

# The Prevalence of Aspiration Pneumonia In Rest Home Residents With Reduced Cough Reflex Sensitivity

A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Master of  
Science

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## Abstract

The aim of this study was to determine whether there was an association between a failed test of cough reflex sensitivity and history of chest infection in a general population of rest home residents. One hundred rest home residents from four different levels of care (rest home, hospital, dementia and psycho-geriatric) were recruited and their cough reflex assessed using a solution of 0.6 Mol/L citric acid nebulised and presented via a facemask. Participant's records were then checked to see if there were any documented episodes of chest infection in the 6 month period prior to cough reflex testing.

The results showed that out of 100 participants, 4 failed the cough reflex test. Of the 4 that failed the test, 3 had no documented episodes of chest infections recorded in the 6 month period prior to cough reflex testing. Data was not available for one participant who was deceased by the time of collection of the second data set. As such, there was no direct association demonstrated between a failed cough reflex test and development of chest infection or aspiration pneumonia. The results of the study are unexpected in two ways. Firstly, the relatively low number of participants who failed the cough reflex test is surprising as 72% of the participants for whom a full data set was obtained had neurological conditions that are known predisposing factors for reduced cough reflex sensitivity. Secondly, the finding of no association between a failed cough reflex test and history of recorded chest infection is not consistent with other studies. There is however an established body of research that indicates the causes of aspiration pneumonia are multifactorial and not solely dependent upon aspiration. The characteristics of participants and the implications of the findings are described. The potential use of cough reflex testing

as a tool to screen against the risks of silent aspiration in relation to assessment of oropharyngeal dysphagia in this frail, elderly population is discussed.

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## Preface

This MSc. thesis conforms to the American Psychological Association (APA) Publication Manual (6th Edition). Spelling is in New Zealand English. This research was carried out between March 2013 and February 2015 in rest homes in Dunedin, New Zealand. The research was conceived and supervised by Dr Maggie-Lee Huckabee of the University of Canterbury.

# Abbreviations

AMA – arm muscle area

AC – arm circumference

BOLD – blood oxygen level dependent

BPSD – behavioural and psychological symptoms of dementia

CAP – community acquired pneumonia

COPD – chronic obstructive pulmonary disease

CRT – cough reflex test

CSE – clinical swallowing evaluation

HAP – hospital acquired pneumonia

HCAP – health care associated pneumonia

INCUR – incidence of pneumonia and related consequences in rest homes

ISLN – internal branch of the superior laryngeal nerve

MTP – maximum tongue pressure

PD – Parkinson's disease

RAR – rapidly adapting receptor

TSF – triceps skin fold thickness

VEES – videoendoscopic evaluation of swallowing

VFSS – videofluoroscopic swallowing study

## Chapter 1 – Introduction

Speech language therapists working with adults in community settings routinely receive referrals to assess the swallowing function of rest home residents. Rest home residents are frail, elderly and may have health conditions that predispose them to having oro-pharyngeal dysphagia (swallowing difficulties). Oro-pharyngeal dysphagia is one of the known causal factors of aspiration (Almirall et al., 2013). Aspiration has been defined as “the misdirection of oro-pharyngeal or gastric contents into the larynx and lower respiratory tract” (Marik, 2011 p. 148). In healthy adults, this results in elicitation of the laryngeal cough reflex to expel the aspirated material. Some neurological conditions cause impairment of the laryngeal cough reflex. This can result in silent aspiration, so called because there are no outward signs, such as coughing, that food or fluid has been aspirated. Impaired cough reflex and silent aspiration have been associated with the development of aspiration pneumonia (Addington, Stephens, Gilliland & Rodriguez, 1999; Addington, Stephens & Gilliland, 1999; Marik & Kaplan, 2003; Marik, 2011). Aspiration pneumonia has been defined as “The development of a radiographic evident infiltrate in the setting of patients with risk factors for increased oro-pharyngeal aspiration” (Marik, 2011 p. 150). Aspiration pneumonia in the rest home population can lead to multiple admissions for treatment in acute hospitals and is a common cause of death (Chen et al., 2006). The causes of aspiration pneumonia are known to be multifactorial (Langmore, Skarupski, Park & Fries 2002; Langmore et al., 1998; Pace & McCullough, 2010), however previous studies have shown that aspiration and/or silent aspiration are associated with aspiration pneumonia (Pikus et al., 2003) even with preventative strategies (Takahashi, Kikutani, Tamura, Groher & Kubok, 2012).

Speech language therapists carrying out clinical swallowing evaluations in rest homes currently have no bedside or portable screening tool to identify patients at risk of silent aspiration.



Cough reflex testing (CRT) is a method of determining whether the laryngeal cough reflex of an individual is intact. A weak or absent cough reflex has been associated with increased risk of silent aspiration and aspiration pneumonia (Addington, Stephens & Gilliland, 1999; Miles, Zeng, Mclauchlan & Huckabee, 2013; Nakajoh et al., 2000a; Nakazawa, Sekizawa & Sasaki, 1993; Sekizawa, Ujiie, Itabashi & Sasaki, 1990; Wakasugi et al., 2008, 2012). Cough reflex testing is increasing in use around the world to assess the laryngeal cough reflex of hospital patients following acute stroke, as a method of identifying patients who are at high risk of silent aspiration.

This study aims to assess laryngeal cough reflex in a general population of rest home residents and to investigate whether there is an association between a failed cough reflex test and documented episodes of chest infection. In Chapter 2.1, the aging swallow is discussed with reference to normal age related changes in swallowing physiology. Chapter 2.2 reviews the current state of knowledge regarding oro-pharyngeal dysphagia and the elderly and Chapter 2.3, the consequences of oro-pharyngeal dysphagia. Chapter 2.4 discusses the current practices and tools used by speech language therapists when carrying out clinical swallowing evaluations. Chapter 2.5 reviews the evidence relating to the laryngeal cough reflex and different methods of cough reflex testing. Chapter 3 describes the study's aims and methodology. Chapters 4 and 5 provide the study results, discussion of results and implications respectively.

## Chapter 2 – Review of the Literature

### 2.1 The Aging Swallow

There are age-related changes in swallowing function that constitute healthy aging, known as presbyphagia. These changes predispose healthy, elderly adults to developing oro-pharyngeal dysphagia. The two main causes are changes in the physiology and anatomy of the muscles of swallowing due to aging and the increasing prevalence of diseases in the elderly which cause dysphagia (Ney, Weiss, Kind & Robbins, 2013).

Changes occurring in presbyphagia include sarcopenia (reduced muscle mass and strength). Sarcopenia occurs in older adults and is associated with dysphagia. Todd, Lintzenich & Butler (2013) have demonstrated reduced isometric tongue strength, but statistically unchanged swallowing tongue strength in healthy older adults compared to younger adults. Maeda & Akagi (2014) studied 104 older adults ( $84.1 \pm 5.6$  years) without a history of neuro-degenerative condition, measuring maximum tongue pressure (MTP). A bulb was placed in the oral cavity and subjects were instructed to apply maximum pressure between the tongue and anterior hard palate to the bulb for 5 seconds. Lower MTP was shown to be associated with age ( $p=0.022$ ), albumin concentration - a measure of risk of malnutrition ( $p=0.032$ ), Barthel Index score ( $p=0.041$ ) and presence of sarcopenia ( $p=0.043$ ). Sarcopenia was determined by calculating arm muscle area (AMA) from measuring mid upper arm circumference (AC) and triceps skin fold thickness (TSF). The authors used Japanese anthropometric data (referenced to a Japanese language journal) for normative values. The 5<sup>th</sup> percentile was considered the cut off point for loss of skeletal muscle mass (sarcopenia). A statistically significant association was demonstrated between lower MTP score in the dysphagic group compared to the non-dysphagic group ( $p<0.001$ ), thereby strongly indicating that sarcopenia plays a role in predisposing older adults to developing dysphagia. The suprahyoid muscles play an important role in

hyo-laryngeal elevation which is extremely important in airway protection and opening of the upper oesophageal sphincter during swallowing. Studies have shown age related changes in the functioning of the supra hyoid muscles. Increased distance between hyoid bone and mandible has been demonstrated in healthy elderly adult males (and not females) compared to younger adult males; the hyoid bone was also in a lower posterior position in male aspirators compared to non-aspirators, (Feng et al., 2014). Older adults (> 70 years) have reduced supra hyoid muscle strength for jaw opening than younger adults < 70 years (Iida, Tohara, Wada & Nakane, 2013). Older adults also have slower oral transit time, pharyngeal delay time and pharyngeal transit time, with resulting increase of liquid into the supraglottic space above the trachea during swallowing when compared to younger adults (Yoshikawa et al., 2005). Older edentulous adults have also been shown to exhibit laryngeal penetration when not wearing dentures compared to when wearing dentures (Yoshikawa et al., 2006). However, both of the aforementioned studies however had relatively small sample sizes.

Xerostomia or dry mouth has also been reported by healthy, independently living 80 year olds (Österberg & Tsuga, 2002) and has been associated with increasing age, number of medications taken and dysphagia (Villa & Abati, 2011). Ineffective oesophageal clearance, which may result in extra-oesophageal reflux (redirection of food and fluids back into the pharynx) has been shown to occur more in healthy older males than healthy younger males (Jou et al., 2009). This study however was a small pilot study investigating the oesophageal clearance patterns of 20 healthy, normal younger and 20 healthy, normal older adults and the difference did not reach statistically significant levels ( $p=0.06$ ).

As well as age related changes in motor functioning of the musculature of the oro-pharynx, sensory changes have also been found. Laryngo-pharyngeal sensation has been shown to decrease across the age span (Aviv, 1997). Aviv used air pulse stimulation delivered via an endoscope to elicit the laryngeal adductor reflex in 80 healthy adults divided into three age groups across the lifespan.

