and risk of malnutrition in patients admitted to a Mexican public hospital. 2) To determine	Sample 568 patients. Malnutrition risk 3.6% at admission, 84% at malnutrition risk after prolonged LOS. BMI<20 Kg/m2 7.4%, 49.5% overweight. Weight loss >10%	*__Weakness:__* Small sample size *__Strength__*: Diagnosed malnutrition using various methods	*Nutritional Screening Tool* Healthcare institutions must improve awareness and training of personnel	IV Moderate

		frequency of patients not meeting energy and protein needs. Assessed hospitalized patients during the first 24-48 hours. Using nutritional risk screening (NRS 2002); anthropometric and dietary parameters	32.9%. Food intake: patients consumed 50% of caloric requirements and 39% of protein requirements; 42% food intake between 70-100%.		and the quality of hospital nutrition/food service.	
Kogo et al.	2016	Retrospective analyse To investigate whether enteral nutrition increases airway complications for the patients with acute respiratory failure receiving NIPPV therapy	Sixty of the 107 subjects (56%) received enteral nutrition during NIPPV therapy. Serum albumin level was significantly lower for the patients received enteral nutrition compared to those who do not receive enteral nutrition (mean 2.7 ± 0.68 mg/dL vs 3.0 ± 0.75 mg/dL, $P = .048$). The rate of *airway complications was significantly higher (53% [32/60] vs 32% [15/47],$P = .03$), and median NIV duration was significantly longer (16 [interquartile range 7–43] d vs 8 [5–20] d, $P = .02$) * airway complications (total number of episodes of vomiting, followed by desaturation, mucus plug, and aspiration pneumonia)	*__Weakness:__* Retrospective study *__Strength:__* The first study investigating the relationship between enteral nutrition and clinical outcomes	*Enteral Nutrition during NIPPV Therapy* Enteral nutrition was associated with increased risk of airway complications 44% of the patients were able to have oral nutrition during NIPPV therapy Risk of aspiration is higher for the patients with EN rather than the patients receiving oral nutrition. What is the optimal type of nutrition for these patients?	III-2 Moderate
Kondrup et al.	2003	Systematic review Evaluation of effectiveness 4 validated methods to assess nutritional status in 531 hospitalized elderly. Data collected <48 hrs of admission and <24 hrs discharge clinical data, nutritional status (BMI, %weight	Significant changes in undernutrition risk not shown by BMI (17% vs 22%), > or = 5% weight loss (53% vs 56%) or MNA 83% vs 81%; admission 93% MUST high risk Vs 47% (p=0.001) at discharge. Multivariate analysis only %weight loss clarified nutritional status. Surgical patients >= 10%weight loss vs medical p <	*__Weakness:__* Lack of homogeneity across the samples *__Strength:__* No recommendations for the critically ill patients who receive oral nutrition	*Nutritional Screening Tool* Comprehensive MNA and MUST were both reliable but MUST easier to implement in practice. Quality nutritional care mandatory before /during/after hospitalization.	I Substantial

		loss) and risk (MNA, MUST), energy requirements and diet.	0.01. Admission >= 5% weight loss predictive of longer LOS. MNA and MUST predictive of longer LOS. Mean energy requirements not significantly different between admission/discharge. 1400 kcal were always lower than on offer approximately 2128 kcal, p=0.0001.			
Kross et al.	2012	Retrospective observational study U.S.A To compare resting energy expenditure (REE), calculated with *published formulas, with measured REE using indirect calorimetry (IC) in a cohort of mechanically ventilated subjects. *Harris-Benedict, Owen, Mifflin, Ireton-Jones, ACCP guidelines (weight based) Category: sex (male: female), obese (class I, ii, iii) mechanically ventilated ICU patients	A total of 1519 IC measurements were made on 971 patients during the reviewed period. None of the equations used to predict REE agree well with actual energy expenditure measured by indirect calorimetry (IC).	*Weakness:* All predictive equations currently used in practice not examined. *Strength:* Largest study to date and supports prior reports that predictive equations do not accurately estimate REE for mechanically ventilated patients, especially in the setting of obesity	*Equation for Adequate Energy Requirement* Unique in the large number of mechanically ventilated, critically ill patients. Supported a need for development of improved predictive equations to assess energy needs, especially among obese, mechanically ventilated patients	III-2 Moderate
Kruizenga et al.	2010	Multi-centre, cross sectional observational study Development and validation of a quick and easy screening tool for the early detection of undernourished residents in nursing homes and residential homes. Screening tool developed in a total of 308 residents and cross validated in new sample of 720 residents. Severely undernourished if: BMI <or= 20 kg/m2 and/or >or= 5%	The four most predictive questions for undernutrition related to: unintentional weight loss more than 6 kg during the past 6 months and more than 3 kg in the past month, capability of eating and drinking with help, and decreased appetite during the past month. The diagnostic accuracy of these questions alone was insufficient (Se=45%, Sp=87%, PPV=50% and NPV=84%). However, combining the questions with measured BMI	*Weakness:* no information is available on how many residents were excluded because they were not able to give informed consent or could not be weighed *Strength:* Large sample size	*Nutritional Screening Tool* Early detection of undernourished nursing- and residential home residents is possible using four screening questions and measured BMI.	IV Moderate

