THE USE OF NEBULISERS IN THE HOME: A STUDY WITH PATIENTS AND CARERS

This thesis is submitted in accordance with the requirements of the University of London for the degree of Doctor of Philosophy by

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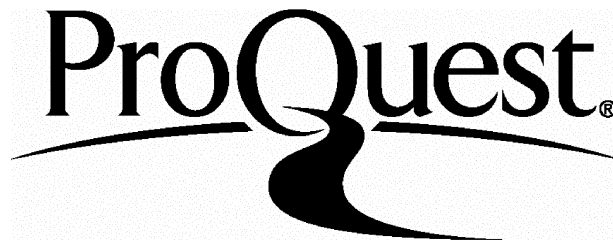School of Pharmacy

University of London

October 2011

ProQuest Number: 10104772

ProQuest 10104772

Plagiarism statement

This thesis describes research conducted in the School of Pharmacy, University of London between October 2007 and October 2010 under the supervision of Prof. Felicity Smith and Prof. Kevin Taylor. I certify that the research described is original and that any parts of the work that have been conducted by collaboration are clearly indicated. I also certify that I have written all the text herein and have clearly indicated by suitable citation any part of this dissertation that has already appeared in publication.

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Acknowledgments

Abstract

Introduction: Inhalational therapy is the mainstay of treatment for COPD, and nebuliser therapy is commonly prescribed for the management of severe COPD in the home. The success of inhalational therapy is multi-factorial and largely depends on the ability of the patient to use correctly the inhaler device. Whilst the problems with the use of pressurized metered dose inhalers and dry powder inhalers are documented in the literature, little is known about how COPD patients and their carers use nebulisers in the home. The aim of the study is to describe the experiences of COPD patients and their carers with the use of nebuliser therapy in the home and to identify their priorities and concerns in the context of current disease management, support and potential health services.

Methods: The study was conducted in primary and intermediate settings within a strategic health region in the UK (North West London). A representative sample including patients with different durations of nebuliser use and different disease severity levels were recruited. Data were collected in the patients' homes on one occasion using semi-structured interviews, non-participant observations and survey methods. A mixed approach to data analysis was used to triangulate data from different methods. The Framework method was used to analyse the qualitative data and the Statistical Package for Social Sciences (SPSS) was used to analyse the quantitative data.

Results: All patients experienced problems with the use of their nebulisers in the home during assembling, filling, cleaning and maintaining their device. The interviews revealed that factors such as: the complexity of setting up the equipment, lack of instructions on its assembly, poor manual dexterity, costs and poor access to accessories contributed to the problems. Practical problems were frequently experienced by patients who had frequent hospital admissions, were treated by more than one doctor and used a facemask. Moreover, 30% of COPD patients were dependent on carers for vital assistance with the use of the nebuliser; on average, the carers spent 3.5 hours per week (range 1 - 10.5 hours) undertaking nebuliser-related activities. Carers performed a range of activities (mean 6, range 2 – 9), which included organisational and practical tasks and they frequently experienced difficulties (mean = 3, range 0 – 9) with providing practical assistance such as setting up, dismantling and cleaning the nebuliser parts. Several factors (timing of therapy, complexity of the dosing regimen, co-morbidities and deterioration in health status) affected the level of carers' involvement which ranged from taking full responsibility to providing assistance with particular aspects of nebuliser use when required. The patients and the carers were shown to be active decision-makers with regard to the need and use of their therapy and overall condition management.

Conclusion: Improving health outcomes for COPD patients and their carers is a central goal of health policy in the UK. A holistic assessment of the use of nebuliser therapy identified that COPD patients and their carers frequently encountered practical problems with the use of nebulisers in the home which should inform healthcare providers to effectively support patients and their carers to optimise treatment outcomes.

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Abbreviations

AED	Aerodynamic equivalent diameter
ANOVA	One way analysis of variance
ATS	American Thoracic Society
BLF	British Lung Foundation
BMI	Body Mass Index
BTS	British Thoracic Society
CAQDAS	Computer Assisted Qualitative Data Analysis Software
CFC	Chlorofluorocarbon
CHD	Coronary Artery Disease
CI	Confidence Interval
COPD	Chronic Obstructive Pulmonary Disease
DPIs	Dry Powder Inhalers
EQ-5D	EuroQol
ERS	European Respiratory Society
FEV_1	Forced expiratory volume in one second
FVC	Forced Vital Capacity
GOLD	Global Initiative for Chronic Obstructive Lung Disease
GP	General Practitioner
HADS	Hospital Anxiety and Depression Scale
HART	Healthcare and Rehabilitation Team
HPCT	Harrow Primary Care Trust
HRQOL	Health-Related Quality of Life measures
HS	Health Status Measures
IFR	Inspiratory Flow Rate
MDI	Metered Dose Inhaler
MHz	Megahertz
NatCen	National Centre for Social Research
NHS	National Health Service
NICE	National Institute for Health and Clinical Excellence
NIV	Non-invasive Ventilation
NSF	National service Framework

NT	Nebulisation time
NWP	Northwick Park Hospital
PC	Personal Computer
PEF	Peak Expiratory Flow
PFR	Peak Flow Rate
pMDIs	Pressurised Metered Dose Inhalers
QOF	Quality and Outcome Framework
QOL	Quality of Life
R&D	Research and Development
SD	Standard Deviation
SF-36	Medical Outcome Survey Short Form
SGRQ	St George's Respiratory Questionnaire
SIP	Sickness Impact Profile
SMI	Soft Mist Inhaler
SOP	Standard Operating Procedures
SPSS	Statistical Package for Social Sciences
UK	United Kingdom
VAT	Value Added Tax
ZBI	Zarit Burden Interview
α-AT	Alfa Anti-trypsin
µg	Microgram

Chapter 1: Introduction

This chapter introduces the subject area and outlines the process by which the research questions were informed and developed. It is divided into two Sections: Section 1.1 provides background information and includes: an overview of chronic obstructive pulmonary disease (COPD), the health and economic burden of COPD, an overview of the management of COPD with a focus on inhalational therapy, types of inhaler devices and factors determining choice, an overview of nebuliser therapy, the current evidence for the role of nebulised therapy in the management of COPD patients in the home, and clinical indications for the supply of nebuliser therapy. Section 1.2 presents a systematic review of the literature and outlines: the aim of the literature review, the search strategy, a critical appraisal of the studies' findings. The chapter conclude with a statement of the overall aim and objectives of the study.

1.1. Background

1.1.1. Overview of chronic obstructive pulmonary disease

The Global Initiative for Chronic Obstructive Lung Disease (GOLD) defines COPD as:

> "A preventable and a treatable disease with some significant extra pulmonary effects that may contribute to the severity in individual patients, its pulmonary component is characterized by airflow limitation that is not fully reversible. The airflow limitation is usually progressive and associated with an abnormal inflammatory response of the lung to noxious particles or gases".
>
> (Global Initiative for Chronic Obstructive Lung Disease, 2010).

COPD is not a single entity syndrome, but an umbrella term constituting a number of overlapping conditions including: chronic asthma, chronic bronchitis, emphysema and small airway disease. The contribution of each component towards the overall manifestation of COPD varies greatly between individual patients (Global Initiative for Chronic Obstructive Lung Disease, 2010). Some patients have an asthmatic element to their COPD and therefore, their airflow obstruction can partially be reversed (although this is only to a certain extent and full reversibility of lung function is not possible despite intensive therapy). The airflow obstruction in COPD is a consequence of airways and parenchymal damage which is caused by

the chronic inflammation induced by cigarette smoking (The National Institute for Clinical Excellence, 2010). Smoking is suggested to account for 90% of cases, and while the decline in lung function after the age of 35 is part of the ageing process, the decline is 2 times faster among 'at risk' smokers (Bellamy and Booker, 2006). Although lung function is not restored after stopping smoking, the rate of decline returns to that of a non-smoker, emphasising the importance of early detection of 'at risk' smokers and persuading them to stop smoking. Genetic and environmental factors have been suggested to play a role in the development of COPD in some smokers. However, studies on these factors were either inconclusive or have not provided the full explanation. A steady decline in lung function over the years of smoking, usually manifests in symptoms after the age of 50 years, when the FEV_1 (forced expiratory volume in one second) drops below 50% (Bellamy and Booker, 2006). Recently COPD has been shown to exist in never-smokers (Nizankowska-Mogilnicka et al., 2007). COPD usually affects patients > 35 years of age, unless the sufferer is deficient in alpha-1 antitrypsin (α_1- AT). Deficiency in α_1–AT, a protective enzyme counteracting the destructive actions of proteolytic enzymes in the lung, is a condition which affects 1:4000 of the population and accounts for severe emphysema between the ages of 20 and 40 years (Bellamy and Booker, 2006). Gender is another risk factor; the prevalence of COPD is 1.7% in men compared to 1.4% in women. Recently, the prevalence of COPD in men reached a plateau while it is increasing in women as a result of smoking (Bellamy and Booker, 2006). Low birth weight, malnutrition of the fetus and respiratory infections during the early years of life; during which alveoli mature and reach adult levels (by the age of 8 years) are other risk factors in developing COPD later in life. Other risk factors include: poor diet, certain jobs with occupational risk factors and air pollution (Bellamy and Booker, 2006).

In susceptible smokers, long standing asthma can result in hypertrophy of the bronchial smooth muscles as a result of long standing bronchial hyperactivity, leading to fibrosis and collagen deposition as a result of the chronic epithelial disruption which leads to permanent damage of the airways and a loss of reversibility (airflow obstruction) (Bellamy and Booker, 2006). Excess mucus production, a symptom of chronic bronchitis can accelerate the decline in lung function. Emphysema, which is characterised by large air spaces distal to terminal bronchioles, results from the destruction of the alveolar walls. The destruction of elastin (a protein which makes up the alveolar wall) is caused by proteolytic enzymes (elastases) which

are produced by the inflammatory cells. Structural changes in the small airway caused by repeated cycles of inflammation and repairs result in narrowing of the airways. The resultant narrowing of the airways increases airflow resistance, while loss of elastin causes the airway to collapse. Airway collapse is worse on exertion or during forced exhalation which consequently leads to 'pursed–lip' breathing (gentle in and out breathing) to maintain the air pressure in the airways and to prevent them from collapse (Bellamy and Booker, 2006). Loss of elastin also causes lung hyperinflation which leads to the use of accessory muscles to aid respiration. The loss of surface area for gas exchange causes inefficient exchange of oxygen and carbon dioxide and abnormal blood gases. Consequently respiratory drive (a response triggered by the detection of abnormal blood gases by central chemoreceptors) and respiration rate is increased to restore abnormalities of blood gases, which then causes the patient to become breathless. However, some patients have a less responsive respiratory drive which means the patients are unable to restore the blood gases to normal but are less breathless. Long term hypoxia (low levels of blood oxygen) leads to cor pulmonale (fluid retention and pulmonary hypertension as a result of renin-angiotension upset brought by the effect of chronic hypoxia on the kidneys), polycythaemia (more haemoglobin produced to overcome the consequences of low oxygen in blood) which predispose to deep vein thrombosis and pulmonary embolism (Bellamy and Booker, 2006). Pulmonary hypertension (increased pressure in the pulmonary vasculature brought about by constriction in the alveolar capillary bed as a result of poor ventilation) increases the workload on the right ventricle, causing it to enlarge, and subsequently fail, thus increasing peripheral oedema. These consequences are poor prognostic factors and if they were not treated effectively, the 3 years survival of those patients who develops them is only 30% (Bellamy and Booker, 2006).

COPD is a systemic disease; patients with severe disease are at increased risk of developing: osteoporosis, depression, cardiovascular disease, muscle wasting, cachexia (loss of free fat mass) and anaemia. These systemic features are caused by inflammatory mediators and have a major impact on mortality and morbidity (Global Initiative for Chronic Obstructive Lung Disease, 2010). Exacerbations, a sudden deterioration of symptoms (worsening breathlessness, cough, increased sputum production and change in sputum colour) that is beyond normal day-to-day variations caused by triggers (bacteria, viruses, or environmental pollutants) are also another amplification of the disease which impact hugely on morbidity and mortality (The

National Institute for Clinical Excellence, 2010). Currently, there is no single test available to diagnose COPD and the diagnosis is based on a clinical judgement after full history taking, combined with physical examination and confirmation by spirometry. A post bronchodilator FEV_1 <80% predicted, in combination with a ratio of FEV_1 to forced vital capacity (FVC) of <70%, which is not fully reversible indicates airflow limitation and is consistent with a diagnosis of COPD (The National Institute for Clinical Excellence, 2010). The symptoms of COPD develop insidiously, making it difficult to determine the incidence of the disease, and many patients are not diagnosed until they are in their 50s. The symptoms and signs of COPD are not specific and other conditions present with similar signs and symptoms. The commonest of these is asthma. Nonetheless, COPD is usually distinguishable from asthma based on history and clinical examination. The criteria for differentiating COPD and asthma are shown in Table 1.1 (The National Institute for Clinical Excellence, 2010).

Table 1.1: Differential diagnosis between COPD and asthma (The National Institute for Clinical Excellence, 2010).

	COPD	**Asthma**
Smoker or ex-smoker	Nearly all	Possibly
Symptoms under age 35	Rare	Often
Chronic productive cough	Common	Uncommon
Breathlessness	Persistent and progressive	Variable
Night time waking with breathlessness and/or wheeze	Uncommon	Common
Significant diurnal or day-to –day variability of symptoms	Uncommon	Common

The assessment of the severity of COPD is based on measurement of the FEV_1, and has implications for therapy and prognosis. Boundaries of the FEV_1 value of 30%, 50%, and 80% are used to classify severity levels as mild, moderate, and severe (Table 1.2). The value of FEV_1 should not be used as a sole parameter to determine the severity of the disease due to its poor correlation with disability. A comprehensive assessment which includes: the degree of airflow limitation, the frequency of exacerbation, and disability should be conducted, as well as known prognostic factors such as: exercise capacity, health status, partial pressure of oxygen in arterial blood and body mass index (The National Institute for Clinical Excellence, 2010).

Table 1.2: Severity of airflow obstruction should be based on the reduction of FEV1 (The National Institute for Clinical Excellence, 2010).

		NICE clinical guideline (2004)	ATS/ERS(2004)	GOLD(2008)	NICE update clinical guideline (2010)
Post- bronchodilator **FEV1/FVC**	**FEV1 % predicted**	Severity of airflow obstruction			
			Post- bronchodilator	Post- bronchodilator	Post- bronchodilator
< 0.7	≥ 80%		Mild	Stage 1 - Mild	Stage 1 – Mild*
< 0.7	50- 79%	Mild	Moderate	Stage 2 - Moderate	Stage 2 - Moderate
< 0.7	30- 49%	Moderate	Severe	Stage 3 -Severe	Stage 3 -Severe
< 0.7	< 30%	Severe	Very severe	Stage 4 -Very severe**	Stage 4 -Very severe**

* Symptoms should be present to diagnose COPD in people with mild airflow obstruction, ** Or FEV1 < 50% with respiratory failure.

1.1.2. Economic and health burden of COPD in the UK

In the UK, the prevalence of COPD has been estimated to be 3.7 million people (Shahab et al., 2006). However, according to recent prevalence counts of the Quality and Outcomes Framework (QOF) between the year 2009 and 2010, only 834,312 (1.5%) people are currently diagnosed with the condition (National Health Service, 2010). This means that around 2 million people remain undiagnosed (British Lung Foundation, 2007), and of those, 5.5% are expected to have milder disease (Shahab et al., 2006). The average GP practice of 7000 patients is expected to have 200 patients with COPD (including undiagnosed cases). Worldwide, COPD was the fifth leading cause of death in 2001 and is anticipated to be the third greatest cause of death in 2020 (Lopez et al., 2006). Recent statistics in the UK showed that COPD was the fifth biggest killer claiming more lives than breast, bowel or prostate cancer in 2006 (The British Thoracic Society, 2006). COPD accounted for 27,478 deaths in 2004 (The British Thoracic Society, 2006). Five year survival after diagnosis is 78% in men and 72% in women for mild disease (not requiring pharmacological therapy) compared with 30% in men and 24% in women in severe disease (requiring treatment and oxygen therapy) (Soriano et al., 2000). Death occurs in 14% of cases, within 3 months after hospital admission (Connors et al., 1996; Roberts et al., 2002).

COPD accounts for 1.4 million GP consultations annually, which is four times more than the number of consultations for angina (Healthcare Comission, 2006). COPD is the second largest cause of emergency hospital admissions in the UK; 1 in 8 admissions (~130,000) are related to COPD (British Lung Foundation, 2007). Hospital re-admission is also increased after an exacerbation (Roberts et al., 2002). Of those admitted for the first time, 30% will be re-admitted in the following first 3 months (The British Thoracic Society, 2006), and the median time for audited re-admissions was 38 days in 2008 (Royal College of Physicians et al., 2008). COPD thus, accounts for more than 1 million 'bed days' each year in the UK (The British Thoracic Society, 2006). The median length of audited stay was 4 days in 2008 (Royal College of Physicians et al., 2008). COPD results in high costs to the National Health Service (NHS) with £930 million for direct costs, of which 50% are related to hospital care (The British Thoracic Society, 2006), and around £24 million for indirect costs relating to annual lost working days (Healthcare Comission, 2006). The average cost to the NHS per patient was

estimated to be around £800 annually, which increases by disease severity (The National Institute for Clinical Excellence, 2010). 35% - 45% of the total cost of COPD is attributed to exacerbations (Andersson et al., 2002; Jahnz-Rozyk et al., 2004).

Patients with COPD often experience impaired health related quality of life (HRQOL). HRQOL among COPD patients is worse than patients with coronary heart disease (CHD) or other chronic conditions (Hu and Meek, 2005). Exacerbations are a common health problem in the natural history of COPD (The National Institute for Clinical Excellence, 2010). Recovery from symptoms and improvement in lung function is often slow (Seemungal et al., 2000), leading to reduced quality of life (Seemungal et al., 1998; O'Reilly et al., 2007). Furthermore, the elderly and patients with COPD are known to have physical and functional limitations and often require help from a carer (Pinto et al., 2007). The value of care provided by family members exceeded the cost of care from nursing homes and paid health care (Schreiner et al., 2006). The Office of National Statistics estimated that about 5 million carers are currently providing informal care in the UK, and 15% of households in England have a carer (3 million households) (The Information Centre for Health and Social Care, 2010). In addition to the impact of COPD on the patient and the healthcare system, COPD affects family life and impacts negatively on the quality of life of family members and carers. Pinto et al. (2007) showed that caring for a patient with COPD adversely affects carers' health. In this study, 50% of the carers reported co-morbidities and took regular medication, while 75% sought medical advice in the preceding year. When these findings from this study were compared with those obtained for carers of patients with dementia, higher co-morbidities were found to be reported by COPD carers compared with dementia carers, despite the fact that the COPD carers were younger. Similar findings were reported by two other studies where wives of COPD patients were shown to report higher subjective stress and lower health and life satisfaction compared to wives of those who did not have a chronic illness (Sexton and Munro, 1985). Levels of loneliness and depression were found to be similar for both patients and their spouses (Kara and Mirici, 2004). In addition COPD carers were shown to assume more new roles and responsibilities, relinquish more social activities and report less satisfactory marital relations (Sexton and Munro, 1985). Social isolation and less social support received from family and friends contribute to loneliness which is positively associated with depression (Kara and Mirici, 2004).

Despite the staggering economic and health impact of COPD on patients, carers and the healthcare system, COPD remains largely under-diagnosed and under-treated (British Lung Foundation, 2007). COPD is a non-curable condition and the principal management is aimed at relieving the symptoms and slowing the progression of the disease. Effective disease management is crucial to combat the huge impact of the disease on patients, their carers and the healthcare system.

1.1.3. Overview of the management COPD

One of the objectives set out in the 'Outcomes Strategy for Chronic Obstructive Pulmonary Disease (COPD) and Asthma in England' published recently was to ensure that people with COPD receive safe and effective care which minimises progression, enhances recovery and promotes independence (Department of Health, 2011). The Outcomes Strategy recommended a treatment for the individual through an evidence-based use of pharmacological and non-pharmacological interventions which are tailored to the individual's choice and are regularly reviewed. One way of achieving this goal is by implementing evidence-based guidelines on the effective management of COPD. The National Institute for Clinical Excellence (NICE) first issued clinical guidelines for the management of COPD in 2004 (National Institute for Clinical, 2004). Recently, these guidelines were reviewed and replaced with an updated version (The National Institute for Clinical Excellence, 2010). Recommendations are proposed in these guidelines for the management of stable COPD, as well as for the management of exacerbations, which includes both pharmacological and non-pharmacological options. A holistic approach including the management of the patients' symptoms as well as the disease systemic effects should be delivered by a multidisciplinary team. This should be guided by the patients' symptoms and disability which change during the natural history of their disease. Ongoing assessment should include: assessment of symptoms, clinical signs, spirometry and frequency of exacerbations.

The pharmacological options recommended for the management of stable COPD include both inhaled (short and long acting bronchodilators and corticosteroids) and oral therapy. Inhaled therapy includes: monotherapy, combination therapy, or triple therapy introduced in a stepwise approach. Oral therapy includes: theophylline, corticosteroids, mucolytics, anti-oxidants, anti-tussives and prophylactic antibiotic therapy. The non-pharmacological options

include: physiotherapy, pulmonary rehabilitation, social and psychological assessment, occupational therapy and nutritional support. Other treatment options include: smoking cessation, oxygen therapy, non-invasive ventilation, vaccination, surgery and palliative care. The management of exacerbations should be aimed at reducing their frequency by the appropriate use of inhaled medications and vaccinations, as well as reducing their impact by offering a self-management plan involving: the early and correct identification of their symptoms, the use of emergency treatment (antibiotics and steroids), non invasive ventilation (NIV) when needed and an early discharge scheme or hospital at home (The National Institute for Clinical Excellence, 2010).

Inhalational therapy is the mainstay of the treatment of COPD, allowing high concentrations of drugs to be deposited at the site of action while minimizing systemic effects (Molimard et al., 2003). Inhaled bronchodilators improve breathlessness, increase exercise tolerance, reduce the frequency of exacerbations and improve quality of life. The role of inhaled steroids is less established. Although improvement in symptoms and a reduction in the frequency of exacerbations have been shown in clinical trials, and improvement in quality of life reported, there are concerns of their side effects. Currently, inhaled corticosteroids are not licensed for monotherapy in COPD and they should only be prescribed as a combination therapy. Short-acting bronchodilators (short acting beta agonist, short acting muscarinic antagonists) prescribed as required or for regular use should be the initial empirical treatment for the relief of breathlessness and exercise limitation. Effectiveness assessment of the patients should include: improvement in symptoms, activities of daily living, exercise capacity, rapidity of symptoms relief and standard assessment of lung function. Patients remaining symptomatic should have their inhaled treatment intensified in a stepwise approach to include: long-acting bronchodilators (long acting beta agonist, long acting muscarinic antagonist), combination therapy (long acting beta agonist and inhaled corticosteroids, long acting beta agonist and long acting muscarinic antagonists) and triple therapy (long acting beta agonist, long acting muscarinic antagonists and inhaled corticosteroids). The choice of drug should be guided by the individual patient's response to a trial of the drug, the profile of side effects, patient preference and costs (The National Institute for Clinical Excellence, 2010).

There are different delivery systems available for the delivery of inhaled drugs with no apparent differences between them in terms of clinical benefit, and thus the choice of a suitable device should be guided by patient preference and cost. In most cases bronchodilator therapy is best administered using a hand-held inhaler device (with a spacer device if appropriate). However, if a patient is unable to use a particular device appropriately or retain a satisfactory inhaler technique after proper instructions and follow up, an alternative device should be found. Nebuliser therapy is indicated if the patient remains breathless, despite using maximal therapy with hand-held inhalers. Nebuliser therapy should be continued if the patients derived benefits such as: improvement in symptoms, increased physical activity and exercise tolerance, or improvement in lung function. The patients and their carers should be assessed for their ability to use the device and offered ongoing support, servicing of equipment and advice (The National Institute for Clinical Excellence, 2010). The choice of a suitable nebuliser system for the patient should be guided by the effectiveness and safety of the system and based on recommendations published in national and international guidelines on nebuliser use (Kendrick et al., 1997; Boe et al., 2001).

Since the aim of the study is to investigate the use of nebuliser therapy by COPD patients and their carers in the home, the remainder of this section will provide an overview of aerosol therapy, the types of inhaler devices available, the advantages and disadvantages of different inhaler devices and the factors determining the choice of a suitable device. A focus on nebuliser therapy will follow with an overview of its history and evolution through the years, the types of nebuliser systems available, the current evidence supporting nebuliser use, and the challenges to achieve optimal therapeutic outcomes. Finally, the current indications for the supply of nebuliser therapy in clinical practice together with any considerations required will be outlined.

1.1.4. Definition of an aerosol, and mechanisms of aerosol deposition in the respiratory tract

The word aerosol was first used in 1932 and was based on "aer" (air) and "sol" (solution) (Dessanges, 2001). For particles to fall into the aerosol definition, it should have a size between 0.01 - 100 μm (0.1 mm); smaller than the lower limit of this size, particles are single molecules, and larger than the upper limit particles are no longer aerodynamic, settle quickly and cannot be suspended in air long enough to be considered aerosol. The aerodynamic properties of an aerosol which determines its particle-air interaction is not only dependant on particle size, but also its shape and density. To simplify this, the aerodynamic diameter is used and is defined as "the diameter of a hypothetical sphere of unit density having the same aerodynamic properties as the aerosol irrespective of the geometric shape, size and density" (Boe et al., 2004).

The human respiratory tract has a natural built-in defence mechanism against naturally inhaled particles. Three principal mechanisms of removing aerosol particles from inhaled air exist; impaction occurs when inhaled air changes direction at high speed at the bifurcation of larger airways; sedimentation occurs from air in the smaller airways and alveolar spaces as a result of gravity; diffusion occurs as a result of the natural Brownian diffusion of small aerosol particles making a chance contact with the respiratory tract. Other mechanisms such as interception and electrostatic interaction have minor roles in aerosol deposition in the airways (Boe et al., 2004; Taylor, 2007). Optimal aerosol deposition in the respiratory tract occurs when aerosol particle size fall within the range of 1-5μm, particle size > 5μm particles impact in the upper respiratory tract and are removed by the mucociliary escalator, while < 1μm are more likely to be exhaled without deposition.

The general pattern of aerosol deposition in the respiratory tract of a young healthy adult for tidal breathing has been previously established (Rudolf et al., 1990). As inhaled air travels down the respiratory tract, the velocity decreases as the airways becomes narrower and the cross-sectional area increases largely. This implies that speed is higher in the central airways and thus large particles >5μm are removed by impaction. However, in the peripheral airways consisting of smaller bronchioles and alveolar spaces, smaller particles are removed by sedimentation and diffusion (Boe et al., 2001). Therefore, the smaller the particle, the more it travels down the airways and the greater the penetration as shown in Figure 1.1.
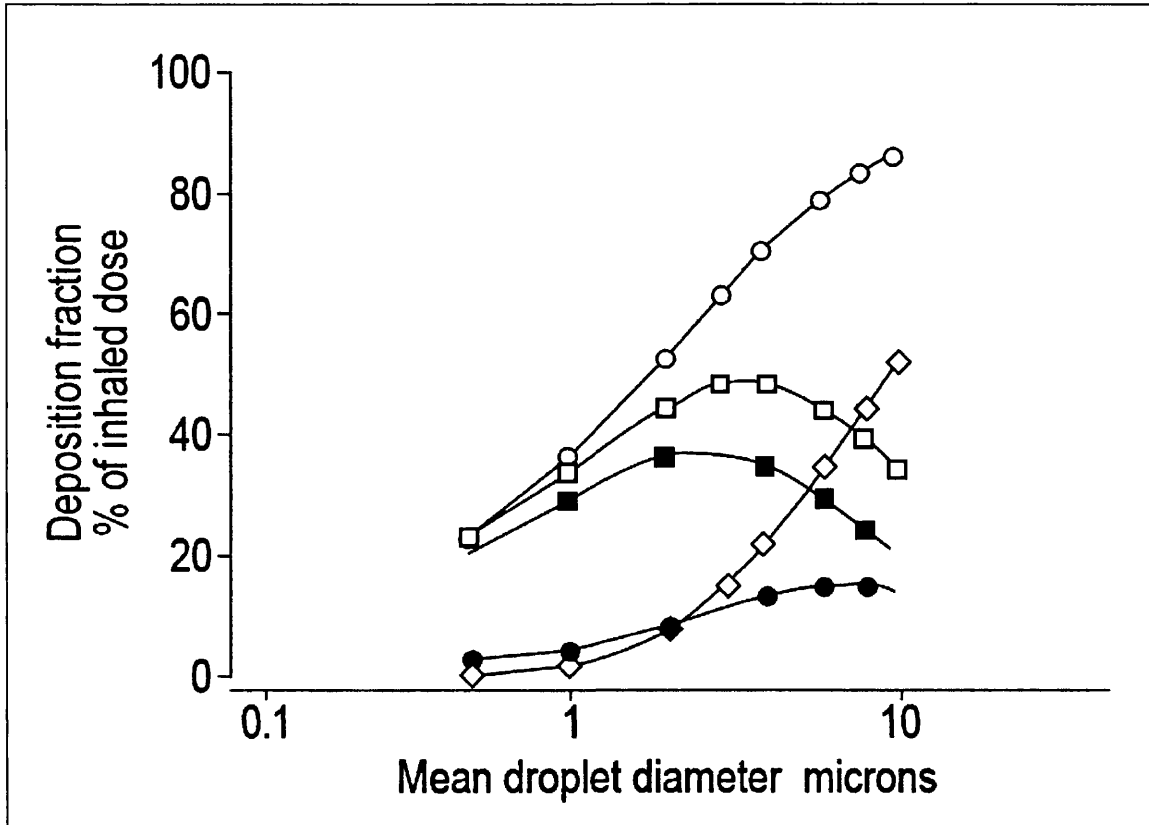
Figure 1.1: Relationship between aerosol aerodynamic diameter and drug deposition in healthy adult lung (based on *in vitro* models) (O: total body; □: total lung; ◇: oropharyngeal; ●: central airways; ■: peripheral airways) (Rudolf et al., 1990)

1.1.5. History of aerosol therapy and the evolution of inhaler devices

The history of aerosol therapy and the evolution of inhaler devices have been previously reviewed by researchers (Dessanges, 2001; Anderson, 2005; Rau, 2005). In the UK, the history of inhalational therapy dates back to the late 18th century when John Mudge, who is thought to be the first to use the term 'inhaler', described using a pot designed device for inhaling opium vapour for the treatment of cough (Anderson, 2005). From the early 19th century onwards, many ceramic pot-like devices were made available. The 'Nelson's inhaler', manufactured in London was one of the most popular earthenware designs favoured for its desirable features (cleanliness, portability, cheapness). The first use of inhalers for asthma in

the UK was in 1803, when General Gent, an asthmatic posted to Madras, imported leaves of Datura ferox to be smoked for therapeutic use (Anderson, 2005). The practice continued until 1992, when cigarettes were withdrawn due to their fatal abuse (Dessanges, 2001) (Figure 1.2). One of the early attempts of inhalational therapy was the use of anti-asthmatic powders which were available for inhalation at that time, and with that came an interesting instruction:

> "Fill a teaspoon with powder, forming a peak, and light the peak (use a saucer or metal object). Inhale the smoke normally, and exhale preferably through the nose. This method is particularly recommended for children and non-smokers."

(Dessanges, 2001)

Another early technique instructed the parents to inhale the smoke, and then to blow it into the nostrils and mouths of little children. Inhaling thermal waters was enjoyed in spas in the middle of the 19th century (Dessanges, 2001). The addition of oily substances that were harmful to the lungs to the thermal water had led to an end to this practice and such therapy fell out of use until the end of the 19th century when antiseptic aerosol therapy was used to treat Tuberculosis (Dessanges, 2001). In those days, inhalational devices depended on steam (Muers, 1997).
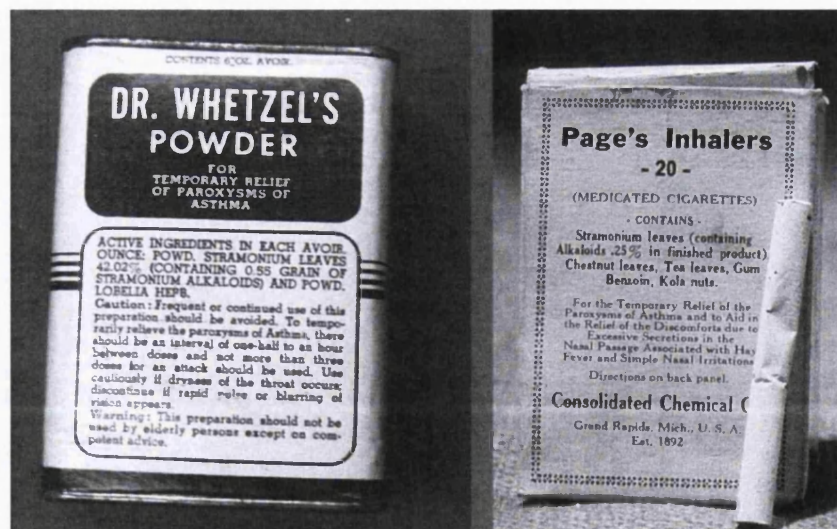
Figure 1.2: Asthma powder and asthma cigarettes (Anderson, 2005)

Early nebulisers were simple atomisers such as glass or hand-bulb atomisers (Anderson, 2005) which generated a wide range of particle sizes, and thus much of the output was not respirable (Dessanges, 2001). Adrenaline was used for the first time to treat asthma in 1912, delivered via 'the pump', which resembled a perfume vaporizer with a rubber squeeze ball (Anderson, 2005). The dose delivered was small and with a large particle size the drug impacted in the upper airways, resulting in side effects, although the effect of the particle size on the deposition in the lungs was not appreciated at that time (Dessanges, 2001) (Figure 1.3).