Subjective self-reporting of whether the air pulse had been perceived was also collected. Results showed that overall there was a reduction in laryngo-pharyngeal sensation with increasing age.

In a small study of the aerodigestive reflexes of younger (n=10) compared to older adults (n=10), Dua, Surapaneni, Kuribayashi, Hafeezullah & Shaker, (2013) found that there were statistically significant differences ( $p=0.05$ ) in the initiation of the reflexive pharyngeal swallow in response to injection of water into the pharynx. The reflexive pharyngeal swallow was absent in 17% of elder swallows when delivered at a slow rate and resulted in laryngeal penetration.

Some researchers have proposed theories of diminished functional reserve or decompensation, meaning the body's ability to cope with infection and disease reduces with age. Therefore, a sudden event, for example a fractured hip or urine infection may lead to more general decline and swallowing difficulties may develop or worsen (Langmore et al., 2002; Ney et al., 2013; Rofes et al., 2010). This phenomenon is commonly seen by speech language therapists working across acute hospital and community settings. Research into the field of motor and sensory functioning of the tongue and laryngo-pharynx in older, healthy adults indicates that older adults are more susceptible to swallowing difficulties and the development of aspiration as they age, but swallowing difficulties per se are not necessarily a natural part of healthy aging. In the rest home population of frail, elderly adults who are no longer able to live independently, the incidence of dysphagia and therefore risk of aspiration increases for a variety of reasons which are described below.

## **2.2 Oro-pharyngeal Dysphagia and Rest Home Residents**

The population in rest homes consists of elderly, frail adults who often have multiple co-morbidities, including stroke and neurodegenerative conditions such as dementia and Parkinson's disease (Danila et al., 2014; Hoegh, Ibrahim, Chibnall, Zaidi & Grossberg, 2013). There are different terms used in the literature to describe institutionalised care for older adults, but the term rest home care will be used in this study. Within rest homes in New Zealand there are four levels of care – rest home,

hospital, dementia and psycho-geriatric. In a recent survey of rest homes in New Zealand (Thornton, 2010) the proportion of rest home care beds was 52% rest home level. This level of care is for a person that has been assessed by a Needs Assessment Service Coordinator as someone who is unable to live safely in the community and is classified as needing high or very high level of care (NZ Ministry of Health website). The proportion of rest home residents requiring hospital level care (for residents who require 24hr nursing supervision) was 34%. The proportion of rest home residents requiring dementia levels of care (intended to minimise risks associated with the confused states of residents with dementia) was 9% and specialised hospital care (psychogeriatric, for residents with an organic illness at the extreme end of dementia and defined by clinicians as those with features of BPSD - behavioural and psychological symptoms of dementia) was 3%. The generic term rest home will be used in this study to encompass all of the differing levels of care.

Studies of medical conditions and admissions to rest homes show prevalence figures of between 43-51.8% for dementias (Hoffmann, Kaduszkiewicz, Glaeske, van den Bussche & Koller, 2014; Van Rensbergen & Nawrot, 2010) approximately 18-24% for stroke and 5% for Parkinson's Disease (Cowman et al., 2010; Van Rensbergen & Nawrot, 2010). There are also a lesser number of other neurological conditions such as Huntington's disease, head injury and motor neurone disease that account for admissions to rest homes. Rest home residents with a history of neurological conditions such as stroke, dementia and Parkinson's disease are more likely to present with oro-pharyngeal dysphagia and be at risk of aspiration and aspiration pneumonia. Studies have shown that as many as 33-64% of institutionalised elderly people have oro-pharyngeal dysphagia (Almirall et al., 2013; Kayser-Jones & Pengilly, 1999; Langmore et al., 1998; Lin, Wu & Chen, 2002; Nogueira & Reis, 2013; Park, Han, Oh & Chang, 2014; Yang, Kim, Lim & Paik, 2013). In a study by Gaskill et al., (2008), 45.6% of rest home residents were reported by carers to have eating and drinking difficulties. The true figure of elderly people in rest homes with dysphagia may be higher however, as there are specific methodological difficulties in the rest home population obtaining consent and performing assessments in people with a combination of physical disabilities, aphasia, cognitive and

sensory impairments. For example, in a study of skilled nursing and intermediate care facilities for the elderly, only 533 of 865 non-tube fed participants consented to execution of a water swallowing test (Lin et al., 2002).

Several studies of patients with dementia have identified a high incidence of oro-pharyngeal dysphagia. Mitchell et al., (2009) followed 323 residents of rest homes with advanced dementia for 18 months. Almost 86% developed eating difficulties and the 6 month mortality rate of residents with eating difficulties was 38.6 %. The mortality rate of residents who developed pneumonia was 46.7%. Bosch et al., (2012) found a hospital mortality rate of 33% and a 6 month mortality rate of 50% in a study of dementia patients aged over 75 admitted to hospital with aspiration pneumonia. The incidence of dysphagia may therefore be higher in rest home residents who require skilled hospital, dementia and psycho-geriatric level care, compared to those that require rest home level care. Oro-pharyngeal dysphagia has been shown to be highly correlated with feeding dependency. Siebens et al., (1986) found that 47% of their sample of 240 rest home residents required some form of assistance to eat and of the 47%, 61% exhibited oral stage swallowing difficulties and 39% pharyngeal stage swallowing difficulties. This sample of rest home residents required varying levels of care from those independent with activities of daily living (17%) to those requiring total assistance (15%). Langmore et al., (2002) also found that feeding dependency was a significant predictor for aspiration pneumonia.

Self-reported oro-pharyngeal dysphagia rates amongst the elderly have varied from 9 – 43% (Nogueira & Reis, 2013; van der Maarel-Wierink et al., 2013). The study by Nogueira and Reis revealed that 43% of participants reported symptoms of dysphagia and 38% showed signs of dysphagia in a water swallowing test. This study did not include rest home residents who were not alert or cooperative enough to participate, or who could not comprehend what was necessary to complete the tests. The authors did not specify the number of clients their criteria excluded, but presumably this group may have contained a significant number of frail, dysphagic patients. The

study by Nogueira and Reis was considerably smaller (272 participants) than the Van der Maarel-Wierink (2013) study (8119 participants), but used a more comprehensive dysphagia self-test containing several questions relating to symptoms of dysphagia, as well as taking a range of objective measures of dysphagia. The Van der Maarel-Wierink study asked one question only. These methodological differences may partially explain the considerable variation between the two different rates of prevalence of self-reported dysphagia in the two studies. These data highlight the prevalence of swallowing difficulties in the rest home population, as well as the significant rates of morbidity and mortality associated with swallowing difficulties, aspiration and aspiration pneumonia.

### **2.3 The Consequences of Oro-Pharyngeal Dysphagia**

Malnutrition refers to the state of “all deviations from adequate and optimum nutritional status” (Shetty, 2003 p. 18). Undernutrition refers specifically to poor nutritional status and may include under-feeding (Shetty, 2003). Studies of malnutrition in rest home residents have shown prevalence rates varying between 18 and 72% (Bartholomeyczik et al., 2010; Gaskill et al., 2008; Törmä, Winblad, Cederholm & Saletti, 2013; van Nie-Visser et al., 2014; Vanderwee et al., 2010; Woo, Chi, Hui, Chan & Sham, 2005). The variation in prevalence rates may reflect the different methodologies used in studies and the varying proportions of heavily dependent residents in the rest homes from which data were collected. Malnutrition has been associated with care dependency and presence of cardio-vascular disease (van Nie-Visser et al., 2014). In a study of malnutrition in elderly people in the geriatric wards of hospitals, Vanderwee et al., (2010) found that 58.6% of rest home residents suffered from malnutrition and that having swallowing difficulties was the most powerful factor associated with malnutrition. Malnutrition can lead to reduced quality of life and is associated with reduced functional status – the ability to perform activities of daily living (Crogan & Pasvogel, 2003), the presence of pressure ulcers (Verbrugghe & Beeckman, 2013) and death (Bergström, Svensson & Hartelius, 2015). In their retrospective study of the records of 153 rest home residents with

dementia, (Ryan, Bryant, Eleazer, Rhodes & Guest, 1995) found that those residents who lost 5% body weight in one month were 4.55 times more likely to die within one year, 16% of the sample lost 5% or more of their body weight within a period of a month. Undernutrition has also been associated with poor oral health in elderly, chronic dysphagic patients which may cause reduced salivary flow and selection of foods that are easier to swallow but may lack required nutrients (Poisson, Laffond, Campos, Dupuis & Bourdel-Marchasson, 2014). A strong association has been shown between dysphagia, reduced salivary flow and candidiasis, which can make bolus formation and mastication (especially with dentures) difficult and unpleasant, leading to loss of appetite (Poisson et al., 2014). However, in a study of mastication in healthy 80 year olds living independently in the community, dietary intake was generally above recommended values (Österberg & Tsuga, 2002).

Rest home residents are also at risk of dehydration, especially if they have dementia and are unable to drink independently (Wu, Wang, Yeh, Wang & Yang, 2011). People with dementia in rest homes who are prescribed thickened fluids may be at risk of dehydration if fluid intake is not closely monitored (Hines, McCrow, Abbey & Gledhill, 2010). The consequences of dehydration may include increased confusion / delirium, urinary tract infections, thrombo-embolic complications, orthostatic hypotension, kidney stones, hyperthermia and constipation (Schols, De Groot, van der Cammen & Olde Rikkert, 2009).