		unintentional weight loss in the past month and/or >or= 10% unintentional weight loss in the past 6 months. Moderately undernourished if: BMI 20.1-22 kg/m2 and/or 5-10% unintentional weight loss in the past six months.	sufficiently improved the diagnostic accuracy (Se=87%, Sp=82%, PPV=59% and NPV=95%).			
Kyle et al.	2003	Prospective study To determine if fat-free mass (FFM) and body fat (BF) differed between patients at hospital admission in Geneva and Berlin and healthy volunteers, and if there is a difference in the prevalence of low FFM (percentile P90) between patients and volunteers. Methods: In total, 1760 patients (Geneva: 525 men, 470 women; Berlin: 397 men, 368 women) were evaluated for malnutrition by BMI, serum albumin, and FFM and BF, determined by bioelectrical impedance analysis (BIA), and compared to 1760 healthy volunteers matched for age and height, and further compared to FFM and BF percentiles, previously determined in 5225 healthy adults.	The prevalence of FFM P Geneva and Berlin patients had lower FFM and higher BF than age-and height-matched volunteers and a higher prevalence of low FFM and high BF. Serum albumin and BMI underestimated the prevalence of malnutrition in patients at hospital admission. Body composition measurements identified patients with low FFM and low or high BF reserves	***Weakness:*** The percentiles used in this study were developed in healthy Swiss adults. Lack of body composition data for healthy German volunteers ***Strength:*** Large sample size	*Nutritional Screening Tool*	II Moderate
Lammel et al.	2013	Cross-sectional study To detect the total acceptance rate and a possible association between oral nutritional supplements intake and nutritional status	The prevalence of malnutrition was 43.7% and overall acceptance of supplements was around 75%. Industrialized supplements have better acceptance among well-nourished inpatients and patients who ate less than 80% of the supplement	***Weakness:*** The cross-sectional design is a limitation of the present work, because it does not detect the real risk for malnutrition. ***Strength:***	*Hospital Under-Nutrition* There was an association between oral nutritional supplements intake and nutritional status, despite the good acceptance rate.	IV Moderate

			offered (industrialized or homemade) had higher risk for malnutrition (48%).	the first study comparing the acceptance of industrialized versus homemade nutritional supplements among well-nourished and malnourished inpatients		
Leandro-Merhi et al.	2009	Cross-sectional study To assess nutritional status indicators of patients about to receive enteral nutrition therapy in a hospital unit. Examined the nutritional status of 100 adult patients before they were introduced to enteral nutrition therapy by calculating their body mass index. Prediction formulas and laboratory indicators of nutritional and metabolic statuses estimated their height and weight.	29% of the patients classified as malnourished according to BMI, 80% low albumin values (<3.2 g/dL). When patients were grouped according to body mass index, the distribution of the reasons for hospitalization did not differ between the groups. Cardiovascular and pulmonary diseases prevailed as the main reasons for hospitalization. When patients were grouped according to body mass index and diagnosis upon admission, the rates of low albumin concentration, i.e., concentration below the reference value, did not differ between the groups.	*Weakness:* Lack of homogeneity across the samples Small sample size *Strength:* Considered underlying disease regarding malnutrition	*Nutritional Screening Tool*	IV Moderate
Liang et al.	2008	A prospective descriptive study To test the suitability of Nutritional Risk Screening 2002 (NRS 2002) among hospitalized patients and to determine the prevalence of nutritional risk, undernutrition, overweight, obesity, nutritional support and the changes of nutritional risk from admission to discharge or over a two-week period. A total number of 1500 consecutive patients, who met the inclusion criteria on	The NRS 2002 was completed by 97.7% of all patients in this study. The overall prevalence of nutritional risk was 27.3%, the prevalence of undernutrition, overweight and obesity was 9.2%, 34.8%, and 10.2%, respectively at admission. Only 24.9% of patients who were at nutritional risk received nutritional support while 6% of non-risk patients received nutritional support. The overall prevalence of nutritional risk changed from 27.3% to 31.9% (p	*Weakness:* Lack of homogeneity across the samples *Strength:* Large sample size	*Hospital Under-Nutrition*	II Moderate

		admission and provided informed consent, were enrolled.	< 0.05), and the prevalence of undernutrition, overweight and obesity changed from 9.2% to 11.7% (p < 0.05), from 34.8% to 31.8% (p > 0.05) and from 10.2% to 8.6% (p > 0.05), respectively during hospitalization.			
Lim et al.	2012	Prospective cohort study To determine prevalence of malnutrition in a tertiary hospital in Singapore and its impact on outcomes and costs, controlling for DRG. Subjective Global Assessment was used to assess the nutritional status on admission of 818 adults. Hospitalization outcomes over 3 years were adjusted for gender, age, ethnicity, and matched for DRG.	Malnourished patients (29%) had longer hospital stays (6.9±7.3 days vs. 4.6±5.6 days, p<0.001) and were more likely to be readmitted within 15 days (adjusted relative risk=1.9, 95% CI 1.1–3.2, p=0.025). Within a DRG, the mean difference between actual cost of hospitalization and the average cost for malnourished patients was greater than well-nourished patients (p=0.014). Mortality was higher in malnourished patients at 1 year (34% vs. 4.1 %), 2 years (42.6% vs. 6.7%) and 3 years (48.5% vs. 9.9%); p<0.001 for all. Overall, malnutrition was a significant predictor of mortality (adjusted hazard ratio=4.4, 95% CI 3.3–6.0, p<0.001)..	*Weakness:* Not have the data on the number of study patients referred for treatment of malnutrition or the outcome of that treatment. *Strength:* The first study to examine the impact of malnutrition on length of hospital stay, readmission, hospitalization cost and mortality in a large sample representative of patients admitted to a major Singaporean tertiary hospital Large sample size	*Hospital Under-Nutrition* Malnutrition was evident in up to one third of the inpatients and led to poor hospitalization outcomes and survival as well as increased costs of care, even after matching for DRG. Strategies to prevent and treat malnutrition in the hospital and post-discharge are needed	II Moderate
Lucchin et al.	2009	Cross-sectional survey Italy To investigate prevalence of nutritional risk on admission to hospital Patients enrolled from 13 large (>400beds) hospitals. Randomly Adults >18yrs included according to a 4-strata model by	1284 patients evaluated. Prevalence nutritional risk 28.6% with similar distribution between sexes and higher rates in medical rather than in surgical departments (33.6% vs 22.8%; p<0.0001). Adults aged 18–65yrs prevalence of “risk of malnutrition” was significantly lower than in	*Weakness:* Lack of homogeneity across the samples *Strength:* Large sample size The data of this study contributed to ‘‘malnutrition mapping’’ of Europe.	*Hospital Under-nutrition*	IV Moderate