Figure 1.3: A hand-bulb nebuliser used for inhalation (Anderson, 2005)

Mechanical pumps to generate the gas flow required for nebulisation were first made in the 19th century (Figure 1.4). These were replaced by electrical compressors in 1930s (Muers, 1997). The first compressor nebuliser was manufactured in Germany in the early 1930s and had a rheostat for the power supply, although around the same time a nebuliser powered by a cylinder of compressed oxygen was being used in London (Anderson, 2005). A better practice of therapeutic aerosols was seen after the invention of the first jet nebuliser and peak flow meter by Tiffeneau and Beauvallet in 1947. The journal 'La Vie Me'dicale', dedicated an entire issue in 1950 to discuss aerosol therapy. In that issue Prof. J. Miner talked for the first time about the use of aerosol therapy in bronchiectasis.
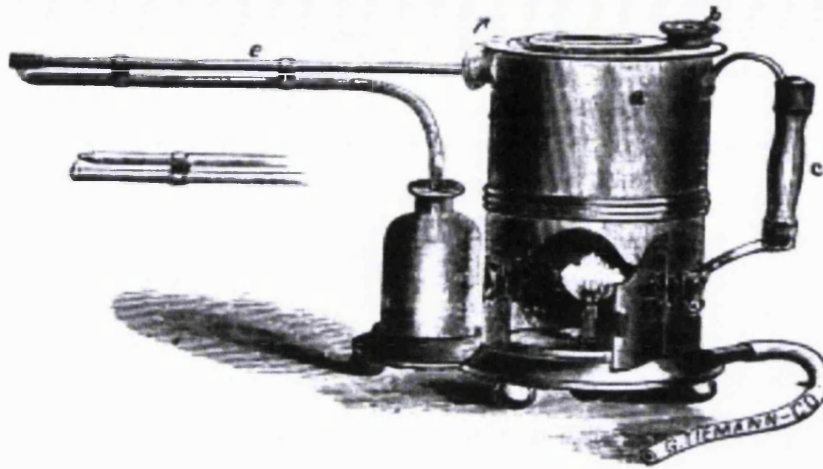
Figure 1.4: An example of the 19th century nebuliser equipment (Muers, 1997)

Modern jet nebulisers use a combination of high flow gas and a precise venturi orifice with a baffle to restrict the size of the particles generated (1 – 5 μm) to the respirable range increasing lung deposition and the efficiency of treatment (Muers, 1997). In 1949, ultrasonic nebulisers were developed in the form of humidifiers before doctors added medication to them to produce therapeutic aerosols (Dessanges, 2001). These were then developed to use a transducer made from a piezoelectric crystal (Anderson, 2005). From 1956, nebuliser practice declined following the evolution of the metered dose inhaler (MDI), which were small, inexpensive and theoretically easy to use device (Dessanges, 2001).

MDIs were the first portable outpatient inhalational device which was developed with the intention of overcoming the problems of a hand-bulb nebuliser (Labiris and Dolovich, 2003). The decline in nebulisation use continued throughout the sixties and seventies, until 1975 when Rosenthal and French invented the "dosimetric method" of nebulisation: when nebulisation was triggered by inspiration. Hargreave developed the "continuous method" at the same time. These two methods improved quantification of inhaled doses as a result of improvement in the nebulisation system (Dessanges, 2001). During the 1980s, nebuliser technology improved, especially with regard to home nebulisation. The evolution of several device designs: breath-enhanced, breath-actuated, and dosimetric devices as well as newer devices incorporating vibrating mesh technology have emerged (Anderson, 2005).

In parallel, the MDIs proceeded in several directions to overcome difficulties and limitations of older designs and to meet new regulatory requirements banning chlorofluorocarbon products, the traditional propellants of pMDI (Anderson, 2005). This led to the development of several devices such as the accessory devices, breath-actuated pMDIs, metered dose liquid inhalers, CFC-free pMDIs and the dry powder inhalers (DPIs) which has been developed earlier (Anderson, 2005).

The DPIs were first introduced in 1960. However, the first commercially successful DPI was launched in 1971 (the Spinhaler by Fisons) to administer sodium cromoglicate (Bell et al., 1971). DPIs were developed to eliminate the co-ordination problems associated with the use of pMDIs (Labiris and Dolovich, 2003). The evolution of inhalational therapy and the emergence of the different types of inhaler devices is shown in Figure 1.5.
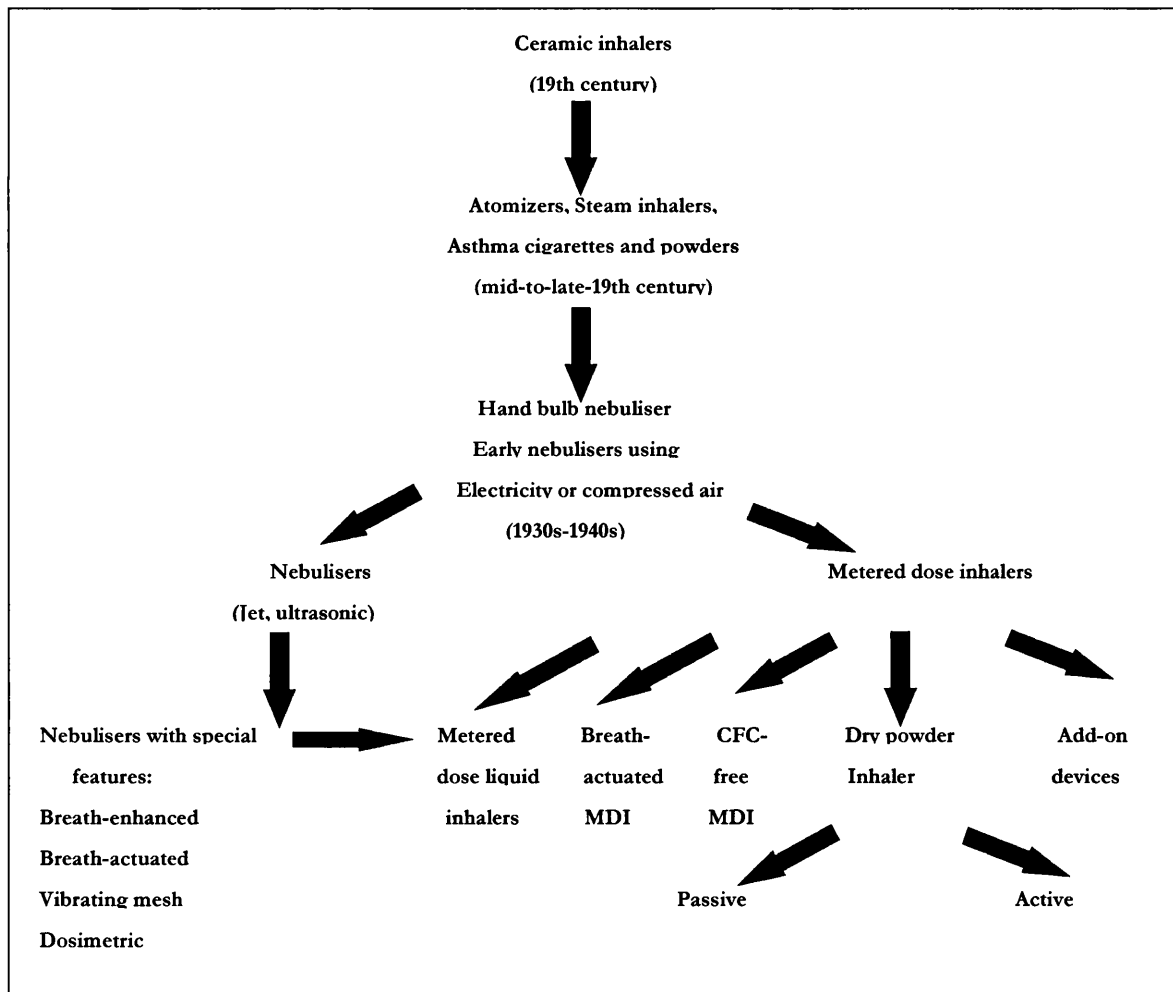
Figure 1.5: Evolution of inhaler devices (Anderson, 2005)

1.1.6. Considerations for choosing a suitable inhaler device

Today, three types of inhaler devices are available to deliver inhaled medications; pMDIs, DPIs and nebulisers. In terms of their popularity, pMDIs have the largest share of the market, compared to DPIs and nebulisers which are less commonly used (Boe et al., 2004). Efficacy and safety assessments of different inhaler devices (pMDIs with or without a spacer/holding chamber, DPIs, and nebulisers) for the delivery of bronchodilators (beta$_2$ agonists, anticholinergic agents) among COPD patients in the outpatient setting, concluded that all devices were appropriate for use (Dolovich MB et al., 2005). Accordingly, the choice of a suitable inhaler device by healthcare professionals considering inhalational therapy for the patient should be based on several other factors such as: the availability of the drug/device combination, the compatibility of the device with the drug formulation, the cost of the device and the ability of the patient to use the device properly.

The ability of the patient to use a device is an important factor determining its choice (Barrons et al., 2011), as the success of inhalational therapy depends largely on the patient's ability to handle the inhaler device properly (Lannefors, 2006). There is a great variation between the existing inhaler devices in the techniques used for operation and medication inhalation. With every type there are several advantages and some drawbacks (Table 1.3). The pMDIs are convenient for patients as they offer portability compared to nebulisers and they have shorter treatment times (Barrons et al., 2011). However, effective treatment depends on the patient's good inhaler technique; the ability of the patient to synchronise device actuation with inhalation and to breathe with a slow inspiratory flow rate (IFR < 60 L/min) (Labiris and Dolovich, 2003). These problems can be minimised with the use of holding chambers and spacer devices, and breath-actuated pMDIs (Labiris and Dolovich, 2003). DPIs eliminate the need for the hand-breath coordination but require the patient to have an inspiratory flow rate of 30 to 90 L/ml (Fink and Rubin, 2005). Particular drawbacks of DPI are the aggregation of the drug particles caused by high humidity, slow IFR, and heat which may affect drug delivery (Labiris and Dolovich, 2003). Nebulisers appear to be advantageous in many ways: they can be used to deliver high doses; drug delivery is independent of patients' inhalation technique or activation of the device; they are easy to use for administration to small children, elderly and confused patients and in emergency situations. They can be driven by oxygen in medical emergencies; and can administer drugs such as antibiotics which are not available in pMDIs or

DPIs. Disadvantages can be that: they can be costly to the patient or the health service, they take a long time to administer treatment, they can be noisy and drug residues can contaminate air. The complexity of treatment and equipment, the need for cleaning, maintenance and servicing of the equipment are further drawbacks of nebuliser use. Also, they can be misused or abused (Boe et al., 2004).

Table 1.3: Advantages and disadvantages of inhaler devices (Labiris and Dolovich, 2003)

Inhaler device	Advantages	Disadvantages
Nebulisers (Jet, ultrasonic)	- No specific inhalation technique or co-ordination required - Aerosoloses most drug solution - Delivers large doses - Suitable for infants and people too sick or physically unable to use other devices	- Time consuming - Bulky - Nonportable - Contents easily contaminated - Relatively expensive - Poor delivery efficiency - Drug wastage - Wide performance variations
Pressurised metered dose inhalers (pMDI)	- Compact - Portable - Multi-dose (~ 200) - Inexpensive - Reproducible dosing	- Inhalation technique and patient co ordination required - High oral deposition - Maximum dose of 5 mg - Limited range of drugs available
Dry powder inhalers (DPI)	- Compact - Portable - Breath- actuated - Easy to use - No hand-mouth coordination required	- Respirable dose dependent on inspiratory flow rate - Humidity causes powder to aggregate and capsules to soften - Dose lost if patient inadvertently exhales into the DPI - Most DPIs contain lactose

The existing guidelines for the management of COPD and the existing variety of inhaler devices available, means that a COPD patient is likely to be prescribed more than one inhaler device: a pMDI (with holding chamber or spacer) or a nebuliser for short acting bronchodilator delivery along with one or more DPI for long acting bronchodilator or/and corticosteroids therapy (Global Initiative for Chronic Obstructive Lung Disease, 2010; The National Institute for Clinical Excellence, 2010). This may create confusion for the patient (Rau, 2006). Shared decision making with the patient and considering the preference of the patient is key to ensuring adherence. However, a recent study showed that shared decision making was limited and discrepancies in nurses' understanding of the shared decision making concept were reported (Upton et al., 2011).

1.1.7. Practical problems with the use of inhaler devices among COPD patients

Substantial evidence concerning the incorrect use of pMDIs and DPIs has been shown (Hesselink et al., 2001; Wieshammer and Dreyhaupt, 2008; Rootmensen et al., 2010). It has been estimated that $5 to $7 billion is wasted annually because of inhaler misuse (Fink and Rubin, 2005). The rate of incorrect inhaler technique with pMDIs and DPIs have been reported to be 28% to 68% (Fink and Rubin, 2005). Common problems previously reported with the use of pMDIs included: failure to shake the inhaler prior to use (Hesselink et al., 2001; Rootmensen et al., 2010), failure to inhale slowly and press the canister (Hesselink et al., 2001; Rootmensen et al., 2010), failure to keep the device in an upright position (Rootmensen et al., 2010), failure to continue to inhale slowly and deeply (Hesselink et al., 2001; Rootmensen et al., 2010). Frequently reported problems with the use of single and multiple DPIs (Diskhaler, Cyclohaler, Rotahaler/Spinhaler, Turbohaler) included: failure to move the slide in and out (Hesselink et al., 2001), failure to perforate the blister (Hesselink et al., 2001), failure to press both ends to open a capsule (Hesselink et al., 2001), failure to rotate grip until 'click' (Hesselink et al., 2001), failure to keep the device in an upright position (Rootmensen et al., 2010), failure to breathe forcefully and deeply (Rootmensen et al., 2010). Several factors were shown to be predictive of poor inhaler techniques in pMDI and DPI such as: the use of more than one inhaler device (Rootmensen et al., 2010), low emotional quality of life (Hesselink et al., 2001), being treated in a group practice (Hesselink et al., 2001), inadequate instruction (Rootmensen et al., 2010), older age (Wieshammer and Dreyhaupt, 2008) and advanced COPD (Wieshammer and Dreyhaupt, 2008). With the exception of the age of the patient and the stage of the disease, other factors are modifiable. This implies that simplifying drug regimens and education are key factors which should be considered to ensure the effective use of inhaler devices (Fink and Rubin, 2005). Education was shown to be effective in improving the inhaler technique in a previous review (Crompton et al., 2006). Nonetheless, the risk of ineffective inhaler technique is high among older patients with advanced COPD despite training (Wieshammer and Dreyhaupt, 2008) which emphasises the previous point of proper device selection.

A common misconception is to consider nebuliser therapy a simpler form of inhalation therapy compared to pMDIs and DPIs (Fink and Rubin, 2005). The use of nebuliser requires the patient to perform multiple steps (assembling the different parts of the nebuliser system, preparing and filling the drug fluid, inhaling the nebulised dose, cleaning and maintaining the equipment after use) (Fink and Rubin, 2005). Several factors have been proposed to pose a challenge to achieve optimal therapeutic outcomes of nebuliser therapy; these can be classified into device, formulation, or patient-related factors. Addressing these factors is therefore central to optimise aerosol deposition and hence the effectiveness of nebuliser therapy. Leading nebuliser manufacturers and pharmaceutical companies strive to enhance device and formulation characteristics. However, without the correct handling of the device by the patient these efforts are wasted. As for the patient-related factors, inter-subject variability in aerosol deposition is attributed primarily to differences in airway geometry and disease state (Newman and Chan, 2008). Newman and Chan (2008) stated that the dimensions of the upper airways (mouth, pharynx, and larynx) vary between individuals and with the position of the tongue which determines the velocity of the inhaled aerosol. They concluded that this in turn determines aerosol impaction in the upper airway, and consequently the amount of aerosol available to reach the peripheral airways. According to Boe et al., (2004), the severity of airways disease influences deposition; as increased severity is associated with increased deposition in the central and upper airways and increased breathing frequency. Secretions contribute to narrowing of the airways and increased turbulent inspiratory flow (Boe et al., 2004). Studies of deposition pattern have shown that lung deposition varies with age (Brun et al., 2000). Breathing patterns are known to affect the amount of drug deposited as well as the site of deposition in the airways; high inspiratory rate results in more central deposition while low inspiratory rates result in more peripheral deposition (Brun et al., 2000). A long breathing cycle is more desirable for optimal drug deposition, although this is not possible in severely dyspnoeic patients (Lannefors, 2006). The inhalation technique is also known to affect the deposition pattern of inhalation aerosols in the airways. Lannefors (2006) has recommended that one should try different inhalation techniques to achieve optimal drug deposition (Lannefors, 2006). Handling of the device by the patient such as cleaning and maintenance procedures employed by the patient can affect the performance of the nebuliser (Standaert et al., 1998; Rubin, 2004).

1.1.8. Types of nebuliser systems

The word nebuliser (from the Latin "nebula", mist) was first used and defined in the Shorter Oxford Dictionary in 1874 as "an instrument for converting liquid into a fine spray, especially for medical purposes" (Muers, 1997). Depending on the driving force, nebulisers are classified into 2 main types: jet nebulisers, and ultrasonic nebulisers. Recently third types using mesh-based technology have become available. Jet nebulisers are the commonest type of nebuliser system used by patients in hospital and in the home setting. The nebuliser system comprises 4 components: the driving force, the nebuliser chamber, the interface and the tubing (Figure 1.6). The nebuliser chamber comprises 3 parts: the medication tank, the baffle (vaporiser head) and the nebuliser cap.
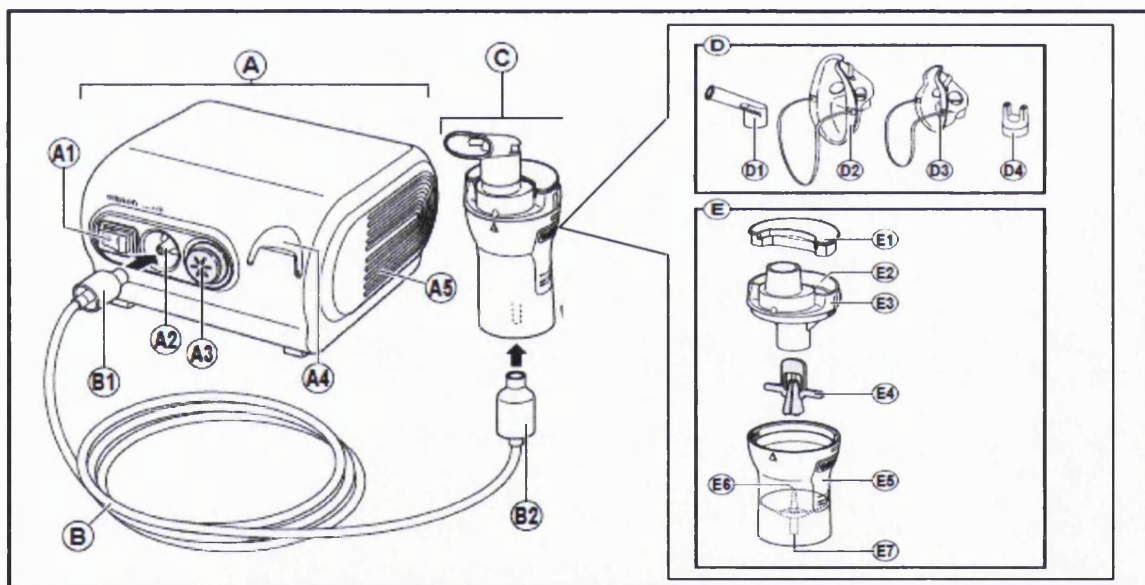
Figure 1.6: A schematic diagram illustrating the different components of the jet nebuliser system. A: compressor unit (A1: power switch, A2: air connector, A3: filter cover, A4: nebuliser kit holder, A5: ventilation slots), B: Tubing (B1 & B2: air plug), C: Nebulising parts [D: inhalation attachments (D1: mouthpiece, D2: adult facemask, D3: child facemask, D4: nose piece), E: nebuliser kit (E1: cap, E2: inhalation air inlet, E3: inhalation top, E4: vaporiser head, E5: medication tank, E6: nozzle, E7: air tube connector)] (Omron Manufacturer's Datasheets).

Jet nebulisers force pressurized gas (usually air) through a nozzle (or jet) at high velocity past a liquid feed tube, so that the nebuliser solution is atomised at the capillary exit. The bulk of the aerosol mist impacts against a baffle, drains back into the reservoir in the base and re-circulates. Only very small droplets (< ~ 5μm, if the system is running correctly) escape the baffle and are available for inhalation (Byron, 2004). There are three types of jet nebulisers: constant output, breath-enhanced, and dosimetric nebulisers. Constant output nebulisers have an open-T-shape design and constant output. Aerosol is emitted during both inhalation and exhalation. A large proportion of available dose is wasted during exhalation; about 20% to the atmosphere and 60-70% on the apparatus (Rau, 2005) (Figure 1.7). With breath-enhanced nebulisers, also known as an "open vent" nebuliser, during inspiration, ambient air with the driving gas is entrained through a 1-way valve; and through a 1-way plastic flapper valve in the mouthpiece during exhalation. This way, the aerosol formed in the apparatus during exhalation is contained in the nebuliser chamber. An example of this type is the Pari LC Plus[®] (Pari GmbH, Germany) (Figure1.8). However, differences exist between available models; the disposable model lacks the 1-way valves that enhances efficiency (Rau, 2005). Dosimetric nebulisers generate aerosol and makes it available only during inhalation (Rau, 2005). An example of this type is the Pari LL[®] (Pari GmbH, Germany) (Figure 1.9).
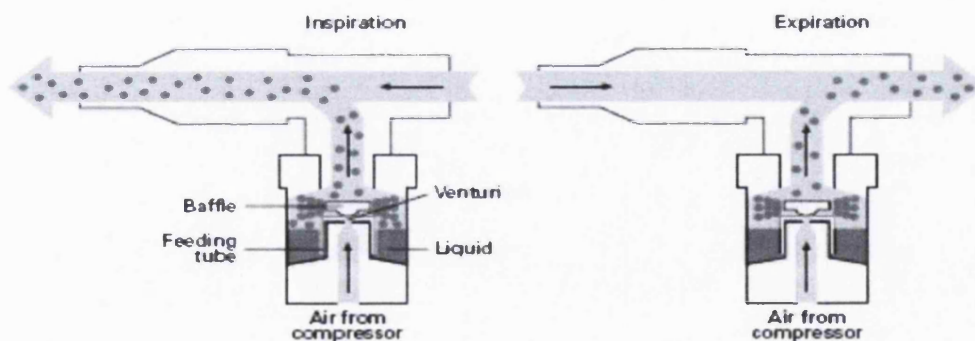
Figure 1.7: A schematic diagram of the jet nebuliser (O'Callaghan and Barry, 1997)
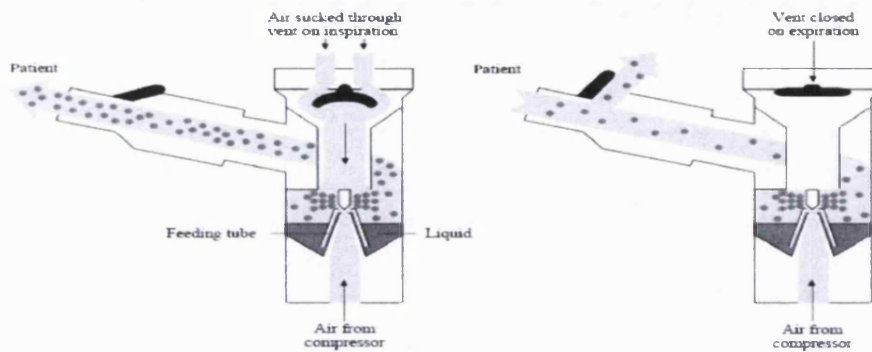
Figure 1.8: A schematic diagram of the breath-enhanced nebuliser (O'Callaghan and Barry, 1997)
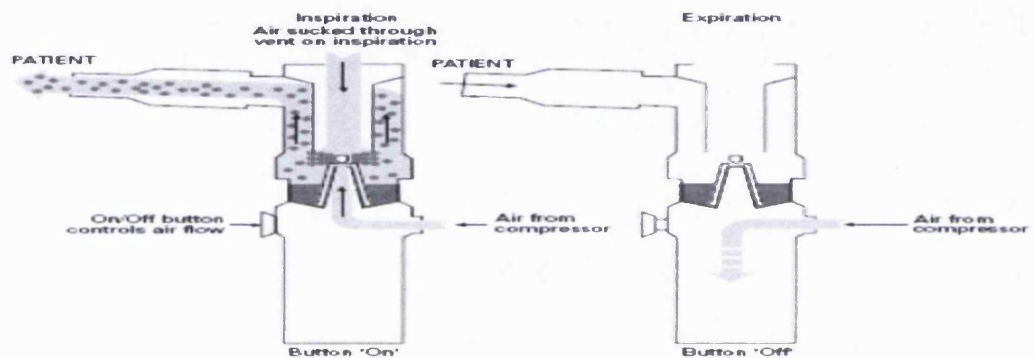
Figure 1.9: A schematic diagram of the dosimetric nebuliser (O'Callaghan and Barry, 1997)

Ultrasonic nebulisers employ a piezoelectric crystal transducer, usually a synthetic ceramic material which vibrates at high frequency (1-3 MHZ) to apply an alternating electric current to shrink and expand the crystal. Vibrations are transmitted to the nebulised fluid either directly or via a coupling fluid (water). This in turn produces a fountain of liquid at the surface, with large droplets at the top and small droplets at the bottom (Taylor and McCallion, 2002). Figure 1.10 shows the principle of operation for the ultrasonic nebulisers. Two theories have been proposed to explain liquid disintegration; the capillary wave theory, where the waves are formed within the bulk of the liquid resulting in peaks and a central geyser, and when the energy is sufficiently high, the crests of the waves breaks off forming the droplets. The other theory implies that the piezoelectric crystal operating at low frequency and imparts vibration to the bulk of the liquid, which results in cavitation bubbles. When these bubbles move to the liquid-air interface the pressure equilibrates with that of the atmosphere causing their implosion and droplet forms at the surface of the liquid (Taylor and McCallion, 2002).
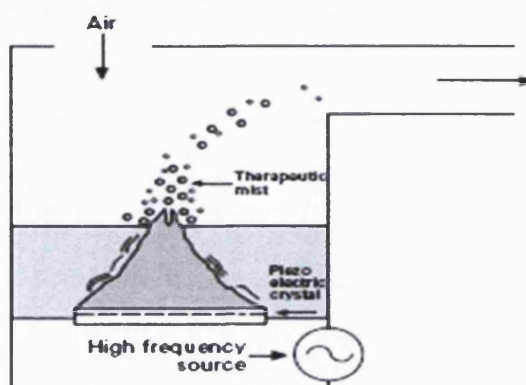
Figure 1.10: Ultrasonic nebulisers (O'Callaghan and Barry, 1997)

Ultrasonic nebulisers are generally quieter and have shorter nebulisation time compared with jet nebulisers. However, they are not suitable for nebulising suspensions and very viscous solutions. They generate heat and raise the temperature of the formulation, and thus not suitable for heat sensitive formulations (proteins) (Taylor and McCallion, 2002).

Nebuliser manufacturers are continuously challenged to provide nebuliser systems that are more convenient and acceptable to the patient while at the same time efficient in delivering the required dose. Newer devices have overcome many limitations of old nebuliser systems and can have one or more of the desirable features; small mono-dispersed aerosol generation, flexible dosing, ease of use, portability, low cost, low energy input, and performance independent of the drug solution or the inhalation flow (Boe et al., 2004). Technological advances in nebuliser designs are either a modification of currently available inhalation systems or employing a new principle (Watts et al., 2008). New nebulisers generate aerosols by means of mechanical, thermo-mechanical or electro-mechanical power (Boer et al., 2008). Devices incorporating specific drug formulations include: the Respimat® Soft Mist Inhaler. Mesh nebulisers include; Aeroneb® Pro, Omron MicroAIR NE-U22, Pari:eflow™ (Smart Nebuliser), and MedSpray®. A summary of the main features of the new devices is shown in Table 1.4.