Aspiration is defined as the entry of oral secretions, food and fluids into the trachea and lower respiratory tract, which is a contributing factor to the development of pneumonia and death (Almirall et al., 2013; Bosch et al., 2012; Marik & Kaplan, 2003; Mitchell et al., 2009; Rofes et al., 2010; Yoneyama et al., 2002). In a study of 2359 patients aged over 70 discharged from an acute geriatric unit following admission for pneumonia or broncho-aspiration, there was a 47.5% prevalence of oro-pharyngeal dysphagia (Cabré et al., 2013) and in the subset of patients admitted from rest homes, the incidence of oro-pharyngeal dysphagia was just over 65%. The authors used a



validated version of the water swallow test or volume-viscosity swallow test combined with pulse oximetry (reduction in oxygen saturation greater than or equal to 3%) to determine the presence of oro-pharyngeal dysphagia. However, swallowing assessments to determine presence of oro-pharyngeal dysphagia were carried out by experienced nurses (not speech language therapists) and no solid food consistencies were used in the swallowing assessments.

Aspiration of food or fluids into the lungs may occur without overt signs such as coughing, change in vocal quality, pallor and respiratory rate. This is termed silent aspiration. Studies have demonstrated that as many as 50% of people who have been shown to aspirate in the first 3 months post-stroke, do so silently (Terré & Mearin, 2006). In a retrospective study of 2000 VFSS completed over a 3 year period, Garon and colleagues (2009) reported aspiration in 50.6 % and 54% of those people that aspirated did so silently. In the Garon study, the subset of patients referred for VFSS with a history of brain cancer, stroke, dementia, head /neck cancer, chronic obstructive pulmonary disease, cardiac conditions and neurodegenerative conditions such as Parkinson's disease were all highly associated with silent aspiration. For example, 68% people with dementia / Alzheimer's disease aspirated and of this subset 68.1% aspirated silently. Higher rates of silent aspiration were recorded for brain cancer, brain stem stroke, head and neck cancer and chronic obstructive pulmonary disease (COPD) / pulmonary conditions. It is worth noting that all of the 2000 patients in the Garon study were inpatients at an acute hospital and were referred for a VFSS because they were suspected of having swallowing difficulties by their physician.

Aspiration pneumonia is an infectious process affecting the lungs caused by aspiration of oro-pharyngeal secretions, food or fluids (Kuyama, Sun & Yamamoto, 2010; Mylotte, 2002; Scannapieco & Shay, 2014). Aspiration pneumonia does not have a universally agreed definition. It can be challenging to diagnose because of difficulties obtaining sputum from frail, older patients. Due to the presence of large numbers of bacteria colonising the oropharynx, it is difficult to distinguish causative bacteria from colonised organisms (Falcone, Blasi, Menichetti, Pea & Violi, 2012).

Pneumonia can be detected by radiographically confirmed infiltrate in to the lungs. Exact definitions of aspiration pneumonia vary, but most include the following criteria (Bosch et al., 2012; El-Solh et al., 2003; Falcone et al., 2012; Hayashi et al., 2014):

- the development of new radiographic infiltrate compatible with pneumonia,
- the presence of symptoms or signs suggestive of lower respiratory tract infection including cough, sputum production,
- fever above 38C or below 35.5C, plus two minor criteria of pleuritic chest pain, dyspnea, delirium, increased alveolar arterial gradient, or white blood cell count 12,000/mm<sup>3</sup>, and/or left shift or leukopenia 3,000/mm<sup>3</sup>) necessitating mechanical ventilation,
- the presence of risk factors for oro-pharyngeal dysphagia (dementia, cerebrovascular disease, neuromuscular diseases, pharyngo-laryngeal dysfunction, documented swallowing abnormality secondary to dysphagia, disruption of the gastroesophageal junction, or anatomic abnormalities of the upper aerodigestive tract.

It is worth noting though that aspiration pneumonia in the elderly may be more subtle in presentation and lack some of the signs stated above. An increase in falls, altered mental status and / or worsening of existing diseases may be indicative in this population (Simonetti, Viasus, Garcia-Vidal & Carratala, 2013). Studies of community acquired pneumonia in the elderly have shown that fever and cough may be absent in as many as 36% and 33% respectively (Riquelme et al., 1996). In a prospective study of 2287 patients with pneumonia, Metlay et al (1997) found that respiratory and non-respiratory symptom reporting across different age groups decreased with increasing age.

Historically, there have been two main classifications of pneumonia, community acquired pneumonia (CAP) and hospital acquired pneumonia (HAP) or nosocomial pneumonia. With the recent trend for care in the community, another sub category of pneumonia has arisen, health care associated pneumonia (HCAP) (Falcone et al., 2012). The Infectious Diseases Society of America /

American Thoracic Society consensus guidelines (2005) have defined HAP as pneumonia that develops 48 hours or more after admission to hospital which was not incubating at the time of admission. HCAP refers to pneumonia in any patient who has been hospitalised in an acute care setting for two or more days within 90 days of the infection or resided in a nursing home or long-term care facility; received recent intravenous antibiotic therapy, chemotherapy, or wound care within the past 30 days of the current infection; or attended a hospital or haemodialysis clinic.

Aspiration pneumonia may be the cause of any of the different sub-types of pneumonia – community acquired pneumonia, hospital acquired pneumonia or health care associated pneumonia. These sub-types of pneumonia are typically defined by the microorganisms thought to be causative in the development of the infection. In community acquired pneumonia, streptococcus pneumoniae, haemophilus influenzae, mycoplasma pneumoniae, chlamydia pneumoniae, moraxella catarrhalis and legionella pneumophila are most commonly found. Hospital acquired pneumonia and health care associated pneumonia share similar aetiologies of multi drug resistant bacteria such as pseudomonas aeruginosa, enterobacteriaceae spp. or methicillin-resistant staphylococcus aureus (MRSA) (Falcone et al., 2012).

In a prospective study of 589 patients admitted to hospital with pneumonia, aspiration was found to be the cause of pneumonia in over 80% of patients aged over 70 years. Overall, across age groups, aspiration pneumonia was the cause of pneumonia in 60% of community acquired pneumonias (CAP) and 86% of hospital acquired pneumonias (HAP) (Teramoto et al., 2008). In a study of 214 patients admitted to an emergency department with pneumonia, Hayashi and colleagues (2014) found that 33.6% of patients with CAP had aspiration pneumonia and 70.1% of patients with health care associated pneumonia (HCAP) had aspiration pneumonia.

A combination of factors are thought to be causal to the development of aspiration pneumonia in the frail older population in rest homes (Addington, Stephens & Gilliland, 1999; Falcone et al., 2012; Langmore et al., 2002; Langmore et al., 1998). Using a cross sectional

retrospective analysis of the minimum data set of the records of over 102,000 nursing home residents, Langmore and colleagues (2002), studied the predictors of aspiration pneumonia. Using a logistic regression model they determined the key predictors of aspiration pneumonia (in descending order) as: suctioning, chronic obstructive pulmonary disease, congestive heart failure, presence of feeding tube, bedfast, high case mix index (multiple aetiologies), indicators of delirium, weight loss, dysphagia, urinary tract infection, mechanically altered diet, dependence for eating, dependence for bed mobility, dependence mobility, increasing number of medications. All of these factors indicate significant illness and point to rest home residents who are frail and more prone to developing aspiration pneumonia.

The mortality rate in elderly rest home residents following aspiration pneumonia is high (Bosch et al., 2012; Mitchell et al., 2009; Yoneyama et al., 2002). In a study designed to assess whether oral cares could reduce the incidence of aspiration pneumonia in rest home residents, Yoneyama et al., (2002) found that 80% of the residents who developed aspiration pneumonia died over the two year period of the study.

There are considerable social and psychological effects of dysphagia in the elderly, including loss of enjoyment in eating, anxiety, panic and avoidance of eating with others (Ekberg, Hamdy, Woisard, Wuttge-Hannig, & Ortega, 2002). A more recent study by Farri, Accornero and Burdese (2007), has also found that elderly people with dysphagia reported not eating with others and feelings of embarrassment when eating due to dysphagia. The data suggest that the prevalence of oro-pharyngeal dysphagia in adults who require institutionalised care is high and that when frail, elderly adults aspirate they are prone to developing aspiration pneumonia which has a high mortality rate.

#### **2.4 Speech Language Therapists and Clinical Swallowing Evaluations**

Speech language therapists receive referrals to assess swallowing disorders in acute, sub-acute and community settings. They are often asked to perform clinical swallowing evaluations (CSEs) on

patients in rest homes suspected of having dysphagia and/or who may have had a recent episode of aspiration pneumonia. At present, there is no standardised clinical swallowing evaluation to detect aspiration and dysphagia (Daniels, Anderson & Willson, 2012). A clinical swallowing evaluation may consist of a review of the patient's notes, discussions with the patient, family members who know the patient well, nurses and carers, a cranial nerve examination, palpation of hyo-laryngeal excursion during swallowing (which helps to assess the movement of the muscles which facilitate epiglottic deflection) and observation of the patient eating and drinking. The cranial nerve examination is used to assess the integrity of cranial nerves V, VII, IX, X and XII which innervate the muscles that are integral to swallowing physiology. With a working knowledge of the neurological and physiological processes of swallowing, the cranial nerve examination for swallowing assists the speech language therapist to make hypotheses regarding the patients swallowing ability. Observation of the patient eating and drinking allows the speech language therapist to identify potential signs of oropharyngeal dysphagia. Signs of aspiration may include coughing, change in respiratory rate or pallor and "wet" sounding voice quality.

In the rest home population, the need for an assessment tool to detect the risk of silent aspiration becomes critical because patients may not be able to participate in a cranial nerve examination or instrumental swallowing assessments, due to physical, cognitive and / or communicative difficulties such as dementia and aphasia. Patients are elderly, frail and may be extremely susceptible to developing aspiration pneumonia due to other factors (Langmore et al., 2002; Langmore et al., 1998; Marik & Kaplan, 2003). Other adjuncts to the CSE which have been used to assess the risk of silent aspiration may include cervical auscultation (CA) and pulse oximetry.