		gender and age (<65 and ≥65 years). Nutritional risk assessed by the Nutritional Risk Screening 2002 tool.	those ≥65 years (18.3% vs 41.9%; p<0.0001).			
Middleton et al.	2001	Prospective study To determine: (i) the prevalence of malnutrition in two Sydney teaching hospitals using Subjective Global Assessment (SGA), (ii) the effect of malnutrition on 12-month mortality and (iii) the proportion of patients previously identified to be at nutritional risk. A total of 819 patients was systematically selected from 2194 eligible patients. Patients were excluded if they were under the age of 18, had dementia or communication difficulties, or were under obstetric or critical care. The main outcome measures were prevalence of malnutrition, 12-month incidence of mortality, proportion of patients identified with malnutrition, and hospital length of stay (LOS).	The prevalence rate of malnutrition was 36%. The proportion of malnourished patients was not significantly different between the two hospitals (P = 0.4). The actuarial incidence of mortality at 12 months after assessment was 29.7% in malnourished subjects compared with 10.1% in well-nourished subjects (P < 0.0005). Malnourished subjects had a significantly longer median LOS (17 days vs 11 days, P < 0.0005) and were significantly older (median 71 years vs 63 years, P < 0.0005) than well-nourished subjects. Only 36% of the malnourished patients had been previously identified as being at nutritional risk.	***Weakness:*** Out-dated study ***Strength:*** decreased sampling bias using systematic sampling by approaching every second patient admitted to the hospitals	*Hospital Under-Nutrition*	II Moderate
Naithani et al.	2008	Qualitative semi-structured interviews To examine in-patients_ experiences of access to food in hospitals.	Almost half of the patients reported feeling hungry during their stay and identified a variety of difficulties in accessing food. Categories 1.organizational barriers: unsuitable serving times, menus	***Weakness:*** Low response rate Response bias ***Strength:*** It included different types of wards and included both elderly and young patients	*Barriers to Adequate Nutrient Intake*	V Not rated for clinical significance

		48 patients from eight acute wards in two London teaching hospitals.	not enabling informed decision about what food met their needs, inflexible ordering systems) 2. physical barriers (not in a comfortable position to eat, food out of reach, utensils or packaging presenting difficulties for eating); 3.Environmental factors (e.g.staff interrupting during mealtimes, disruptive and noisy behaviour of other patients, repetitive sounds or unpleasant smells). Surgical and elderly patients and those with physical disabilities experienced greatest difficulty accessing food.	with a wide range of medical conditions.		
Neelemaatet al.	2008	Prospective cohort study To develop a quick and easy malnutrition screening tool and to measure its diagnostic accuracy in malnourished hospital outpatients.	1107 patients were included The three original SNAQ questions proved to be the best set of questions for the outpatient population as well. In the preoperative and general outpatient population the diagnostic accuracy resulted respectively in a sensitivity of 53% and 67%, a specificity of 97% and 98%, a positive predictive value of 69% and 72% and a negative predictive value of 94% and 97%.	*Weakness:* Lack of homogeneity across the samples *Strength:* Large sample size	*Nutritional Screening Tool*	II Moderate
Norman et al.	2008	Systematic review To investigate the prognostic implications of disease-related malnutrition.	Prevalence of hospital malnutrition ranges between 20% and 50% depending on the criteria used in order to determine malnutrition and the patient's characteristics. Furthermore, nutritional status is known to worsen during hospital	*Weakness:* Lack of homogeneity across the samples *Strength:* High level of evidence	*Hospital Under-Nutrition* Since it has been demonstrated that proper nutritional care can reduce the prevalence of hospital malnutrition and costs, nutritional assessment is mandatory in order to	I Substantial

			stay which is partly due to the poor recognition by the medical staff and adverse clinical routines. Length of hospital stay is significantly longer in malnourished patients and higher treatment costs are reported in malnutrition.		recognise malnutrition early and initiate timely nutritional therapy.	
Meijers et al.	2009	A cross-sectional, multi-centre study Netherland To provide data on malnutrition prevalence in hospitals, nursing homes and home-care organisations in The Netherlands in a nationally representative sample, and to assess the factors such as age, sex, time since admission, ward type and disease for identifying patients at high risk of malnutrition.	In this study, 12 883 patients were included. The prevalence of malnutrition was the highest in hospitals (23.8 %), followed by home-care organisations (21.7 %) and nursing homes (19.2 %). Logistic regression analysis revealed no association with age, time since admission and ward type. Being female was associated with malnutrition only in nursing homes. Blood diseases, gastrointestinal tract diseases, infection, chronic obstructive pulmonary disease, dementia and cancer were the factors associated with malnutrition in hospitals. Dementia was associated with malnutrition in nursing homes, while gastrointestinal tract diseases, diabetes mellitus and cancer were the associated factors in home care. This study shows that malnutrition is still a substantial problem in hospitals, nursing homes and home care in The Netherlands. Malnutrition is a problem for more than one in five	*Weakness:* Not able to measure the progression over time of certain disorders and their possible risk factors *Strength*: Large sample size One of the first large-scale, multi-centre prevalence studies focusing on health-care problems carried out annually in The Netherlands	*Hospital Under-Nutrition*	IV Moderate

			patients. Despite growing attention to the problem, more continued alertness is required.			
Morphet, Clarke & Bloomer	2016	Descriptive questionnaire (Survey) Australia To explore Australian nurses' enteral nutrition knowledge and sources of information	Self-rated knowledge: Their enteral nutrition knowledge was good (*n* = 205, 60.1%) or excellent (*n* = 35, 10.3%), but many lacked knowledge regarding the effect of malnutrition on patient outcomes. *Knowledge deficits* Respondents reported knowledge deficits in relation to gut physiology, feed formulation and administration rates. Feed formulation, including a lack of understanding of different feed formulas, types of formulations required for different clinical presentations and calculation of regimes and calories were commonly reported. Information were hospital-based in-services and dietitians.	*Weakness:* Low response rate: may have response bias Self-report: may over or under report their level of knowledge in self-report studies, which can affect the results. *Strength:* Inclusion of nurses from across Australia, with a diverse range of clinical education and experience	*Barriers to Adequate Nutrient Intake*	IV Moderate
Mowe et al.	2006	Survey Denmark, Sweden and Norway. To investigate nutritional practice in different hospital settings in relation to published ESPEN standards (e.g.: screening of all patients, assessment of at-risk patients) by Scandinavian doctors and nurses.	4512 (1753 Drs, 2759 RNs) answered questionnaire. Screening and assessment of at-risk patients differ between countries. Screening Denmark (40%), Sweden (21%), Norway (16%). Measuring dietary intake Denmark (46%), Sweden (37%), Norway (22%). Agreement with importance of nutritional screening: Denmark 92%, Sweden 88%, Norway 88%) and measuring dietary intake:	*Weakness:* Low response rate *Strength:* Large sample size	*Hospital Under-Nutrition* Large discrepancy between nutritional attitudes and actual practice - standards recommended by ESPEN are not fulfilled.	IV Moderate