Table 1.4: A summary of the new nebuliser devices main features

Device	Technology	Formulation	Particle size (μM)	Respirable dose (%)	Nebulisation time (min/ml)	Company	Country
Respimat	High pressure microspray	Fenoterol+ Ipratropium	4-5	65	< 1	Boehriger Ingelheim	Germany
MedSpray	Spray chip technology	Available formulation				ODEM	UK
Pari:eflow™	Vibrating mesh	Available formulation	4	90	1	Pari	Germany
MicroAIR U22	Vibrating mesh	Available formulation	1-5	98	0.4-0.5	Omron	Japan
AeroNeb Pro	Aperture plate	Available formulation	2.1	83		Aerogen	Ireland

Respimat® Soft Mist Inhaler (Boehringer Ingelheim, Germany) is a novel, hand-held, multi-dose device that contains an aqueous solution of therapeutic agent (Koehler et al., 2004). The device uses mechanical power to force drug solutions through a sophisticated system of nozzles (Newman et al., 1998). This in turn generates a slow-moving aerosol; 5 times slower than aerosol released from a pMDIs, with high percentage of respirable particles (65% of the drug dose) (Noord et al., 2000). Advantages of this device include: a reduction of drug impaction in the oropharynx and an increase in lung deposition, a reduction of the need to co-ordinate actuation with inspiration and thus, an improvement of efficacy and tolerability of inhaled medications (Koehler et al., 2004) (Figure1.11).
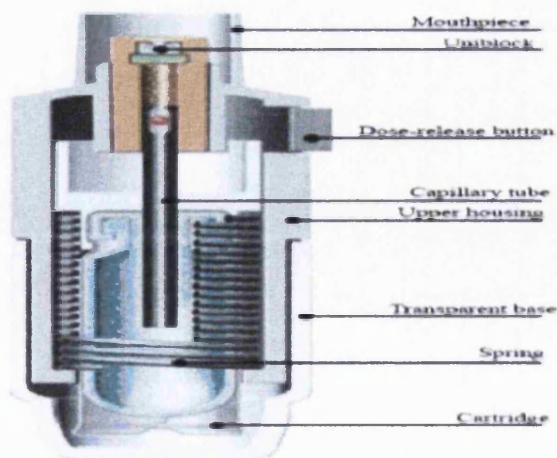
Figure 1.11: A schematic diagram of the Respimat® soft mist inhaler (Noord et al., 2000)

The Aeroneb® Pro (Aerogen Inc., Galway, Ireland), is an active vibrating mesh nebuliser, it employs a micropump technology by adapting a vibrating piezoelectric crystal to a laser-bored mesh plate. When oscillated, fluid is pumped from a small volume reservoir through thousands of tapered holes to produce the aerosol (Watts, et al., 2008). Figure 1.12 shows a schematic diagram of the Aeroneb Pro nebuliser and principles of its operation. Advantages of this device include: the ability to aerosolise drugs which are sensitive to heat, higher output rates, shorter nebulisation times and nebulisation of very small volumes (Watts et al., 2008).
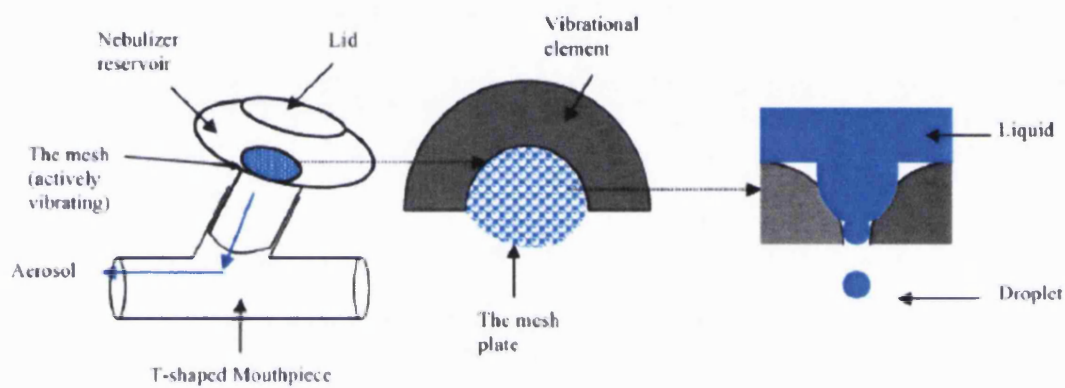
Figure 1.12: A schematic diagram of the Aeroneb Pro nebuliser, principles of operation is shown on the right (Ghazanfari et al., 2007)

The Omron MicroAIR NE-U22 is a passive vibrating mesh nebuliser employing the same operating principle as the Aeroneb® Pro. However, the ultrasonic vibrations are passively conducted through a thin layer of fluid to the mesh plate (Watts, et al., 2008) (Figure 1.13).
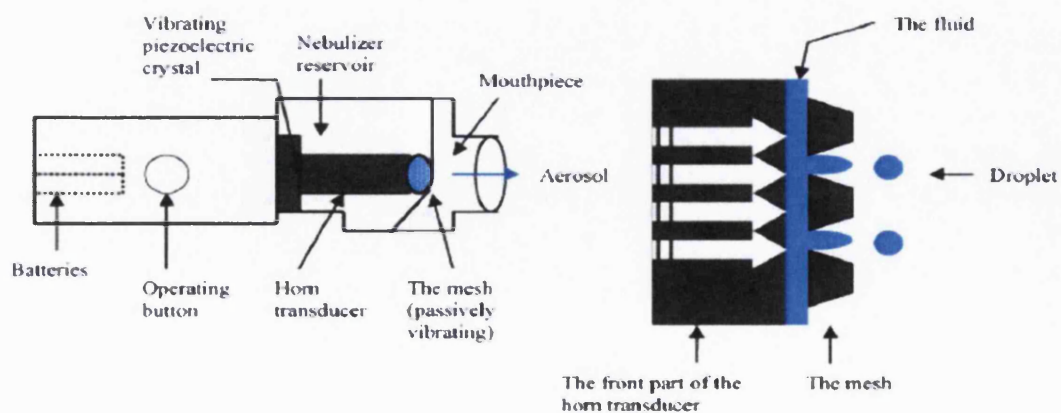
Figure 1.13: A schematic diagram of the Omron MicroAIR NE-U22, principles of operation is shown on the right (Ghazanfari et al., 2007)

The Pari-eflow™ is a portable, electronic aerosol platform, which uses mesh-based technology to increase the efficiency and safety of aerosol delivery. Advantages of this device include; short treatment time as a result of the high output rate, high delivery efficiency (up to 90%). It also generates aerosol of low velocity, is light, silent, and portable, can be adjusted to accommodate a wide range of formulations, and can be used across a range of applications (PARI Pharma, 2011) (Figure 1.14).
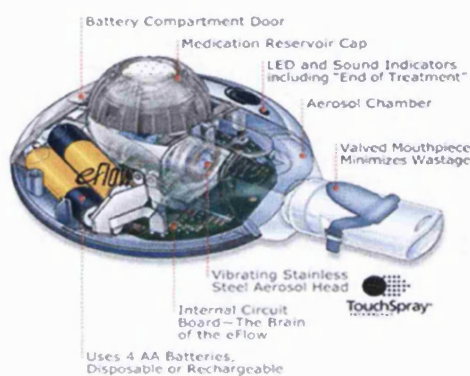
Figure 1.14: A diagrammatic representation of the e-flow nebuliser from PARI (PARI Pharma, 2011).

The MedSpray® inhaler device is a simple hand-held inhaler, consisting of a spray nozzle combined with a special design pump system. Aerosol is formed when drug solution is pressed mechanically through an array of nozzles into a special design mouth piece, which mixes the aerosol with air (Boer, et al., 2008). Actuation of the device, by pressing a button at the top of the inhaler loads the spring between this button and the drug container, which releases the drug from the pump system into the spray nozzle (Boer et al., 2008) (Figure 1.15). Advantages of this device include; aerosol discharged at a low velocity, the aerosol is mixed in a special shape mouthpiece with an air flow resistance prior to being discharged from the device, impaction is prevented and droplet coalescence is minimized. Also, hand-lung coordination and patient training is minimum (Boer et al., 2008).
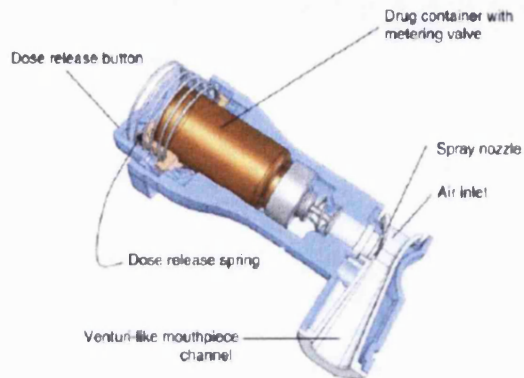
Figure 1.15: A schematic diagram of the MedSpray® (Boer et al., 2008)

1.1.9. What is the current evidence concerning the effectiveness of nebuliser therapy in COPD?

Much of the evidence concerning the effectiveness of nebuliser therapy in COPD has focused on the drug rather than the effect of the device. In these studies, the effect of the nebulised drug was either compared to placebo (Baumgartner et al., 2007), or to the addition of another nebulised drug (e.g. monotherapy vs combination therapy) (Tashkin et al., 2007). However, a few studies have investigated the effect of using nebuliser therapy in terms of the effect of the device. Results from systematic reviews have failed to show that nebuliser therapy is superior to any other forms of inhalational therapy both in the management of stable COPD (Brocklebank et al., 2001) and exacerbations (Turner et al., 1988). However, much of the evidence from these reviews has been based on a few small scale clinical trials which excluded patients with severe disease and poor inhaler techniques who might benefit from nebuliser therapy. There is some evidence from a few home-based studies suggesting that nebuliser therapy might have a role in the management of severe COPD patients in the community (Bosley et al., 1996; Corden et al., 1997; Osman et al., 1997). Evidence from these studies has suggested that the use of nebuliser therapy in the community had a positive impact on the quality of life (QOL) of COPD patients. A study conducted by Corden et al. (1997) to assess compliance with nebulised therapy, using the St George's Questionnaire (SGRQ) over a period of 4 weeks, showed that low levels of compliance with nebuliser treatment resulted in greater impairment of QOL. Although no correlation was observed between compliance and the QOL scores measured by SGRQ1 at the start of the study, total scores of the SGRQ2 correlated negatively with percent compliance at the end of the study. Moreover, compliance

correlated negatively with the symptom and impact subscale of the SGRQ2. The authors argued that poor compliance leads to a greater impairment of QOL. They suggested that efforts should be made to improve patients' engagement with their illness to reduce morbidity, costs of therapy and to increase QOL (Corden et al., 1997). Bosley et al. (1996) used mixed methods; semi-structured interviews and instruments (SGRQ and Hospital Anxiety and Depression Scale (HADS)) to examine the relationship between adherence to domiciliary nebuliser treatment and psychological factors; patient's attitude, anxiety and QOL. Analysis of scores from the interviews, demographic data, percentage adherence and HADS scale with SGRQ showed that the total score was negatively associated with percentage adherence, feeling supported by clinical staff and patients feeling that they tried to ignore their chest disease while positively associated with depression score. Moreover, the symptom and impact subscales (from the SGRQ) were found to be negatively correlated with adherence. Thus it was concluded that patients who reported poor QOL are more likely to feel depressed and unsupported and consequently are less likely to adhere to treatment. The authors recommended that increasing levels of clinical support and psychological treatment may be beneficial interventions in such patients (Bosley et al., 1996). On the other hand, a study carried out by Osman et al. (1997) used both interviews and instruments (SGRQ) to examine whether QOL as measured by the SGRQ can predict the risk of hospital re-admission or use of resources in a sample of patients with COPD. Results showed that higher SGRQ scores (indicating greater impairment of QOL) were positively associated with increased hospital re-admission and use of nebulisers but no difference was found between SGRQ scores in patients who had died or those who had survived after re-admission. In this study, re-admission was independent of age, sex or pulmonary function. Although the use of nebulisers was found to be associated with poorer QOL, in this study it was seen as a marker of disease severity rather than a reflection of the use of the nebuliser. Nebuliser provision was seen as a reflection of the impact of the disease on daily activities and a significant cause of distress to patients; therefore, poor SGRQ scores were shown to be associated with more use of resources such as nebulisers. Analysis of components of the SGRQ scale revealed that the symptoms and impact subscales were positively related to re-admission while the Impact subscale was positively related to nebuliser provision after adjusting for age, sex and lung function. The authors further explained that assessing the patient for the impact of disease is a normal part of a clinical assessment, and therefore, QOL measures can be used to reflect this (Osman et al., 1997).

1.1.10. Considerations for the supply of nebuliser therapy in clinical practice

It has been proposed that nebuliser therapy may be valuable for patients who require high dose treatment and have mucus clearing problems (O'Driscoll, 1991). It has been shown that about half of the patients who remained breathless despite high dose bronchodilator delivered by pMDI or DPI, derived subjective and objective benefits from domiciliary nebuliser therapy (O'Driscoll et al., 1992). However, careful selection of patients is key to achieve optimal therapeutic effects from nebuliser therapy. There is evidence that laboratory tests are of little value in predicting patients who are likely to benefit from long term nebuliser use in the home (O'Driscoll et al., 1990). Out of 20 patients who were prescribed nebulised therapy (5 mg salbutamol, 0.5 mg ipratropium bromide or a mixture of both drugs to be used 4 times a day for a period of one month) and who demonstrated a similar subjective and objective response to nebuliser therapy when assessed in a laboratory, only 14 requested domiciliary nebuliser therapy, and a further 9 had their peak flow measurements highest during the home trial (O'Driscoll et al., 1990). There was no correlation between their subjective response, laboratory response and their home response (Spearman correlation coefficient; subjective score, laboratory vs. home, $r=0.27$, $P=0.03$; peak flow response 30 min after treatment, laboratory vs. home, $r=0.31$, $P<0.02$) (O'Driscoll et al., 1990). Moreover, the hospital study was also unreliable in predicting side effects during domiciliary nebuliser use (O'Driscoll et al., 1990). Therefore, decisions to supply nebuliser therapy should only be made after conducting a home trial for a period of time (O'Driscoll, 1991). National guidelines on the use of nebulisers were first published by the British Thoracic Society in 1997, to regulate the provision and use of nebuliser therapy (British Thoracic Society, 1997). Soon after, these guidelines were considered outdated and replaced by a newer international version, published by the European Respiratory Society (Boe et al., 2001). The aim of the guidelines was to improve clinical practice, enhance the safety and efficacy of nebuliser use and to serve as an educational and scientific resource to stimulate future work. The guidelines state that the prescriber had a responsibility to ensure that the use of nebulised medication is appropriate for the patient. The supply of nebulised bronchodilators should only be considered for patients with severe COPD after conducting an 'inhaled therapy optimisation' trial. Ideally, the minimum effective dose which is delivered in the simplest and most convenient device should be prescribed for the patient. However, there is no clear cut off point indicating when a certain dose becomes more effective or convenient which depends largely on the individual patient (breathing pattern and

side effects) and the hand-held inhaler device (performance as determined by aerosol output and particle size) which is being compared with the nebuliser. Doses up to 1 mg salbutamol and 160-240 µg ipratropium bromide should be given using a hand-held inhaler after which a nebuliser may be indicated for more convenience. Clinical experience suggests that doses which require > 10 puffs using a hand-held inhaler are unpopular with patients (Boe et al., 2001). There are other indications when a nebuliser is considered; such as where the patient is incapable of using another hand-held device. Assessment of cognitive function is sometimes indicated to ensure appropriate supply (The National Institute for Clinical Excellence, 2010).

If nebulised therapy has been considered for the patient, the technical characteristics of the nebuliser system should guide the choice. Numerous nebuliser systems are available in the UK (British Medical Association and Royal Pharmaceutical Society of Great Britain, 2011) (Table 1.5), each with different features and technical characteristics which affect performance and hence potentially the efficacy of the nebulised dose. The assessment of the performance of a particular nebuliser system should take into consideration all components of this system: the nebuliser chamber, the compressor (or other driving force), as well as the patient interface (mouthpiece or a facemask) (Boe et al., 2001). The effectiveness of the nebuliser system to deliver the required amount of the drug to the required site of action depends on the aerosol output which is determined by the gas flow rate of the compressor as well as the size of the aerosol which determines the site of drug deposition in the airways. Leading nebuliser system manufacturers recommends that their compressor is used with the marketed nebuliser chamber. The reason for this is that quality control tests were conducted on this combination. Thus, using a nebuliser chamber different than this means that the amount of the nebulised dose reaching the patient's airways is unknown (Boe et al., 2004). It was recognised in the guidelines that comparing nebuliser systems on the grounds of their performance poses a challenge due to the diversity of the methods used by manufacturers to assess their systems (Boe et al., 2001). This dilemma will be solved with the introduction of a European Standard and manufacturers are urged to use standardised methods for assessing the performance of their nebuliser systems which is hoped to provide an effective means of comparing different nebuliser systems available and guide healthcare professionals in making an informed choice of a suitable device (Boe et al., 2004). In the meantime, healthcare professionals are advised to establish a standard operating practice (SOP) where different nebuliser systems are compared and a guide is developed. There are some published data comparing the characteristics of

different nebuliser chambers and different compressors (Kendrick et al., 1997) (Table 1.6 and 1.7).

Table 1.5: Nebuliser models available in the UK (British Medical Association and Royal Pharmaceutical Society of Great Britain, 2011)

Nebuliser type	Brand	Company
Jet Nebulisers	Medix All Nebuliser®	Medix
	Medix Antibiotic Circuit®	Medix
	Medix System®	Medix
	Pari LC Plus Filter®	Pari
	Pari LC Plus®	Pari
	Sidestream Durable®	Medic-Aid
	Ventsream®	Medic-Aid
Compressors	System 22 CR50	Medic-Aid
	System 22 CR60	Medic-Aid
	Turboneb	Medix
Compressors with nebulisers	AC 2000 HI FLO®	Medix
	Aquilon®	Henleys
	Econoneb®	Medix
	Freeway Lite®	Medic-Aid
	M-Flo®	Medix
	Medi-Neb®	Timesco
	Pari TurboBoy®	Pari
	Pari WalkBoy®	Pari
	Porta-Neb®	Medic-Aid
	Pulmo-Aide®	DeVilbiss
	SunMist®	DeVilbiss
	Tourer®	Henleys
	Ultima®	Henleys
	World Traveller Hi FLO®	Medix
Ultrasonic	AeroSonic®	De Vilbiss
	F16 Wave®	Parkside
	Omron UI MicroAir®	Hutchings
	Omron NE U07®	Hutchings
	Sonix 2000®	Medix
	Ultra Neb 2000®	De Vilbiss

Table 1.6: Nebuliser/compressor combinations used with bronchodilator therapy (Kendrick et al., 1997)

Flow rate	compressor	Nebuliser chambers sold with compressor unit	Multivolt?
High flow rate (>6.0 l/min)	AFP Classic	MicroMist	No
	AFP Aquillon	MicroMist	No
	AFP Ultima	MicroMist	Rechargeable battery
	AFP Tourer	MicroMist	
	Flaem Nuova Combineb	Flaem Nuova Type 3	Yes
	Flaem Nuova Micelfluss Pro	Flaem Nuova Type 2	Yes
	Medic-Aid CR50	Medic-Aid Sidestream	Yes
	Medic-Aid CR60*	Medic-Air Ventstream	No
	Medic-Air Freeway Yes		No
	Gast*†		Yes
	Inspiron*	MiniNeb, Incenti-Neb	?
	Medix M Flo	Medix A11	No
	Medix AC2000*	Medix A11	No
	Medix World Traveller	Medix A11	No
	Medix Econoneb	Medix A11	Yes
	Medix Minor*†	Cirrus	No
	Medix Turboneb	Cirrus	No
	Porta-Neb	Medic-Aid Sidestream	No
		Medic-Aid Ventstream	No
	Porta-Neb Multi	Medic-Aid Sidestream	Yes
	SunMist Plus	Perma Neb	No
Medium flow rate (4.0–6.0 l/min)	Aeroneb HP†	Cirrus	No
	Atomolette†	Own	No
	Flaem Nuova M70	Flaem Nuova Type 2	No
	NebuPump†	Acorn	No
	Novair II	Cirrus	No
	Pari InhalierBoy†	Own	No
	Pari TurboBoy	Pari LC Plus, LC Plus Junior	No
	Pari JuniorBoy	Pari LC Plus, LC Plus Junior	No
	Pulmo-Aide†	Own	No
	SunMist	Perma Neb	No
	DeVilbiss Traveller	Perma Neb	Yes
Low flow rate (<4.0 l/min)	Aeroneb Standard†	Own, Cirrus	No
	Pari WalkBoy	Pari LC Plus,	Yes
	Aeroneb HP†	Own	No
Others	Aerolyser CF1B†	Wright	Yes
	Aerolyser CF1R†	Respi-Neb	Yes
	Aerolyser 216†	Respi-Neb	Yes
	Flaem Nuova Travelneb	Flaem Nuova Type 3	Yes
	Henley HCU-1†	Hudson MK II	Yes

*Compressors have been tested with 19 nebuliser chambers (Acorn, Aerflo, Cirrus, DeVilbiss, Econoneb, Hudson II, Jet set, MicroCirrus, MicroNeb III, MiniNeb, Sandoz, Suremist, Turret Turbo, Unicorn, Unimist, Unineb, Upmist and Wee Neb) and achieved flow rates at the nebuliser of >6.0 l/min, † These devices may not be currently available but may still be in use.

Table 1.7: Characteristics of nebuliser chambers (Kendrick et al., 1997)

Nebuliser chamber	Residual volume (ml)	Maximum Fill volume (ml)	% nebulised		% particles Under 5 μm	MMD (μm)
			5 minute	10 minutes		
Acorn	1.76	15	30	38	79	3.69
A11	1.1	?	30	38	58	4.42
Aeroflo	?	?	?	?	?	?
Aeroneb	?	?	19	38	30	7.50
Aeromist	?	?	?	?	?	?
Aiolos	?	?	?	?	?	?
Atomolette	?	?	33	36	28	7.60
Ava Neb 1780	?	?	32	48	58	4.30
Cirrus	0.9	10	40	46	80	3.50
Cloud Chamber	?	10	?	?	42	?
DeVilbiss 646	2.1	3	26	44	70	2.20
Econoneb	?	25	?	?	40	?
Flaem Nuovo Type 2	0.5	7.0	?	?	?	1.32/2.36*
Flaem Nuovo Type 3	0.5	8.0	?	?	?	1.07/4.64*
Hudson Neb MKII	?	?	50	57	82	2.60
Hudson UD I	2.3	17	?	?	82	4.80
Hudson UD II	1.4	10	25	33	79	3.29
Incenti-Neb	?	20	?	?	54	?
Jet set	?	?	?	?	?	?
MicroCirrus†	1.2	10	?	?	90	1.20
MicroMist	?	10	?	?	76	2.10
MicroNeb	0.9	13	28	59	78	3.63
MiniNeb	2.3	38	41	51	79	3.54
Pari Boy	2.0	9	50	64	64	4.16
Pari LC Plus	1.0	8	50	50	60	3.80
Pari LC Plus Junior	0.9	8	55	55	54	4.60
Perma Neb	1.2	9	39	75	70	2.50
Raindrop	?	?	?	?	?	?
Respi-Neb	?	?	?	?	?	?
Respirgard II†	1.3	9	?	?	?	1.88
Sandoz	?	?	?	?	?	?
Medic-Aid Sidestream	0.7	12	?	?	83	3.18
System 22 Mizer	2.0	15	?	?	73	4.65
Turret Turbo	?	20	?	?	73	?
Unicorn 1035	?	10	?	?	68	?
Unineb	?	?	?	?	?	?
Upmist	?	?	?	?	?	?
Venticaire	?	?	?	?	?	?
Medic-Aid Ventstream	1.0	10	?	?	86	3.17
Wee Neb	?	?	?	?	?	?
Wright	?	20	?	?	83	?

The data in this table have been compiled from various sources and provide a guide only: residual and maximum fill volumes are accurate, percentage of solution nebulised at 5 and 10 minutes is best figure obtainable, % of particles under 5 ml is taken from various sources, (? indicate there are no data currently available from any known source, * Depends on configuration of nebuliser chamber (Type 2) and on type of compressor unit, † Data with pentamidine).

With respect to the nebulised medication, several drugs are available for nebulisation in the UK (British Medical Association and Royal Pharmaceutical Society of Great Britain, 2011). COPD patients are commonly prescribed nebulised bronchodilators to use as part of a self-management plan in the home. These can be available in a single preparation or in a combination preparation (Table 1.8). If two formulations are prescribed for the patient, the compatibility of drug formulations should be checked by the prescribing doctor, as certain drug mixtures are known to be chemically unstable when used together. Currently, guidelines on compatibility of nebulised drugs are unavailable. However, a few papers have addressed this issue and therefore prescribing doctors and dispensing pharmacists should consult available information prior to prescribing combination therapy to the patient (Joseph, 1997; Kamin et al., 2006; Burchett et al., 2010). If drugs used by the patient were compatible, it is advisable to mix the drugs together (given that the mixture is tolerated and no side effects occur) which will reduce the overall time needed to nebulise the medication and improve compliance to therapy among older people. Moreover, some nebuliser designs are not suitable to nebulise corticosteroid suspensions and therefore, manufacturers' data sheets should be consulted prior to supply of nebulised corticosteroids or choosing a nebuliser chamber (Boe et al., 2001). A choice of a facemask or a mouthpiece should be offered to the patient. However, in cases where cholinergics or corticosteroids are required a mouthpiece should be given in preference to a facemask or alternatively a tight fitted facemask should be supplied to minimise side effects (Boe et al., 2001).

Table 1.8: Drugs available for nebulisation in the UK (British Medical Association and Royal Pharmaceutical Society of Great Britain, 2011)

Drug	Drug	Name of preparation	Company
Bronchodilators	Ipratropium	Atrovent	Boehringer Inglheim
		Ipratropium Steri-Neb®	IVAX
		Respontin®	A & H
	Salbutamol	Salamol Easi-Breathe®	IVAX
		Ventolin Nebules®	A & H
	Terbutaline	Bricanyl Respules®	AstraZeneca
Combination bronchodilators	Salbutamol/ipratropium	Combivent®	Boehringer Inglheim
Corticosteroids	Budenoside	Pulmicort Respules®	AstraZeneca
	Fluticasone	Flixotide Nebules®	A & H
Antibiotics	Tobramycin	Tobi®	Novartis
	Pentamidine	Pentacarinat®	Sanofi Aventis
Mucolytics	Dornase alfa	Pulmozyne®	Roche

Patients prescribed nebulised therapy should be given verbal and written information on the frequency of dosage. The patients are usually instructed to use their nebuliser 'as required' up to four times per day (British Thoracic Society, 1997). The occasional use of nebuliser therapy during emergency attacks should not be considered due to the limited evidence supporting the effectiveness of the therapy for this indication. However, some patients feel more confident with a 'back up' nebuliser in the home, which would reduce the need for hospitalisations and can be a cost effective option. Though, without an agreed management plan there would be a risk of dependency and delaying access to emergency services (Boe et al., 2001). Patients should be advised to monitor their response to therapy using a peak flow meter and a clear action plan on what to do in emergencies if therapy failed to bring a relief with contact details of whom to contact should be provided by healthcare professionals (Boe et al., 2001).

Full instructions on how to use, clean and maintain the nebuliser should be provided to patients according to manufacturer's recommendations. Most manufacturers provide a step-by-step guide on how to assemble the different parts of the nebuliser system. Dilution of the nebulised medication is sometimes required with some nebuliser designs with a residual

volume > 1ml and with all ultrasonic nebulisers (Kendrick et al., 1997). Patients should fit the facemask by it tightening securely around the face, or when using a mouthpiece, by placing it in the mouth, holding it between the teeth, with the tongue positioned under the mouthpiece with the lips sealed around it. Ill-fitting facemasks can result in drug aerosol escaping to the surrounding atmosphere which reduces the amount of inhaled dose. Additionally, a loose fitting facemask can result in aerosol deposition on the face and in the eyes (Sangwan et al., 2004) causing side effects such as glaucoma following bronchodilator therapy (Mulpeter et al., 1992; Hall, 1994). Patients should sit in an upright position; however, trying certain body manoeuvres can help in targeting poorly ventilated airways. COPD is characterised by airway constriction (Hasegawa and Nishimura, 2007) and limited drug deposition pattern in the lung and in particular in the smaller airways (Lin and Goodwin, 1976). The deposition pattern was also related to the degree of airflow constriction as lower FEV_1 values correlated to lower penetration indices i.e. lower deposition in the lung periphery (Greening et al., 1980). Breathing through the mouth is recommended as breathing through the nose results in drug being deposited in the nasal airway and can reduce the amount of drug reaching the lung. A larger amount of aerosol was shown to be needed to compensate for that lost in the nose was shown previously (Heyder et al., 1986). Breathing deeply through the mouth at a slower rate and holding breath for few seconds before exhalation was shown previously to increase the amount of drug deposited in the airways by at least two folds compared to normal tidal breathing (Smaldone, 2002).

An end point for nebulisation should be clearly defined by patients and is usually guided by the sputtering sound which occurs towards the end of the session. At this point, tapping the nebuliser a few times will ensure that no fluid remain in the chamber. The nebulisation ends when vapour is no longer generated. Ideally and depending on the volume used in the nebuliser chamber, the nebulisation session should last between 10 – 15 minutes; nebulisation times up to 20 minutes are usually acceptable to the patient (Kendrick et al., 1997). After nebulisation is complete, the patients should switch off the compressor, dismantle the components of the nebuliser system and discard liquid remaining in the chamber and follow the manufacturer's cleaning instructions (Boe et al., 2001). The nebuliser system should be maintained regularly to ensure optimal performance and effective nebulisation. Most nebuliser manufacturers recommend that accessories including facemasks, mouthpieces and tubing are replaced every 3 months with daily use. Disposable nebuliser chambers should be replaced

every 3 months, while durable chambers can last up to a year if adequately cleaned. The filters should be checked monthly and replaced if discoloured, and the compressor should be serviced annually and checked for electrical fault (British Thoracic Society, 1997). Healthcare professionals should provide patients prescribed nebuliser therapy in the home two sets of nebulisers and tubing initially and regularly every 3 months thereafter (Boe et al., 2001). Ongoing support and advice should also be provided and patients should be followed up, and reassessed 3 months after commencing nebuliser therapy and regularly thereafter. The components of the assessment should include: assessing the need of therapy, side effects, and their technique should be checked (Boe et al., 2001).

In summary, nebuliser therapy is commonly prescribed for the management of severe COPD patients in the home. Despite the limited information available on the extent of nebuliser use, Muers (1997) argued that nebulisers accounted for a substantial amount of healthcare expenditure with an estimated 40, 000 compressors currently in use for adult domiciliary treatment in the UK, with annual associated drug costs of £40 million (Muers, 1997). A major teaching hospital in Scotland reported an annual use of 32, 000 daily doses of nebulised bronchodilators (Caldwell et al., 1991). When compared with usage in the UK, other countries in Europe appear to have even higher demand. In Switzerland it was reported that 215 nebulisers are used per 10^5 population compared with 70 per 10^5 population in the UK (Brandli, 1994). Recently, better understanding of pulmonary drug delivery has led to the recent advancement in nebuliser technology and more efficient systems with enhanced design features became available and more are in the pipeline. This suggests that the use of this type of therapy is likely to expand in the near future. Therefore, there is a need to understand the experiences and views of patients who are using this type of therapy in their home. The next section reviews studies on nebuliser use among COPD patients in the home.

1.2. Systematic literature review of studies investigating the use of nebuliser therapy by COPD patients in the home

1.2.1. Introduction

Nebuliser therapy is commonly prescribed for the management of COPD patients in the home. However, little is known about the role of this therapy in the daily management of COPD from the perspectives of patients. Moreover, the correct use of inhaler devices is crucial in achieving successful therapy (Stevens, 2003). The use of inhaler devices is known to pose a challenge for older patients (Abley, 1997; Jarvis et al., 2007), and has been linked to suboptimal health outcomes. The handling and use of pMDIs and DPIs has been extensively studied in the literature (Johnson and Robart, 2000; Coakley, 2001; Molimard et al., 2003; Ho et al., 2004; Jarvis et al., 2007). However, the use of nebulisers has attracted less attention compared to hand-held inhalers (Rau, 2006). Possibly because of good inhalational technique; a key factor in the success of inhalers is thought to be less applicable when patients are using nebulisers (Rau, 2006). Therefore, there is a need to conduct a comprehensive literature review to investigate nebuliser use by patients in the home.

1.2.2 Aim of this literature review

The aim of this review is to investigate the role and the use of nebuliser therapy among COPD patients in the home.

1.2.3. Search strategy

Seven databases: Cochrane library, PubMed/Medline, EMBASE, the ISI Web of Knowledge, IPA (International Pharmaceutical Abstracts) and IBSS (International Bibliography of the Social Sciences) were accessed and searched during the study period from Jan/2007 – Sept/2011 using different combinations of keywords: [Vaporisers, Vaporiser, Inhalers, Inhaler, Inhalators, Inhalator, Nebulisers, Nebuliser, Atomizers, Atomizer, Inhalation Devices, Device, Inhalation, Devices, Inhalation, Inhalation Device] AND [home, domiciliary, home care] AND [COPD, Chronic Obstructive Pulmonary Disease, COAD, Chronic Obstructive Airway Disease, Chronic Obstructive Lung Disease, Airflow Obstruction, Chronic, Airflow Obstructions, Chronic, Chronic Airflow Obstructions, Chronic Airflow Obstruction, Emphysema, Chronic bronchitis] AND [Patient Satisfaction, self-administration, acceptability,

qualitative, Qualitative Research, questionnaires, Questionnaires, survey, surveys, handling, misuse, abuse]. The search was not restricted to specific publication dates but was limited to original research articles which were published in English language.

1.2.4. Studies retrieved and exclusion criteria

After removing duplicates, the search strategy yielded a total of 46 articles; an initial review of the abstracts of the identified articles has excluded 40. Articles excluded from this review shown in Figure 1.16
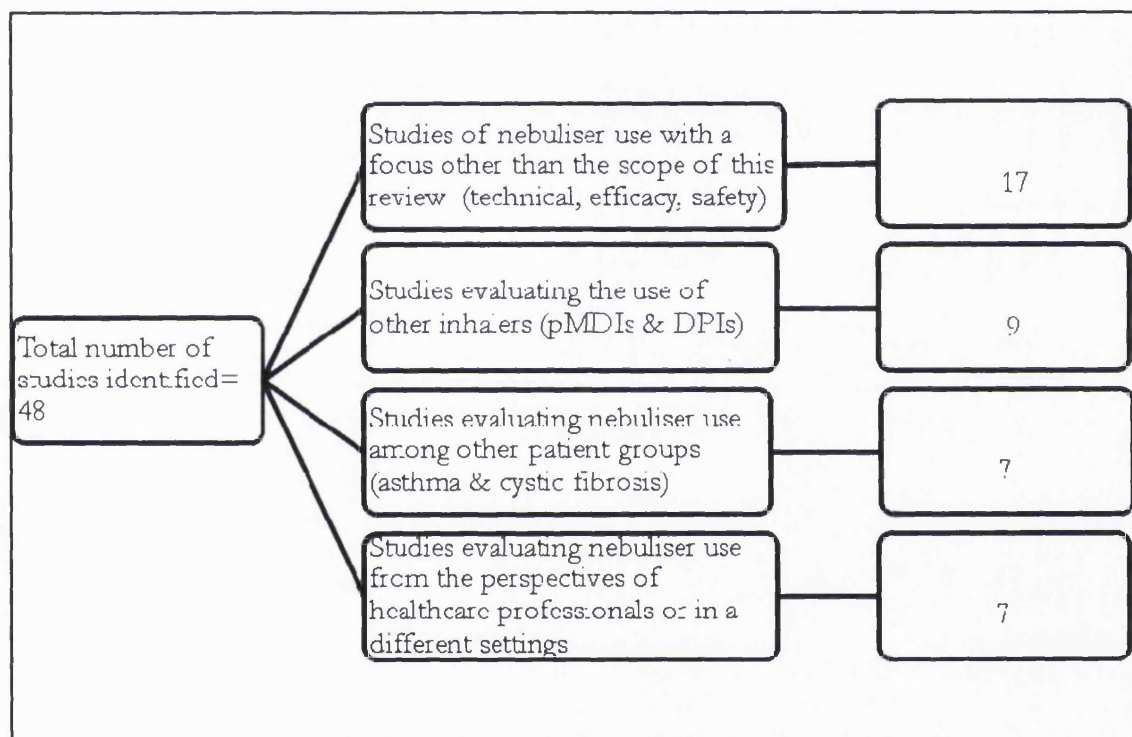
Figure 1.16: Exclusion criteria and selection of studies included in the systematic review

Only 6 articles were considered relevant for this review. References of these articles were further searched for relevant articles and two more articles were identified. A hand search of key journals (Respiratory Medicine, European Respiratory Journal, European Respiratory Review, COPD, Thorax, and Chest) identified no additional articles. The final review included 8 articles [(Murphy and Holgate, 1989; Teale et al., 1995; Mansfield, 1996; Godden et al., 1998; Melani et al., 2001; Barta et al., 2002; Melani et al., 2002; Boyter and Carter, 2005)]. Table 1.9 summaries methodological issues and key findings from the studies.