Cervical auscultation (CA) involves placing a stethoscope above the cricoid cartilage and listening to the sounds of swallowing. CA has been shown to have a specificity of 0.70 and sensitivity of 0.94 in detecting dysphagia, but requires a high level of training (Borr, Hielscher-Fastabend & Lücking, 2007). It is also evident from this study that there is no clear understanding of what

physiological structures or processes during the act of swallowing cause the sounds that form the acoustic structure of swallowing. The authors concluded that further research is needed into the validity and reliability of CA as a screening tool for aspiration and that at present the evidence for CA as a standalone tool to detect aspiration is “too weak” (p. 233). Data from inter-rater reliability studies have provided variable results with a tendency of speech language therapists to over-detect dysphagia (Borr et al., 2007; Leslie, Drinnan, Finn, Ford & Wilson 2004; Stroud, Lawrie & Wiles, 2002). Leslie et al., (2004), have also reported weak intra-rater reliability when a group of 11 speech language therapists listened to recorded swallowing sounds of normal and abnormal swallow sounds (confirmed penetration and aspiration under videofluoroscopic evaluation of swallowing). Factors such as years of experience did not make a difference to intra-rater reliability.

There have been numerous studies examining the use of pulse oximetry as a screening tool to detect aspiration during swallowing (Collins & Bakheit, 1997; Ramsey, Smithard & Kalra, 2005; Wang, Chang, Chen & Hsiao, 2005) with varying results. Pulse oximetry has been shown to be a reliable method to measure arterial oxygen saturation levels in blood by placing a probe on the finger tip. It has been hypothesised that when aspiration occurs during swallowing, there may be a reduction in oxygen saturation levels due to occlusion of the airway and reduction in airflow through lung tissue. There may be other reasons for a reduction in oxygen saturation levels, including variability in the equipment used, duration of swallowing apnea (a brief period during swallowing in which breathing stops) and poor co-ordination of breathing and swallowing. Normal subjects have also been found to have naturally occurring reductions in arterial oxygen saturation levels. Wang et al., (2005) concluded that a reduction of more than 3% in blood oxygen saturation levels does not correspond to aspiration detected under videofluoroscopic swallowing study. Ramsey et al., (2006) studied 189 consecutive acute hospitalised stroke patients who received a modified bedside swallow assessment and pulse oximetry. A smaller proportion (29%) of the patients also received VFSS. The modified bedside swallowing assessment consisted of water being replaced by radio-opaque contrast agent followed by chest radiography to detect aspiration. The results showed that

desaturation did not occur in any of the silent aspirators and that desaturation > 2% measured by pulse oximetry occurred in only 32.9 % of patients found to have unsafe swallows by modified bedside swallowing assessment and desaturation of >5% occurred in only 7.1 %. These extremely low rates of sensitivity led the authors to conclude that pulse oximetry did not have a high enough sensitivity or specificity when used with the modified bedside swallow assessment to detect aspiration. It is worth noting the study's exclusion criteria resulted in a bias towards mild to moderate strokes and as a result may have excluded a number of severely dysphagic patients. In a systematic review of the evidence for screening dysphagia risk after stroke, Daniels and colleagues (2012 p. 893) omitted studies involving cervical auscultation and pulse oximetry because of the "questionable feasibility and contradictory validity findings".

Instrumental assessments of swallowing which can objectively detect aspiration include videofluoroscopic swallowing study (VFSS) and videoendoscopic evaluation of swallowing (VEES). Videofluoroscopic swallowing study involves the patient ingesting barium mixed with food or fluids of different consistencies, whilst a digital fluoroscopic image is taken. VFSS allows the structures of swallowing to be seen in lateral and anterior – posterior planes. Aspiration of material below the vocal folds or penetration of material into the laryngeal vestibule and trachea can clearly be observed as can cough response to the aspirate. The disadvantages of VFSS in the elderly nursing home population include impaired cognitive and communicative functioning causing difficulties following the instructions required for the procedure, the physical ability required to transfer and sit upright in a chair, transportation to a hospital for the procedure, general disorientation due to a sudden change in the environment.

VEES involves the insertion of an endoscope with a camera into the nasal passage to view the pharynx and laryngeal vestibule. VEES allows the anatomy and physiology of the pharynx and larynx to be directly observed. The patient is given food and fluids of different consistencies to ingest. Food and fluids may be dyed to help determine the presence of material below the glottis

after the patient has swallowed. VEES enables pharyngeal residue post swallow to be seen directly, as well as the presence of penetrated material in the laryngeal vestibule (above the level of the vocal folds) and aspirated material below the level of the vocal folds. In cases where there is no coughing following aspiration of food, fluids or saliva, silent aspiration can be diagnosed. Direct observation of aspiration cannot be viewed under VEES due to “White out”, when the pharynx constricts and the base of tongue contacts the posterior pharyngeal wall during the pharyngeal phase of swallowing and temporarily obstructs the view of the larynx. Aspiration or penetration of food or fluids is determined by the presence of dye in the laryngeal vestibule post swallow.

Takahashi and colleagues (2012) performed VEES and clinical swallowing examinations in 148 rest home residents suspected of having oro-pharyngeal dysphagia. Residents were given regular oral cares by trained carers and other measures including food modification, postural advice, carer guidelines for eating and drinking and modified food intake. Using pneumonia as the primary outcome measure, following a three month review, 8% of the population developed pneumonia. Interestingly, aspiration of saliva detected with VEES was shown to be a significant risk factor for the development of pneumonia when comparison was made between the non-pneumonia and pneumonia residents ( $p=0.026$ ).

VEES is an instrumental assessment of swallowing that can be used to detect the risks of aspiration and silent aspiration. It can be performed in rest homes as the equipment required is portable and does not require a fluoroscopy suite, however skilled personnel and specialist equipment are required to perform this procedure. VEES is an invasive procedure that frail, elderly rest home residents may find unpleasant and difficult to tolerate. It is evident from this review of the literature that there still remains a need for an inexpensive, portable screening tool as an adjunct to the clinical swallow evaluation carried out by speech language therapists that can be used to detect the risk of aspiration and silent aspiration.



## **2.5 The Laryngeal Cough Reflex and Cough Reflex Testing**

The use of cough reflex testing (CRT) to detect the risk of silent aspiration has been proposed as a simple, inexpensive addition to the clinical swallowing evaluation carried out by speech language therapists (Miles & Huckabee, 2013; Miles, Zeng, McLauchlan & Huckabee, 2013; Sato et al., 2013; Wakasugi et al., 2008, 2012). Cough reflex testing is a method of testing the integrity of the superior laryngeal nerve to determine whether the sensory pathways for the cough reflex is intact. There are different methods of cough reflex testing described in the literature. The different tussive agents and methods of administration are described in Chapter 2.5.2.

### **2.5.1 The Neurophysiology of Cough**

The European Respiratory Society guidelines (Morice, Fontana, Belvisi, Birring & Chung, 2007 p. 1258) have defined cough as, “a three phase expulsive motor act characterised by an inspiratory effort (inspiratory phase), followed by a forced expiratory phase against a closed glottis (compressive phase) and then by opening of the glottis and rapid expiratory airflow (expulsive phase). In the literature surrounding cough, there is also discussion of two separately mediated types of cough reflex – a mechanosensory cough reflex and a chemosensory cough reflex which may have different evolutionary roots and afferent pathways (Brooks, 2011).

The mechanosensory cough reflex or true cough reflex is thought to be elicited in response to mechanical stimulation. This produces a strong “expiration reflex” (Tatar, Hanacek & Widdicombe, 2008 p. 385) or true cough reflex, in which there is no inspiratory phase. The expiration reflex is thought to be the true anti-aspiration reflex, as there is no prior inspiratory phase to cause aspiration of material in to the airways (Tatar et al., 2008). This reflex is thought to be initiated by rapidly adapting receptors (RARs) that act through A $\delta$  (A delta myelinated afferent) fibres which do not react to chemical stimuli such as capsaicin (Brooks, 2011; Canning, 2011). The reflex occurs in response to mechanical stimulation of receptors in the laryngeal or tracheo-bronchial mucosa. It has been hypothesised that the mechanosensory cough evolved as the larynx

descended closer to the entry of the oesophagus, in order to provide a defence mechanism against aspiration of acidic stomach contents. It is thought that acetic, citric and phosphoric acids can trigger the cough reflex through these rapidly adapting receptors, unlike capsaicin (Wong, Matai & Morice, 1999), another commonly used tussive agent.

The chemosensory cough reflex is thought to result from nerve impulses from chemosensory nociceptors in the airway epithelium and walls which send nerve impulses via slow conducting unmyelinated vagal fibres which may produce the urge to cough sensation (Brooks, 2011). This chemosensory cough reflex can be elicited by exposure to stimuli such as citric acid and capsaicin and commences with inspiration. Jafari, Prince, Kim, & Paydarfar, (2003) anaesthetised the internal branch of the superior laryngeal nerve (ISLN) in 16 subjects by injecting the para glottic space with bupivacaine to demonstrate the role of the supramedullary pathways and ISLN involved in airway protection during swallowing. Subjects underwent cough reflex threshold testing with capsaicin as well as videofluoroscopic swallowing study, submental electromyography and manometry. Laryngeal penetration in the control subjects who did not receive anaesthetisation of the ISLN was rare (1.4%) and there was no tracheal penetration in this group, but 43% of the experimental group experienced laryngeal penetration and of these 56% experienced tracheal penetration. Interestingly, all participants who experienced tracheal penetration did elicit a cough response, but the authors hypothesised that coughing may have been delayed as a result of anaesthesia. Jafari and colleagues concluded that the afferent signal from the ISLN is necessary for ensuring closure of the larynx during swallowing. fMRI scanning with measurement of blood oxygen level dependent (BOLD) responses during capsaicin cough reflex testing has also demonstrated the involvement of supramedullary brain areas in the elicitation of cough reflex, suppression of cough reflex and volitional cough. Movement artefact was minimised by use of foam padding around the head and exclusion of participants with head movements of greater than 3mm during coughing. The medulla has been shown to be the brain region most involved during evoked cough responses and cough suppression (Mazzone, Cole, Ando, Egan, & Farrell, 2011).