			Denmark 97%, Sweden 95%, Norway 97%.			
Mowe et al.	2008	Survey To study doctors and nurses' self-reported knowledge in nutritional practice, with focus on ESPEN's guidelines in nutritional screening, assessment and treatment.	The most common cause for insufficient nutritional practice was lack of nutritional knowledge: found it difficult to identify patient in need of nutritional therapy (25%), lacked techniques for identifying malnourished patients (39%) found it difficult to calculate the patients' energy requirement (53%), lacked national guidelines for clinical nutrition (66%). Twenty-eight percent answered that insufficient nutrition practice could lead to complications and prolonged hospital stay. Those that answered that their nutritional knowledge was good had also a better nutritional practice.	*Weakness:* Not revealed the actual nutritional knowledge *Strength:* Implication: Low nutritional knowledge might lead to inappropriate nutritional practice.	*Barriers To Adequate Nutrient Intake: health professionals' lack of knowledge*	IV Moderate.
Nava & Fanfulla	2014	Electronic book	Stated general information on NIPPV such as complications and effect of NIPPV	Weakness: Insufficient information about nutrition during NIPPV therapy Strength: Offered general knowledge of NIPPV	EN during NIPPV	Not rated
Ordonez et al.	2013	Retrospective observational study To investigate the relationship between the nutritional status (NS) and clinical outcome and length of stay (LOS) among patients admitted to the internal medicine ward.	396 patients were included in the study, 42.2% were over 60 years of age, what was associated with the presence of hypertension ($p < 0.001$), diabetes mellitus ($p = 0.003$) and required diet with modifications consistency ($p = 0.003$). According to combined diagnostic tools, 45.7% of patients were malnourished. Decreased	*Weakness:* Not concerned about underlying disease on nutritional status *Strength:* The use of different tools t in order to define the nutritional diagnosis,	Hospital Under-Nutrition	III-2 Moderate

		The NS was assessed using: subjective global assessment (SGA), body mass index (BMI), triceps skinfold thickness (TST), muscle arm circumference (MAC) and combined tools.	food intake (p = 0.01), malnutrition according to SGA (p = 0.02) and MAC (p = 0.03) were associated with increased mortality. Patients with tertiary level of care (p = 0.01), decreased food intake (p = 0.001), who died (p = 0.004) and diagnosed with malnutrition by SGA (p = 0.001) and by the combined tools (p = 0.001) had a longer LOS.			
Pasquini et al.	2012	Prospective observational study Brazil To assess the evolution of nutritional status (NS) and the effect of malnutrition on clinical outcome of patients at a public university hospital of high complexity in Brazil NS was evaluated using subjective global assessment up to 48 h after admission, and thereafter at intervals of 4-6 days	On admission, patients (n = 109) were classified as well-nourished (n = 73), moderately malnourished or at risk of malnutrition (n = 28), and severely malnourished (n = 8). During hospitalization, malnutrition developed or worsened in 11 patients. Malnutrition was included in the clinical diagnosis of only 5/36 records (13.9% of the cases, P = 0.000). Nutritional therapy was administered to only 22/36 of the malnourished patients; however, unexpectedly, 6/73 well-nourished patients also received commercial enteral diets. Complications were diagnosed in 28/36 malnourished and 9/73 well-nourished patients (P = 0.000). Death occurred in 12/36 malnourished and 3/73 well-nourished patients (P = 0.001). A total of 24/36 malnourished patients were discharged regardless of NS.	_Weakness:_ Only include three wards: internal medicine, oncology, and infectious disease wards Small sample size _Strength:_ Presentation of the effect of malnutrition on clinical outcome	*Hospital Under-Nutrition-Nutritional Screening Tool*	II Moderate .
Rahman et al.	2015	Prospective observational study Canada	A total of 315 patients were included (female, n = 160 [51%];	_Weakness:_	*Hospital Under-Nutrition-Nutritional Screening Tool*	II Moderate

		To define the point prevalence of malnutrition risk at a major tertiary care centre in Hamilton, Ontario, using the Malnutrition Universal Screening Tool (MUST) to determine feasibility of hospital-wide screening in the Canadian context.	male, n = 155 [49%]; average age, 71 years). We identified 31% at high risk for malnutrition and 14% at medium risk, keeping with reported rates of malnutrition in the literature. Survey of dietitians and interns indicated that the MUST was easy to use and perform and that they had support of their unit supervisors. All respondents thought that the screen was useful and they wanted to repeat it.	Not assess actual nutrition status; some patients who were identified as high risk for malnutrition based on the MUST may not have been malnourished. *Strength:* System-wide malnutrition risk screening which allows institutions to determine economic feasibility and whether system-wide screening and intervention can improve outcome measures such as length of stay and readmission.		
Rice & Normand	2012	Retrospective data analysis Establish the annual public expenditure from care of patients with diet-related malnutrition (DRM) in the Republic of Ireland. Costs were calculated by (i) estimating the prevalence of DRM in health-care settings derived from age-standardised comparisons between available Irish data and large-scale UK surveys and (ii) applying relevant costs from official sources to estimates of health-care utilisation by adults with DRM. No attempt has been made to estimate separately the costs of DRM and any associated disease, since each can be a cause or consequence of the other. Settings: Hospitals, nursing homes, out-patient clinics,	The annual public health and social care cost associated with adult malnourished patients in Ireland is estimated at over 1.4 billion, representing 10%of the health-care budget. Most of this cost arises in acute hospital or residential care settings (i.e. 70%), with nutritional support estimated to account for, 3% of spend.	*Weakness:* Large-scale Irish studies using MUST were available only for hospital in-patients, necessitating age-adjusted comparison with or extrapolation from UK studies for other settings *Strength:* Raised attention to growing pressure on health-care budgets	*Hospital Under-Nutrition*	III-2 Moderate