Table 1.9: Summary of studies investigating nebuliser use by COPD patients in the home				
Author/ Year/ Country	Setting for recruitment	Sample size/ diagnosis	Aim/objectives	Design/Data collection	Key findings and conclusions
Murphy and Holgate, 1989, UK	Physiotherapy Chest clinics Paediatric clinics Medical clinics	N=153 (asthma, bronchitis, emphysema) Used therapy for different duration of times	To evaluate domiciliary nebuliser use in Isle of Wight to discover local practice, assess need, efficacy & safety	Cross-sectional Postal questionnaires Phone interviews or home interviews in case incomplete questionnaires returned	<u>Nebuliser use</u> - Salbutamol most frequently used drug, combination drugs were also used, compatibility issue was highlighted - Maximum Salbutamol dosage = 20 mg regularly daily, only 6 used > 20 mg, during exacerbations 16% exceeded recommended dose - Few had peak flow meter or used it to monitor response to therapy - Persistence with nebuliser use, and delay in accessing emergency services if treatment failed - Most patients reported perceived benefits. Use of nebuliser prior to hospital admission helped many patients, 4 had no medical contact in the previous year - Side effects were minor (tremor, palpitation, throat discomfort, cramps, bad taste, and wheeze - Reported problems included: inconvenience, technical problems, noise) <u>Services and support</u> - Most patients adhered to instructions received on cleaning & servicing equipment every three months, nebuliser unavailable due to mechanical/power failure (18%) - Nebuliser shared with other users in 13%, usually within the household, and one patient had the nebuliser taken by GP for use with other patients - Decision to supply nebuliser therapy was made mostly by GPs, sources of funds voluntary & private, few received instructions on peak flow meter use, no action plan was given in the event of emergency, physiotherapy department was source of instructions and servicing
Teale et al, 1995,UK	Physio department at a regional health district	N=40 (no information on diagnosis) Mean duration of nebuliser use = months, range 6 – 120 months	To determine the prevalence & nature of difficulties with use of domiciliary nebuliser among elderly	Cross-sectional Observational study	<u>Nebuliser use</u> - No information provided on drugs used. 8% used incorrect dose. - All patients perceived objective benefit at the beginning of the study, no information provided on side effects. - Reliance on carers = 33%, reasons for dependency (breathless, pre-existing disabilities, visual impairment, Arthritis, previous stroke)

					- Problems observed One or more =50% (Filling =18%, Assembly = 13%, cleaning = 40%), problems rated moderate-severe = 35% Compressors were serviced 6 monthly Services and support - All equipment loaned by hospital - Patients were assessed prior to nebuliser supply at the beginning of the study patients were assessed and a lung function test was performed - All patients received instructions on use at the beginning of the study
Melani et al, 2001, Italy	27 respiratory centres	N=1257 (included patients with lower respiratory disease (COPD, Asthma), upper respiratory disease, and patients with no pulmonary problems). Included different duration of nebuliser use (< 0.5 yr, 0.5 – 2 yrs, 2 – 5 yrs, and > 5 yrs).	To evaluate how nebuliser therapy is performed and the need for implementation of guidelines on their use & maintenance	Cross-sectional Self-administered questionnaires	Nebuliser use - Daily and occasional use, variations in frequency of use, daily use more common in >60yrs, 71% complied with doctor instruction - Nebulisers were perceived more effective than other inhalers, similar in patients with no or previous experience with other inhaler devices, reported benefits (reduction of dyspnoea, easier expectoration, reduction of cough, reduction of wheezing, and reduction of running and closed nose). No information on side effects - Inhalers were perceived easier to use compared to nebulisers - 15% never dismantled reservoir, 25% did not clean reservoir after each use and 35% never dried it. Method of cleaning (rinsing with tap water = 52%, dipping in water & heating until boiling= 27%, washing with bleach = 11%, others = 32%). 36% never disinfected reservoir. Presence of macroscopic residuals in tubes/reservoir = 6% - 47% only replaced reservoir when visual/auditory defects and 40% never did - Adherence to cleaning and maintaining was associated with female sex, young age & receiving instructions from healthcare workers Services and support - Patients made their own decision about obtaining a nebuliser without advice from prescribing physician, decision based on minimum characteristics required for effective treatment rather than technical reason (optimal compatibility of device & drug was not possible)

					Services and support - Source of information on use and maintenance reported (leaflet from manufacturer, physician, retailer, friend/relative, nurse/physio), > 60% had no information received - Optimal interface system or optimal/minimal fill volume before nebulisation = 97%, hygiene & care > 75% - None of those felt this was a problem - Education level inversely related to instructions received
Melani et al, 2002, Italy	27 respiratory centres throughout Italy	Same as above	Investigating Equipment and drugs used in home nebulisation in Italy	Cross-sectional Self-administered questionnaires	Corticosteroids most frequently used, 90% used combination drugs of which 88% used bronchodilators + steroids.
Barta et al, 2002, UK	Respiratory clinic at a hospital	N=75 (included patients with COPD and asthma). The median FEV1 (% predicted) 40%. No information on duration of nebuliser use.	To examine patients subjective views on the use of domiciliary nebulisers, in relation to compliance, symptom control, dependency, technical issues, and side effects	Cross-sectional Postal questionnaires	Nebuliser use - Salbutamol or Ipratropium used (32%) or combination of both drugs (56%). 75% complied with instructions on use, change in frequency of use associated with symptoms and side effects - Perceived advantages: wellbeing and symptom control, independence & increased self-confidence - Perceived disadvantages: dependency(major), worried in case become too dependent, worried if machine broke down, time & technical issues (minor), too heavy to carry (50%), restriction on going out (1/5), embarrassed in public (some) - Side effects were minor & infrequent, reported side effects (dry mouth, change in taste, tremor, palpitations). Overall benefits using nebuliser outweighed potential disadvantage (92% vs. 2%) - Majority had no problem with cleaning Services and support - Most patients had their nebuliser loaned from hospital
Boyter and Carter, 2005, UK	Respiratory unit at a hospital	N=117 (included COPD, asthma). Overall patients used nebulisers 2 – 8yrs, COPD patients used their nebuliser for 2 - 7yrs, while asthma patients used it for 5 – 15yrs.	To ascertain the reported use , maintenance & side effects related to therapy	Cross-sectional Postal questionnaires	Nebuliser use - Majority of patients used combination therapy (salbutamol + ipatropium).Variations in frequency of use reported - No information on perceived efficacy reported, reported side effects (dry mouth, tremor, dry eyes, headache & tachycardia) - Advice followed by 68% - Most patients adhered to cleaning procedures and method of cleaning - Servicing and maintaining were suboptimal and less than predicted

					Services and support - Most patients had their nebuliser loaned from hospital - All patients were given written instructions on the use & maintenance prior to beginning of study
Mansfield, 1996, UK	A nebuliser service unit at a local trust	N=32 (included COPD and asthma)	To determine problems experienced by patients provided with a nebuliser service to improve patient care	Cross-sectional Postal questionnaires	Nebuliser use - Salbutamol alone used in 50%, most patients used nebuliser daily - No information on the perceived efficacy or safety was provided. - In adequate servicing and replacing of disposables Services and support - All patients included were issued a nebuliser from the nebuliser service unit
Godden et al, 1998, UK	Chest clinic at a local hospital	N=405 (included COPD and asthma). FEV1 %predicted = 22%. No information provided on duration of use.	To assess practical problems and the value of domiciliary nebuliser therapy in preventing hospital admissions	Cross-sectional Structured interview + review of case records + assessment of technical performance of nebuliser compressors	Nebuliser use - Single and combination therapy used, salbutamol + ipratropium used in 12%. Majority used nebuliser once daily, mean frequency of use 3x daily (range 1 – 6 x daily). Persistence with nebuliser use, and delay in accessing emergency services if treatment failed - Significant reduction in hospital admissions 2 yrs after supply of nebuliser, but mean number of admissions & duration remained unchanged. Increased duration related to severity, activity & breathless scores. Majority perceived their health as much better. 54% reported side effects (Tremor, Eye complications, Dry mouth, Dizziness). Side effects were related to frequency of use & commoner in younger age. Death occurred in 7% within 2 yrs of nebuliser supply, though patients were older and had more severe disease - Average time replacing filter = 8.6 months, parts replaced only when broken. Half compressors malfunctioning (only 65% had desired flow rate, and 41% had free flow). Blockage of inlet filter was found Services and support Decision to supply nebuliser based on apparent clinical need, no assessments were conducted. Understanding of nebuliser treatment poor and unclear action plan

1.2.5 Characteristics of the reviewed studies

The studies were conducted over the period between 1989 and 2005, possibly reflecting inconsistency of knowledge in this area and periods of popularity and unpopularity of nebuliser use. The studies identified were conducted in the UK except for one study, which was conducted in Italy (Melani et al., 2001). In all studies, COPD was the predominant diagnosis, but some studies included asthmatics and other upper respiratory disease (Godden et al., 1998; Barta et al., 2002; Boyter and Carter, 2005) (Melani et al., 2001). Disease severity (as measured by $FEV_1\%$ predicted) was reported in two studies (Godden et al., 1998; Barta et al., 2002). Other measures of disease severity reported were the dyspnoea score and health status (Godden et al., 1998) or the use of oxygen therapy (Murphy and Holgate, 1989). The duration of nebuliser use reported in these studies ranged from 0.5 to 10 years. However, the duration of use was not specified in some studies (Mansfield, 1996; Godden et al., 1998; Barta et al., 2002). Some studies only included patients who were using their nebuliser for at least six months prior to the conduct of the study (Murphy and Holgate, 1989; Teale et al., 1995; Melani et al., 2001). All studies had a similar focus, which was to evaluate nebuliser use among patients in the home setting.

1.2.6. Study design and methods employed

All studies employed a cross-sectional and descriptive design as the study participants were approached on one occasion. Except for two studies which were conducted on a large national scale (Murphy and Holgate, 1989; Melani et al., 2001; Melani et al., 2002), all studies were conducted in one setting (a clinic within a local hospital) (Teale et al., 1995; Mansfield, 1996; Godden et al., 1998; Barta et al., 2002; Boyter and Carter, 2005). The sample size in these studies ranged from 32- 1257, a good response rate was achieved in most studies (range 73%-100%).

The method employed for data collection in most of the reviewed studies was by means of postal questionnaires which were completed by the patients (Murphy and Holgate, 1989; Mansfield, 1996; Melani et al., 2001; Barta et al., 2002; Boyter and Carter, 2005), with the exception of only one study which used observation methods (Teale et al., 1995). In these studies, it cannot be ascertained whether the patient was the one who completed the

questionnaire (Boyter and Carter, 2005). Researcher-administered questionnaires can overcome this limitation, but might have introduced researcher bias, an effect that may influence the participants' responses. Structured interviews when combined with other means of data collection such as a review of clinical records and health status (Godden et al., 1998) are desirable for providing reliable findings by means of triangulation, a method employed commonly by social researchers (Bowling, 2009). Although the use of postal questionnaires is very common in health and social research and findings can be generalised to a wider population given that all other aspects of research such as sample size, randomization, response rate, follow up of non-responders, reliability and validity have been considered, this was rarely the case in the studies described. Finally, description of data analysis which provides a way of ascertaining the validity and reliability of the findings was often overlooked and only briefly mentioned.

1.2.7. Findings of the studies

<u>Drugs nebulised and range of equipment used</u>

Bronchodilators were used more often than steroids in most of the studies (Murphy and Holgate, 1989; Mansfield, 1996; Godden et al., 1998; Barta et al., 2002; Melani et al., 2002; Boyter and Carter, 2005). However, the use of corticosteroids was particularly common in Italy (Melani et al., 2002). Most frequently used bronchodilators were beta$_2$ agonists and antimuscarinics. Salbutamol (Murphy and Holgate, 1989; Mansfield, 1996; Godden et al., 1998; Barta et al., 2002; Melani et al., 2002) and ipratropium bromide (Murphy and Holgate, 1989; Godden et al., 1998; Barta et al., 2002; Melani et al., 2002) were the most commonly prescribed drugs in these studies. Combination drugs were used more often than single drugs in some studies (Godden et al., 1998; Barta et al., 2002; Melani et al., 2002; Boyter and Carter, 2005), while in other studies single drugs were used more often (Murphy and Holgate, 1989; Mansfield, 1996). Commonly used combinations were; salbutamol and ipratropium bromide (Mansfield, 1996; Godden et al., 1998; Barta et al., 2002; Boyter and Carter, 2005), salbutamol and sodium cromoglycate (Murphy and Holgate, 1989). Salbutamol and ipratropium bromide was found to be the commonest drug combination in these studies (Godden et al., 1998; Barta et al., 2002; Boyter and Carter, 2005). Furthermore, the mixing of drugs raises concerns about

safety and compatibility of different drug combinations; the physical and chemical incompatibility has been noted in one study for salbutamol and sodium cromoglicate (Murphy and Holgate, 1989). Dilution with physiological saline was used by 43% of the patients (Melani et al., 2002).

The range of nebuliser equipment was only specified in two studies (Mansfield, 1996; Melani et al., 2002). In both studies the majority of patients used jet nebulisers; in Italy the rotary piston compressors were used by almost half of the patients (Melani et al., 2002), whereas in the UK, the majority used Medix compressors (Mansfield, 1996). In one study, a significant number of patients used compressors which were no longer available in the market (Mansfield, 1996). The compressors generated compressed air and the majority used a face mask in one study (Melani et al., 2002). Patients used disposable drug chambers (Mansfield, 1996; Melani et al., 2002), and nearly half of these were made of glass (Melani et al., 2002). Ultrasonic nebulisers were less frequently used (7%), and their use was commonly associated with corticosteroid suspensions (Melani et al., 2002), a combination not currently supported in clinical guidelines (Muers, 1997; Boe et al., 2001).

Frequency of nebuliser use

The majority of patients in these studies used nebulisers on a daily basis; which ranged from 1 to 6 times a day (Murphy and Holgate, 1989; Mansfield, 1996; Godden et al., 1998; Melani et al., 2001; Barta et al., 2002; Boyter and Carter, 2005). However, occasional use was described in some studies (Mansfield, 1996; Godden et al., 1998; Melani et al., 2001; Boyter and Carter, 2005) which is currently not recommended in the guidelines and may provide evidence of nebuliser misuse (Muers, 1997; Boe et al., 2001). The frequency of use was found to be dependent on the class of drug in one study; as bronchodilators were associated with regular use while steroids were associated with both regular and occasional use (Melani et al., 2002). Moreover, regular use was found to be common in patients of sixty years of age and older (Melani et al., 2002). An increase in use was found to be initiated mostly by physicians in response to a chest infection or inadequate symptom control, while a decrease in use was initiated mostly by patients in response to side effects, improvement in symptoms, fear of dependency, and time constraints (Barta et al., 2002). Persistence in using nebulisers by some

patients when their symptoms deteriorate (Murphy and Holgate, 1989; Godden et al., 1998), is an example of misuse.

Good compliance with nebuliser therapy was noted in some studies (Murphy and Holgate, 1989; Melani et al., 2001; Barta et al., 2002; Boyter and Carter, 2005). However, some patients increased their dosage/used their nebuliser more than prescribed (Murphy and Holgate, 1989; Godden et al., 1998; Barta et al., 2002; Boyter and Carter, 2005), used their nebuliser less than prescribed (Godden et al., 1998; Melani et al., 2001; Barta et al., 2002; Boyter and Carter, 2005), or occasionally used an incorrect dosage (Teale et al., 1995). Good compliance with nebulised therapy noted in some studies can be explained by the high perceived effectiveness experienced by patients in some studies (Melani et al., 2001; Barta et al., 2002), or the safety of treatment in another (Boyter and Carter, 2005). High compliance was found to be associated with women, young age, receiving instructions and regular prescriptions from healthcare professionals. Multiple drug regimens and chronic lung disease were associated with low compliance with nebulised therapy (Melani et al., 2001).

Perceived effectiveness and safety of nebuliser therapy

The majority of patients in most of the studies perceived domiciliary nebuliser therapy to be effective (Murphy and Holgate, 1989; Godden et al., 1998; Melani et al., 2001; Barta et al., 2002). In some of these studies where patients were also using hand-held inhalers, nebulisers were perceived to be more effective than their hand-held inhalers (Murphy and Holgate, 1989; Melani et al., 2001; Barta et al., 2002). Nebulisers reduced hospital admissions in two of the studies (Murphy and Holgate, 1989; Godden et al., 1998), although in one of those studies the mean number of admissions and duration remained unchanged (Godden et al., 1998). Moreover, in this study the increased duration was related to severity of the disease, activity and breathless scores at the time the nebuliser was supplied. Benefits reported in the studies were related to improvement in symptom control: reduction of dyspnoea (80%), easier expectoration (34%), reduction of cough (28%), reduction of wheezing (23%) reduction of a runny nose (13%) (Melani et al., 2001; Barta et al., 2002),and increased independence and self-confidence (Barta et al., 2002).

Frequently reported side effects were; tremor (Murphy and Holgate, 1989; Godden et al., 1998; Barta et al., 2002; Boyter and Carter, 2005), dry mouth (Godden et al., 1998; Barta et al., 2002; Boyter and Carter, 2005) and eye problems (Godden et al., 1998; Boyter and Carter, 2005). Palpitations (Murphy and Holgate, 1989; Barta et al., 2002), cramps (Murphy and Holgate, 1989), and dizziness (Godden et al., 1998) were less frequently reported. Although side effects were frequently reported in some studies, they appeared to be: minor (Murphy and Holgate, 1989), related to the combined use of salbutamol and ipratropium (Boyter and Carter, 2005), or the frequency of nebuliser use (Godden et al., 1998). More serious side effects such as palpitations were reported in only two studies (Murphy and Holgate, 1989; Barta et al., 2002), but appeared to be infrequent (Barta et al., 2002). Eye problems reported in one study were associated with the use of facemasks (Godden et al., 1998). Death within two years of nebuliser supply was observed in a few cases (Godden et al., 1998). However, compared with survivals these patients were older and had more severe disease at the time the nebuliser was supplied (Godden et al., 1998). Side effects were shown to be commoner in younger patients (Godden et al., 1998).

The problems experienced with the use of nebuliser therapy

Problems were reported with assembling the nebuliser parts, dosage and filling the drug formulation (Teale et al., 1995). Nebulisation time ranged from 4 - 45 minutes, with an average time of 13.7 minutes (Godden et al., 1998), a number of patients (30%) had a nebulisation time more than 15 minutes (Melani et al., 2002). The patients defined the endpoint for nebulisation (Melani et al., 2002). Residual volume was sometimes reported to be minimal (Mansfield, 1996) or was never less than 2.5 ml (Melani et al., 2002). The majority of the patients discarded the residual liquid after use, while 12% of patients re-used the residual liquid (Melani et al., 2002). In the majority of studies, cleaning procedures were shown to be inadequate (Murphy and Holgate, 1989; Teale et al., 1995; Melani et al., 2001; Boyter and Carter, 2005). Some patients did not dismantle their reservoir, wash it or dry the parts after each use (Melani et al., 2002). The patients did not adhere to the manufacture's instructions regarding the method for cleaning (Melani et al., 2001; Boyter and Carter, 2005). The method used for cleaning varied largely and included; rinsing with tap water (52%) and (15%) (Melani et al., 2001; Boyter and Carter, 2005), warm soapy water then rinse (68%) (Boyter and Carter, 2005), dry with a cloth

(55%) (Boyter and Carter, 2005), dry naturally (35%) (Boyter and Carter, 2005), dipping in water and heating until boiling (27%) (Melani et al., 2001) and washing with bleach (11%) (Melani et al., 2001). Disinfection was shown to be inadequate (Melani et al., 2001; Boyter and Carter, 2005). The presence of macroscopic residues in tubes and reservoirs were noted in one study (Melani et al., 2001) while sharing of nebulisers within the household was noted in another study (Murphy and Holgate, 1989). Replacing the disposables was found to be inadequate in most of the studies (Murphy and Holgate, 1989; Teale et al., 1995; Mansfield, 1996; Godden et al., 1998; Melani et al., 2001; Boyter and Carter, 2005). Inadequate replacing of filters (Mansfield, 1996), tubing (Mansfield, 1996; Boyter and Carter, 2005) and chambers (Murphy and Holgate, 1989; Mansfield, 1996; Boyter and Carter, 2005) were reported. The patients only replaced their reservoir in the event of visual or auditory defects (Godden et al., 1998; Melani et al., 2001). Servicing of the compressors was found to be inadequate in all studies (Murphy and Holgate, 1989; Teale et al., 1995; Mansfield, 1996; Godden et al., 1998; Melani et al., 2001; Boyter and Carter, 2005). Servicing was mostly done in the physiotherapy department of a hospital in one study (Murphy and Holgate, 1989). A significant number of patients didn't had their nebuliser available in case of an emergency due to a mechanical or power failure (Murphy and Holgate, 1989). In one study the compressors were serviced every six months for all patients recruited in the study (Teale et al., 1995). Furthermore, technical problems; weight (Barta et al., 2002), restriction on going out (Barta et al., 2002), embarrassment to use in public (Barta et al., 2002), noise (Murphy and Holgate, 1989) and inconvenience (Murphy and Holgate, 1989) were also reported. Nebulisers were perceived to be easier to use than hand-held inhalers (Melani et al., 2001). Adherence to cleaning and maintenance practices was associated with young age (Melani et al., 2001), female gender (Melani et al., 2001) and receiving instructions from healthcare professionals (Murphy and Holgate, 1989; Melani et al., 2001; Boyter and Carter, 2005).

Decision, assessment, and source of nebuliser

With the exception of two studies (Godden et al., 1998; Melani et al., 2001), the decision to obtain a nebuliser was mostly made by healthcare professionals (Murphy and Holgate, 1989; Teale et al., 1995; Mansfield, 1996; Godden et al., 1998; Barta et al., 2002; Boyter and Carter, 2005). The patients were assessed for their suitability for domiciliary nebuliser therapy prior to

their recruitment in the study according to predefined criteria using subjective and objective responses to therapy (Teale et al., 1995; Barta et al., 2002; Boyter and Carter, 2005). Hand-held inhalers were prescribed for patients prior to the supply of nebuliser therapy in three studies (Mansfield, 1996; Godden et al., 1998; Barta et al., 2002). However, in two studies, the patients were never prescribed a hand-held inhaler before commencing nebuliser therapy (Murphy and Holgate, 1989; Melani et al., 2001). The patients either obtained their nebuliser privately (Murphy and Holgate, 1989; Godden et al., 1998; Melani et al., 2001), or had it loaned to them from a hospital.

Current services and support

It is not clear whether an action plan in the event of treatment failure was provided in the studies, with the exception of one study it is stated that an action plan in case of an emergency was not provided (Murphy and Holgate, 1989). In the event of experiencing a treatment failure; the majority of patients would call a doctor/report to a hospital (Murphy and Holgate, 1989), or try a different treatment (Godden et al., 1998). Some patients would persist with using their nebuliser or do nothing (Murphy and Holgate, 1989; Godden et al., 1998). Except in two studies (Mansfield, 1996; Melani et al., 2001; Melani et al., 2002), the patients received instructions on the use of nebulisers (Murphy and Holgate, 1989; Teale et al., 1995; Barta et al., 2002; Boyter and Carter, 2005). Instruction on the use of the peak flow meter and monitoring the response to therapy was also reported (Murphy and Holgate, 1989; Teale et al., 1995). The source of the information on the use, cleaning and maintenance was most commonly provided by the physiotherapy department (Murphy and Holgate, 1989) or leaflets from the manufacturer (Melani et al., 2001). In one study, despite instructions being received at the start of recruitment, cleaning and servicing was found to be less than predicted (Boyter and Carter, 2005). The majority of patients (66%) did not have an action plan in the event of equipment breakdown (Mansfield, 1996). A nebuliser service unit was provided by the local hospital in some studies (Murphy and Holgate, 1989; Mansfield, 1996; Barta et al., 2002; Boyter and Carter, 2005).

Assistance received with the use of nebulisers

Dependency and reliance on carers was reported in only two studies (Teale et al., 1995; Barta et al., 2002). Reasons for reliance were; breathlessness, pre-existing disabilities, visual impairments, and arthritis (Teale et al., 1995). Other studies did not report any problems (Mansfield, 1996; Godden et al., 1998; Boyter and Carter, 2005).

1.2.8. Limitations of studies

The reviewed studies had several limitations which might affect extrapolating findings from these studies to other populations or settings. One of the limitations of these studies was the inclusion criteria used in the reviewed studies; three of the studies included patients who were carefully selected and received instructions prior to inclusion in the study (Murphy and Holgate, 1989; Teale et al., 1995; Barta et al., 2002; Boyter and Carter, 2005). In one of these studies, selection was biased and only motivated patients were recruited into the study (Teale et al., 1995). A minimum duration of use, for six months or more was a part of the inclusion criteria in some studies (Murphy and Holgate, 1989; Teale et al., 1995; Melani et al., 2001). Many of these studies were conducted by healthcare professionals as part of an audit to assess their nebuliser service (Mansfield, 1996) or recruited patients through a nebuliser service unit which was available within a local hospital (Murphy and Holgate, 1989; Mansfield, 1996; Barta et al., 2002; Boyter and Carter, 2005). In these studies, patients were more advantaged compared to patients who did not have access to a nebuliser service unit. These factors might have biased findings, as problems might have been more profound if these factors were not controlled.

With regard to the findings reported in these studies, limited information was provided on the different types of nebuliser equipment used by COPD patients in the home. The types of equipment used by the patients in their home were only reported in two studies, one conducted in Italy and the other in the UK, and findings might reflect discrepancies between different countries in nebuliser practice. Furthermore, since the date of the most recent study included in this review, new developments in device design and evidence of efficacy and safety of different drug formulations have emerged. Further research is required to establish the range of drugs and equipment currently in use for domiciliary nebuliser therapy.

Implementation of clinical guidelines is required to optimize the choice of drug and device supplied to the patients for domiciliary use.

Compliance rates were not assessed using validated tools, and in some studies where good compliance was noted by the authors, this might be biased as patients were properly assessed and received instructions prior to their recruitment (Barta et al., 2002; Boyter and Carter, 2005). Despite the fact that patients perceived effectiveness with using domiciliary nebuliser therapy, these studies did not mention whether this outcome was measured by means of validated questionnaires. Only two studies described the instruments used to assess the subjective benefits, however, no details were given about their validity and reliability (Melani et al., 2001; Barta et al., 2002). Moreover, in one of these studies no measure of objective validity was obtained for the responses, and no information was collected on non respondents (Melani et al., 2001). In studies where patients' suitability has been assessed for the supply of domiciliary nebuliser therapy before recruitment, benefits were measured both objectively using spirometry and subjectively with the use of symptom and activity questionnaires (Teale et al., 1995; Barta et al., 2002; Boyter and Carter, 2005). Two studies (Mansfield, 1996; Boyter and Carter, 2005) did not assess the benefits from using domiciliary nebuliser therapy. Similarly results from these studies showed no evidence that domiciliary nebulisers were harmful, however, more rigorous methods should be employed to confirm these findings. Previous studies showed domiciliary nebulisers to be safe and effective for a carefully selected group of individuals (O'Driscoll and Bernstein, 1996; Simpson et al., 1998). A small number of patients found nebulisers to be ineffective or even to worsen their symptoms; there is a concern about these patients continuing to use nebulisers (Barta et al., 2002). More studies are required, possibly including a placebo group to confirm findings from these studies.

Many studies have included a range of users who had been using their nebulisers for different lengths of time (Murphy and Holgate, 1989; Teale et al., 1995; Boyter and Carter, 2005). However, in some studies, patients were excluded if they hadn't used their nebuliser in a specified time prior to enrolment. In one study, patients were excluded if they hadn't used their nebuliser in the previous year (Murphy and Holgate, 1989), while in other studies only patients who were using the nebuliser for at least 6 months prior to the study were selected and included (Teale et al., 1995; Melani et al., 2001). In some studies patients had a nebuliser service unit available at their local hospital where proper assessment and training was provided

to patients prior to enrolment which might have biased findings. Deviation from optimal practices might be more profound in patients who used their equipment less frequently or did not receive proper assessment and instructions on use. Similarly, information on the assessment, decision, and source of nebulisers in the reviewed studies may not reflect the provision of domiciliary nebuliser therapy in real clinical settings. Furthermore, The problems were identified by the use of postal questionnaires which relied on self reports from the patients and therefore the validity of the information provided is questionable and required the patient to be able to recognise the problem, which is not always the case. Additionally, no further details about the nature of the problem, or the cause of the problem were provided in these studies. For example, how the patients performed activities such as: assembling the different parts of the nebuliser system, diluting, mixing and filling the drug formulation. Also, the inhalation technique and breathing pattern and the drug administration through the face mask or the mouth piece were not investigated in these studies.

1.2.9. Rationale for the current study

Despite the scarcity of the studies investigating nebuliser use and the limitations of the methods employed in these studies, these studies highlighted key issues. First: limited information is available on the range of nebulisers and drugs currently in-use by patients in their homes. Second: the discrepancies in the provision of domiciliary nebuliser therapy among healthcare professionals. Third: an evidence of equipment misuse and mishandling by patients which was improved following receipt of instructions from healthcare professionals. Fourth: the perceived effectiveness and safety of nebuliser therapy as an option for the management of COPD patients in the home. However, more studies employing rigorous methods are needed to confirm the findings of these studies. Moreover, the role of carers was not adequately addressed in these studies and should therefore be documented and described. The recently published report 'Outcomes Strategy for Chronic Obstructive Pulmonary Disease and Asthma in England', emphasised the need to ensure that people with COPD receive safe and effective care which minimises disease progression and promotes independence (Department of Health, 2011). Therefore, exploring how patients and their carers use nebuliser therapy in the home is valuable in this respect and will inform the development of services to ensure optimal treatment outcomes.

1.2.10. <u>Aim and objectives</u>

The aim of this study was to examine the use of nebuliser therapy in the care of COPD patients in the context of their daily lives in the home setting and to consider how patients and their carers may most effectively be supported.

There were six objectives of this study are the following:

1. To document the use of nebuliser therapy by patients in the context of their clinical-management and daily lives.

2. To examine the use of nebuliser therapy in relation to condition-management, clinical outcomes and quality of life.

3. To identify the frequency and range of problems experienced by patients and their carers in technical aspects of the operation, cleaning and maintenance of nebulizer equipment that may lead to sub-optimal care or treatment failure.

4. To investigate the management, support for and impact of the transfer of care for patients and their carers across the interface of secondary, primary and home care (after hospital discharge).

5. To describe the roles of patients and their carers in the use of nebulisers and administration of medication and relating this to carer-burden.

6. To identify the priorities and concerns of patients and their carers in the context of current and potential future service provision.

The methods which will be employed to achieve the objectives of the study will be described in detail in the next chapter.

Chapter 2: Methods

This chapter describes the methods employed to achieve the aim and objectives of the study. It is divided into nine sections. Section 2.1 describes the preliminarily fieldwork and the justification for the chosen sites (primary care and intermediate care). Section 2.2 describes the design of the study. Section 2.3 describes the sampling strategy, and includes: the participants' inclusion and exclusion criteria, the sampling procedures employed to recruit the study sites (Healthcare and Rehabilitation Team (HART) at Northwick Park Hospital (NWP), and GP surgeries within Harrow Primary Care Trust HPCT), and the patients. Section 2.4 justifies the methods chosen for data collection, and describes the instruments used to facilitate data collection. Section 2.5 describes data protection and ethical considerations and approval for the study. Section 2.6 describes the data collection procedures employed and piloting of the instruments used. Section 2.7 describe the analysis of qualitative and quantitative data, Section 2.8 describes measures employed to ensure the validity and reliability of the data.