It has been hypothesised that neurological conditions such as cerebral infarcts may temporarily or permanently depress the laryngeal cough reflex. (Addington, Stephens, Widdicombe & Rekab, 2005 p. 7) proposed a theory of “brainstem shock”, which may account for temporary or permanent depression of the reticular activating system, respiration and laryngeal cough reflex. Several studies have demonstrated that the laryngeal cough reflex is depressed following neurological conditions such as Parkinson’s disease and cerebro-vascular accident (CVA) (Addington et al., 2005; Addington, Stephens & Gilliland, 1999; Imoto, Kojima, Osawa, Sunaga & Fujieda, 2011; Miles, Moore, Mcfarlane et al., 2013).

### **2.5.2 Cough Reflex Testing**

Cough reflex testing involves the administration of a of a tussive agent to induce a cough. Various tussive agents and methods of administration have been used by research groups in respiratory medicine since the 1950’s. The main tussive agents more recently used by researchers include capsaicin, tartaric acid and citric acid (Addington, Stephens & Gilliland, 1999; Miles, Moore, Mcfarlane et al., 2013; Monroe & Manco, 2014; Morice et al., 2007; Tatar et al., 2008; Wakasugi et al., 2008, 2012). These tussive agents are diluted in sodium chloride and inhaled using a mouth piece or facemask connected to a nebuliser. Behavioural responses to cough reflex testing may measure reflexive cough (which may lead to a non-reflexive cough e.g. the mere suggestion of a cough test may lead to a non-reflexive cough being elicited) or suppressed cough (which may minimise the artefact of unwanted volitional cough response). However the ability to volitionally suppress a cough requires relatively preserved cognitive and linguistic functions and may not be suitable for some populations such as the frail elderly and those with dementia.

Cough reflex sensitivity can be screened by delivering citric acid at a single specified concentration or can be used to identify threshold sensitivity by presenting increasing concentrations. The citric acid stimulates sensory receptors in the larynx and tracheobronchial tree through the internal branch of the superior laryngeal nerve to the nucleus tractus solitarii in the

brain stem, to elicit a cough response (Fontana & Lavorini, 2006). There has been considerable discussion and research about standardisation of cough reflex testing (Miles, Moore, et al., 2013; Morice et al., 2007; Wright, Jackson, Thompson, & Morice, 2010). In the literature many tussive agents have been used.

There have also been different methods of administering tussive agents and a lack of consensus as to what constitutes a normal threshold to concentrations of the different tussive agents used in the literature. These methodological issues make it difficult to compare research findings. There are also gender differences in cough reflex sensitivity (Morice et al., 2007). A recent study of cough reflex testing to establish normative data in healthy younger < 60 years of age and older > 60 years of age has demonstrated statistically significant differences in the natural cough and suppressed cough reflexes between males and females. Females have a more sensitive cough reflex which triggers at lower concentrations of citric acid than males. The younger participants also demonstrated a lower natural cough threshold compared to suppressed cough threshold ( $P= 0.001$ ), whereas the older age group did not demonstrate this difference, (Monroe et al., 2014).

There was also no reduction in the natural cough reflex sensitivity between younger and older participants, although there was a statistically significant difference between the suppressed cough reflex in younger and older participants, with younger participants being able to suppress a cough reflex at higher levels ( $p=0.009$ ). A striking finding from this piece of research was that 5% of participants did not cough at any concentration of citric acid administered and 21.9 % did not display a suppressed cough at any concentration. In view of this finding in healthy / normal participants, it may be difficult to apply these findings to people with neurogenic, respiratory and cardiac conditions. Also, the possibility of bias was not controlled for as investigators were not blinded to concentration levels of citric acid administered, there was no mention of experience and training of researchers or measurement of the quality of the cough response elicited.

There have been no reported side effects to administration of citric acid solution in over 50 years of use in respiratory medicine - and it has the ability to stimulate both chemoreceptors and mechanoreceptors in the mucosa of the larynx and tracheobronchial tree (Canning, 2011). Citric acid solution is also relatively inexpensive. In addition, citric acid may be known to participants and therefore more readily accepted. It is contained in citrus fruits such as lemons and limes and is used commercially as a flavouring and preservative in food and drinks. Some studies have used a mouthpiece (Addington, Stephens & Gilliland, 1999; Addington, Stephens, Gilliland & Rodriguez, 1999; Sato et al., 2012), but this method has challenges for use in the rest home population as it requires preserved cognitive and communication skills to follow the instructions required for testing. The mouthpiece method of administration also makes it difficult to include participants who have difficulties maintaining a tight lip seal around the mouthpiece (such as those with facial palsy secondary to stroke or other neuromuscular diseases). There have been different methods of assessing the response to cough reflex testing. The ERS guidelines on the assessment of cough (Morice et al., 2007), describe the C2 and C5 methods to assess the cough response. C2 refers to two consecutive coughs without intervening inspiration and C5, five consecutive coughs occurring within a 15 second period. The ERS guidelines recommend that both C2 and C5 responses are recorded, however in view of the frail, elderly population being tested, the C2 method alone was used in this study. A C2 response within 15 seconds was considered a passed cough reflex test.

### **2.5.3 The Relationship between Cough Reflex Testing and Aspiration**

Reduced cough sensitivity has been associated with increased rates of aspiration, pneumonia and mortality in elderly independent and rest home residents (Addington, Stephens & Gilliland, 1999; Nakajoh et al., 2000; Nakazawa, Sekizawa & Sasaki, 1993; Sekizawa, Ujiie, Itabashi & Sasaki, 1990, Yamanda et al., 2008). In a study of patients aged 43 to 83 with a history of recurrent pneumonia (but no other associated health conditions), cough reflex sensitivity was found to be significantly reduced when compared to an age matched group of healthy males with no history of pneumonia

(Niimi et al., 2003). Capsaicin was used as a tussive agent to test cough reflex sensitivity in this study and the sample size was extremely small. The authors did not describe how the capsaicin was administered. Addington and colleagues (1999) assessed cough reflex sensitivity in post stroke patients to evaluate the relationship between reduced cough reflex sensitivity using a solution of tartaric acid, aspiration documented by modified barium swallow and development of aspiration pneumonia. In the group of patients classified as having an abnormal cough reflex, 5 (17%) developed pneumonia, but in the normal cough reflex group no patients developed pneumonia ( $p < 0.01$ ). The authors did not provide data to support the rationale for the concentration of tartaric acid used and the method of administration of the tartaric acid may have excluded a number of dysphagic stroke patients from the study. Two of the criteria for the study were that patients should be able to follow verbal commands and that "leakage around the mouth and puffing the nebuliser were not considered effective inhalations" (Addington, Stephens, & Gilliland, 1999 p.1204). The authors did not document how many patients were excluded from the study because of these factors, but presumably a number of aphasic patients with dense CVA's may have had both severe aphasia, dysphagia, hemiparesis and facial palsy affecting their ability to form a tight lip seal around the mouthpiece.

In a comprehensive CRT validation study, Miles, Moore et al., (2013) studied CRT in comparison to VFSS and VEES. Patients underwent CRT at three different concentrations of citric acid, 0.4 mol/L, 0.6 mol/L and 0.8 mol/L administered via a facemask attached to a nebuliser, as well as either VEES or VFSS. Sensitivity and specificity of CRT for aspiration detected by VFSS were found to be optimised at a concentration of 0.6 mol/L (71% and 71% respectively). When CRT was compared to aspiration by videoendoscopy, sensitivity and specificity were optimised at a concentration of 0.4 mol/L (69% and 71% respectively). When trace aspirators were removed from the analysis, sensitivity and specificity peaked at 85% and 71% respectively. The authors concluded that reduced cough reflex sensitivity demonstrated by CRT was significantly associated with aspiration confirmed by instrumental assessment and that the concentration of citric acid used in

CRT could be varied depending upon the population being targeted. For example, in a population at high risk of aspiration, clinicians may prefer to use a concentration of citric acid that gives a higher sensitivity over specificity (0.4mol/L) or alternatively when screening a general population with a lower risk of aspiration may prefer to use a concentration of citric acid that provides a higher specificity 0.8mol/L.

In a study of 204 patients with dysphagia of different aetiologies, Wakasugi et al., (2008) found a specificity of 0.89 and sensitivity of 0.87 of CRT (using citric acid at concentration of 1.0 w/v%) in detecting silent aspiration when compared to videoendoscopic evaluation of swallowing or VFSS. In a follow up study of 160 patients who were suspected of having dysphagia, Wakasugi and colleagues (2012) used a handheld nebuliser to compare CRT with either videoendoscopy or VFSS to screen for silent aspiration. Sensitivity was found to be 0.86 with specificity at 0.71 demonstrating reproducibility compared to their earlier study. It is however difficult to compare research findings between research laboratories because of the different measurements used and varying methods of administration of citric acid. Variables such as the type of nebuliser used, inspiratory flow rate, concentration of citric acid and method of response recording require standardisation (Morice et al., 2007).

The evidence suggests that a failed cough reflex test is associated with a significant risk of aspiration and could therefore be a useful adjunct to a clinical swallowing evaluation, which alone cannot detect the risk of silent aspiration. There are limitations to CRT that have been highlighted. One is the wide variation in individual responses to cough reflex testing (Miles, Moore et al., 2013, Morice et al., 2007). Indeed, the 2007 European Respiratory Society guidelines on the assessment of cough recommend that as there is such wide inter-individual variation in cough, that there may be no intrinsic value to capsaicin and citric acid inhalation cough challenge, other than following change in the cough reflex sensitivity of an individual over time. However, subsequent research by Monroe et al., (2014) has shown that, excluding the 5% of healthy individuals who did not cough in response

to the cough reflex test at any concentration of citric acid, 89% of participants triggered a cough by  $\leq 0.8\text{mol/l}$  and 97.3% triggered a natural cough by  $1.6\text{ mol/l}$  concentration of citric acid.