		primary-care clinics and home care. Subjects: All adult patients receiving hospital in-patient, out-patient or specified community health-care services.				
Rowell & Jackson	2011	Retrospective data analysis Estimate the cost of inpatient malnutrition conditional upon admitting diagnosis and recorded nutritional treatment.	The total cost of coded malnutrition to the Victorian public hospital system in 2003-2004 was estimated to be least AU $10.7 million. Only 1.87% of inpatients were coded as malnourished. As administrative data are known to underreport the prevalence of malnutrition, our estimate represents a credible lower boundary on the true cost of inpatient malnutrition.	*Weakness:* some uncertainty about the prevalence of coded malnutrition in the medical record *Strength:* The first study to estimate cost of untreated malnutrition in the Victorian inpatient population Large sample size	*Hospital Under-Nutrition*	III-2 Moderate
Rubenstein et al.	2001	Retrospective data analysis To develop a screening version of this instrument, the MNA-SF, that retains good diagnostic accuracy. Reanalysed data from France that were used to develop the original MNA and combined these with data collected in Spain and New MEXICO	The MNA-SF was strongly correlated with the total MNA score (r = .945). Using an MNA-SF score of > or = 11 as normal, sensitivity was 97.9%, specificity was 100%, and diagnostic accuracy was 98.7% for predicting undernutrition.	*Weakness:* No randomise control trial *Strength:* Large sample size	*Hospital Under-Nutrition- Nutritional Screening Tool* The MNA-SF can identify persons with undernutrition and can be used in a two-step screening process in which persons, identified as "at risk" on the MNA-SF, would receive additional assessment to confirm the diagnosis and plan interventions.	III-2 Moderate
Sanchez et al.	2014	Systematic review (guideline)	General guidelines about caring for patients receiving NIPPV therapy	*Weakness:* Not enough information about nutrition associated with NIPPV therapy *Strength:* Australian guideline for NIPPV therapy for patients with acute respiratory failure	EN during NIPPV	? Moderate
Sorensen et al.	2008	Prospective cohort study Implement nutritional risk screening (NRS-2002) and	Of the 5051 study patients, 32.6% were defined as ‘at-risk’ by NRS-2002. ‘At-risk’ patients had more	*Weakness:* Some patients may have been misclassified due to the	*Hospital Under-Nutrition- Nutritional Screening Tool*	II Moderate

		assess the association between nutritional risk and clinical outcome.	complications, higher mortality and longer lengths of stay than 'not at-risk' patients and these variables were significantly related to components of NRS-2002, also when adjusted for confounders.	estimation of body weight or presence of oedema in about a third of patients *Strength:* Large sample size		
Stratton et al.	2006	Retrospective cohort study The 'Malnutrition Universal Screening Tool' ('MUST') has been developed to screen all adults, even if weight and/or height cannot be measured, enabling more complete information on malnutrition prevalence and its impact on clinical outcome to be obtained.	Only 56 % of patients could be weighed, all (n 150) were screened with 'MUST'; 58 % at malnutrition risk had greater mortality (in-hospital and post-discharge, P<0.01) and longer LOS (P=0.02). 'MUST' categorisation and component scores (BMI, weight loss, acute disease) were significantly related to mortality (P<0.03). Clinical outcome worse in those at risk of malnutrition.	*Weakness:* No randomise control trial: the results are not generalizable *Strength:* The first study to indicate the practicality and predictive validity of 'MUST' in a group of acutely ill, hospitalised elderly patients	*Hospital Under-Nutrition- Nutritional Screening Tool* 'MUST' predicted clinical outcome in malnourished hospitalised elderly. Higher prevalence of malnutrition and associated poorer clinical outcome supports the importance of routine screening with a tool.	III-2 Moderate
Thorensen et al.	2008	Survey To assess the opinions among doctors, nurses and clinical dietitians regarding the use of clinical dietitians' expertise in the hospital units and, further, to assess whether the presence of clinical dietitians in hospital departments influenced doctors and nurses focus on clinical nutrition	The response rate of clinical dietitians, nurses and doctors were 53%, 46% and 29%, respectively. Nurses and doctors who saw clinical dietitians often found it less difficult to identify undernourished patients and found that insight into the importance of adequate nutrition was better than those who saw clinical dietitians seldom. Clinical nutrition had a higher priority in units with frequent visits by clinical dietitians.	*Weakness:* Small response rate *Strength:* The first study to assess the present status for clinical dietitians working in hospitals in Scandinavian countries, regarding co-operation with doctors and nurses, and the use of their expertise in the treatment of undernourished patients.	Nutritional barriers - *Health professionals' knowledge and attitude towards nutrition*	II Moderate
Wakabyashi & Sashika	2014	Prospective cohort study. To investigate association between nutritional status and rehabilitation outcome in elderly	A total of 148 patients (87.6%) were malnourished, and 21 were at risk for malnutrition. There were no patients with normal nutritional	*Weakness:* *Small sample size* *Strength:*	*Hospital Under-Nutrition/ Nutritional Screening Tool*	II Moderate

		inpatients with hospital-associated deconditioning.	status. Chronic disease-related malnutrition, oral intake, and parenteral nutrition were associated with the Barthel Index score at discharge. There were significant correlations between the Barthel Index score at discharge and nutritional score, albumin, and total lymphocyte count. In multiple regression analysis, Mini Nutritional Assessment Short Form, albumin, and chronic disease-related malnutrition were significantly associated with the Barthel Index score at discharge	This study showed association between malnutrition, evaluated by a validated nutritional assessment method, and poor rehabilitation outcome in elderly inpatients	Most elderly inpatients with hospital-associated deconditioning are malnourished. Nutritional status, albumin, and chronic disease-related malnutrition are associated with poor rehabilitation outcome in hospital-associated deconditioning.	
Watterson et al.	2009	Integrated/thematic review	Malnutrition is a considerable problem that increases with age. Patients over 80 years have a higher odds risk of being malnourished compared with those between 61-80 years. Chronically ill patients, many of whom are elderly, will be in and out of hospital regularly. Adequate flagging of these patients on admission is required, as is appropriate follow up at discharge. Patients with a reduced energy intake the month before hospitalisation have been shown to have a reduced nutritional status compared to other patients. Further examination of malnutrition in medical patients has highlighted a second group of patients, who while not malnourished on admission, are at high risk of becoming so.1These patients need to be identified early and treated effectively to minimise	<u>*Weakness:*</u> Written by dietitian but minimal discussion of their role in the MDT, some of the factors impinging on them achieving this role (implicit rather than explicit) The author's suggested strategies to improve nutrition did not address all the factors limiting nutritional intake. <u>*Strength:*</u> provide evidence of the prevalence of malnutrition in hospitals in Australia Raised the issue of insufficient energy intake month prior to admission which is then linked to continued decreased energy intake in hospital. Raised factors effecting decreased nutritional intake.		Not rated

			a further decline in nutritional status.			