2.1. Preliminary fieldwork

2.1.1. Aim of preliminary fieldwork

The preliminary fieldwork had three main aims:

• To gain insights into the numbers of nebulisers currently in use by COPD patients, the provision of nebuliser therapy, and the services currently in place for nebuliser users.

• To incorporate priorities and concerns of healthcare professionals involved in the care of COPD patients into the main study.

• To discuss the feasibility of conducting the study and inform on suitable methods for collecting data and recruiting participants.

2.1.2. Meetings with the Healthcare and Rehabilitation Team at Northwick Park hospital

The HART at NWP provides intermediate care and its primary role is to treat acutely ill cases and prevent them from re-admission by providing two key services; an early discharge scheme and hospital at home. Therefore it was considered a suitable setting to

participate in the study, allow inclusion of patients who recently admitted to hospital and treated for an exacerbation. The HART is the first team in Greater London providing both acute and community care to patients. The team includes: skilled nurses, physiotherapists, occupational therapists, as well as other non clinical staff. HART services include; rapid responses, surgical, speech therapy, physiotherapy, occupational therapy, oxygen short term and nebuliser therapy. At the time of the meeting, respiratory services were being reshaped, and COPD chronic disease management was due to start the following year. The HART team was contacted by the researcher and a meeting was arranged with clinical nurses at Northwick Park Hospital on Friday the 8[Th] of February 2008. Discussions at the meeting focussed on key issues such as: the total number of referrals the team had every month, and the number of respiratory cases seen by the team, approaches to recruitment and clinical data collection, nebuliser loan services offered by the team, selection and assessments of patients, servicing and maintaining services, and other educational packages offered to the patients. The team highlighted a number of priorities and concerns:

1. The difficulty of following up patients who had been sent home on a nebuliser, which reflected problems of communication at the interface.
2. Patients frequently experienced problems with regard to operating the nebuliser and some patients weren't even able to switch on the machine.
3. The price of repairing a broken compressor unit exceeded the price of replacing it which highlighted difficulties and barriers to good practice in maintaining and servicing the nebulisers.
4. Patients were usually relatively old with co-morbidities and some degree of disability and often depended on their carers for their drug administration which highlighted the role of the carer in assisting the taking of medication, their skills and knowledge with regard to the use of nebulisers, the burden experienced and how they would be supported.
5. The lack of a specialized nebuliser service at their site reflected an issue related to the support and provision of care.

2.1.3. Meetings with pharmacists from Harrow Primary Care Trust

Harrow Primary Care Trust (HPCT) is located in North West London, and is one of 31 PCTs comprising the London Strategic Health Authority. The PCT serves a population of approximately 214,400, and had a prevalence of COPD according to QOF Register of

1,646. Harrow has the fifth most diverse population in the country, 41% of Harrow's population comprises minority groups. Therefore, it was considered a suitable setting to participate in the study and to include patients who were more stable and were managing their condition in the community. Two medication management pharmacists from HPCT were contacted by the researcher and a meeting was arranged on Wednesday 28th May 2008. Discussions at the meeting focused on the numbers of COPD patients currently using nebulisers in their home, current services and care pathways available for COPD or nebuliser users through the PCT. The pharmacists discussed their priorities and concerns at the meeting:

1. Preventing hospital admission and saving costs was a top priority for the PCT trust particularly cutting costs on COPD related admissions.
2. Reinforcing the instructions given to COPD patients prior to their discharge from hospital with regard to the use and maintenance of their nebulisers.
3. Infection control and cleaning issues were of particular interest to the Trust.
4. Carers who deliver care and were involved in medication administration often lack the skill to do so.
5. Surgeries attached to a nursing or a residential home may have a large number of patients cared for by contracted carer services.

2.1.4. Impact of preliminary fieldwork on the development of the study

The preliminary fieldwork informed the development of the study methods and the instruments to be used in the study (Figure 2.1). The numbers of COPD patients admitted for exacerbations through the HART were around 500 referrals a month, of which 10 were respiratory cases who were issued nebulisers. The number of patients who are using nebulisers at home were identified through the surgery databases by searching for patients prescribed nebuliser therapy, e.g. nebules or Respules[®]. Based on information gained at the meetings, the most suitable way to approach COPD patients who were using nebulisers in their home was to send invitation letters to their home address as patients were expected to have difficulties in approaching healthcare professionals and accessing services due to reduced mobility. Interviews at patients' homes was seen the most appropriate method for data collection. It was also appreciated that nebuliser services were not firmly in place through the hospital or the PCT and accordingly this issue was incorporated into the interview schedule to investigate the needs of the patients. Based on the issues identified in

the meetings and the priorities and concerns raised, carers were included in this study and an interview schedule was developed to investigate their contribution and their needs. Additionally, problems with the use of the nebulisers were a concern raised at the meetings and therefore an investigation of the problems was incorporated into the study instruments.

Figure 2.1: Methodological design employed for the main study

Methodological design:	A mixed methods cross-sectional study
Settings:	Intermediate care and primary care

Northwick Park Hospital   Harrow PCT

(Ethical approval granted for the conduct of the study)

Sampling and recruitment   Sampling strategy from two levels of care

Intermediate care   **Primary care**
(HART at NWP hospital)   (38 surgeries within Harrow PCT)

Invitation letters sent to 180 COPD patients and their carers
Reply slip received

Data collection: Conducted at patients' homes & Surgeries

Qualitative data   **Quantitative data**

1. Interviews (Semi-structured)   1. Observations (Non-participant)
                                2. Instruments (HRQOL, carer-burden)
                                3. Clinical data

Data processing and analysis: Mixed approach to data analysis

Qualitative data   **Quantitative data**

Framework method + FrameWork software   SPSS
transcribing, identifying initial themes,   Descriptive
data labelling, data sorting and sifting,   Bivariate tests
summarising data, identifying dimensions,   (simple linear regression,
categories, descriptive report, associative   independent t-test, one
analysis   way ANOVA)
                                                      Multivariate tests
                                                      (multiple regression)

2.2. The design of the study

To achieve the study objectives a cross-sectional study with a mixed methodological design using qualitative and quantitative methods was chosen. The qualitative component involved conducting semi-structured interviews with the patients and their carers, which allowed detailed information about nebuliser use, the assistance provided, and the problems experienced in the context of using and assisting with the nebuliser to be identified. The experiences of the patients and the carers can be considered separately to provide data from different perspectives. The quantitative component involved administering questionnaires to assess the quality of life of the patients, the carer burden, and to quantify the problems encountered with the use of nebuliser therapy. Clinical and demographical data will be collected during interviews and scheduled surgery visits. The quantitative data will serve to complement and validate the findings obtained from the qualitative component.

2.3. Rationale of the chosen methods

In considering a suitable method, triangulation of several methods was necessary to achieve the study objectives. Semi-structured interviews, non-participant observations and survey methods were all used in this study as a way of triangulation which is in some instances was used to address the same issue as a way of validation, or to complement and address a set of related issues to gain a deeper understanding of the concepts under investigation or the subject area. This way the study is a mixed methodological design and provides detailed data to achieve the study objectives. Additionally, data from COPD patients and their carers provides data from two perspectives, sometimes used to address the same or a separate issue. Justification of the chosen methods and the objectives addressed by these methods are provided in this section.

2.3.1. The semi-structured interviews

The face-to-face interview is the most commonly used qualitative method and is a well-established research technique (Pope and Mays, 2006). Semi-structured interviews include a list of core questions designed to address the study objectives (Pope and Mays, 2006), therefore allowing the researcher to elicit participants' responses on similar issues across all

cases to aid in quantifying the views. They offer flexibility and allow collection of a range of views regarding a particular issue. In addition, unlike structured interviews, the wording and order of the questions are not standardised which allows the researcher to use the participant's own vocabulary in framing additional questions (Pope and Mays, 2006). Therefore, the use of this type of interviews was considered appropriate to meet the study objectives. Focus groups is an alternative method of data collection which has the advantage of using group dynamics to stimulate discussion and gain an in-depth understanding of a topic (Bowling, 2009). However, it was not considered appropriate in this study as participating in front of a group might inhibit some participants from discussing sensitive issues (Bowling, 2009), as well as not being suitable for participants who had limited physical activity and difficulty in travelling. Interviewing older people can pose a challenge to producing in-depth accounts of experiences which is the aim of conducting interviews (Kirkevold and Bergland, 2007). Older people have frail health and specific disease related problems which makes them tire easily, suffer from decreased concentration and have difficulty in focusing on important issues during interviews as well as language problems (Kirkevold and Bergland, 2007). Therefore, the researcher should carefully design the interview process with the older person. Previous research has described several ways to increase trustworthiness of data obtained from frail, older participants during interviews (Kirkevold and Bergland, 2007). Attention should be given to the design of the study by including a large sample size, lengthening the interview duration; and giving more time for participants to make decisions. Additionally, the interaction between the researcher and the older participant should be addressed, as well as enhancing the older person's self-esteem by not exposing his/her disability (Kirkevold and Bergland, 2007).

<u>The development of the interview schedule</u>

To achieve objectives 1, 2, 4, 5 and 6 (section 1.2.10), two versions of interview schedules; one for the patients and another for the carers were developed to meet objectives 1, 2, 4, 5 and 6 of the study (section 1.2.10). The preliminary fieldwork and the literature review informed the questions which were included in the interview schedules. Previous studies were reviewed and issues relevant to the study objectives were included, as well as priorities and concerns raised by healthcare professionals at the preliminary meetings. The schedules comprised both open-ended and close-ended questions. Open ended questions were

designed to elicit patients' and carers' views and experiences with the use of nebuliser therapy in the context of their daily life, while closed questions were designed to capture demographic and clinical data. The patients' interview schedule covered topics on the general experience of using nebuliser therapy in the home, in the context of daily management such as; information on the use, impact on symptoms, and side effects, treatment failure, assembling and operating, cleaning and maintaining, services and support available. It also included questions on assistance received with the use of nebuliser therapy. Technical information on nebulised drugs and equipment, demographic information were also included in the schedule (Appendix I). The carer interview schedule covered similar questions but they were worded to reflect the assistance provided with the use of nebuliser therapy. It also included similar questions about their views on the use, effectiveness and safety of nebulisers, assembling and operating, cleaning and maintaining, services and support available. Questions on details of care provided and personal information were also included (Appendix II). Both the patient and the carer interview schedules included probes to assist in capturing views on relevant issues consistently across all cases. The function of probing is to stimulate responses from participants without biasing their response on questions which they find difficult or are hesitant to answer, and to encourage focusing on the content of the question (Bowling, 2009).

2.3.2. The non-participant observations

Non-participant observation involves recording activities or behaviours in the capacity of an outside observer (Smith, 2002), this way it is different from participant observation methods in that the researcher disassociates him/herself from the study participants so as not to influence their behaviours or bias the findings. Both qualitative and quantitative methods were used in non-participant observations. With a qualitative approach, the researcher's intention is to observe behaviours in order to compare them against participants' background or contextual factors, whereas with a quantitative approach, the researcher intends to provide a quantitative description of the issues under study in order to investigate associations of these issues with other predetermined factors. Non-participant observation methods have been used both as an additional data method to provide data from another perspective, or as a sole method of data collection to serve a number of objectives (Smith, 2002). In this study, non-participant observation were used in addition to interviews to meet objective 2 (section 1.2.10) to quantify the problems encountered with the use of nebuliser therapy as way of triangulating to complement and

validate interview data. A disadvantage is the Hawthorne effect which is the extent the observer's presence influences the behaviours of the participants (Smith, 2002). There are many ways to minimise this effect, one of which is to discard the data collected initially (Smith, 2002). The representativeness of the data collected is achieved by collecting data on different days and at different times (Bowling, 2009). Quantifying the problems can be achieved through self reports, however, this method is considered more accurate than relying on self reports by the patients. Additionally observing patients while they use their nebuliser will offer opportunities for the researcher to identify problems and issues that might not be obvious to the patient, and thus would have been missed if a self report was the method employed.

<u>The development of the nebuliser use checklist</u>

Standardisation of the observation is recommended in quantitative methods to increase rigour and provide means of quantifying the data (Smith, 2002). To achieve objective 3 (section 1.2.10) of the study, which was to identify the range of the problems encountered with the use of nebuliser therapy, a checklist was developed which consisted of a total of 40 steps which are required to be performed correctly by the patient in order to complete the nebulisation process (Appendix III). The steps were categorised into three stages in relation to the inhalation of the nebulised dose to prior, during, and after inhalation. 13 steps included in the "prior to inhaling the nebulised dose" stage which are related to the assembling of the nebuliser therapy (5 steps), filling the drug fluid (7 steps) and operating the equipment (1 step). 7 steps included in the "during inhaling the nebulised dose" stage which are related to inhaling manoeuvres and breathing technique. 20 steps included in the "after inhaling the nebulised dose" stage which are related to dismantling and cleaning the parts (13 steps), replacing the parts, servicing and maintaining the compressor (7 steps).

2.3.3. The health related quality of life questionnaires

Health Related Quality of Life (HRQOL) instruments have been developed in the United States and the UK (Ferrer et al., 1996) and are primarily used to quantify the impact of the disease and the treatment on the patient's life in a standardized manner (Gonzalez et al., 2005). The fact that treatment goals in COPD are often palliative, aimed at reducing symptoms and increasing the quality of life (Osman et al., 1997), coupled with the fact that there is no single physiologic measure which correlates to HRQOL in COPD (Gonzalez et

al., 2005), made these instruments a valuable outcome measure of any intervention in COPD patients. They are frequently used in patients with COPD as descriptive instruments or as outcome measures (Engstrom et al., 2001). HRQOL measures have been commonly used in COPD research, and to a lesser extent in clinical practice to evaluate interventions or treatment such as pulmonary rehabilitation programs, oxygen therapy, bronchodilator therapy, other drug therapy, and training programs (Molken et al., 1999).

HRQOL questionnaires are often evaluated by means of their psychometric properties, which provide a numeric estimate of the trustworthiness of the measures obtained (Lareau et al., 1996). Most researchers will describe one form or another of testing for reliability and validity. Internal consistency measures the degree to which individual item performance relates to other items in a scale and can be tested with Cronbach's α; a value >0.70 is considered satisfactory for new questionnaires and >0.80 for old questionnaires, while test-retest measures the stability of administering the questionnaire for two test periods. Concept under investigation is usually assumed to be stable between the test periods which are 2 weeks apart when tested with correlational analysis; the closer to 1.00 the more stable the measure (Lareau et al., 1996). Content validity is defined as the adequacy with which the specified content is sampled by the items, while Construct validity is defined as the adequacy of the questionnaire in measuring the concept (construct) of interest which can be either; convergent which is the degree to which the measure comes together with other measures of the concept and can be tested with either correlational analysis or factor analysis, or discriminant which is the degree to which the total measure (or individual items) distinguish between other measures that are related but different and can be tested with either correlational analysis or factor analysis (Lareau et al., 1996).

Research using questionnaires with older people found that participants expressed difficulties in completing questionnaires. Ulf and colleagues (2007) conducted a study to elucidate the process of completing a questionnaire in a supportive face-to-face manner. The researchers read the statements aloud while the participants answered verbally or by pointing to an enlarged copy of the reply slip. Analysis of the dialogue data revealed four recurrent themes: making a prompt decision, deciding after a pensive dialogue, deciding after an explanatory dialogue, and deciding after an encouraging dialogue (Ulf et al., 2007). The authors concluded that a supportive face-to-face interview is valuable in obtaining valid data from elderly individuals when completing a questionnaire. Moreover, they emphasized the skills and expertise of the researcher as important factors in reducing bias

obtained from interviews (Ulf et al., 2007). The need to continuously refine the interview technique throughout the study, and overcoming hearing and vision impairment in elderly by using an enlarged copy of the instrument and reading the questions in a loud voice were also identified (Ulf et al., 2007).

To achieve objective 2 (section 1.2.10), which was to examine the use of nebuliser therapy in relation to condition management, clinical outcomes and quality of life, two health related quality of life instruments were used in this study: a generic quality of life scale (the EuroQol questionnaire) and a disease-specific quality of life scale (the St. Georges' Respiratory Questionnaire). To achieve objective 5 (section 1.2.10), which was to relate the role of the carers to their perceived level of burden, the Zarit Burden Interview was used. The rationale for using these instruments in this study is provided below:

<u>The EuroQol: a generic instrument</u>

A variety of generic instruments has been used in studies of patients with COPD including; the Sickness Impact Profile (SIP) (Bergner et al., 1981), the Hospital Anxiety and Depression Scale (HADS) (Zigmond and Snaith, 1983), the Mood Adjective Check List (MACL) (Nowlis and Nowlis, 1956), and the Short Form (SF-36) (Ware et al., 1993). A literature review concerning the use of QOL measurement in the elderly concluded that the generic questionnaire (EQ-5D) was commonly used in the elderly population (Alesii et al., 2006). It has been argued that there is no specific prevalent measurement tool used in the elderly; however each researcher or clinicians administered the one they considered most suitable for the particular pathology under research. Beside physical health, researchers have emphasized the importance of incorporating other dimensions such as; family relationship, quality of friendship, social contacts, economic independence, mobility, psychological well-being, spirituality, ability to enjoy spare time, and planning for the future in measuring the QOL in elderly people (Alesii et al., 2006).

The EQ-5D is a self-completed, generic health status measure developed in 1991 by a multi-country, multi-centre, multi-disciplinary group with the intention of complementing other HS measures and to generate cross-national comparisons. It has been purposefully developed to generate a cardinal index of health allowing for use in health evaluation. It has a standard 5-dimensional format (Brooks, 1996). It is divided into four components; a description of the respondent's own health, rating of own health by means of the EuroQol thermometer, valuation of a standard set of health states defined by the EuroQol

classification, and background information about the respondent (Appendix IV). The second and third components are the only ones used to simply collect data about the health status. In the second component the respondents should describe their own health state based on five dimensions; mobility, self-care, usual activities, pain discomfort, and anxiety/depression. One of three levels should be chosen for each dimension, and the resulting health state is represented by a five digit number (for example 21132). Combinations yield 243 possible health states which can then be converted into a health status score with the use of table of values. A score = 1 indicates best health and 0 indicates death. In the third component they are asked to rate their health on a thermometer calibrated from zero ('worst imaginable health state') to 100 ('best imaginable health state').

A number of studies examined the psychometric properties of the EQ-5D in COPD (Harper et al., 1997; Stavem, 1999; Stavem and Jodalen, 2002; Hazell et al., 2003; Brazier et al., 2004; Covelli et al., 2005; Stahl et al., 2005; Savoia et al., 2006). These studies provided evidence supporting the use of the instrument in COPD. Findings from these studies showed that the instrument had good validity and reliability. The validity in these studies was shown by construct validity both in terms of convergent and discriminate validity while the reliability was shown using a test-retest method. The ability of the EQ-5D to differentiate between disease severity levels was previously shown in both stable disease (O'Reilly et al., 2007) and during exacerbations (O'Reilly et al., 2007; Menn et al., 2010).

The St Georges' Respiratory Questionnaire: a disease specific instrument

Disease-specific instruments include factors which are closely related to a health condition (Haave et al., 2006). They are more responsive to the effects of health care and focus on aspects more relevant to patients with certain conditions, and thus are more preferred by clinicians (Ferrer et al., 1996). The literature review identified that the St. Georges' Respiratory Questionnaire (SGRQ) has been widely applied in COPD patients both nationally and internationally. It has been applied in the context of using the nebuliser therapy which allows for comparison (Bosley et al., 1996; Corden et al., 1997; Osman et al., 1997). The SGRQ (Jones et al., 1991) was developed to assess the impact of respiratory disease on patient's quality of life. The questionnaire includes 50 items and 76 weighted responses, which are divided into three components: symptoms, activity, and impacts (Appendix V). The symptom component includes several respiratory symptoms which

affect the patient's life, the activity component includes activities which are limited by, or caused breathlessness, and the impact component includes a range of aspects concerning social and psychological disturbances that result from airways disease. Scores were calculated for each component, as well as an overall score which can range from 0 to 100, with a zero score indicating minimum impairment of QOL and 100 indicating maximum impairment of QOL. The developer did not provide cut off points to classify the quality of life of the patient into predetermined groups, however, stated that a 4 points change in total score translates into clinical significance (Jones et al., 2003). The SGRQ has been shown to be usable, valid, and reliable in many studies of patients with COPD. The SGRQ symptoms domain discriminated between patients with respiratory symptoms and those without (Jones et al., 1991). However, it was only weakly correlated with physiological measures, dyspnoea grade, mood state, and SIP scores (0.07 – 0.12) (Jones et al., 1991). The activity and impact domains of the SGRQ correlated moderately with MRC dyspnoea grade, physical function test, physiological functioning, and general health. The strongest correlation was reported for the impact domain and the anxiety and depression domain (Jones et al., 1991). High levels of test-retest reliability were reported by the developer (total = 0.92). Evidence for responsiveness was reported as little change for physiological variables, dyspnoea grade, and SIP scores, with changes most positively correlating with dyspnoea grade (Jones et al., 1991).

Previous research has shown that COPD is most prevalent in older men of low socio-economic status. Therefore, the ability to complete a battery of questionnaires is important when considering research in COPD subjects (Stahl, et al., 2003). The length and complexity of the questionnaire have previously been shown to be important factors in determining the feasibility of administering a questionnaire (Stahl, et al., 2003). Stahl et al (2003) have examined the ease/difficulty of completing, time of completing of two HRQOL questionnaires (the SF-36 and the SGRQ), two utility questionnaires (the EQ-5D and the HS-COPD), as well as others among a sample of COPD patients with a mean age of 64 years. They concluded that 92% of subjects ranked the SF-36 as "very easy" to "acceptable" compared with 90% for the SGRQ and 80% for the EQ-5D. The mean time for completing all the questionnaires was 39 minutes, and the majority of the participants scored "good" for understanding, as reported by the administrator (Stahl, et al., 2003). It was concluded that participants' opinion on the ease of completion of several questionnaires is age dependent. Although gender (women more than men), socio-economic status and disease severity were influencing the participant's opinion to some

extent, these were not found to be statistically significant except for women who reported that completing the EQ-5D was more difficult than men. The authors argued that co-morbidities in the elderly explain differences noted with age, as the latter affects reading, writing, and cognitive abilities. In the previous study the majority of the participants had good reading skills which might have influenced the results. The study highlighted the importance of completing the questionnaires in a relatively short time, as participants with COPD suffer from increased burden of the disease if they needed more than one hour to complete the questionnaire. Moreover, it highlights the importance of age and the severity of the disease as influencing factors to determine the ease of completion of questionnaires in subjects with COPD (Stahl, et al., 2003).

The Zarit Burden Interview

Carer burden can be measured objectively by assessing the number of hours spent on providing care or the number of tasks performed by the carer, and subjectively by assessing the impact of providing care on the carer (Norissa et al., 2008). The latter is often measured using multi-dimensional instruments which address the impact of providing care on several aspects of the carers' life such as: health, employment, social life, finance, and relationship with the patient. Since carer burden is a multidimensional construct, a global score may not provide a complete understanding of the perceived burden. It follows from this argument that carers with identical burden scores are not necessarily affected in the same way. Arguably, a subjective measure provides a more accurate estimate of the carer burden as it is a "representation of the carer emotional reaction to the impact of providing care" (Norissa et al., 2008). Ideally, when measuring carer burden, instruments using both subjective and objective measures should be used (Norissa et al., 2008). Several factors should be considered when choosing an instrument to measure the subjective carer burden. The chosen instrument must have the capability to measure multiple aspects of the burden, have good reliability and validity in the population being studied, easily obtained and scored with minimum administrator and respondent burden (Norissa et al., 2008).

Several questionnaires have been described in the literature to quantify the subjective domain of the carer burden, with the Zarit Burden Interview (ZBI) (Zarit et al., 1987) being the most widely applied. The 22-item ZBI (Zarit et al., 1987) is a self-administered questionnaire assessing the impact of care on several aspects of the carer's life such as: physical, psychological, emotional, social and financial problems (Appendix VI). The carer

is asked to rate each item which corresponds to a negative impact of care on a five point scale from 0 (never) to 4 (almost always). The scores from the items are summed to create a total burden score having a potential value from 0 – 88, with higher scores indicating higher perceived burden. Zarit and Zarit (1987) originally proposed a classification of the burden using a range of scores where 61 to 88 range indicating severe burden, 41 to 60 indicating moderate to severe burden, 21 to 40 indicating mild to moderate burden, and < 21 indicating little or no burden (Zarit and Zarit, 1987). The ZBI has been developed with carers of dementia (Zarit et al., 1987) and was found to be particularly useful in assessing the burden associated with the care of older people (Bocquet, et al., 1996). It has been applied to carers with a range of care-recipients' diagnosis (Parkinson disease, heart disease, cancer) including COPD (Fried et al., 2005; Schreiner et al., 2006; Takata et al., 2008). The original ZBI scale had 29 items (Zarit et al., 1986), although shorter versions (4, 12, and 22 item) exist, most researchers use the 22 item version of the ZBI which evolved from the original 29-item version and was first published in 1980 (Bedard, et al., 2001). The 22 item scale has shown good reliability (internal consistency and test–retest reliability) and validity (correlations and responsiveness) in previous studies (Zarit et al., 1987; Bedard et al., 2001; Bachner and O'Rourke, 2007). The developers reported a good internal consistency, a Cronbach's alpha = 0.89 (Zarit et al., 1987). Evidence for responsiveness of the scale has been demonstrated by the developer (Zarit et al., 1987); carers in the intervention treatment group (receiving support and counselling) showed sustained improvement in their burden score over 1 year follow up compared to carers in the waiting list. A recent review identified 102 studies which used the ZBI, and concluded that the instrument was reliable across different populations of carers and patients (including COPD) (Bachner and O'Rourke, 2007). The mean internal consistency was 0.86 (SD 0.06), only five studies reported Cronbach's alpha of < 0.69, and the mean test- retest reliability correlation coefficient was 0.59 (SD = 0.22) over an average interval of 31.56 months (SD 27.72). The variations in reliability between the studies was interpreted as a function of the sensitivity of the scale rather than suspect reliability (Bachner and O'Rourke, 2007). Additionally, differences in reliability were statistically significant when using versions of the ZBI of < or > 22 items. It was concluded that where feasible, the 22 item version of the ZBI should be used in research and clinical practice (Bachner and O'Rourke, 2007). Evidence for the validity of the scale in COPD was provided in terms of predictive validity (Schreiner et al., 2006); a ZBI cut off score of 24 correctly identified carers at risk for depression. In another study, a cut off point of 27 was used to group carers of COPD patients into heavily or lightly burdened, and found significant differences between the two groups in terms of the

time spent providing care, the duration of care, and use of social services (Takata et al., 2008). Additionally, carers who desired more communications with their COPD patients reported significantly higher burden score than those who did not (Fried et al., 2005). Therefore, the ZBI was considered an appropriate tool to assess the subjective burden of the carers in this study. The findings obtained from the instrument will be considered alongside the objective burden assessed during the interviews by questions relating to the frequency, duration, and number of activities provided, in order to gain a deeper understanding of the carer burden and relate it to the experiences of the carers.

2.4. Data Protection and Ethical approval

Data protection legislation was complied with and the data collected was handled with confidentiality throughout the study period. The data were kept in a coded format without the name of the patients/carers and locked at all times in a designated cabinet for this purpose. The data stored in PC was kept password protected and was only accessed by the researcher and the responsibility of the data was overseen by the academic supervisors. Furthermore, according to the agreement signed by the researcher with the local ethics committee, the data will be kept for a period of 3 years and 9 months and will be destroyed after completion of the study.

2.4.1. Application to Ethics committee and R&D

The required documents to apply to the local ethics committee (Brent & Harrow Research Ethics Committee) were prepared ahead of the scheduled committee meeting on the 1st of September 2008 and enclosed with a cover letter for review (Appendix VII). The documents included the following: interview schedules, copies of the questionnaires, letter of invitations, information sheets, and other relevant materials. The Committee advised that the researcher attend the meeting to respond to members' queries and provide further clarification if necessary; based on this advice, the researcher attended the meeting with one of the supervisors.

2.4.2. Response to letter from Ethics Committee

A response letter was received on the 12th of September 2008 in which the Committee granted the study a favourable ethical opinion, subject to receiving further information, and minor modifications to the documents (Appendix VIII). Additionally the Ethics required that a submission to be made to the local R&D department. An ethical concern was raised by the Committee on accessing clinical notes to identify eligible patients prior to consent being granted by the patient. The researcher wrote back clarifying that the researcher was not intending to access the clinical data and the identification was to be carried out by collaborators who were members of the healthcare team. The researcher incorporated all the changes requested by the Committee, further information and requirements were met and provided to the Committee on the 10th November 2008 (Appendix IX). An approval letter was received on the 1st of December 2008 (Appendix X).

2.4.3. Permission to use the questionnaires

In order to comply with copyrights of the developers for the chosen instruments, a permission to use the instrument in the study was sought from the developers. Authorisation for the use of the St. Georges' questionnaire (SGRQ), and the EuroQol (EQ-5D) was granted free of charge from The Centre for Health Economics at University of York, UK for the EQ-5D and The Health Status Research Team at St. Georges' University of London, UK for the SGRQ via email communication. A copy of the SGRQ was available for download from the university website, a copy of the EQ-5D was provided by post. A user-agreement form was completed and sent to The Mapi Research Trust, France and a fee of 300 Euros was paid to obtain authorization for the Zarit Burden Interview (ZBI). Accordingly a copy of the ZBI was received by post.

2.5. Sampling strategy

All patients identified through the HART at NWP who were receiving intermediate care after being discharged from hospital, and all those identified through 37 GP surgeries in Harrow (all surgeries within HPCT except one) who were more stable cases and were managed through primary care who were using nebulisers for different duration of time were considered eligible to take part in the study. Accordingly, all patients (n = 180) were invited to participate in the study. This ensured that all patients were given an equal chance

to participate and that the sample would have a range of demographic and clinical characteristics and findings would be of relevance to other settings and wider population. Additionally, recruiting patients from two levels of care ensures that the sample was representative and included patients with different disease severity levels and different duration of nebuliser use. The aim was to achieve a sample size of 50 patients; based on preliminary discussions with the collaborators from both study sites 10-15 patients were anticipated to be recruited from the intermediate care during the 12 month study period, and 45-50 are anticipated to be recruited from primary care.

2.5.1. Inclusion criteria

For COPD patients the inclusion criteria were:

- Patients with a confirmed diagnosis of COPD from the medical notes.
- Patients prescribed nebules/Respules® +/ - Combivent®.
- Patients who use their nebuliser in their own home or a residential home.
- Patients who are registered at surgeries within Harrow PCT.
- Patients who have been admitted to NWP experiencing an exacerbation.

For their carers the inclusion criteria were:

- Family member, a friend or any non-professional carer who assisted with the use of the nebuliser.
- Having at least weekly face-to-face contact with that patient.
- Providing informal care (unpaid) to a COPD patient living in their home or residential home.

2.5.2. Exclusion criteria:

Participants were excluded in the following cases:

- Patients and carers who did not consent to participate in the study.
- Patients with mental illness, severe cognitive impairment, unwell or had a serious illness (e.g. metastasis) were identified and excluded in collaboration with GPs.

2.5.3. Sampling procedures and recruitment of study sites

Recruitment of NWP hospital

The HART were approached initially and following preliminary discussions, NWP was chosen as a site to recruit patients from intermediate care level.

Recruitment of GP surgeries

All surgeries within Harrow PCT were invited to participate in this study. An invitation package which included an invitation letter addressed to healthcare professionals was prepared during the initial phase of the study and included a brief description of the study's aim and objectives, the study procedures, what it will involve for them, how it will affect the care they receive from their team if they agree to take part, and contact details of the researcher (Appendix XI). A reply slip with a pre-paid envelope to return to the researcher address (Appendix XII). However, the collaborators suggested that the researcher prepare a quick reference guide to hand out to GPs and practice managers in addition to the original letter due to the limited time available in the practice. This would also increase the response rate of GPs and speed up the recruitment phase by ensuring the invitation was read quickly by the GPs. The quick reference guide included similar information as the initial invitation letter but in concise bullets points (Appendix XIII). The researcher accompanied the collaborators on their routine surgery visits and was introduced to the practice manager or the doctor by the collaborator. The quick reference guide was given by hand to practice managers and GPs who were directly involved with the care of COPD patients.

2.5.4. Sampling procedures and recruitment of participants

Recruitment from NWP hospital

All patients admitted during the study period experiencing an exacerbation and had been or would be discharged home with a nebuliser were identified through the HART at NWP. Prior to their discharge and once they were stabilized, patients were approached by clinical staff at Northwick Park Hospital and were given an invitation package between 2 weeks to 1 month prior to the anticipated date of the interview. However, if already discharged the

letter and the information pack was either sent out to their home address or given out by the clinical staff during a routine home visit.