There have been studies which have evaluated the use of cough reflex testing with clinical swallowing evaluations and algorithms to determine whether pneumonia rates could be reduced (Addington, Stephens & Gilliland 1999; Miles, Zeng et al 2013). Using pneumonia as the endpoint of their study, Addington and colleagues (1999) followed two cohorts of patients at two different hospitals. Four hundred consecutive acute stroke patients received cough reflex testing with tartaric acid along with a clinical treatment algorithm (to aid decision making in determining whether patients were appropriate for oral feeding or not), whilst 204 acute stroke patients at a sister hospital received standard treatment. The clinical algorithm also included data gleaned from a clinical swallowing evaluation and cognitive screen. The authors demonstrated an odds ratio of 0.08 comparing the odds of not developing pneumonia without administration of cough reflex testing compared to the odds of not developing pneumonia with administration of cough reflex testing. This highlighted the evidence that the use of cough reflex testing combined with a clinical swallowing evaluation and clinical treatment algorithm can have a statistically significant effect in favour of not developing pneumonia when compared to standard treatment without cough reflex testing. The design of the Addington study did contain methodological flaws. Firstly, the method of administration of tartaric acid (described above) may have resulted in a bias of participant selection towards exclusion of participants with more severe strokes in the larger group receiving cough reflex testing. There was also no justification given for the concentration of tartaric acid used in the study or comparison to normative data in healthy individuals in response to cough reflex testing with tartaric acid. The use of different clinical practices at the two hospital sites may have also led to differences in pneumonia and mortality rates.

In a randomised control trial of cough reflex testing following dysphagia post stroke, with an outcome measure of pneumonia rates 3 months post stroke, Miles et al., (2013) found that there



was no statistical difference between pneumonia rates in the control group and the experimental group. The control group received standard treatment (swallowing evaluation and treatment without CRT) and the experimental group received swallowing evaluation with CRT. The authors highlighted that the lack of a defined protocol for management of patients following failed cough reflex testing may have contributed to the lack of difference in the development of pneumonia between the control and experimental groups, as the decision making process between clinicians at the four different centres participating in the studies was not controlled. These data would suggest that implementation of CRT is more effective in preventing the development of pneumonia in acute stroke patients when used in conjunction with a clinical treatment algorithm to guide clinical decisions regarding oral feeding.

There have been no studies of the relationship between cough reflex sensitivity and the development of aspiration pneumonia in a general population of rest home residents. CRT studies have primarily focussed on assessing the cough reflex of healthy individuals (Lee, Kim, Seo & Kang, 2014; Monroe et al., 2014; Pecova, Javorkova, Kudlicka & Tatar, 2007), those with a history of stroke (Addington, Stephens & Gilliland, 1999; Addington, Stephens, Gilliland & Rodriguez 1999; Miles, Zeng, McLauchlan, et al., 2013), patients with aspiration pneumonia and a group of controls (Nakazawa, Sekizawa, Sasaki, 1993; Sekizawa, Ujiie, Itabashi, Sasaki, 1990; Yamanda et al., 2008), patients with a history of dysphagia (Lee et al., 2014; M. Sato et al., 2012; Wakasugi et al., 2008, 2012), subjects with a history of recurrent pneumonia and no underlying cause (Niimi et al., 2003) and people with Parkinson's disease (Leow et al., 2012). There have been two studies of CRT in rest home residents, one which examined cough reflex sensitivity (threshold method) at 3 days, 10 days and 30 days in response to an intensive daily oral care treatment protocol (Watando et al., 2004) and the other, a prospective study of the cough reflex sensitivity of hospital patients admitted to a rest home following a stroke. All 143 patients were assessed as having pneumonia (Nakajoh et al., 2000). Nakajoh et al., (2000) divided their sample into three groups: oral feeding without dysphagia, oral feeding with dysphagia and those receiving naso-gastric feeding. In addition, they also studied a

group of bedridden subjects with tube feeding. All subjects underwent cough reflex testing using citric acid dissolved in saline solution and delivered using an ultrasonic nebuliser. The citric acid solution was delivered at “two fold incremental concentration of 0.03 to 36%” (Nakajoh et al., 2000 p. 41) until the subject produced a cough response eliciting 5 consecutive coughs as measured by a pneumotachograph. Latency of swallow was also measured by recording the time from injection of a bolus of 1ml water into the pharynx via a nasal catheter to initiation of swallow. Initiation of swallows was recorded by submental electrical myography and observation of laryngeal elevation. Nakajoh et al., (2000) demonstrated that dysphagia was associated with a swallow latency longer than 4 secs and that the incidence of pneumonia was observed in those with a latency of 5 seconds or longer and a citric acid cough reflex threshold greater than 1.35 (log, mg, mL<sup>-1</sup>). The Nakajoh study demonstrated a strong association between latency of swallow initiation, response to cough reflex testing and development of aspiration pneumonia in a group of post-stroke patients that were admitted to a rest home over a two year period. The study was not representative of a more general population of rest home residents with other aetiologies.

## Chapter 3 – Study Aims and Hypotheses

The population of rest homes consists of frail, elderly adults who are predisposed to having oro-pharyngeal dysphagia and other comorbidities that are high risk factors for developing aspiration pneumonia. There is no simple, portable screening test currently available to speech language therapists that can identify the risk of silent aspiration during a clinical swallowing evaluation. A failed cough reflex test has been shown to have reasonable sensitivity and specificity in detecting silent aspiration when compared to VFSS. A strong relationship has been demonstrated between a failed cough reflex test, silent aspiration and the development of aspiration pneumonia.

### **Question**

There have been no studies of cough reflex testing in a general sample of rest home residents to answer the following questions: “what is the proportion of a sample rest home residents that may present with a failed cough reflex test and secondly, is a failed cough reflex test in rest home residents associated with a documented history of chest infection or aspiration pneumonia?”

### **Hypothesis**

A failed cough reflex test in a general sample of rest home residents will result in documented history of chest infection.

### **Justification**

A failed cough reflex test as described in Chapter 4 has a sensitivity and specificity of 71% and 71% respectively in detecting silent aspiration when compared to VFSS (Miles, Moore, et al., 2013).

Studies have shown prevalence rates of oro-pharyngeal dysphagia in the rest home population ranging from 33 – 64% (Almirall et al., 2013; Kayser-Jones & Pengilly, 1999; Langmore et al., 1998; Lin, Wu & Chen, 2002; Nogueira & Reis, 2013; Park, Han, Oh & Chang, 2014; Yang, Kim, Lim & Paik, 2013).

## **Significance**

Cough reflex testing in the rest home population holds potential as a tool to screen for the risk of silent aspiration. This study provides the first insight into the numbers of rest home residents that might fail a cough reflex test (as described in Section 4 methodology) and also, whether a failed cough reflex test is indicative of documented episodes of aspiration pneumonia. As the study will use data taken retrospectively from residents records, it is acknowledged that a causal association between reduced cough reflex sensitivity and aspiration pneumonia cannot be made, as radiographical and microbiological evidence of infection will not routinely be performed or be available.

# **Chapter 4 - Methodology**

## **Methods and Materials**

Ethics approval for the study was obtained from the University of Canterbury Human Ethics Committee (reference no HEC 2013/153), Otago University (reference no H14/045) and Health Research South (University of Otago, Dunedin School of Medicine and Southern District Health Board). Participants were rest home residents from a number of rest homes in the greater Dunedin area requiring rest home, hospital, dementia and psychogeriatric levels of care. Nursing staff in each rest home approached residents to recruit participants to take part in the study and obtain a signed consent form. If a participant was not considered to have capacity to provide informed consent to take part in the study, this was obtained by the participant's next of kin or enduring power of attorney (EPOA). There were no exclusion criteria as the aim of the study was recruit a general population of rest home residents. All participants were fed orally and none had feeding tubes.

## **Procedure**

Citric acid was diluted in 0.9% sodium chloride to obtain a concentration of 0.6 mol/L. citric acid solution was delivered using a face mask attached to a nebuliser. The facemask was placed over the

participant's mouth and nose. Prior to commencement of cough reflex testing after placing the facemask, each participant was given the verbal instruction, "Please breathe normally, this may make you cough". The nebuliser used was a Medix Turboneb 2 with a flow rate restrictor attached to provide a restricted flow rate of 8 L per minute. This is in line with the flow rate used in previous studies by this laboratory. Each dose was administered for up to 15 seconds, or until a response was elicited (if less than 15 seconds). A delay of approximately 30 seconds (until the participant had returned to baseline condition) was used between administrations of each dose. A positive cough response was defined as two consecutive coughs without interim inhalation. A pass was recorded if a positive cough response was elicited on two out of three tests. An absent cough on two out of three was recorded as a failed test. There were differences in the strength of cough response elicited by participants, but as no objective measures of strength of cough response were used, only presence or absence of cough was recorded.