Appendix A. 3 Content analysis of ICU NIPPV Policies

Author/organisation	Date	Name of Policy/guideline /procedure	**Aspiration** **Oral intake** **NGT**
Barnes, D.	2007	Non-invasive Ventilation in COPD 2: Starting and Monitoring NIV. Clinical Guided Learning	The full face mask is recommended for the initial 24 hours and is better for COPD patients who tend to mouthbreathe. Ensure frequent breaks for food and fluids, chest physiotherapy and prescribed nebulisers Extent of mention of nutritional needs
Capital Health Pennington New Jersey USA.	2011	Interdisciplinary Clinical Manual. Non-Invasive Positive Pressure Ventilation (NIPPV)Policy/ Procedure	No reference to nutrition – warn of vomiting but no rationale An interdisciplinary manual – but no information for dietitians in the NIPPV procedure
ICSN and ICCMU - Intensive Care NSW: Agency for Clinical Innovation (ACI).Intensive Care NSW. Australia.	2017	Australia Nursing care, nutrition and hydration for NIV adults	Oral feeding is to be initiated if the patient is able to tolerate small periods off NIV. (Consensus) Dietetics and nutritionist assessments are to be undertaken and documented for the patient receiving NIV 24 hours after initiation of therapy. Patients should be able to tolerate small periods off NIV for the purpose of maintaining nutritional intake to meet the increased physiological requirements associated with his or her increased respiratory effort. If unable to tolerate these periods of NIV should be considered for escalation of ventilator support. Advice for variables used to monitor outcomes of patients receiving NIV does not include nutritional status.
Lowe F (2017) Salisbury NHS Foundation Trust	2017	Continuous Positive Airway Pressure in the Acute Setting	**Risk of aspiration due to gastric distension.** The Boussignac CPAP valve system allows vomit to pass through. However, to reduce the risk of aspiration, patients who develop gastric distension or who are nauseous should have a naso-gastric tube inserted, put on free drainage and the tube aspirated every 4 hours. Regular anti-emetics should also be administered. **Dehydration and malnourishment**: Due to the nature of the illness the patient is unlikely to be able to maintain an adequate oral intake. Closely monitor fluid balance and if indicated, commence IV fluids and consider a fine bore nasogastric feeding tube.
Thomas P Study ICU	2016	SS1022798 ICU- Non Invasive Ventilation	***Perquisites:*** Adequate glottis reflexes should be present to protect from aspiration (?? COAD Pts) ; No oral or NG intake ***Complications:*** Aerophagia, gastric distension, aspiration (no interventions suggested)

Osteraas & Fuzzard	2001	Non-invasive Positive Pressure Ventilation in the Emergency Department	***Contraindication:*** Vomiting ***Complication:*** Gastric distention, abdominal pain, regurgitation aspiration. ***Causes:*** air swallowing, poorly fitted mask, excessive positive pressure, eating or drinking immediately before or during NIPPV. ***Interventions:*** delay commencing NIPPV until 2 hrs after a meal; discourage eating and drinking during NIPPV; administer antigas medication; adjust device setting and fit of interface
Pilbeam et al. USA	2006	Part II: Introduction to Noninvasive Positive Pressure Ventilation in the Acute Care Setting.	Preserves airway defence, speech, and swallowing mechanisms Increased risk of aspiration More difficulty with speech Inability to eat with mask in place ***Gastric Insufflation (Aerophagia) and Gastric Distention*** Excessive pressure or air swallowing can cause air gastric inflation (insufflation) and gastric distention Use pressures less than 20 to 25 cm $H2O$ Use simethicone (anti-flatulent) agent **Use of Nasogastric Tubes** Use of nasogastric tubes to take air from the stomach is controversial The tube increases leaking around the mask The tube itself blocks a nasal passage Compression of tube against the skin by the mask may increase risk of skin breakdown If an NG tube must be used, one possible solution is to use an interface between the tube and the skin and mask
ResMedica RES	2014	Non-Invasive Positive Pressure Ventilation Guidelines	Periods off NPPV allow for intake of oral nutrition, fluids
Royal College of Physicians, British Thoracic Society, Intensive Care Society 2008.	2008	Chronic obstructive pulmonary disease: non-invasive ventilation with bi-phasic positive airways pressure in the management of patients with acute type 2 respiratory failure. Concise Guidance to Good Practice series, No 11. London RCP,	**NGT:** If a NGT is in place, a fine bore tube is preferred to minimize mask leakage [C] **Exclusion criteria for NIV:** vomiting **Gastric distension** Check for abdominal pain or distension occurring during NIV. Try to reduce IPAP if possible. Consider a NGT with a nasogastric tube guard, accepting a small leak as small leaks should not cause a problem.
Saskatoon Health Region (SHR)	2016	Policies & Procedures: CPAP/BiPAP-Non Invasive Ventilation (NIV) - Care and I.D. #1114	**Note:** Patients may be at high risk of aspiration or loss of seal with repeated removal and re-application of the mask **Oral Intake:** The patient will be NPO for the first 24hrs of NIV. Medications that must be given orally can be maintained, but all others should be temporarily held or switched to IV route. After 24hrs, decisions regarding nutritional and oral intake will be made according to patient stability and likelihood of intubation. ***Nutrition*** Consult physician prior to any oral intake.