Recruitment from GP surgeries

The reply slips were collected from the GPs at another time and sometimes the GPs agreed verbally and the researcher completed the reply slip which the GP then signed. The majority of the GPs responded at the same time after taking a few moments to read the invitation letter and asked a few questions. However, some GPs preferred to read the material later and gave a response at another time. Once consent was obtained by GPs expressing their willingness to take part in the study, the collaborator identified all COPD patients using nebulisers in the surgery. Two software systems were used in the surgeries for electronic medical records; each required a different search strategy to identify eligible patients. The initial search strategy sought to identify all COPD patients with a diagnosis of COPD according to the Quality and Outcomes Framework (QOF), and then look for those who were prescribed nebulised medication. Prior to the introduction of the system, COPD patients were previously entered as asthmatics. Additionally, it was understood that there might be an overlap between the two conditions (COPD and asthma), or a misdiagnosis, or in some cases asthmatics may later develop COPD in the course of disease. This created confusion. To ensure that no cases were missed a clinical judgment was sometimes made and patients were excluded if they didn't have a smoking history, age if younger than 35 and/or had no documented history of spirometry. The identified patients were sent an invitation package. The letter was sent between 2 weeks to 1 month prior to the anticipated date of the interview.

The invitation package included an invitation letter (printed on a headed paper with Northwick Park Hospital logo and signed by the HART team or printed on a headed paper with Harrow PCT logo and signed by the GP) (Appendix XIV). It also included a patient information sheet explaining; the purpose of the study, study procedures and how the study will be conducted, possible disadvantages and benefits from taking part, sponsorship and confidentiality of data, the researcher's contact details (Appendix XV), a consent form (Appendix XVI), a reply slip (Appendix XVII) and a pre paid envelope with the researcher address. A similar invitation package was prepared for the carers and printed on yellow paper (Appendix XVIII). The carer pack included similar material as the patients (Appendix XIX, XX, and XXI), and was included with the patient's letter. The patients

were asked to hand out the pack to a relative or a friend who they receive any assistance from with the use of the nebuliser. The pack also included a photograph of the researcher so that patients and carers know who they will be expecting if they wished to take part in the study (Appendix XXII).

Patients and carers who returned the reply slip expressing willingness to take part in the study were contacted by the researcher and a convenient time was arranged for the conduct of the interview. The interview with the patient and the carer was conducted on one occasion at their home. The patients who did not respond by sending the reply slips back were identified and were sent a reminder letter by the collaborator (as the patients has not yet consented to take part in the study). Recruitment of patients in the study commenced in April 2009 and continued for 12 months until April 2010.

2.6. Data collection

The steps undertaken during the data collection phase are described in this section in the same chronological order as undertaken by the researcher in the patients' homes and in the surgeries. In the patients' homes, interviews with the patients and the carers were commenced first, followed by observations and finally the administration of quality of life questionnaires. The collection of the clinical data in the surgeries commenced after the patients were interviewed.

2.6.1. Conduct of interviews

All patients who returned the reply slips and expressed willingness to participate were contacted by the researcher to arrange a convenient time for the interview. The researcher visited the patient and the carer together in their home on one occasion at the pre-arranged time carrying an identification badge. At the start, the researcher went through the information sheet with the patient and the carer. Patients and carers were given the chance to ask any questions prior to deciding to take part in the study. A request from the patients and the carers was made by the researcher to audio-record the interview which will aid in transcribing the data for analysis, however if a patient/carer was not happy for this, hand notes were taken instead. The researcher used the relevant interview schedules as a guide throughout the interview with the patient and the carer. Although the interview schedules comprised detailed information, the information were only used by the researcher as a guide and probes were only used as necessary to elicit responses from the participants.

Finally, a request from the patients was made to take a photo of their nebuliser system and permission sought from the patients to obtain information from their medical notes.

After conducting the initial 5 interviews, a meeting was held with the supervisors to discuss issues that emerged during these interviews, and the adequacy of the information obtained by the interview schedule. After considering the information obtained, the interview schedule was considered suitable for collecting relevant information to meet the study objectives. However, minor changes were introduced with regard to the language used in the interview schedule. Based on the five initial interviews it was noted that two of the patients had difficulties in answering questions which involved recalling frequencies or remembering dates, for example 'When was your last contact with the medical care?'. Thus the question was re-worded to: 'Did you have any contact with the medical care in the last year?'

2.6.2. Conduct of observations

The patients were asked to demonstrate how they used their nebuliser therapy while the researcher observed their technique and recorded the results in a step-by-step checklist developed purposively for this study. Incidents where the patient had omitted or failed to perform a step correctly were recorded in the checklist. It is important to take into consideration that the patients were only simulating the steps required to use their nebuliser with the exception of three cases where the dose was actually required by the patient at the time the interview was conducted. Therefore, there is a potential risk of bias introduced by this process and it is likely that what is known to the patient and hence he/she was able to demonstrate in front of the researcher was different than what was done in actual practice when the patient is actually administering the nebulised dose. Also, in the event of unsafe practice or when the patient has performed an essential step incorrectly which is likely to affect the inhaled dose, the collaborator who was involved with the care of the patient was notified of the mistake.

2.6.3. Administration of the questionnaires

After conducting the interview with the patient, two HRQOL questionnaires (EQ-5D, and SGRQ) were administered to the patient by the researcher (interviewer-administered). Similarly, after conducting the interview with the carer, a carer burden questionnaire (ZBI)

was self-administered by the carer. The researcher adhered to the developer's guidelines with regard to the administration process of the SGRQ which was supplied by the developers via personal communication (Jones et al., 2003):

- The questionnaire was administered in a quite area, free from distraction. As noted by the developers the questionnaire should be administered to the patient alone when no other family member was present. The merit of doing so is to get a true reflection of the patient's perception on their health, and for them not to be influenced by relatives, friends, or others. Although this was not achieved in five cases where the carer was present in the same room (when a joint interview was conducted beforehand), the researcher stressed that the family member should remain quiet and not interact with the patient during administration of the questionnaire.

- The patients were informed about the reasons for completing the questionnaire (i.e. being important to understand the impact of their condition on their daily life). They were informed that there were no right or wrong answers, and were asked to be as honest as possible when giving an answer to any of the questions.

- The developers state in their manual that the SGRQ was designed to be a supervised self-administered questionnaire. However, the questions can be read aloud if the patients have difficulty with reading but the responses should be their own. A more flexible approach was adopted in this study taking into consideration the barriers to self- administration in this group of patients (eyesight problems, and dexterity problems) and the fact that self-administration was previously shown to result in higher numbers of missing values compared to interviewer-administration. Consequently, the patients in this study were asked whether they preferred to self-complete the questionnaire or to be assisted by the researcher. All patients except for three female patients (54, 59, and 58 years of age) preferred to be assisted by the researcher.

- The researcher administered the questionnaire with the use of a prepared package (each question was re-typed using larger font size on laminated paper. If the question was short, a few questions were included on one card. The laminated cards were given to the patients in the correct order to mirror the questions in the original questionnaire, the researcher read the question aloud and asked the patient

to shout their answer and the researcher marked the given answer on the original questionnaire.

- The severity of the attack in part 1, question 5, relates to the patient's own judgment of severity and NOT that of medical staff.

- The patient was informed that the medication question relates to any medication given for their chest condition and an emphasis was made on nebuliser therapy which is the central focus of this study.

2.6.4. Collection of clinical data from the medical records

All patients (n = 50) signed a consent form agreeing to share some clinical information from their medical notes with the researcher for the purpose of the study. The clinical information collected was used in the qualitative analysis to compare the views of the patients in terms of their clinical characteristics to assist in explaining the findings. Additionally, they were used in the quantitative analysis to investigate possible associations between various clinical parameters and the problem score. This enabled identification of characteristics of patients which were prone to poor inhaler technique in order to make recommendations for healthcare professionals to assist in targeting patients. The researcher visited the surgery to collect the relevant clinical information for each patient (except one patient who was registered in a surgery which was not within the PCT) after the conduct of the interview. The researcher collected the patients' clinical parameters which included: the forced expiratory volume in 1 sec (FEV$_1$ % predicted) as an indicator of the disease severity level, the body mass index (BMI), the number of previous hospital admissions in the last 3 years, details of co-morbidities, and respiratory medications prescribed. Some data were missing, and inconsistencies were noted with regard to the information recorded for patients within and across the surgeries.

2.7. Data processing and analysis

2.7.1. Analysis of qualitative data

Many approaches to qualitative data analysis have been described by previous researchers. However, the chosen approach should serve to answer the analytical query and provide a

systematic way in which an outsider researcher should be able to follow the steps undertaken and judge the quality of the findings. A framework method is one approach to data analysis which was developed by the National Centre for Social Research (NatCen), UK (Ritchie et al., 2003) in the 1980s, specifically for applied or policy research in which the information requirement is known in advance. This study had a predefined set of objectives and therefore this approach was the chosen to analyse the data. Although the analysis remained grounded; in the sense that the emerging theory is representative of the participants' own views and experiences. The Framework method is a matrix-based analytical method, hence the name, which provides a rigorous and a systematic way of analysing the data, incorporating all the steps necessary in a qualitative analytical hierarchy, while allowing movement between different levels of abstraction without losing sight of raw data.

The use of computer assisted qualitative data analysis software (CAQDAS) has been increasingly used by qualitative researchers to facilitate data analysis and aid in the management of large amounts of textual data, and to increase rigour in analysis by making the process more systematic (Bowling, 2009). It is worth noting that the use of the software does not replace the intellectual skill of the researcher nor does it conduct the analysis automatically. It is best considered as a tool to assist and speed the process of data analysis (Ritchie et al., 2003). There are many types of software available, each equipped with different features, and the choice of the most suitable software depends on the purpose of research and the approach to analysis. Therefore, the ideal software is one that would enable the researcher to be in control of the data analysis process rather than forcing a structure of analysis on the data. Hallmark features required for any type of qualitative analysis is that it allows: the concepts developed to remain grounded in the data, captures the synthesis of the evidence, allows sifting and ordering of data, supports searching the data for associations within and between cases, is flexible and allows refinement of data, and provides a systematic way of data analysis (Ritchie et al., 2003).

During the study period, NatCen had launched the FrameWork software, which is a CAQDAS package developed to support the Framework method. The program assists in synthesising the data by storing each piece of data within a thematic matrix, which can be printed out. Prior to this, the use of A3 datasheets were used to display data. The software incorporates most features of existing software, including search options to interrogate data by case or theme, as well as unique features such as:

- Allows creation of in-depth summaries and synthesis of the data.

- Allows interrogation of the data according to predefined criteria (analytical query), and allows these queries to be saved.

- Creates a range of outputs such as index reports (extracts of verbatim) and matrix displays (summarised data).

- Allows notes to be made throughout the analysis and allows them to be assigned to the relevant step.

It was pertinent in this study to use software that was developed specifically to support the method of data analysis employed. The software is available at a reduced price for students. Prior to applying analytical procedures, all interviews with 50 patients and 14 carers, recorded using the Olympus Digital Voice Recorder WS-320, were downloaded into a software DSS player- Lite supplied with the recorder which enabled the organisation of the files according to the date the interview was conducted. In adherence with confidentiality and protection of the data, all recorded data were anonymised at this stage and the files were assigned numbers to distinguish between them which reflected the order in which they were carried out. The carer interviews which were conducted separately were given a corresponding number to that of their patient. The recorded data were transcribed verbatim, the transcribing process paralleled the data collection, and interviews were transcribed by the researcher soon after they were conducted. Field notes collected by the researcher which included observations such as facial expressions, interactions between the participant and the researcher outside the period of the interview, interruptions to that occurred during the interviews and the presence of other individuals, were also transcribed verbatim and added onto the relevant interview transcript. Although gathering extensive data is recommended in conducting qualitative research, it is worth noting that there is an ethical issue with gathering information about the participants which were not included in the information leaflet and therefore, participants were not aware of such data being recorded by the researcher.

A project was created in FrameWork, and all textual data were imported into the software in a way that each data unit imported represented a case, or in the case that the data unit had multiple participants as in the case of joint interviews conducted with both the patient and the carer, the program allows differentiation of the data by assigning a source name. The project was configured to include the source names C and P to represent the carer and

patient. Additionally, the program is equipped with a feature that allowed assigning labels to each data unit imported to define the characteristics of the case. The Framework method (Ritchie et al., 2003) was used to analyse the transcripts which included interview data and observational field notes. The analysis involved two main stages: data management, and producing the descriptive/explanatory accounts.

Data management

Organisational steps were undertaken to reduce the large amount of textual data and make it more manageable before proceeding to the higher order analytical stage which involves producing the descriptive and explanatory accounts. It is worth noting that throughout this stage, extra care was taken to avoid superimposing concepts and theories. This stage involved familiarisation with the data and developing the conceptual framework in which the data will be organised. For this purpose an initial sample of 15 interviews, of which 10 corresponded to the patient and 5 to the carer were selected from the whole sample according to their demographic and clinical characteristics to ensure a representative sample. The interview transcripts for this initial sample were read several times to identify recurring themes and concepts. An initial conceptual framework was developed from the recurrent themes, and issues introduced in the interview schedule as shown in Table 2.1. The purpose of the initial conceptual framework was to ensure clarity at the conceptual level of the issues, so that no omission or overlap existed at this stage.

Table 2.1: The initial conceptual framework developed

Technical information about nebuliser system
Drugs
Equipment
Others
Views/experiences of nebuliser use
Details of nebuliser use
Perceived/efficacy/benefits/advantages
Treatment failure
Monitoring of condition
Perceived problems/disadvantages
Problem solving/trouble shooting/self-repairing
Perceived safety/side effects
Others
Views on care related to nebuliser
Routes of obtaining nebuliser
Current services/support on nebuliser
Potential services/information needs/suggestions for improvement
Others
Help/assistance
Basic information about care
Details of help/assistance given/roles of carers
Problems experienced with this help
Views on current services/support with care
Potential services/information needs/suggestions for improvement
Others
Other issues not covered above
Personal
Service related

The initial conceptual framework was applied to the data set by assigning each piece of data (word, sentence, and paragraph) which can be of a substantive nature or more of a methodological ilk to the relevant section of the index. This process continued until no new issues were detected in the data (this occurred after indexing the 30th transcript). At this point refinement of the initial framework was carried out as some themes were further divided to reflect distinctions noted during this process, other themes were collapsed where the data concerning this theme was not much detected, and new themes emerged. The final conceptual framework was then applied to the whole data set. In the next step the indexed data were sorted and matrices were produced for each main theme. Textual data assigned to subthemes was then reduced and summarised, this is done by distilling the essence without inferring analytical concepts at this stage. This step can be approached in two ways, i.e. working through the indexed text theme by theme or case by case. The former method was adopted as it allows exploration of the issues relating to a particular theme across all cases, hence gaining an overall picture of the issues pertaining to a specific issue, which is central to meeting the objectives of the study. Reducing the data enabled the researcher to

focus on the important issues in the next stage of analysis. An example of a matrix illustrating the summarised data is included in Appendix XXIII.

Descriptive and explanatory account

In the second stage the evidence was mapped and a descriptive report was produced for all themes across all cases. The purpose of this step was to display the data in a conceptually pure way and to provide meaningful distinctions. This involved detecting dimensions, refining categories, and developing classes. Detecting dimensions involved identifying elements relevant to the issue being investigated, in this step the new theme stayed close to the data. In the second step this theme was refined and the level of abstraction was higher. The last step involved grouping similar categories into a higher order category or class. An example of the steps undertaken to identify dimensions, develop categories and classes is included in Appendix XXIV. A description report was then produced for the emergent categories. The content of this report can be illuminated with verbatim quotations from the raw data.

Figure 2.2: The steps involved in moving from raw data to conceptual data
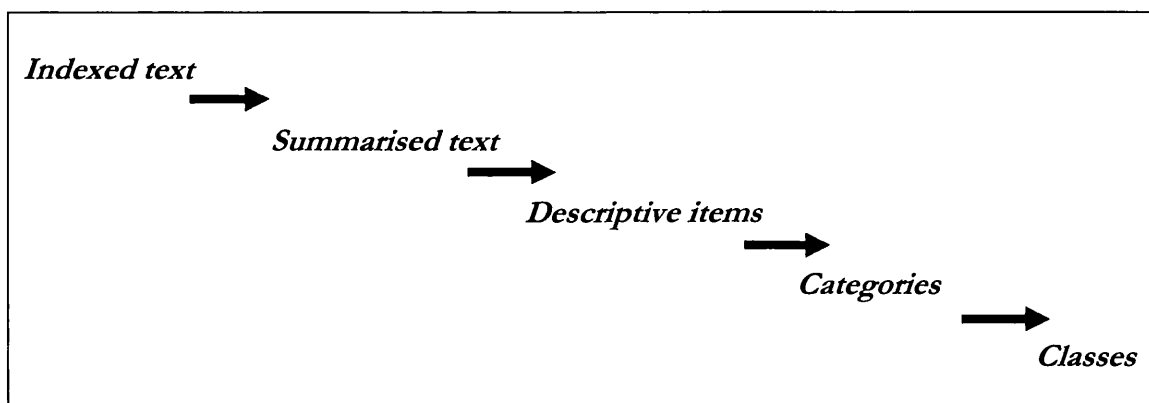
The aim of the qualitative research is to answer questions of why and how, and therefore the analysis of the qualitative data is not complete without explaining and interpreting the findings. This involved detecting associations and links which are led by something said by one participant, a link noted during earlier stages of analysis, or an existing hypothesis. For example, it was noted that previous research showed that instructions received from healthcare professionals led to adhering to cleaning and maintaining practices by nebuliser users. Accordingly, the data were searched for evidence to support this assertion whether it was applicable to the patients included in this study. Another type of associative analysis

applied in this study was to detect linkage between a phenomenon and a group of participants defined according to demographic characteristics or pre-defined sampling criteria (such as comparing the views of both carers and patients relating to a particular issue, or those of patients who obtained their nebuliser through different route). The link was then verified across all cases and the frequency of which this pattern occurred was noted. Additionally, negative cases where this pattern did not apply and missing data were also accounted for. Finally, explanations were provided by drawing from empirical research.

2.7.2. Analysis of quantitative data

Analysis of the quantitative instrument data used in this study included the analysis of the St Georges' Respiratory Questionnaire (SGRQ) (Jones et al., 1991), the EuroQol Questionnaire (EQ-5D) (Brooks, 1996), the Zarit Burden Interview (ZBI) (Zarit et al., 1987), and the 'nebuliser use' checklist. Data from the disease specific, St. George's Respiratory Questionnaire (SGRQ), the generic health status EuroQol questionnaire (EQ-5D) and the carer burden Zarit Burden Interview (ZBI) were all analyzed according to the user manual supplied by the developers.

The SGRQ provided four scores:

• A symptom score: reflects the effect of respiratory symptoms in terms of frequency and severity.

• Activity score: reflects activities which cause or are limited by breathlessness.

• Impact score: reflects the impact of the condition on aspects such as social functioning, and psychological disturbances.

• An overall score: summarises the impact of the condition on the overall health status.

The scores were calculated for each patient (n = 15) by entering the responses of all items into an Excel spreadsheet, the 'SGRQ Calculator' which was provided by the developer. The positive responses were entered as 1 while negative responses were entered as 0, the missing items were left blank. The scoring programme adjusts for up to 24% of missing items in the questionnaire. However, if more than 24% of the items were missing the

scoring programme will return a value of 'missing'. Additionally, the open question 7 was analysed by content analysis and themes identified were reported.

The EQ-5D provided a self-reported health status score which is based on the patients' own rating of problems concerning five health domains: mobility, self-care, usual activity, pain/discomfort and anxiety/depression. The patients rated the problem concerning each domain as: 1 indicating no problem, 2 indicating a moderate problem, or 3 indicating a severe problem. The scores for the five domains were combined to give a unique health status for each patient (n = 50). The health status was then converted into a score using a table of values which was supplied by the developer. The EQ-5D also provided a visual analogue score, obtained from the thermometer. The patients were asked to rate their own health status on a visual scale from 0 – 100. The point where the response crossed the scale was interpreted and coded using a 3 digit format (e.g. 040 represent a value of 40).

The 22-item Zarit Burden Interview (ZBI) was used in this study to collect data on the subjective carer burden (n = 15). The burden score for each carer was calculated by summing the responses of all items in the scale.

The 'nebuliser use' checklist was used to calculate a total problem score for each patient by adding the steps performed incorrectly by the patient.

The first stage of analysis was descriptive. All scores obtained from the instruments used were coded and entered into the Statistical Package for Social Sciences (SPSS), version 18, and analysed descriptively for the mean and the range. In addition to the total scores obtained for the instruments, the responses to the individual items of each instrument were coded and entered into SPSS and a descriptive analysis was conducted to obtain the frequency of the responses. Similarly, the checklist data were coded and entered into SPSS to determine the frequency of problems which occurred at each step.

The second part of the analysis sought to find relevant association between a range of variables and problem score. Bivariate analysis using simple linear regression, independent sample T-test, and one way ANOVA were conducted to test the association between a range of demographic and clinical variables and the problems. A range of clinical and demographic information which were obtained from the patients' medical records during

scheduled surgery visits and during interview were available for analysis such as: the forced expiratory volume in 1 sec ($FEV_1\%$ predicted), the body mass index (BMI), the number of hospital admissions in the last 3 years, the number of co-morbidities, details of respiratory medications prescribed, the number of treating doctors at the surgery, the duration of use, the nebulised medication prescribed, the compressor model, the type of accessory used, other technological devices used, the pattern of use, the instructions received, the source of the nebuliser, gender, ethnicity, smoking history, activity, education, qualification, and living arrangement. Data were missing on the number of doctors (n = 1), model of compressor (n = 1), duration of nebuliser use (n = 1), instructions (n = 1), and BMI (n = 4). Some variables were transferred to meet the assumptions of normality prior to conducting the relevant statistical test.

The final stage of analysis sought to identify the factors which predicted the problems. Accordingly, relevant characteristics found to be statistically significant (p < 0.05) in the bivariate analysis were then entered in a multiple regression model to investigate their ability to predict the problem score. The non-significant variables were removed from the subsequent model with the independent variable with the largest p value removed first until all variables in the model were significant. The final model was reported in the results. The preliminary assumptions were met prior to conducting the analysis (Appendix XXVIII, XXIX, XXX and XXXI).

Finally, the findings obtained from the quantitative instruments were also related to the findings obtained from the interviews. Similarly, the findings obtained from the checklist were considered alongside the patients' reports to assist in explaining and interpreting the data.

2.8. The validity and reliability of the data

A conscious effort was made to ensure the validity and reliability of the study findings. The reliability refers to the extent to which results obtained are reproducible, while validity refers to the extent to which the results are true representation of the issues investigated (Smith, 2002). It has been argued that qualitative methods have inherent validity due to the capacity of the participants to discuss issues relevant to the phenomena without forcing a structure or an agenda (Smith, 2002). Although a semi-structured interview schedule was used to elicit participants' responses on a range of issues concerning the use of nebuliser

therapy, the schedule served to elucidate the participants' views on relevant issues without influencing their response, while open questions and prompts sought additional comments or further issues they wished to express. Additionally, to ensure the validity of the data obtained from interviews the following steps were undertaken:

- The researcher attended tutorials on conducting qualitative research and the use of questionnaires in research, and read books on interviewing techniques which informed the development of the methods, making an informed choice about the instruments to be used.

- The interview schedule was devised after conducting a literature review and preliminary fieldwork which ensured the inclusion of all the relevant issues concerning the phenomena being investigated. Also attention was given to the wording of the questions so as not to influence responses from the participants.

- The researcher ensured that participants understood the questions and repeated the answer given in a different ways in cases where the participant gave an unclear response to a particular issue.

- The data was audio taped and transcribed verbatim to assist in applying analytical procedures, and a checklist was used as a way of standardization the data collected during observations.

- The findings obtained after conducting the initial five interviews were reviewed, and modification of the interview schedule was conducted to ensure the findings represented the views of the participants, rather than being a product of a structured instrument. Similarly the checklist was reviewed and modified after the initial application to ensure applicability to the participants.

- The use of the FrameWork Software ensured validity of the findings by providing a systematic approach to data analysis.

- In terms of the validity of the findings obtained from interview data, much of the explanation and interpretation of the data stem directly from the data where the participants gave direct explanations of their behaviours. However, in some cases the researcher had to make interpretation in cases where the interviewees did not understand the reason for their behaviour. However, this was done systematically and verified across all cases.

- The findings were compared from two perspectives. This was facilitated by the use of Framework software which allowed separation of the views of patients and carers. The separation of the views obtained in joint interviews was facilitated by a

feature built in the software which permitted labelling of the text by allowing the user to differentiate between responses from different individuals by assigning source names. This option allowed the data obtained from the patients and the carers to be compared.

- The findings obtained were compared with previous studies, which is termed cumulative validity (Smith, 2002), and negative cases where views were inconsistent with the majority were also considered and explained, which is termed argumentative validity (Smith, 2002).

- A journal was kept by the researcher through the data collection phase. The notes collected contained information about interaction between the researcher and the participants outside the structured interview period, facial expressions, voice tone and other forms of data. These notes were considered alongside the transcribed text during analysis.

- Triangulation of data obtained from two perspectives (patients and carers), and data obtained from different methods (interviews and quantitative instruments, interviews and observations) were used to validate and complement the findings (Smith, 2002). Similarly, photographs of the nebuliser system were taken and were verified with interview data to ensure consistency reports obtained from participants during interviews on the cleaning and maintaining of the findings. The photographs provided additional information on the condition of the nebuliser system and evidence of equipment misuse.

- Whenever possible, the frequencies of the responses obtained from participants were counted and presented to give an indication of the consistency of the views obtained.

To ensure the validity of the quantitative data the choice of instruments used was based on previous reports of the validity and reliability by researchers in similar participant groups. Additionally the researcher considered the validity of these instruments in the study sample by assessing the content validity, construct validity (Appendix XXV), and discriminant validity (Appendix XXVI and XXVII) of the questionnaires.

- Prior to conducting the statistical analysis, preliminary tests were conducted to ensure no violation of the assumption of the statistical tests conducted. The assumptions of multicollinearity, normality, linearity and homoscedasticity were met for multiple regression and the standardised Beta coefficients were used to

compare the contribution of each predictor variable. Log transformation was conducted for some independent variables to meet the assumption of regression and to ensure a normal distribution.

In order to ensure the reliability of the data collected during the interviews, non-participant observations and the administration of the instruments and the collection of clinical data from surgery databases, the following measures were undertaken by the researcher:

- One researcher was involved in data collection which eliminated inconsistencies in the procedures employed by ensuring the same order was followed in data collection in every interview. This begins with briefing the patient or the carer on the purpose of the study, obtaining the consent, beginning with the interview and administering the questionnaire. During the interview, effort was made by the researcher to keep a similar order of the questions.

- The issues encountered during data collection and interviews were recorded throughout in a journal, and informed the researcher in the development of methods and handling issues in subsequent interviews.

- Similarly, collection of clinical data was carried out by one researcher which ensured that similar issues were extracted from the surgery databases.

- The choice of instruments was confined to those which demonstrated good reliability in a similar study sample. Additionally, the reliability of the SGRQ, and the EQ-5D was assessed for the study sample using Cronbach α (Appendix XXV).

In summary, the methods developed and employed in this study allowed the collection of extensive data both qualitative and quantitative to serve the study objectives. The data obtained from different methods were triangulated and considered alongside each other using a mixed approach to analysis, to validate and complement the study findings. The data collected and analysed using the methods described in this chapter will be presented in Chapter 3 and Chapter 4. A reflection on the methods and the analytical procedures employed in this chapter including their strengths, weaknesses, and the extent to which the aim and objectives of the study were achieved will be provided in Chapter 5.

Chapter 3: Response rate and characteristics of participants

This chapter reports the response rate, and the characteristics of surgeries and participants which were included in this study. The measures taken to raise the response rate and the reasons for non-participating are also outlined. The characteristics of the participants will include demographics and clinical characteristics for both the patients and the carers. The implication of the response rate and the characteristics of the sample on the generalisability of the study findings will be discussed in Chapter 5.

3.1. The response rate and characteristics of the surgeries

The methods employed for recruiting the GP surgeries were described in Chapter 2. All surgeries approached by the researcher agreed to take part, except for one surgery which had recently moved premises and was too busy to participate in research (n =37, response rate 97%). The number of doctors at the participating surgeries ranged from 1 to 11 doctors. Four of those surgeries were single handed, and 25 surgeries had an asthma clinic. The number of patients registered in the QOF with a diagnosis of COPD, and prescribed nebulised medication varied across the surgeries (mean 5, range 0 – 13), in 2 surgeries none of the patients were eligible to participate according to the inclusion criteria. The majority of surgeries were visited on one occasion for the purpose of recruitment, and identification of eligible patients. In a few cases several visits were necessary as the doctor or the practice manager was not available or busy.

3.2. The response rate and characteristics participants

The methods employed for recruiting the patients and their carers are described in Chapter 2. Overall, of the 180 patients who were sent invitation letters to take part in the study, 83 responded by sending the reply slip back to the researcher (response rate 46%). Of those who responded, 50 consented to take part and were subsequently interviewed (participant rate 28%), while 23 declined to take part in the study (non-participant rate 13%). After sending reminder letters to non-responders an 18% increase in response rate was achieved; 97 patients did not respond despite being sent the reminder letter (non-respondent rate 54%) Figure 3.1. The data collection ceased when the target number of 50 patients was achieved which left 10 more patients willing to participate but who were not interviewed.
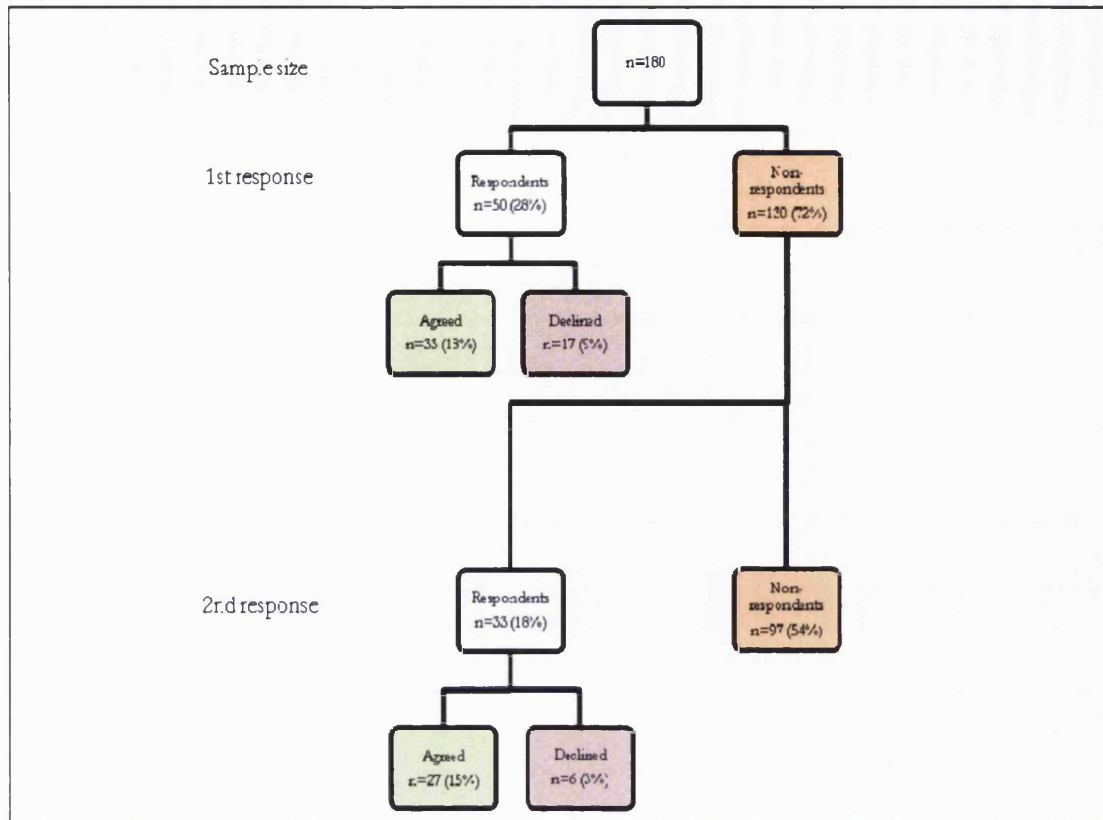
Figure 3.1: A flow diagram showing the first and second response after sending reminder letters

The patients were asked to identify a person who assisted them with the use of their nebuliser therapy. The amount of assistance was not restricted in the invitation letter and carers were encouraged to participate even if they contributed little. Nonetheless, only 15 patients identified a family member who assisted them with the use of the nebuliser therapy (15/50, 30%). It is also likely that other patients (n = 4) who lived with other members of family received some assistance but did not necessarily recognise this person as a carer. All carers invited, except one, consented to take part in the study and were subsequently interviewed. This carer did not consent due to time restraints and other commitments.