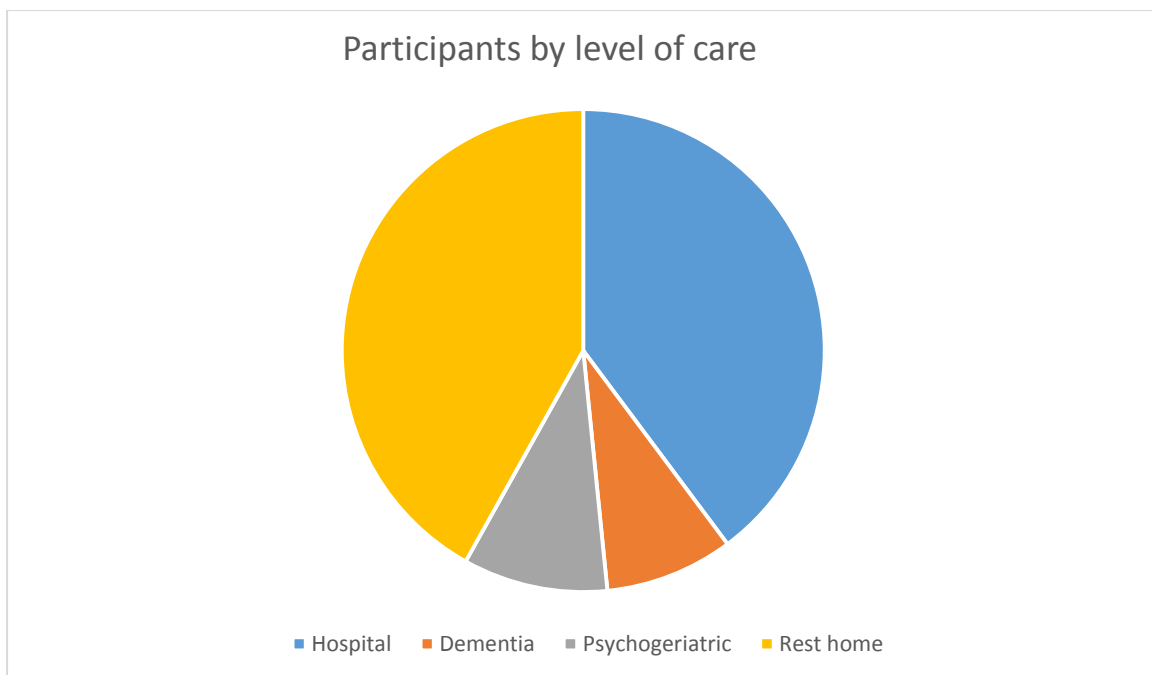
A clinical audit of each resident's records for 6 months prior to the date of cough reflex testing was then conducted to identify documented episodes of chest infection. The clinical audit was completed after all data relating to cough reflex testing was carried out, however there was no blinding during collection of the second data set. In view of the difficulties obtaining specific diagnostic information from this clinical setting, a criteria similar to the INCUR (incidence of pneumonia and related consequences in nursing home residents) was used (Kelaiditi et al., 2014). This methodology used diagnosis of pneumonia from clinical conditions recorded in the participant's medical records. All doctors recorded contacts with participants and infection records were examined for documentation of worsening or onset of cough, fever, crackle sounds on thoracic auscultation and administration of antibiotics for treatment of chest infection. The following data were also collected – age, gender, ethnicity, comorbidities, presence of neurological, respiratory and cardiac conditions and dependence for oral cares.

# Chapter 5 – Results

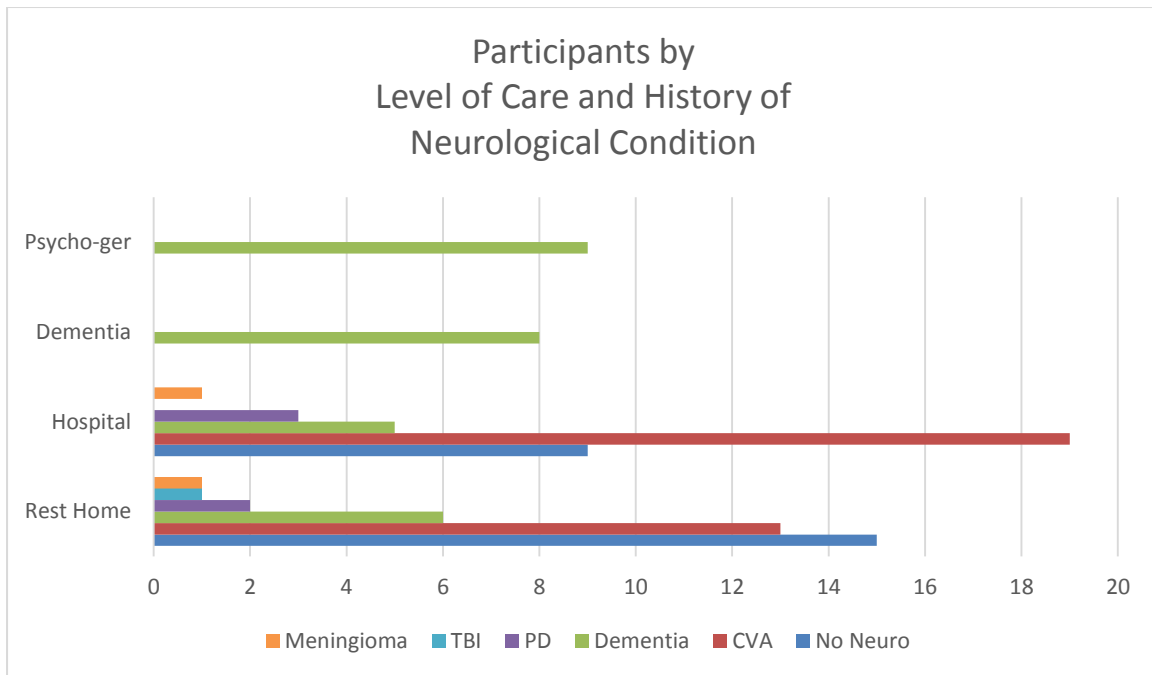
## Participants

In total, the cough reflex of 100 rest home residents was tested using the methods described above. The majority of the rest home residents were aged over 65 with the exception of five participants who were younger. The mean age of residents was 80.89 years. A range of participants from each level of care, rest home, hospital, dementia and psycho-geriatric was obtained (see Table 1 below). Five participants who refused to undergo the cough reflex test more than once required psychogeriatric level of care and were unable to be included in the study. Tables 2 and 3 below provide an analysis of participants by level of care and history of neurological condition and level of care and presence of respiratory / cardiac condition and dependence for oral cares respectively.

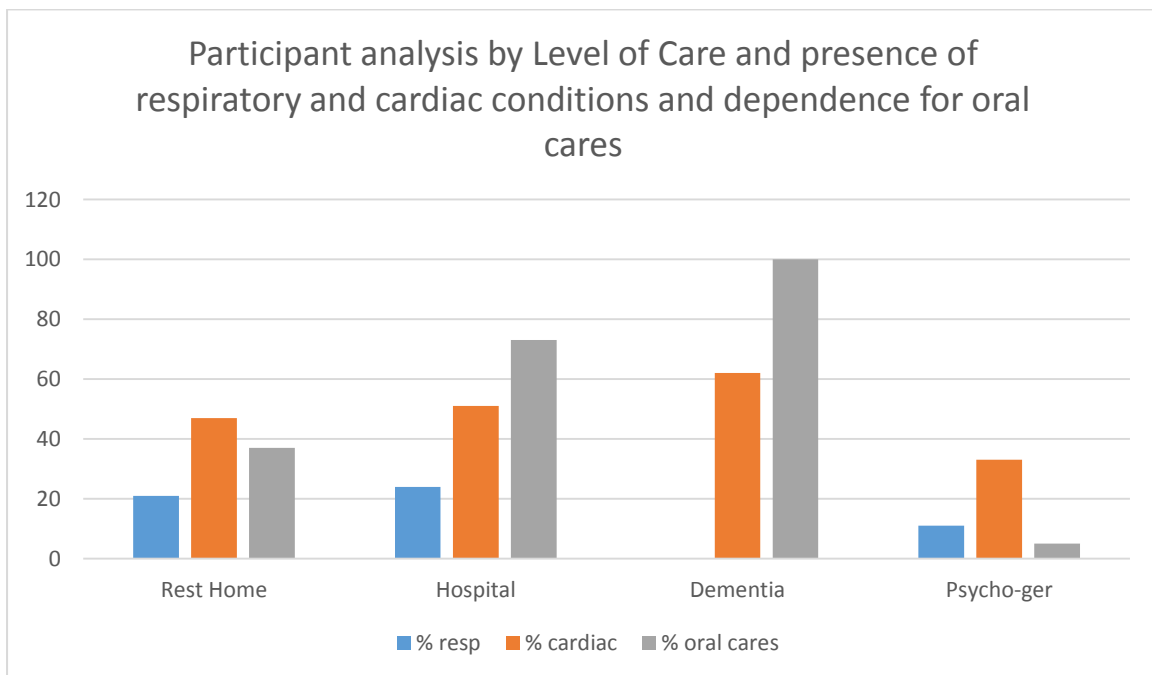
**Table 1 Participant breakdown by level of care**



**Table 2 Participants by Level of Care and History of Neurological Condition**



**Table 3 Participants by Level of Care and History of Neurological Condition**



### **Cough reflex test**

Overall of the 100 participants who underwent testing, 96 passed the test and 4 failed.

### **Chest infection**

Of the four participants who failed the test, three had no recorded history of chest infection in the 6 month period prior to the date of testing and data was not available for one participant who was receiving palliative care at the time of testing (and who was deceased prior to the clinical audit taking place). There were 7 other deceased participants during the course of data collection, so out of the 100 participants tested, a clinical audit of notes was only completed for 92. Of the 92 participants for whom a full data set was obtained, 3 failed the cough reflex test and none of these had a recorded history of chest infection in the 6 month period prior to testing. Of the remaining 89 participants, 71 (80%) had no documented chest infections. 18 participants (20%) of the 89 who passed the test had documented episodes of chest infection ranging from 1 to 5 episodes each.

### **Other Variables**

Of the 18 participants who had documented history of chest infections, only one had no history of neurological, respiratory or cardiac condition, but did require assistance in completing oral cares. It is recognised that a limitation of the study was that in the review of the notes, data concerning presence or absence of swallowing difficulties was not collected. Of the participants who had documented episodes of chest infection / pneumonia, 12 were male and 6 female. 72% had a history of neurological condition including CVA, dementia, Parkinson's disease, meningioma or traumatic brain injury. 44% of participants with a history of chest infection also had a history of respiratory and / or cardiac condition and were dependent for oral cares.