			Note: The patient will be NPO for the first 24 hours of NIV. After 24 hours, decisions regarding nutrition and oral intake will be made according to patient stability and likelihood of intubation **Relative Contraindications:** Aspiration risk, nausea or vomiting **Reducing Risk of Aspiration** The patient will be NPO for the first 24 hours of NIV. Medications that must be given orally can be maintained, but all others should be temporarily held or switched to IV route. After 24 hours, decisions regarding nutrition and oral intake will be made according to patient stability and likelihood of intubation.
Tamworth Base Hospital (Victoria Australia)	2012	Non-invasive positive pressure ventilation (NIPPV) package	***Advantages:*** Patient can eat, drink and communicate ***Contraindication:*** Vomiting/ and or high aspiration risk; Gastric distention ***Troubleshooting*** S/S: Gastric distension, Abdominal pain, Regurgitation and Aspiration Causes: Air swallowing Poor fitting mask Excessive air pressure Eating and drinking prior to commencement Interventions: Delay starting BiPaP for 2/3 hours; Nil by mouth; Administer antiemetics; Adjust mask; Consider NG insertion ***Before you initiate NIPPV you should do:*** • A complete history and physical examination. • Nil by mouth. ***Patient considerations:*** After a few hours, or when you can see they can maintain a patient airway the patient can eat. The patient may utilise a nasal mask or nasal prongs.
Western Health St Albans VIC 3021	2016	Guideline for Non Invasive Ventilation (NIV) in the Cardiac Care Unit (CCU)	Patient remains nil orally whilst CPAP in use. ***Potential complications:*** Aspiration pneumonia; Gastric distension: (routine gastric decompression is unnecessary).

Appendix B. 1 Clinical Reporting Form (CRF)

Patient Enrolment Number : **(gender/ age)**	
ICU Admission date and time	
Reason for ICU Admission	
Body weight / height on admission	
APACHE II score on admission	
SOFA score on admission	
Commencement of NIPPV (date / time)	

	D 1	D 2	D 3	D 4	D 5	D 6	D7
Type of NIPPV (√)							
CPAP							
BIPAP							
HFNC							
Type of interface (√)							
Nasal							
Oro-nasal							
Total hours on NIPPV							
ABG results (am)							
PaO_2/ PaCO2							
pH							
HCO_3							
Lactate							
Haematological results (am)							
albumin							
Haemoglobin							
Vital sighs (8am/ 8pm)							
BP *(mmHg)*							
RR (/ min)							
Temp (°C)							
HR (/min)							
SpO_2 ***(%)***							
GCS							

Diagnosis of aspiration pneumonia confirmed by chest X-ray (Yes or No)

Discharge status: 1. Home, 2. Another ward, 3. Another hospital 4. ICU death 5. Other & discharge date /time

Additional comment:

Appendix B. 2 Clinical Reporting Form (CRF)

Flinders UNIVERSITY

Nutrition	D1	D2	D3	D4	D5	D6	D7
Date and Time (D1=commencement of NIPPV)							
Oral nutrition (√)							
If oral, go to the nutrient intake daily chart (p.2 -3)							
Enteral nutrition (√)							
If enteral, specify the site/ tube size							
Nasogastric							
Jejunal							
Other							
Feeding rate							
Brand Feed							
Symptoms or episodes of:							
Nausea							
Vomiting							
Abd. distension							
Other							
Hours stopped feeding / reasons							
Procedure							
Aspiration							
High Gastric Residual Volume							
Other							
Parenteral nutrition (Y/N)							
IV Site							
Rate ml/ hr.							
Hours stopped feeding / reasons							
Procedure							
Other							

Appendix C. 1 Food and Fluid Chart

Daily Nutrient Intake Chart	**Day:**		**Date :**
BREAKFAST:	***Amount consumed***	**MORNING TEA:**	***Amount consumed***
Drink (Type):	……….. ml	Drink (Type):	……….. ml
Fruit (Type):	……….. cup	Supplements (specify):	……….. ml
Cereal (specify):	………… cup	Snack (specify):	………..
Milk (Full cream/ Low fat)	………… ml	**Type of diet**	**Reason for not eating**
Sugar	………...tspn/s	Standard meal ( )	No appetite ( )
		High energy/ protein ( )	Nausea / vomiting ( )
		Low residue menu ( )	Respiratory distress ( )
		Other ( )	Procedure ( )
		Specify:	Other ( )
Hot dish (specify):	………… serve	Feeding: patient ( )/ by other ( )	Comment:
LUNCH:	***Amount consumed***	**AFTERNOON TEA:**	***Amount consumed***
Soup	………..ml	Drink (Type)	……….. ml
Meat/fish/chicken/omelette	………..serve	Supplements (specify):	……….. ml
Potato/rice	………..serve	Snack (specify):	………..
Vegetables/salad	………..serve	**Type of diet**	**Reason for not eating**
Bread /Butter (Y/N)	………..slice/s	Standard meal ( )	No appetite ( )
Sandwich (specify)	………..	High energy/ protein ( )	Nausea / vomiting ( )
		Low residue menu ( )	Respiratory distress ( )
		Other ( )	Procedure ( )
Drink (specify):	………..ml	Specify:	Other ( )
		Feeding: patient ( )/ by other ( )	Comment:

Appendix C. 1 Food and Fluid Chart

Daily Nutrient Intake Chart	**Day:**	**Date :**	
DINNER:	***Amount consumed***	**SUPPER:**	***Amount consumed***
Soup	………..ml	Drink (Type):	……….. ml
Meat/fish/chicken/omelette	………..serve	Supplements (specify) :	……….. ml
Potato/rice	………..serve	Snack (specify):	………..
Vegetables/salad	………..serve	**Type of diet**	**Reason for not eating**
Dessert /fresh fruit (specify):	……….. serve	Standard meal ( )	No appetite ( )
		High energy/ protein ( )	Nausea / vomiting ( )
		Low residue menu ( )	Respiratory distress ( )
		Other ( )	Procedure ( )
		<u>Specify</u>:	Other ( )
Hot dish (specify):	………… serve	Feeding: patient ( )/ by other ( )	<u>Comment:</u>
Dietitian consult: **(yes or no)**			

Appendix C. 2 Extra Food and Fluid Chart

Extra food and drink consumed Day: Date:				
Time	**Type of food**	**Amount consumed**	**Type of drink**	**Amount consumed**
0800				
0900				
1000				
1100				
1200				
1300				
1400				
1500				
1600				
1700				
1800				
1900				
2000				
2100				
2200				
2300				
2400				
0100				
0200				
0300				
0400				
0500				
0600				
0700				
0800				

Appendix D. 1 Cover letter and Explanation sheet

Dear ICU nurses,

Hello, I am Sowha Jeong who is a master's student in the Nursing and Midwifery at Flinders University. I am undertaking research leading to the production of a thesis and other publications on the subject of "Nutrient intake in patients receiving non-invasive positive pressure ventilation (NIPPV) therapy in the intensive care unit (ICU)".