Demographics and clinical characteristics obtained from the clinical notes and during the interviews are given for the patients and their carers who participated in the study in Table 3.1. Respiratory medications prescribed for COPD including: the nebulised medication, other inhalational therapy, and oral respiratory medications are given in Table 3.2. Devices used for COPD or other respiratory conditions including: the nebuliser system (nebuliser device and compressor), other portable nebuliser systems, and other technological devices used are given in Table 3.2. Additionally, photographs illustrating nebuliser designs and compressors used in the home are given in Figures 3.2 – 3.7 and Figures 3.8 – 3.17.

Table 3.1: Characteristics of participants (50 patient and 14 carers)

Variable	Carer	Patient
Mean age (SD)	61 (17)	71 (8)
Gender Male Female	 4 10	 21 29
Ethnicity White Non white	 10 4	 41 9
Smoking Ex-smoker Current smoker Never smoker	 N/A 	 34 3 13
Activity Retired Employed Housewife	 N/A 	 42 4 4
Education continued after minimal school leaving age Yes No	 10 4	 20 30
Qualification or a degree Yes No	 10 4	 16 34
Disease severity Severe Moderate Mild	 N/A 	 24 16 10
Mean BMI (SD)	N/A	27 (7)
Mean co morbidity (SD)	N/A	4 (2)
Mean hospital admissions in the last 3 years(SD)	N/A	3 (3)
Living arrangement Alone With the patient/family members	 - 14	 32 18
Have a carer Yes No	 N/A 	 15 35
Relationship to patient Spouse Son/Daughter	 10 4	 N/A

The mean (SD) is given for continuous variables, and frequencies are given for categorical variables.

Table 3.2: Details of medications and devices used for COPD

Nebulised medication by class	Frequency
Short acting beta2 agonist	22
Short acting beta2 agonist & anticholinergic	24
Inhaled corticosteroids	1
Short acting beta2 agonist & inhaled corticosteroids	1
Short acting beta2 agonist, anticholinergic & inhaled corticosteroids	1
Antibiotic	1
Other inhalational therapy by class	
Short acting beta2 agonist	42
Long acting beta2 agonist	1
Short acting anticholinergic	5
Long acting anticholinergic	26
Inhaled corticosteroids	2
Combination therapy (Inhaled corticosteroids & Long acting beta2 agonist)	45
Oral respiratory medication	
Theophylline	14
Mucolytics	11
Leukotriene receptor antagonist	5
Nebuliser device	
CX Nebkit VC, Omron, Japan	1
Disposable Sidestream, Philips Respironics, UK	7
HOT top plus nebuliser, Intersurgical, UK	6
Microneb III, Clement & Clarke, UK	7
Micro-mist, Hudson, USA	9
Durable Sidestream, Philips Respironics, UK	4
CXpro JetAIR plus, Omron, Japan	3
Ventstream nebuliser, Philips, Respironics, UK	1
V.V.T. Nebuliser, Omron, Japan	5
LC SPRINT, Pari, Germany	1
Jet nebuliser kit, Medel, Italy	1
VixOne Disposable, Devilbiss, USA	1
Compressors	
Portaneb, Philips Respironics, UK	10
Compair, Omron, Japan	9
MedixAC4000, Clement & Clarke, UK	9
Cx, Omron, Japan	4
Pulmostar, Devilbiss, USA	3
Actineb, Clement & Clarke, UK	3
MedixAC2000, Clement & Clarke, UK	2
TurboBoyS, Pari, Germany	2
Econoneb, Clement & Clarke, UK	2
Medel silver aerosol, Parma, Italy	1
Arianne power, Norditalia, Italy	1
Hi Flo World Traveller, Clement & Clarke, UK	1
Portable nebuliser systems	
MicroElite, Philips Resperonics, UK	1
KN-9210, PolyGreen®, USA	1
Aeroneb®, Go, Aerogen, Ireland	1
Freeway elite, Philips resporonics, UK	1
Stulz GmbH ultrasonic nebuliser, Germany	2
Other technological devices	
CPAP (Continuous positive airway pressure machine)	2
LTOT (Long term oxygen therapy)	17
NIV+LTOT (Non-invasive ventilation therapy + long term oxygen therapy)	3
NONE	28

Figure 3.2: Sidestream disposable

Figure 3.3: Ventstream nebuliser

Figure 3.4: Pari LC Sprint

Figure 3.5: Omron CX Nebkit VC

Figure 3.6: HOT Top

Figure 3.7: Sidestream durable
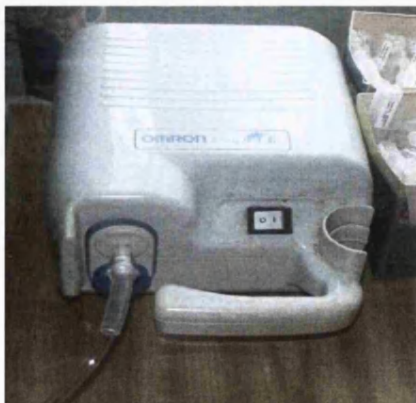
Figure 3.8: Compair

Figure 3.9: Pulmoaide

Figure 3.10: Pari TurboBoyS

Figure 3.11: Actineb

Figure 3.12: Econoneb
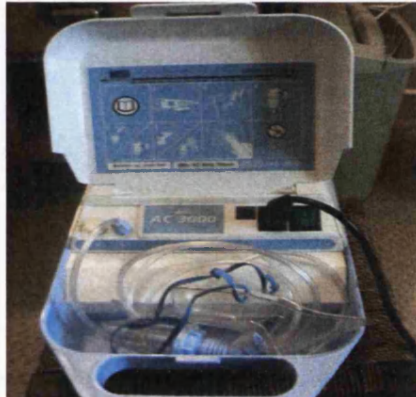
Figure 3.13: AC3000

Figure 3.14: MicroElite

Figure 3.15: Stulz GmbH

Figure 3.16: Aeroneb®
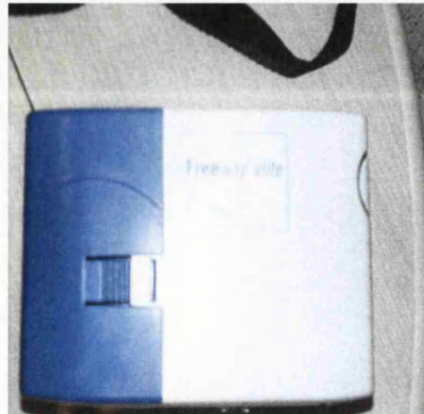
Figure 3.17: Freeway elite

3.3. Characteristics of non-participants and non-responders

Based on the available information obtained from the non-participants who returned reply slips (11reply slips were returned blank 11/60, 18%), the non-participants ratio of females to males was similar to that achieved for participants which was 29 females, 20 males. The reasons for not participating in the study as reported by the non-participants in the returned reply slips are given in Table 3.3. The most common reason given by the non-participants was feeling unwell (n = 13). However, according to clinical data collected from the medical records, almost half of the patients (24/50, 48%) included in this study had severe disease (FEV_1 % predicted < 30%). Similarly, the infrequent use of the nebuliser was reported as a reason for not participating in the study (n = 10). However, according to reports from the patients during interviews almost half of the patients (24/50, 24%) used their nebuliser occasionally. Thus, based on the available characteristics of non-participants, there was no evidence of response bias. In compliance with the ethical requirements, no information was obtained for non-respondents (those who did not respond despite sending a reminder letter).

Table 3.3: The reasons for not participating

Reason	Patient (N)*
Feels unwell (age, breathless, cared for, disability)	13
Do not have a nebuliser at home	5
The nebuliser is very rarely used	10
Do not need help with the nebuliser	2
Privacy concerns/ felt intrusive	5
Lots of hospital appointments	4
Time constraints/other commitments (moving home, travel, home improvement, family problems)	5
In a legal battle with hospital	1
Deceased	1

  * Fourteen patients did not report any reason

3.4. Conduct of interviews

All interviews were conducted in the patients' homes as planned. For those patients who had carers, interviews with the carers were initially planned to be conducted separately. However, this was not possible in 5 cases where the carer chose to join the patient during the interview. This resulted in interactions between the patients and the carers. Interactions were in the form of agreement, or disagreements on issues raised by one participant. In this case, the researcher observed the interaction and waited till the issue was resolved by both

participants agreeing on the issue. This proved to be advantageous in the study, in particular when one participant had difficulty in recalling an event or a past experience, in which case the other participant remembered. In general, conducting the interviews was a smooth process, the atmosphere was relaxed and the participants were at ease in discussing issues related to their health. However, in one case a male patient who gave favourable views on his care from the hospital, presented negative views after audio recorder was turned off. Additionally, on two occasions the interview had to be paused briefly due to the patient feeling breathless. In both cases, the patients wished to continue the interview after a brief break. A few interruptions occurred due to the phone or door bell ringing. One patient informed the researcher ahead of the interview about the need to leave for an appointment; consequently, the researcher had to go through the interview quickly. Overall there was a good coverage of information from all interviews; on average the interviews lasted for 42 minutes and 5 seconds (range 20 minutes and 48 seconds to 2 hours and 39 minutes). Recording ceased in one interview due to dead batteries, hand notes were taken instead.

3.5. The quality of life questionnaires

3.5.1. The health status of the patient as measured by the EQ-5D questionnaire

A broad, generic measure of the quality of life which takes into consideration the impact of other co-morbidities on the perceived quality of life was administered to all 50 patients in this study (response rate 100%). The mean time for completing the EQ-5D was 9 minutes (range was 6 – 15 minutes). The completion rate was 100% (none of the patients had missing responses for any of the items). None of the patients expressed any difficulties in responding to items on the EQ-5D questionnaire.

The responses obtained for the five domains were coded for all 50 patients and a score was produced using a previously constructed table supplied by the developer. All responses obtained from 50 patients were then entered into SPSS, version 18 and analysed descriptively. The mean self-reported health status for the patients was 0.42 (SD 0.35, range – 0.36 to 1.00). Seven patients had a negative self-reported health status indicating a 'worse than death' health status. The mean score of the visual thermometer was 50.2 % (SD 21, range was from 4 % to 100 %).

Frequencies were obtained for the individual domains. Table 3.4 showed that 46 patients (92%) had either moderate or severe problems with mobility, 25 patients (50%) had either moderate or severe problems with self-care, 42 patients (84%) had either moderate or severe problems with usual activities, 40 patients (80%) had either moderate or severe problems with had pain, 28 patients (56%) had either moderate or severe problems with anxiety and depression.

Table 3.4: Frequencies of individual domains of the EQ-5D

Domain	Level1	Level2	Level3
Mobility score	4	45	1
Self-care score	25	20	5
Usual activities score	8	31	11
Pain/Discomfort score	10	28	12
Anxiety/Depression score	22	23	5

Level 1: no problem, Level 2: moderate problems, level 3: severe problems.

3.5.2. The health status of the patients as measured by the SGRQ

In addition to measuring the impact of general health on quality of life, the impact of COPD on the patients' quality of life was measured using the disease specific St. Georges' Respiratory Questionnaire (SGRQ). Data were available for all 50 patients included in this study (response rate = 100%). The mean time for completing the SGRQ was 20 minutes (range was 13 – 33 minutes). The mean completion rate was 83% for the SGRQ (17 patients had missing responses). The completion rate for each domain of the SGRQ was 66% for the symptom domain, 100% for the activity domain, 100% for the impact domain, and 66% for the overall domain. A few patients expressed difficulties in answering some items from the symptom domain which resulted in these missing values. There were five items from the symptom domain which were missed by 34% of the patients. The missing values resulted in excluding these patients from the reliability analysis of the symptom subscale and the overall scale. A description of the missing items and the number of patients with missing responses are shown in Table 3.5.

Table3.5: Missed items of the symptom domain from the SGRQ

Item no	Description of item	N
3	"Over the past 4 weeks, I have had shortness of breath"	1
4	"Over the past 4 weeks, I have had attacks of wheezing"	2
5	"During the past 4 weeks, how many severe or very unpleasant attacks of chest trouble have you had?"	3
6	How long did the worst attack of chest trouble last?"	14
7	Over the past 4 weeks, in an average week, how many good days (with little chest trouble) have you had?"	1

The responses to the individual items of the questionnaire obtained from all 50 patients were coded and entered in the Excel calculator supplied by the developer. The calculator produces a score for each domain (symptom, activity, and impact) and an overall score for every patient. The scores were then entered into SPSS, version 18 and analysed descriptively for the mean scores, standard deviations, and ranges of the individual components scores as well as the overall score of the scale (Table 3.6). Scores could range from 0 – 100, with a higher number indicating greater impairment of the quality of life.

Table3.6: Descriptive statistics of SGRQ domains and overall score

Subscale score	N	Mean	SD	Minimum	Maximum
Symptom	50	68	24	0	97
Activity	50	85	14	41	100
Impact	50	57	18	10	92
Overall	50	68	15	20	95

Scores can range from 0 – 100 indicating minimum to maximum impairment of quality of life.

Additionally, all responses obtained for the individual items from 50 patients were entered into SPSS, version 18, and analysed descriptively. The frequencies of the individual items are given in Table 3.7.

The majority of the patients responded that they had experienced symptoms either 'most days a week' or 'several days a week' in the last four weeks, the symptoms arranged in a descending order starting with the most frequently experienced symptom to the least experienced symptom were: shortness of breath (n = 44), cough (n = 34), sputum production (n = 33) and wheezing (n = 26). However, some patients did not experience any symptoms at all; these patients might be on the milder spectrum of the disease or asthmatics.

The majority of patients reported that they had experienced attacks in the previous 4 weeks which ranged from 1 attack to more than 3 attacks (n = 36), with the attack lasting 'a week or more' (n = 15). This finding indicates suboptimal disease management in this patient

group and possibly the suboptimal use of the nebuliser therapy. A small number of patients reported not experiencing any attacks. A possible explanation for this might be the short recall period specified in this question which asks patients to recall any attacks experienced in the last 4 weeks. This version of the questionnaire has been found to produce a lower symptom and overall score than the 3, and 12 month version (Jones et al., 2003).

With regard to the items constituting the activity domain, the majority of the patients responded that all activities, except for 'sitting or lying still', although to varying extent would make them feel breathless. This finding is not surprising given the compromising nature of the disease (reduced mobility and self-care) which leads to loss of independence and the consequent high dependency on carers. This emphasises the role of the carers in assisting in activities of daily lives for this particular group of patients. However, a minority of the patients did not find these activities to cause breathlessness, indicating that at least for some of the patients, self-care and daily activities were not compromised. As expected, the activities which required more effort on behalf of the patient to accomplish were more frequently reported by the patients to cause breathlessness. In a descending order these were: 'playing sports or games' (50), 'walking up hills' (50), 'walking up a flight of stairs' (49), 'walking outside on the level' (41), 'getting washed or dressed' (37), and 'walking around the home' (34). However, a number of patients were breathless despite being at rest and not performing any activities (15). These patients might well be at the severe end of the spectrum of the disease, or this might reflect poor disease management and suboptimal therapy. The need for investigation and intervention in this group of patients may be advised.

The majority of patients gave negative responses to all items constituting the impact component, with the exception of the item which asks the patient to indicate whether their chest trouble was a nuisance to their family, friends, and neighbours, where 35 patients responded that this statement was false. A majority of the patients gave positive responses in relation to four items relating to the use of their medication (which they were asked to relate to their nebuliser therapy), indicating that: their medication helped them very much, they did not experience side effects from their medication, they were not embarrassed by using their medication in public, and their medication did not interfere with their life. However, a significant minority of patients responded that their medication did interfere with their life, they were embarrassed by using their medication in public, and that they experienced unpleasant side effects from their medication.

Table 3.7: Descriptive analysis of SGRQ items (N= 50)

<table>
<tr><td colspan="6" align="center">PART 1</td></tr>
<tr><td colspan="6">Questions about how much chest trouble you have had over the past 4 weeks.</td></tr>
<tr><td colspan="6" align="right">Please tick (✓) one box for each
question:</td></tr>
<tr>
<td></td><td></td>
<td>most
days
a week</td>
<td>several
days
a week</td>
<td>a few
days
a month</td>
<td>only with
chest
infections</td>
<td>not
at
all</td>
</tr>
<tr><td>1.</td><td>Over the past 4 weeks, I have coughed:</td><td>30</td><td>4</td><td>5</td><td>3</td></tr>
<tr><td>2.</td><td>Over the past 4 weeks, I have brought up phlegm (sputum):</td><td>29</td><td>4</td><td>7</td><td>2</td></tr>
<tr><td>3.</td><td>Over the past 4 weeks, I have had shortness of breath:</td><td>36</td><td>8</td><td>2</td><td>1</td></tr>
<tr><td>4.</td><td>Over the past 4 weeks, I have had attacks of wheezing:</td><td>23</td><td>3</td><td>4</td><td>5</td></tr>
</table>

Note: In the table above, the five response columns are: most days a week, several days a week, a few days a month, only with chest infections, not at all. The recorded values fall under columns 2–5:

	most days a week	several days a week	a few days a month	only with chest infections	not at all
1. Over the past 4 weeks, I have coughed:		30	4	5	3
2. Over the past 4 weeks, I have brought up phlegm (sputum):		29	4	7	2
3. Over the past 4 weeks, I have had shortness of breath:		36	8	2	1
4. Over the past 4 weeks, I have had attacks of wheezing:		23	3	4	5

5. During the past 4 weeks, how many severe or very unpleasant attacks of chest trouble have you had?

Please tick (✓) *one*:

more than 3 attacks	14
3 attacks	4
2 attacks	8
1 attack	10
no attacks	11

6. How long did the worst attack of chest trouble last?
(Go to question 7 if you had no severe attacks)

Please tick (✓) *one*:

a week or more	15
3 or more days	6
1 or 2 days	7
less than a day	9

7. Over the past 4 weeks, in an average week, how many good days (with little chest trouble) have you had?

Please tick (✓) *one*:

No good days	14
1 or 2 good days	11
3 or 4 good days	14
nearly every day is good	4
every day is good	6

8. If you have a wheeze, is it worse in the morning?

Please tick (✓) *one:*

No	25
Yes	25

Continued Table 3.7: Descriptive analysis of SGRQ items (N = 50)

PART 2

Section 1

9. How would you describe your chest condition?

Please tick (✓) *one*:

The most important problem I have	23
Causes me quite a lot of problems	20
Causes me a few problems	5
Causes no problem	2

10. If you have ever had paid employment.

Please tick (✓) *one*:

My chest trouble made me stop work altogether	15
My chest trouble interferes with my work or made me change my work	4
My chest trouble does not affect my work	31

Section 2

11. *Questions about what activities usually make you feel breathless* <u>*these days*</u>.

Please tick (✓) in *each box* that applies to you *these days*:

	True	False
Sitting or lying still	15	35
Getting washed or dressed	37	13
Walking around the home	34	16
Walking outside on the level	41	9
Walking up a flight of stairs	49	1
Walking up hills	50	0
Playing sports or games	50	0

Continued Table 3.7: Descriptive analysis of SGRQ items (N = 50)

Section 3

12. *Some more questions about your cough and breathlessness these days.*

Please tick (✔) in *each box* that applies to you *these days*:

	True	False
My cough hurts	23	27
My cough makes me tired	29	21
I am breathless when I talk	38	12
I am breathless when I bend over	39	11
My cough or breathing disturbs my sleep	29	21
I get exhausted easily	47	3

Section 4

13. *Questions about other effects that your chest trouble may have on you these days.*

Please tick (✔) in *each box* that applies to you *these days*:

	True	False
My cough or breathing is embarrassing in public	31	19
My chest trouble is a nuisance to my family, friends or neighbours	15	35
I get afraid or panic when I cannot get my breath	37	13
I feel that I am not in control of my chest problem	31	19
I do not expect my chest to get any better	41	9
I have become frail or an invalid because of my chest	36	14
Exercise is not safe for me	30	20
Everything seems too much of an effort	41	9

Section 5

14. *Questions about your medication, if you are receiving no medication go straight to section 6.*

Please tick (✔) in *each box* that applies to you *these days*:

	True	False
My medication does not help me very much	5	45
I get embarrassed using my medication in public	16	34
I have unpleasant side effects from my medication	13	37
My medication interferes with my life a lot	19	31

Continued Table 3.7: Descriptive analysis of SGRQ items (N = 50)

Section 6

15. These are questions about how your activities might be affected by your breathing.

Please tick (✓) in *each box* that applies to you *because of your breathing*:

	True	False
I take a long time to get washed or dressed	39	11
I cannot take a bath or shower, or I take a long time	40	10
I walk slower than other people, or I stop for rests	50	0
Jobs such as housework take a long time, or I have to stop for rests	45	5
If I walk up one flight of stairs, I have to go slowly or stop	49	1
If I hurry or walk fast, I have to stop or slow down	49	1
My breathing makes it difficult to do things such as walk up hills, carrying things up stairs, light gardening such as weeding, dance, play bowls or play golf	4	1
My breathing makes it difficult to do things such as carry heavy loads, dig the garden or shovel snow, jog or walk at 5 miles per hour, play tennis or swim	50	0
My breathing makes it difficult to do things such as very heavy manual work, run, cycle, swim fast or play competitive sports	50	0

Section 7

16. *We would like to know how your chest usually affects your daily life.*

Please tick (✓) in *each box* that applies to you *because of your chest trouble*:

	True	False
I cannot play sports or games	50	0
I cannot go out for entertainment or recreation	18	32
I cannot go out of the house to do the shopping	22	28
I cannot do housework	30	20
I cannot move far from my bed or chair	13	37

Continued Table 3.7: Descriptive analysis of SGRQ items (N = 50)

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17. Here is a list of other activities that your chest trouble may prevent you doing. (You do not have to tick these, they are just to remind you of ways in which your breathlessness may affect you):

Going for walks or walking the dog

Doing things at home or in the garden

Sexual intercourse

Going out to church, pub, club or place of entertainment

Going out in bad weather or into smoky rooms

Visiting family or friends or playing with children

Please write in any other important activities that your chest trouble may stop you doing:

Analysis of comments given to this question reveal the following themes (n):

Participating in social events	15
Housework/gardening	14
Playing with children	13
Walking about or walking the dog	11
Going out in bad weather or smoky rooms	10
Hobby and leisure activities (wood crafting, fishing, shooting, hunting, badminton, dancing, cycling, yoga	8
Usual activities (driving a car, shopping)	8
Going on holiday	6
Others (sexual intercourse, sleeping, praying)	3

In addition to indicating the specific activities affected by their condition, some patients gave broader responses when confronted with this question such as:

"It stops me doing everything I would naturally do", "It affects my whole life", "It stops me doing anything at the speed of wanting to do it", "It affects the whole life and turned it the other way round, it made me a prisoner in my own body", and "It stops me doing anything practical".

Now would you tick in the box (one only) which you think best describes how your chest affects you:

It does not stop me doing anything I would like to do	4
It stops me doing one or two things I would like to do	11
It stops me doing most of the things I would like to do	25
It stops me doing everything I would like to do	10

Thank you for filling in this questionnaire. Before you finish would you please check to see that you have answered all the questions.

3.5.3. The carer burden as measured by ZBI

The Zarit Burden Interview (ZBI) was used to give an estimate of the subjective burden of the carers. All carers completed the ZBI (response rate 100%). The mean time for completing the questionnaire was 6 minutes and 5 seconds (range 4 to 12 minutes). The questionnaire had 100% completion rate (no missing items). The carers had no difficulty in understanding the items constituting the scale.

Data are available for 15 carers in this study, the overall burden score was calculated for each carer by adding the scores of the individual items. The overall burden score had a potential range of 0 – 88, with a higher score indicating a higher perceived burden. The carers' final burden scores were entered into SPSS, version 18 and analysed descriptively. The mean burden score was 22 (SD 15, range 4 to 65). Additionally, the responses of the carers to the individual items were entered into SPSS, version 18, and analysed for the frequencies (Table 3.8).

Overall, the majority of the carers gave positive responses in terms of the frequency of which they reported problems to occur with respect to the majority of the items of the scale. However, two third of the carers reported that they 'nearly always' or 'quite frequently' felt that their relative was dependent on them (n= 10), and four carers reported that they 'nearly always' felt that their relative seemed to depend on them as if they were the only one they depend on. A similar number 'sometimes' felt that their relative seemed to depend on them as if they were the only one they depend on. Nearly half of the carers reported that they 'nearly always' or 'quite frequently' were afraid of what the future holds for their relative(n= 7). Three carers reported that they 'quite frequently 'felt stressed between caring for their relative and trying to meet other responsibilities for work or family, and four carers reported that they 'sometimes' felt stressed between caring for their relative and trying to meet other responsibilities for work or family.

With regard to the last item of the interview, which asks the carer to state how burdened they feel in caring for their relative, the majority have stated that they were 'not at all' burdened, whereas few stated they were 'a little burdened', and only one carer was 'moderately burdened', and another one was 'severely burdened'.

Table 3.8: Frequencies of the individual items of the ZBI as reported by carers (N = 15)					
Item	**Never (N)**	**Rarely (N)**	**Sometimes (N)**	**Quite Frequently (N)**	**Nearly Always (N)**
Do you feel that your relative asks for more help than he/she needs?	8	6	0	1	0
Do you feel that because of the time you spend with your relative that you don't have enough time for yourself?	5	2	6	1	1
Do you feel stressed between caring for your relative and trying to meet other responsibilities for your family or work?	3	5	4	3	0
Do you feel embarrassed over your relative's behaviour?	12	2	1	0	0
Do you feel angry when you are around your relative?	6	5	4	0	0
Do you feel that your relative currently affects your relationships with other family members or friends in a negative way?	13	1	0	1	0
Are you afraid what the future holds for your relative?	2	2	5	4	2
Do you feel that your relative is dependent on you?	1	2	2	5	5
Do you feel strained when you are around your relative?	5	7	3	0	0
Do you feel your health has suffered because of your involvement with your relative?	8	3	3	0	1
Do you feel that you don't have as much privacy as you would like because of your relative?	10	2	2	0	1
Do you feel that your social life has suffered because you are caring for your relative?	4	6	3	1	1
Do you feel uncomfortable about having friends over because of your relative?	14	0	0	1	0
Do you feel that your relative seems to expect you to take care of him/her as if you were the only one he/she could depend on?	6	1	4	0	4
Do you feel that you don't have enough money to take care of your relative in addition to the rest of your expenses?	8	4	2	1	0
Do you feel that you will be unable to take care of your relative much longer?	10	2	2	0	1
Do you feel you have lost control of your life since your relative illness?	13	0	1	0	1
Do you wish you could leave the care of your relative to someone else?	10	3	2	0	0
Do you feel uncertain about what to do about your relative?	8	5	1	1	0
Do you feel you should be doing more for your relative?	4	3	6	2	0
Do you feel you could do a better job in caring for your relative?	5	3	6	1	0
	Not at all	**A little**	**Moderately**	**Extremely**	
Overall, how burdened do you feel in caring for your relative?	8	5	1	1	

Chapter 4: Results

This chapter reports the themes identified from the analysis of 50 interviews with patients and 14 interviews with carers. The findings from the interviews are reported separately for the patients and the carers, and are organised in five sections. The themes identified from the analysis of the patients' interviews are reported in four sections: Section 4.1 describes the use of nebuliser therapy in the home, Section 4.2 describes the impact of nebulised therapy on condition management and daily life, Section 4.3 describes the problems encountered with the use of nebulisers, an estimate of the problems encountered with the use of nebuliser therapy and the factors which predicted the problems are presented at the end of this section, Section 4.4 describes current services related to the nebuliser use and the information needs of the COPD patients using nebuliser therapy in the home. The themes identified from analysis of the carers' interviews are reported in Section 4.5 which describes the roles of carers in assisting COPD patients with the use of their nebuliser therapy in the home.

4.1. The use of the nebuliser therapy by COPD patients in the home

This section fulfils the first objective of the study, and documents how patients use their nebuliser therapy in the home in the context of their symptoms and daily life. It provides an insight into the decisions they make regarding the need, timing, and frequency of therapy, which is essential information for providing appropriate support.

4.1.1. Information on the use of nebuliser therapy

All patients (50) were asked during the interviews to indicate the duration for which they have been using nebuliser therapy, and how often they used it. The mean duration of using nebuliser therapy for the patients in this study was 9 years, with a range of 6 months to 30 years. The analysis of interview data revealed that the use of nebuliser therapy varied greatly between COPD patients in the home. There were two distinct patterns of use identified by the patients, 'regular' and 'occasional', and a similar proportion of patients used their nebuliser regularly, on a 'daily basis' (n = 26) as those who used the nebuliser 'occasionally' (n= 24). Some patients expressed difficulty in identifying the frequency of using their nebuliser particularly in cases where the nebuliser was rarely used. Instances where the nebuliser therapy was used very rarely were identified from the data, and in one case, the nebuliser had not been used for over a year.

I only use it when my chest starts to get tight probably at the beginning of an infection... I can tell when I'm going to get an infection... I can't say really how often.... I get infections probably about three or four times a year.

Female, 67 yrs old, used a nebuliser for 10 yrs

Nebuliser therapy is often prescribed for the patient to be used 'as required' up to four times a day. The majority of the patients adhered to this instruction and used their nebuliser therapy either 'less than four times a day', or 'four times a day' (Table 4.1). Exceeding the recommended daily dose was identified in four patients who reported using their nebuliser 'more than four times a day'. The majority of the patients differentiated between their 'normal use' and their use on 'bad days' when their symptoms were not adequately controlled by their usual dosage, usually during exacerbations. In most cases, the patient adhered to the four hour interval between subsequent doses. However, in two cases, the dosage interval was less than 2 hours, and two other patients indicated that they repeat the nebulisation if one session fails to control their symptoms.

Table 4.1: Frequency of nebuliser use on normal and bad days

Frequency of use per day	Normal use	On bad days
Less than 4 times	26	22
Four times	16	19*
More than 4 times	4	5*

* On bad days three patients reported they would increase their dosage frequency from 'less than four times a day' to 'four times a day', and one patient reported increasing it from 'less than four times a day' to 'more than 4 times a day'. Data was missing from four patients.

4.1.2. Decisions about using nebuliser therapy

The data suggest that the patients were continually making judgments about their needs. Active clinical decisions were discussed by the patients in the context of assessing their symptoms. The majority of patients described initiating nebuliser therapy in response to symptoms, with subsequent doses often being guided by the patients' deterioration of symptoms. In this case, a dosing schedule was worked out by the patient to ensure the longest period of remaining free of symptoms.

It's just that I know that's when I need to use it to keep a smooth run, otherwise I might run out of breath... I start gasping, you know, and it's easier to use this (nebuliser) and keep a smooth flow going.

Female, 76 yrs old, used a nebuliser for 5 yrs

> If I take it at six o'clock in the morning, and six o'clock at night time, it's ok, but if I tend to go over... over that to maybe nine o'clock at night... my breathing starts going haywire.
>
> Male, 58 yrs old, used a nebuliser for half a year

However, some patients described a preventative approach where judgments were often based on past experience with triggers such as bad weather, or taking up an unusual physical activity which are known to cause a deterioration of their symptoms. In this case, the decision to administer a prophylactic dose was viewed as a precautionary measure to avoid worsening of their symptoms.

> A lot of it (the doses or the nebulisation sessions) is to do with the weather which commands how I'm going to use it, it's like today... for ordinary people it is normal walking about, for me it's dry air, it's less oxygen so ... that's why I'm struggling now.
>
> Male, 60 yrs old, used a nebuliser for 1.5 yrs

On other occasions, the dosing schedule was not always determined by the symptoms but by the patient's daily routine. For example one female patient described how she incorporated her nebuliser doses to fit with her daily routine and lifestyle.

> Well I do it (nebuliser therapy) with all the pills I have to take in the morning and I nebulise then in the morning. Then it's just like habit I suppose... I do it lunch time or if I go out and I'm not home till about 2 you know... I go out once or twice to the shops so I'm not around at 12 you know... so I do it then and then I do it in the evening about... I can't remember all... when it fits in really because the time seems to go so quick. I'll be, I got to nebulise you know, so I do that then. It's three times a day I do it.
>
> Female, 70 yrs old, used a nebuliser for 10 yrs

4.1.3. The use of a peak flow meter in monitoring the response to nebuliser therapy

All patients (50) were asked during interviews whether they had a peak flow meter at home and how often they used it to monitor the response to the nebuliser therapy. Patients using nebulisers in the home are recommended to monitor their response to therapy by recording their PFR before and after use using a peak flow meter, and to keep a symptom diary. The majority of the patients stated that they had a peak flow meter at home (n = 35), which was obtained from their local GP practice or hospital (one patient had two peak

flow meters one given to him by the hospital and one through the GP). The data indicate poor compliance with the use of peak flow meter in monitoring the response to the nebuliser therapy. The frequency at which the patients used their peak flow meters is reported in Table 4.2. Only three patients used their peak flow meter on a daily basis to monitor their response to the nebuliser therapy. The majority of the patients reported that the peak flow meter was either used sometimes, or never used.