The three participants who failed the cough reflex test (for whom a full data set was collected) required rest home and hospital levels of care. One had no record of neurological, respiratory or cardiac conditions, but the other two had a documented history of oro-pharyngeal dysphagia



resulting from CVA and Parkinson's disease. Care plans were in place to manage oro-pharyngeal dysphagia. Interestingly the ethnicity of all participants with the exception of one was recorded as NZ European. The one participant of Maori ethnicity failed the cough reflex test but had no history of oro-pharyngeal dysphagia or chest infections.

## Chapter 6 – Discussion

A strong association has previously been shown in studies of rest home residents and frail elderly patients between reduced cough reflex sensitivity and aspiration pneumonia (Nakajoh et al., 2000, Nakazawa et al., 1993, Sekizawa et al., 1990, Watando et al., 2004, Yamanda et al., 2008). In this study of cough reflex testing in a general population of rest home residents, there was an unexpected finding of no obvious association demonstrated between a failed cough reflex test and documented history of chest infection. This contrasts with a finding of 54% pneumonia rate in the oral feeding group of the other study of CRT in the rest home population (Nakajoh et al., 2000b). However, there were considerable differences in the methodologies and aims of the two studies. Participants in the Nakajoh study were 143 patients admitted to a rest home over a two year period following a stroke more than 6 months before the study. Approximately 70% of the participants were assessed to have oro-pharyngeal dysphagia in a water swallowing test and 36% required tube feeding due to difficulties maintaining adequate nutrition / hydration levels. Participants in the Nakajoh study were followed prospectively for a year to determine the incidence of pneumonia. Participants had a high prevalence of oro-pharyngeal dysphagia. The Nakajoh study also used a cough threshold measure of testing as opposed to the single dose method, so it is difficult to compare findings.

There are several methodological factors that must be considered when interpreting these data. Firstly, the population of participants had an (unintended) bias towards those requiring rest home and hospital levels of care – 41.9% and 39.8% respectively, therefore there were few participants with dementia or advanced dementia, a sub group known to have a high prevalence of oro-pharyngeal dysphagia. As a result, those participants requiring dementia and psychogeriatric levels of care were not as well represented (8.6% and 9.7% respectively). It is worth noting that 5 participants requiring psychogeriatric care were tested once and then refused any further testing and were therefore unable to be included in the study. A potential reason may be that CRT causes

minor irritation such as coughing and eye watering and may therefore be inherently difficult to repeat more than once in people with advanced dementia who may not understand the reasons for repeating the test. However, despite this, the proportion of participants requiring different levels of care in the study, was comparable to a recent study of aged residential care in New Zealand (Thornton, 2010). Another potential limitation of the study was the homogeneous nature of the participant's ethnicity. There was one participant of Maori ethnicity and all other participants came from an NZ European background. The one Maori participant failed the cough reflex test and this may also raise the question of whether there are any ethnic differences in response to cough reflex testing. The method of selection of participants may have caused inherent bias in recruitment of participants to the study. All participants were initially approached by nursing staff to obtain consent to take part in the study. In some rest homes, participation in the study was raised at resident's regular meetings and residents were asked if they would be willing to participate. However, in most rest homes nursing staff recruited those with a known history of oro-pharyngeal dysphagia, chest infection and / or neurological condition. This would make the findings more surprising as only 4% of participants failed the cough reflex test.

The concentration of citric acid used in the study was 0.6Mol/L, as this concentration was shown to have the highest overall sensitivity and specificity (0.71 and 0.71 respectively) in detecting silent aspiration when compared to VFSS in the general dysphagic population. At this concentration, sensitivity and specificity was slightly lower when compared to videoendoscopic swallowing study (0.67 and 0.66 respectively) with trace aspirators removed (Miles et al., 2013). Videofluoroscopic or videoendoscopic swallowing studies on participants who failed the cough reflex test would have provided definitive information on the risk of aspiration / silent aspiration. Further instrumental assessments of the swallowing function of the three participants who failed the cough reflex test were not completed, as one had no history of oro-pharyngeal dysphagia or chest infection and did not show any signs of dysphagia during a clinical swallowing examination. The other two

participants who failed the cough reflex test were known to have oro-pharyngeal dysphagia, had care plans in place to manage this and had no recent history of chest infections.

Cough reflex testing is a measure of sensitivity of the airway to a tussive stimulus (in this case citric acid). A limitation of this study was that no objective measures of cough strength or quality were applied to the data (i.e. it is possible to pass the test but the cough may not be productive or timely enough to clear aspirated material). Widdicombe et al., (2011) suggest a number of ways that cough can be objectively measured including by airflow, gastric pressure, expiratory muscle EMGs, chest wall acceleration and sound generation. In a review of the different types of cough and implications for aspiration following stroke, Morice et al., (2007) and Widdicombe and colleagues (2011) have suggested that for a process as complex as cough, a subjective judgement of the sound of the cough alone is probably not sufficient. Anecdotally, there was considerable variation in the time taken to elicit a cough response in participants who passed the cough reflex test. At present it is not known whether the time taken to elicit a cough response in CRT as carried out in this study is relevant to aspiration or silent aspiration occurring and the subsequent development of aspiration pneumonia.

Other methodological limitations of the study include the absence of definitive data collected regarding diagnosis of aspiration pneumonia. Not all recorded chest infections will be aspiration related. An inherent limitation of this study was the inability to obtain specific data on diagnosis of pneumonia / aspiration pneumonia as this information is not routinely obtained in this population. There was also no blinding of the researcher to the result of the cough reflex test and the collection of demographic data and history of recorded chest infection, however in view of the small numbers of participants who failed the test this is unlikely to have affected the results. Another possible factor to be considered when interpreting these data is the question of whether the 6 month period prior to the cough reflex test was enough time to indicate an association between a failed CRT and development of aspiration pneumonia.

These data show that a failed cough reflex test is not indicative of a history of chest infection / aspiration pneumonia in a general population of rest home residents. This is consistent with data from other studies that indicate the development of aspiration pneumonia is multifactorial (Langmore et al., 1998, Langmore et al., 2002). Indeed, in Langmore's (2002) retrospective analysis of the Minimum Data Set of 102,842 nursing home residents, there was a finding of 3% prevalence of aspiration pneumonia. In this much smaller study, two of the four participants who failed the test had documented oro-pharyngeal dysphagia and specific care plans were already in place to manage the risks of aspiration. This may have contributed to the absence of any documented chest infections in the 6 month period prior to testing. Unfortunately, there were no data available for one of the participants who failed the cough reflex test. The remaining participant who failed the cough reflex test was referred to the speech therapy department for a swallowing assessment (as per the study protocol) and was found to have no oro-pharyngeal dysphagia. Also this study did not recruit many participants who were unable to give consent to take part in the study. The low number of participants who failed CRT may have been partially due to an unintended bias towards the selection of more able residents. Recent research that has shown 5% of normal healthy people do not cough at any concentration of citric acid concentration (Monroe et al., 2014). There is also emerging evidence that aspiration and silent aspiration of thin liquids (detected by VEES) may be a normal occurrence in as many as 30% of healthy elderly adults, without significant changes in lung function as confirmed by thoracic CT scanning (Butler et al., 2010; Butler, Hollins, Baginski, Todd, Lintzenich & Leng, 2014).

Another factor which may have influenced the results of the test is the nature of the instruction given prior to the cough reflex test "please breathe normally this may make you cough". The suggestion of cough may have unknowingly made some participants cough. Some studies of CRT have used CRT with citric acid interspersed with a placebo dose of 0.9% NaCl to prevent a placebo effect and possible tachyphylaxis (Miles, Moore, et al., 2013). Use of this technique may have helped to eliminate unwanted placebo cough response.

## **Future research**

Further studies of CRT with larger numbers of rest home residents could be used to measure latency of cough and strength of cough response which would provide additional information than merely presence or absence of cough response. However in practice, a simple screening measure such as cough reflex testing highlights the potential risk of silent aspiration and would be used as an adjunct to information gleaned from the clinical swallowing evaluation. The existing body of evidence regarding cough reflex testing indicates that it is an acceptable low cost, portable assessment tool that can help to identify the risk of silent aspiration in a population that may not be appropriate for instrumental measures of swallowing such as videoendoscopic and videofluoroscopic swallowing studies. Cough reflex testing at present does offer an acceptable addition to the speech language therapist's clinical swallowing evaluation in this vulnerable population.

## **Conclusions**

Although in this study, there was no evidence associating a failed cough reflex test with the development of aspiration pneumonia in the rest home population, the proportion of patients who failed the test and the proportion of patients who developed pneumonia were extremely low. There is a considerable body of research demonstrating that a failed cough reflex test is indicative of a high risk of silent aspiration and aspiration pneumonia. CRT could be used by speech language therapists in rest homes and other community settings as an assessment tool to identify those at high risk of silent aspiration which a clinical swallowing evaluation alone cannot detect. This could inform treatment and quality of life decisions. Treatment options such as improved oral hygiene (Almirall et al., 2013, Yoneyama et al., 2002, Yoshino, Ebihara, Ebihara, Fuji & Sasaki 2001, Watando et al., 2004), dysphagia therapy (Becker et al., 2011), use of menthol (Ebihara et al., 2006), ACE inhibitors (Sekizawa, Matsui, Nakagawa, Nakayama & Sasaki, 1998, Shimuzu, Fujioka, Otonashi, Kondo & Sekizawa, 2004) and education of care staff feeding patients have all been effective in reducing rates

of aspiration pneumonia in this population and these options could be used to directly target those shown to be at risk.

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