I would like to invite ICU nurses to assist with this project by completing observational audit forms which cover certain aspects of this topic. Thirty days would be required to perform data collection for this research project.

This is an observational audit. Observational audit forms are comprised of two sections: clinical audit form and nutrition chart. Inclusion criteria of the patients are all adult patients (age ≥ 18years) administered in the ICU and have been staying at least for 12 hours. A research nurse would help screen the eligible patients. There is a brief explanation of completing the audit forms below.

Clinical reporting form

The clinical reporting form will mainly be completed by this researcher with reviewing the medical chart. You need only complete the columns highlighted on the form. Then, if possible, please give any comments at the end of the form if the patient has a specific event during the day. In this form, day 1 is the day when the patient commences NIPPV therapy.

Nutrition chart

The nutrition chart is made up three pages. On the front page, please identify what kind of nutrition the patient has: oral, enteral, or parenteral. If the patient is given more than one nutritional support, such as oral feeding in combination with parenteral nutrition, please tick the box on oral feeding as well as parenteral nutrition. The second page is food chart for orally fed patients. Please fill in the food chart as accurately as possible including three meals (breakfast, lunch and dinner) and teas (morning tea, afternoon tea and supper). Please record the amount food consumed using '*ml, teaspoon, cup, serve, packet or slice'.* If the patient has any extra food or drink, record the list and the amount of the food or drink on the last page of the form. In this form, day 1 is also the day when the patient commences NIPPV therapy. Please keep recording the observation forms for 2-week or until the patient is discharged (or dies). I have attached the sample observational forms; please have a look at them before filling in the form.

If you have any inquiries relating to this project, please do not hesitate to contact this researcher by mobile on 0450 700 949, or e-mail, jeon0049@flinders.edu.au. You can also contact me in person; I will visit the ICU every day between 11am to 2pm.

Thank you for your attention and assistance.

Yours sincerely,

Sowha Jeon

Appendix E. 1 Approval from the Flinders University Social and Behavioural Research Ethics Committee

FINAL APPROVAL NOTICE

Project No.:	**6457**
Project Title:	Nutrition in patients receiving non-invasive positive pressure ventilation therapy in an intensive care unit
Principal Researcher:	Miss Sowha Jeong
Email:	jeon0049@flinders.edu.au

Approval Date:	17 April 2014	Ethics Approval Expiry Date:	**31 December 2015**

The above proposed project has been **approved** on the basis of the information contained in the application, its attachments and the information subsequently provided.

Appendix E. 2 Approval from the Lyell McEWIN Hospital Research and Ethics Committee

Government of South Australia
SA Health

Northern Adelaide Local Health Network
LYELL McEWIN HOSPITAL
Haydown Road
ELIZABETH VALE SA 5112

Intensive Care Unit
Level 2
Ph: 61 8 828 20890
Fax: 61 8 828 20889

Director
Dr PD Thomas OAM, MBBS
FRACP, FANZCA, FCICM
ABN: 8449918952
Provider No: 0156587F

13th March 2014

Dr Diane Chamberlain
Senior Lecturer: Critical Care Studies
School of Nursing and Midwifery
Faculty of Health Services
Flinders University
Sturt Road
Bedford Park SA 5042

Dear Di,

It was nice to hear from you. I am writing to provide permission for your Master student to conduct research in our ICU, as you requested. Nutritional support in patients on NIPPV is an important issue about which there is little published information, so I am delighted to support research endeavours in this area.

Yours sincerely,

DR PD THOMAS OAM, MB BS, FRACP, FANZCA, FCICM
Director Intensive Care Services
Northern Adelaide Local Health Network

Appendix E. 3 Approval of Human Research Ethics Committee

Government of South Australia
SA Health

10 September 2014

Dr Diane Chamberlain
School of Nursing and Midwifery Flinders University
Sturt Road
Bedford Park SA 5042 Dear Dr Chamberlain

Human Research Ethics Committee (TQEH/LMH/MH)
Basil Hetzel Institute DX465101 The Queen Elizabeth Hospital
28 Woodville Road Woodville South SA 5011 Telephone: 08 8222 6841
Email: qeh.ethics@health.sa.gov.au

HREC reference number: HREC/14/TQEHLMH/155
Project title: Patients receiving non-invasive positive pressure ventilation therapy in an intensive care unit are more likely than not to be undernourished and the resulting complications of undernutrition.

RE: HREC Application HREC/14/TQEHLMH/155 – Request for Further Information

The Human Research Ethics Committee (TQEH/LMH/MH) Chairman has expedited the review of your protocol under Section 5.1.19 of the National Statement on Ethical Conduct in Human Research.

In order to make a determination of the ethical and scientific acceptability of your project, please clarify the following issues:

- A "clean" version of the NEAF required – it is difficult to read the document provided with tracked changes.
- Details of who is funding the project (including in-kind support) is required on page 5 of the NEAF. *[NS 5.2.7]*
- All documents should contain page numbers, and version number/date for document version control (e.g. Clinical Audit forms and protocol).
- Page 7 of the NEAF contains incorrect HREC name – should be "Human Research Ethics Committee (TQEH/LMH/MH) - EC00190".
- Page 16 of the NEAF states that data will be collected about the participant by another person. Clarification is required who is collecting the patient data (e.g. is a LMH staff member collecting the data, is it being de-identified before being sent to Flinders Unit, etc).
- The Participant Table on page 12 of the NEAF must be completed in full. *[NS 4]*

In order to facilitate the HREC's consideration of your project, please provide the requested information as soon as possible.

Please ensure your response includes a covering letter addressing each point. Any documents that are re-submitted should have the changes clearly highlighted (or tracked changes) and footers updated with a new version number and date.

Should you have any queries about this matter, please contact Ms Melissa Kluge on 08 8222 6841 or qeh.ethics@health.sa.gov.au

Yours sincerely

A/Professor Timothy Mathew
Chairman, Human Research Ethics Committee (TQEH/LMH/MH)
TM:mk