Table 4.2: The frequency of using the peak flow meter in monitoring the response to the nebuliser therapy (n = 35)

Daily	Weekly	Sometimes	Rarely	Never
3	1	13	6	12

Additionally, when the peak flow meter was used, this was rarely to monitor the response to nebulised therapy; instead it was either used during exacerbations of symptoms to closely monitor any further deterioration in the score warranting additional medical help or during good times, when they felt better to check whether the peak flow meter reading and lung capacity correlated with their subjective feeling of improvement in breathlessness.

> If I take my peak flow and it's under 150, I don't even bother with that (using the nebuliser), I call the ambulance straightaway, because I then can't think. If I get to 150 or under, and I need to use my nebuliser, I can't put it together. I know, I mean, I've used it for years, and I know, but because you've not got the oxygen, do you know what I mean?
>
> Female, 58 yrs old, used a nebuliser for 20 yrs

> If I am having a good part of the day, I want to see what my capacity is.
>
> Male, 67 yrs old, used a nebuliser for 1.5 yrs

Only three patients reported using the peak flow meter before and after using the nebuliser to monitor the effectiveness of therapy. Of these patients, two noted an improvement in their score while one patient stated there was no difference in the peak flow meter score before and after using the nebuliser.

> I went up to 200, not all the time but I went up to 200 that was good, I never gone that before so it's good now, I feel good.
>
> Female, 80 yrs old, used a nebuliser for 2.5 yrs

> I did it yesterday before and after, and there were no difference what so ever.
>
> Female, 74 yrs old, used a nebuliser for 10 yrs

There was a strong agreement between COPD patients in this study, on the lack of usefulness of the peak flow meter as a monitoring tool. Only a few patients noticed a difference in their scores between good and bad times, suggesting a lack of correlation between the peak flow meter scores and their symptoms. Difficulties with determining a 'score' as a result of being out of breath were expressed by the patients. Inconsistency in scores was noted by one patient suggesting a lack of reliability of the device.

> One of the things I've noticed is the inconsistency. I do best out of three, and I've sometimes had 180, and the next two I can't get above 150. It's not always the first one; it can be the middle one or the last one. And as far as I know I am doing exactly the same thing.
>
> Female, 58 yrs old, used a nebuliser for 20 yrs

4.2. The impact of nebuliser therapy on condition management and daily life

This section fulfils the second objective of the study and provides insights on the impact of nebuliser therapy on patients' daily lives by describing the positive and negative aspects of nebuliser use. These aspects will be discussed in terms of perceived effectiveness, control of symptoms, perceived safety, side effects and other advantages and disadvantages of nebuliser use. This section provides healthcare professionals with valuable information to assist them in optimising therapy and health outcomes for COPD patients who are using nebulisers in the home.

4.2.1. Positive views reported by the patients on the use of nebuliser therapy

The perceived effectiveness of nebuliser therapy

All patients (50) were asked about their views on effectiveness in terms of controlling their symptoms. The data support the use of nebuliser therapy in the home by showing that the majority of the patients perceived their nebuliser therapy to be effective (n = 36). The main effect of nebuliser therapy is to improve the symptoms of COPD and it is not intended to cure the condition. Analysing the patients' accounts indicated that in most cases, the patients in this study were aware of this fact.

> It's not a cure of course. There's not a cure for these thing (COPD) but it does help, yeah I must say.
>
> Male, 67 yrs old, used a nebuliser for 2 yrs

In terms of the time taken to notice any improvement in the symptoms, in most cases, the patient stated that a relief was felt immediately after using the nebuliser therapy while other patients described a gradual relief taking some time to build.

> Every time I use it it's almost like an instant relief... I can breathe properly every time... I'm very impressed with it.
>
> Male, 70 yrs old, used a nebuliser for 4 yrs

> I don't feel an effect immediately. It needs about half an hour, because it's a slow process, it's not like taking an injection. You take it at first and half an hour later you realise how much better you are feeling. It takes ten minutes to do it, but the effect of that will open you out and gradually, whatever congestion you've got is dealt with by your system.
>
> Male, 67 yrs old, used a nebuliser for 1.5 yrs

In most cases the effect of nebulised medication was described as being only a temporary relief lasting for a short duration of time and eventually requiring repeated dosing to maintain the effect. This can be explained by the fact that those patients who used bronchodilators (beta agonists and anticholinergics) will notice an instant relief compared to those who were using steroids.

<u>The benefits attained from using nebuliser therapy</u>

The effectiveness was manifested in several aspects of improving symptoms of COPD such as: relieving breathlessness, aiding in expectoration of mucus, relieving congestion symptoms, improving activity levels, helping to sleep better and having a calming effect on the patient (Table 4.3).

> I loosen up mucus through this (the nebuliser), and this (the nebuliser) has been very, very good... the preventative sort of stuff for me, because I get mucus plugs, and this is what causes me to have problems.
>
> Female, 62 yrs old, used a nebuliser for 1.5 yrs

> I find that if I'm out somewhere, and I'm not using it (the nebuliser)... if I go fishing for instance and it gets to about six o'clock in the evening, I think - oh, I'd better take my reliever, I'm having trouble breathing - and I suddenly realise I haven't had my nebuliser.
>
> Male, 75 yrs old, used a nebuliser for 2 yrs

The patients viewed their nebuliser as an alternative to making emergency visits to the hospital, or scheduling an appointment with their doctor, hence increasing their independence and self-confidence.

> It's an extra life line... it enables me to stay at home longer than I would if I didn't have it... I probably been in hospital more often if I didn't have it and that is the beauty of it.
>
> Female, 75 yrs old, used a nebuliser for 5 yrs

Consequently, some patients expressed concerns about being without a nebuliser.

> But I don't want to lose my nebuliser. If that broke down I'd have to get another one, a replacement straightaway, because the fact that I hadn't got it would probably panic me into an attack anyway.
>
> Female, 58 yrs old, used a nebuliser for 20 yrs

Table 4.3: The benefits of using nebuliser therapy, as reported by the patients

Perceived benefit*	(N)
Relieving breathlessness and opening the airways	34
Help to stay independent and avoid unnecessary hospital admissions	11
Feel lost without it/emotional and psychological benefit	11
Aid in expectoration of mucus	8
Help in increasing the level of activity	4
Helps to relax or sleep better	3
Help in relieving congestion symptoms	1

* Some patients reported more than one perceived benefit.

The data provided further evidence that the patients made conscious decisions regarding the need for therapy, the timing of the dose, and the frequency of dosage, which were influenced by their views and concerns on the effectiveness of the therapy. The effectiveness was described as being dose-dependent, and in some cases it was related to the duration of using the nebuliser therapy. As a result, the patients described using their nebuliser therapy more as a response to a deterioration of their symptom, and less if an improvement in their symptoms was noticed. The increase in the dose was described in the context of either increasing the dosage frequency or using two formulations in response to deterioration of symptoms. Conversely, the patients reported reducing the dose if an improvement was noted in their symptoms, which was described in terms of the frequency of dosage or the number of drug formulations used.

> If things are very bad, and I can't seem to shift anything, then I will use both of them (salbutamol and ipratropium bromide nebules), and when I use both of them, yes, I use them together.
>
> Male, 80 yrs old, used a nebuliser for 10 yrs

> If my dose goes up, as soon as I feel well, I put it back down again, to what my doctor says it should be. I don't stay on the higher doses, because what are they going to use when those no longer work?
>
> Female, 58 yrs old, used a nebuliser for 20 yrs

In terms of the duration of time the patients had to use the nebuliser before an effect can be felt, some patients indicated that their symptoms were more effectively controlled if they used the nebuliser regularly on a daily basis. However, this was not the case for all patients, in particular those patients, who used their nebuliser occasionally and only needed to use it when they experienced an exacerbation of symptoms (Section 4.1.1). The frequency at which patients experienced exacerbations varied between patients and for the same patient, which reflects the unpredictable nature of COPD. In this respect, some patients stated that they experienced exacerbations every month, while for others it was once a year.

Other advantages of using nebuliser therapy

In addition to the benefits described above, the patients mentioned other advantages which were attributed to the features of the device rather than being an effect of a particular drug formulation delivered from the nebuliser. For example, some patients mentioned that nebuliser therapy enhanced their social life, which was attributed to the portability of their equipment, allowing them to visit family and friends or even travel abroad which was not an option if they didn't have the nebuliser.

> It's very portable (nebuliser), if you're going somewhere. You know you can just close that (the compartment), tuck all these in the bag (the accessories) and that's it, when I used to go visit somebody and stays somewhere I always took it with me.
>
> Female, 65 yrs old, used a nebuliser for 10 yrs

The patients also commented that they were not embarrassed by using the nebuliser therapy in public, and regarded it as a life saving machine.

A diabetic is not embarrassed about having a life saving injection. I am not going to be embarrassed about something that's going to save my life. I used to be, it used to be embarrassing when I first had one. I used to think that they think I'm putting it on (illness), because I'm so well, and suddenly I get this machine out and starts using it.

> Female, 58 yrs old, used a nebuliser for 20 yrs

4.2.2. Negative views reported by the patients on the use of nebuliser therapy

Exceptions to the perceived effectiveness

Although the majority of the patients perceived nebuliser therapy to be effective, exceptions were identified in a few cases where only marginal benefits were attained (n = 6).

> I suppose there is a small amount of benefit, but it's not that great...You don't sort of feel after using as if you have regenerated your life or something.
>
> Male, 80 yrs old, used a nebuliser for 1 yr

Although the extent of the benefit was perceived marginal in six cases, it was appreciated by the patients in this study, and these patients continued using their nebuliser.

Some patients indicated that benefits were either not attained at all (n = 3), or not on all occasions the nebuliser was used (n = 3). Instances where nebuliser therapy was perceived ineffective occurred when the patient was not feeling very ill prior to using the nebuliser.

> I have in the past (didn't get a relief), probably when I've used it just as a routine maybe in the afternoon... I've got in the habit of using it now whether I really needed or not... so I've used and say it hasn't been much different... but then I didn't feel all bad before I took it.
>
> Male, 83 yrs old, used a nebuliser for half a year

On other occasions, the ineffectiveness was sometimes attributed to the severity of the condition; one patient indicated that the only time the nebuliser did not work for her was during chest infections.

> The only time I don't feel the benefit is if I got a chest infection and all that sort of thing.
>
> Female, 62 yrs old, used a nebuliser for 30 yrs

The patients' views on the ineffectiveness of therapy impacted on their decision to use the nebuliser. The lack of perceived effectiveness from the nebulised therapy resulted in discontinued use by only one patient.

> I didn't feel that it achieved anything … Obviously people are different because my elder daughter …. felt that it cleared things for her, but I don't feel it does anything for me. Well what I've done really is just stop using it.
>
> Female, 77 yrs old, used a nebuliser for 1 yr

Uncertainty about the effect of nebuliser therapy was articulated by some patients (n= 3). The chronic nature of the condition and the fact that a nebuliser had been used for a long time have obscured these patients them from ascertaining the exact effect of their therapy. Refraining from using the nebuliser for some time was described by one patient to be a good way to assess the exact effect of the nebuliser therapy.

> These things I find very difficult because you don't know how you would be without using it so you don't know if they also help when you use them. I really don't know if it's doing any good to me or not the whole set up whether if I packed it up tomorrow I'll be any different. I really don't know without doing it.
>
> Female, 82 yrs old, used a nebuliser for 15 yrs

Some patients developed ways of assessing the efficacy of the nebuliser therapy, which was for one patient to note the difference in his activity level between times when the nebuliser therapy has been used or not.

> No, the funny thing is, when I come off the ventilator I always think that's done no good at all - it just hasn't done any good at all, but later on I realise it has, because I'm going through the evening and I'm having no trouble, whereas if I forget it and I don't use it for some reason I have trouble in the evening, and even my wife now turns around and says - have you had your second one? And I say - oh no, and I have it and I'm fine again.
>
> Male, 75 yrs old, used a nebuliser for 2yrs

Confusion arises due to the added effect of co-morbidities, and patients being on multiple medications made some patients uncertain about the effect of the nebuliser on their breathlessness. Although for the majority of the patients interviewed in this study, the COPD was their main concern, for some patients other conditions were their primary

concern. Despite this uncertainty about the effect of nebulised therapy, the patients chose to continue with the use of the therapy.

Additionally, a decline in the effectiveness of nebuliser therapy was noted by the patients when it was used over a prolonged period of time. These patients indicated that the benefits they acquired from their nebulised medication were more noticeable when nebuliser therapy was first commenced. The decline in the perceived benefit was sometimes attributed to disease progression, or to developing tolerance to medication with frequent use. As a result these patients kept their use at a minimum.

> I don't know how essential now they are to me because I've been using them for many years I don't really need them now. Not that my lungs have improved they haven't they've deteriorated, but it's useless to me...
>
> Female, 82 yrs old, used a nebuliser for 15 yrs

> I am rather reluctant to use this more than I have to, on the grounds that I feel, from what I've said before, about the tablet, the more I use it the less effective it's likely to be, and although consultants have said no, that isn't so, I've lived with a number of things that I don't think this is anywhere near as effective now as when I first started using it.
>
> Male, 80 yrs old, used a nebuliser for 10 yrs

The perceived safety and side effects of nebuliser therapy

All patients (50) were asked during interviews to give their views on the safety of nebuliser therapy, and any side effects they had experienced. The long term safety of using nebuliser therapy is not well established in controlled clinical trials, or from the patients' perspectives. The data suggest that chronic use of nebuliser therapy at home seem to be a safe option for COPD patients; more than half of the patients perceived their nebuliser therapy to be safe and reported that they did not experience any side effects after use (27).

> I'm not too concerned... I actually only found that out (about the side effects) recently, when I was in hospital one of the doctors told me about that (the side effects).
>
> Male, 68 yrs old, used a nebuliser for 4 yrs

Although a significant number of patients reported experiencing side effects after using nebulised therapy (n = 22) (Table 4.4), in most cases, the patient reported that side effects occurred very occasionally and were dose-dependent; occurring when a higher strength of the nebulised drug was used, or when the dose was doubled.

> I think this is a smaller dose... I used to have 5 ml... I'm on 2.5 ml (salbutamol nebules)... now this does makes a difference.
>
> Female, 74 yrs old, used a nebuliser for 4 yrs

> Some months ago, I put two in (nebules), and then I start to get palpitations and my hands were shaking.
>
> Female, 67 yrs old, used a nebuliser for 10 yrs

Furthermore, the patients reported that the side effect disappeared after a period of rest, or after persistent use, suggesting tolerance being developed after a period of using nebuliser therapy.

> Now the interesting thing is, if you use it once you shake, if you use it four times a day, or you are using it twice today and twice tomorrow the shaking goes off.
>
> Male, 80 yrs old, used a nebuliser for 10 yrs

Table 4.4: The side effects of using nebuliser therapy as reported by the patients

Side effects *	(N)
Shake/ tremor	10
Palpitations	5
Dizziness	5
Feels tired afterwards	3
Mouth ulcers	2
Eye problems	2
Cough	1
Muscle pain cramps	1

* Some patients reported more than one side effect.

In terms of the perceived severity of the side effect, in most cases the side effect was well tolerated by the patient and regarded as being minor or non-significant and did not stop them using their nebuliser. However, this was not the case for all patients as some were concerned about the long term safety of their medication.

No, I didn't (experience any side effect) but when I was in hospital of course I had quite a lot of this (the nebulised medication) and they made the point that they had to, before they released me, that they had to sort of slow this down, slow the nebuliser down in another words cut it back until they release me. So obviously somewhere along the line they've had something happen or some feedback so that is one of the things that stuck in my mind and one of the reasons that I don't go over the top or use it unless it's absolutely necessary or as otherwise instructed.

Male, 78 yrs old, used a nebuliser for half a year

These concerns impacted on decisions to use their therapy. A reduction in dosage was initiated by the patients, which was described in the context of limiting the use of the nebuliser or reducing the frequency of the dosage.

Very rarely, if I can get away with it (responding to a question on how often she used her nebuliser), because, I don't know if you know much about nebulising, if you use it too often you can get the shakes. That's why I don't want to use it very often.

Male, 68 yrs old, used a nebuliser for 4 yrs

I should use it at least four times a day, but I don't because it gives me shakes, so at least I do it once a day.

Male, 80 yrs old, used a nebulise for 1 yr

On other occasions where the side effects were troublesome, the doctor was consulted by the patient providing an opportunity for healthcare professionals to intervene. In these cases, the doctor either prescribed a lower strength of the drug formulation, or in one case in which patient was already prescribed the lowest dose, the drug formulation causing the side effect was discontinued.

Discontinuation of use as a result of experiencing side effects was reported in two cases. In one case this was due to tremor and in the second it was due to palpitations. One patient stated resuming use after some time, while the other patient discontinued her nebuliser permanently.

I can tell you I feel quiet scared and I don't really want to use my nebuliser again... I have. I overcame my fear but it really frightened the life out of me because my hands were shaking and my heart was going like a drum. It's awful. It's awful.

Female, 67 yrs old, used a nebuliser for 10 yrs

> Very rarely, if I can get away with it (responding to a question on how often she used her nebuliser), because, I don't know if you know much about the nebulising, if you use it too often you can get the shakes. That's why I don't want to use it very often. Maybe if I get a bad dose (breathlessness), then I might use it for a couple of days, three times a day.
>
> > Male, 68 yrs old, used a nebuliser for 4 yrs

Additionally, three patients could not ascertain whether side effects experienced were caused by nebuliser therapy or other medications. In cases when two nebulised medications were being used, the patient was not sure which product was causing the problem.

> I don't know if it's this (the salbutamol nebules), or the other one (the atrovent nebules) that does it (the tremor).
>
> > Female, 62 yrs old, used a nebuliser for 1.5 yrs

Other disadvantages of using nebuliser therapy

In addition to the side effects reported by the patients, other disadvantages reported related to the device rather than the effect of a particular drug formulation delivered by a nebuliser device such as: the inconvenience of the weight of the device, the impracticality of carrying it around inside or outside of the house, and the noise of operation.

> The only disadvantage is the fact that it's heavy and that you need to have around you, I suppose.
>
> > Male, 76 yrs old, used a nebulise for 5 yrs

> It does make a bit of a noise. I put that on and the wife grabs the television and up goes the sound.
>
> > Male, 75 yrs old, used a nebuliser for 2 yrs

The effectiveness of nebuliser therapy in relation to other therapies

Some patients compared the effectiveness of their nebuliser therapy to other therapies such as their regular hand held inhalers or oxygen therapy. When the nebuliser therapy was compared with hand held inhalers, nebuliser therapy was usually regarded as more effective than hand held inhalers.

> I don't get benefit from the inhalers. I find that I'm struggling, if I need it and my lungs are so bad, because I've got heart and lung disease anyway, I'm on oxygen twenty four seven normally. And I find, with taking the inhalers, they don't do the work they should be doing.... That one [the nebuliser] does.
>
> > Female, 62 yrs old, used a nebuliser for 5 yrs

However, when nebuliser therapy was compared with oxygen therapy, the latter was often regarded more effective than nebuliser therapy. Interestingly, one patient gave an account on the distinctive roles of nebuliser and oxygen therapy.

> The oxygen performs one function but it doesn't perform the same as that [nebuliser], the oxygen replaces the oxygen that I need but it doesn't clear my chest or help with my nose or anything else, but that [oxygen] I definitely couldn't do without.
>
> > Male, 60 yrs old, used a nebuliser for 1.5 yrs

4.3. The problems encountered with the use of nebuliser therapy in the home

This section fulfils the third objective of the study and identifies the frequency and range of problems encountered with the use of nebuliser therapy by COPD patients in their home, which might lead to treatment failure. The findings presented in this section provide insights into the patients' techniques in terms of setting up the equipment, inhaling the medication, cleaning and maintaining the equipment, and identify areas of weakness where support is needed. The problems encountered with the use of the nebuliser will be presented in three sections according to the time the problem is encountered in relation to the administration of the inhaled nebulised dose: Section 4.3.1 describes the problems occurring prior to inhaling the nebulised dose, Section 4.3.2 describes the problems occurring during inhalation of the nebulised dose, and Section 4.3.3 describes problems occurring after inhaling the nebulised dose. The frequency of the problems encountered during each stage and the overall process and the factors which predicted the occurrence of the problems will be provided in Section 4.3.4.

4.3.1. Problems occurring prior to inhaling the nebulised dose

All patients (50) were asked to demonstrate and describe how they set up and operated their nebuliser system. They were asked by the researcher how they: assembled the

different components of the nebuliser chamber, diluted the drug fluid (if required), mixed the drug formulations (if two formulations were used), filled the drug fluid into the nebuliser reservoir, and operated the compressor. The patients were observed by the researcher while they demonstrated their technique, and recorded the steps performed by the patient in a step-by-step checklist developed for the purpose of this study, comprising steps required to be performed correctly to accomplish each activity (Chapter 2). The problems encountered by the patients while performing these activities are given in Table 4.5. The themes identified from the patients' accounts are described in relation to the activities: assembling the components of the nebuliser system, filling the drug formulation, diluting the drug fluid, and compatibility issues.

Table 4.5: The problems encountered by COPD patients prior to inhaling the nebulised

Theme	Description of step performed incorrectly	N (50)
Assembling and operating	**Failure to remove the nebulizer cap from the medication tank ***	11
	Failure to ensure the vaporiser head is freely moving prior to filling the drug fluid *	22
	Failure to re-insert the vaporiser head in the medication tank **	3
	Failure to re-connect the nebuliser cap to the medication tank *	1
	Failure to fit the facemask/mouth piece on the nebuliser cap *	4
	Failure to connect the tubing to the medication tank from one end and to the compressor from the other *	6
	Failure to switch on the compressor **	0
Filling the drug	Failure to store the drug correctly	0
	Failure to use the drug at room temperature	0
	Failure to prepare the drug immediately prior to use	3
	Failure to dilute the drug *	0
	Failure to mix the drug formulations	0
	Failure to fill the medication tank with the drug fluid *	6
Compatibility	**Failure to use the correct nebuliser for the drug ***	0
	Failure to use the correct nebuliser for the compressor ?	25
	Failure to use compatible drug formulations *	0

Steps highlighted in **BOLD** are essential steps and are likely to result in either a reduced drug output (*), no drug output (**) or an unknown drug output (?) if performed incorrectly by the patient.

Assembling the components of the nebuliser system

During assembling, patients were required to set up their nebuliser system correctly by connecting the different components of nebuliser system which comprised of: a nebuliser chamber (the part that hold and nebulise the medication, accessories (the facemask or the mouthpiece), tubing (which connect the nebuliser to the compressor), and a compressor (the equipment which is the source of the compressed air). The nebuliser chamber comprises of 3 pieces which are required to be assembled correctly; the nebuliser cap, the medication tank, and the vaporiser head. Failure to assemble the nebuliser parts correctly affects the performance of the nebuliser, and can lead to leakage during nebulisation.

With regard to assembling the different components of the nebuliser system, 11 patients revealed that their nebuliser system was assembled at all times (even when not in use), and were therefore, not require to assemble the components of the nebuliser chamber each time they had to use the nebuliser. The most common reason for having the nebuliser system set up all the time was limited manual dexterity, and the unpredictable pattern of flare ups. However, those patients who assembled their nebuliser system prior to use, demonstrated more confidence, and regarded themselves (to some extent) as having control over their condition. Having the nebuliser set up beforehand eliminated panicking during the onset of attacks by ensuring medication can be administered quickly.

> If I was sleeping in the bed tonight, and I needed it, I'd go next door and use it next door, and sit in the chair, and I leave it plugged in, because the point is, when you do need it, you probably, to help not panic the best thing is to get it going as soon as possible, so next to that chair I've actually got the nebules, and that's already set up, and is there, and with very little movement I can get it. I sit in the chair, pull the top off, and squirt the thing in, drop the nebule into the empty nebule thing, into a box I've got there for that purpose.
>
> Male, 80 yrs old, used a nebuliser for 10 yrs

When nebulisation was required, those patients either filled the medication tank through the opening of the nebuliser cap (n = 6), or sometimes through the opening of the facemask (n = 5). This was regarded by some patients as a more convenient option than unscrewing the cap to fill the medication (explained by one patient), while others felt it was unnecessary to open the cap every time for filling, and justified this by explaining that the medication will still end up in the same compartment.

I would normally (open the nebuliser cap to fill in the drug fluid), but no, I am not trying to screw it, I am trying to do that [pour the medication from the opening of the facemask]. Because I used to unscrew it, but if you drop the medication in there it still goes to the same place, and it's quicker than unscrewing it and needing an extra hand.

Male, 80 yrs old, used a nebuliser for 10 yrs

Failing to assemble the nebuliser system from scratch when needed, or to open the nebuliser cap to pour the drug fluid for the reasons discussed above, resulted in a proportion of patients failing to ensure that the vaporiser head was freely moving prior to filling the drug fluid (n = 47). This may mean the part not rotating freely, and affects the nebulisation of the drug. Additionally, those patients who had their nebuliser chamber set up all the time were found to adopt inadequate cleaning procedures, and the vaporiser head was frequently found to be stuck and/or not rotating when the compressor was started. This is a major problem which will result in low vapour output and reduced effectiveness of the inhaled dose. When this issue was brought to the attention of one patient, the action was justified by blaming healthcare professionals for not providing enough information on the use of the nebuliser therapy. More disturbingly, even when the patients assembled the different components of the nebuliser chamber prior to every use (n = 39), all except 3 failed to ensure that the vaporiser head was freely moving due to lack of understanding on their part for the purpose of this part or the fact that it was detachable. In one case the patient thought it was supposed to be tight fitting.

I use one ampoule and then I put it in there tighten that (the vaporiser head), it has to be secure then put that back on (the nebuliser cap) and then I use the mask...

Female, 82 yrs old, used a nebuliser for 3 yrs

Only a few patients appeared to have a clear understanding on the importance of this part being freely moving for the nebuliser to work properly and generate the aerosol output (n = 3).

If anything goes wrong, I would think the piece to go wrong would be here (the vaporiser head) although it would fail to vaporise and you wouldn't get anything out of here. Well you would, but it wouldn't be any good so it would be something wrong with this (the vaporiser head) so you have to change this you know get in touch with the people and order one of these.

Male, 78 yrs old, used a nebuliser for half a year

Moreover, three patients described instances where they forgot to replace the vaporiser head in the chamber. One patient realised the part was missing without seeking any professional assistance. One patient lost the vaporiser head during cleaning, and had to seek help from the local pharmacist, who explained about the missing part and replaced it.

> I wash it and then this fell off (the vaporiser head), then I try to work this thing there is no vapour, then I went to the pharmacy......
>
> > Male, 72 yrs old, used a nebuliser for half a year

With regard to connecting the tubing to the compressor or to the nebuliser chamber, difficulties reported by the patients were attributed to poor manual dexterity and poor grip (n = 6). As a result, some patients had to rely on help from relatives or carers to perform this step (section 4.5.3.2.).

> It's not a problem at all, when you get the new one you get this tube. You just push that on there, because my hands been so rough it takes me some time but my son usually comes in and pushes it right in and that's it, you're set.
>
> > Female, 65 yrs old, used a nebuliser for 10 yrs

With regard to attaching the nebuliser cap back onto the medication tank, one patient described an incident where the cap was not fitted correctly back on the medication tank and consequently suffered a leakage.

> That is the one big weakness on these (nebulisers), is that if you slightly over tighten (the cap), it will snap it
>
> > Male, 60 yrs old, used a nebuliser for 1.5 yrs

Additionally, with regard to fitting the facemask back onto the nebuliser cap, four patients had their facemask fitted inverted which resulted in drug depositing on face and in the eyes causing side effects, and aerosol loss to the surrounding atmosphere. None of the patients experienced any problems with operating the compressor (plugging it in to the mains and/or press the power button).

Filling the drug fluid

With regard to filling the medication, all patients but three prepared the drug immediately prior to use. Six patients reported experiencing problems with performing this step. The two reasons identified were confusion about which formulation to use, and the physical

and functional limitations of the patient (poor grip and eyesight problems). In these cases the patient had to rely on carers for help. Difficulties were also described in context of opening vials as one patient commented on the difficulty of opening some vials but not others, this patient preferred one brand over another for their relative ease in opening.

> Now the other thing I wanted to say the different makers and some of them I find quiet difficult to twist to separate. Not this, not this lot now this is...they're easy, I can do them quite easy, that's fine. I just tested to show you but I've had ones that are quite difficult, that I have to go off and get help, these are easy....
>
> Male, 74 yrs old, used a nebuliser for 10 yrs

Additionally, one patient described filling the medication the wrong way when he first started to use the nebuliser. This patient described his learning experience as one of 'trial and error'.

> I put it in the wrong way... first of all when I first started using it; it was a bit of trial and error...
>
> Male, 70 yrs old, used a nebuliser for 2 yrs

Diluting the drug formulation

Diluting the drug formulation results in increasing the volume required to be nebulised and increases the duration of nebulisation. This can be a desirable option for those patients who would like to run their nebulisation session over a longer period of time to achieve more relief. Conversely, it could be an unattractive option for those patients who felt that a long duration of the nebulisation was troublesome and inconvenient. Dilution is required for some nebuliser designs with residual volume > 1ml, and with all ultrasonic nebulisers. The majority of patients in this study were using modern compressor nebulisers with a residual volume of < 1ml (n= 29) and were therefore not required to dilute the drug formulation before use. Despite this, two of those patients were still diluting their medication. For them the time taken to nebulise their medication was not a concern (20 and 15 minutes). However, one patient was identified in this study using a VixOne™ Nebuliser, Devilbiss, USA, which had a residual volume > 1ml (according to the manufacturer data sheets). This patient reported that he only sometimes diluted the drug formulation, and did not know why a dilution was required. He described being confused about the fact that it was not done in hospital. In his case, this is an issue of concern, as failure to dilute the drug formulation, means that he is only receiving a fraction of the

prescribed dose. The patient was also confused about the amount of saline which should be used for dilution.

> They're a big tube (saline) and you take it by injection 2 ml or 2.5 ml and put it in there (the chamber) and use it. But I have no idea why it is this amount, no idea, even the doctor never told me.
>
> Male, 75 yrs old, used a nebuliser for half a year

Further confusion about the need or the reason to dilute the fluid was shared by many patients in this study; one patient thought the dilution was to mask the nasty taste of her medication, while another patient was substituting saline with distilled or boiled water in his nebuliser. Additionally, one patient was found to be using expired saline vials. This patient did not feel it was a problem as they were completely sealed, and was wondering if she could use her irrigation solution (prescribed for her leg wound) in her nebuliser.

It was not possible to comment on the appropriateness or whether a dilution was necessary for the patients who were using a nebuliser chamber of unknown residual volume (n=3). Two of those patients were concerned about the long duration of nebulisation. The need for dilution and the inconvenience of this step can be eliminated for those patients if this was unnecessary. This can be determined by identifying the residual volume for the nebuliser used by those patients. If this was not feasible an alternative option for those patients is to change their nebuliser chamber to a newer model with a known residual volume of < 1ml (one that does not require dilution). In addition, one patient who was using Colistin antibiotic was diluting his medication with 2 ml of saline, which was appropriate in his case (British Medical Association and Royal Pharmaceutical Society of Great Britain, 2011).

Compatibility issues

Drug admixtures

Compatibility of drug formulations should be checked by the prescribing doctor if two formulations are prescribed for the patient, as certain drug mixtures are known to be chemically unstable when used together. If drugs used by the patient were compatible, it is advisable to mix the drugs together (given that the mixture is tolerated and no side effects occur) which will reduce the overall time needed to nebulise the medication and improve

compliance to therapy among older people. The drug formulations used with the nebuliser system were recorded for all patients in this study (Chapter 3). In this study almost half of the patients were found to be using combined therapy, two of which were using Combivent 2.5mg/2.5ml (a pre-combined preparation of albuterol and ipratropium bromide). None of the patients were found to be using incompatible drug formulations. Drug combinations used are shown in Table 4.6.

Table 4.6: Drug combinations used by patients in this study

Drug combinations used	Patients (N)
salbutamol + ipratropium Br	23
budenoside + combivent (albuterol + ipratropium bromide)	1
budenoside + salbutamol	1

Of those patients who used two formulations, all except one, reported mixing the drug formulation together in the nebuliser chamber based on their doctor's advice, or the severity of their symptoms. Only one patient who was using two drug formulations (salbutamol and budenoside) reported using the drug formulations separately, the patient has been doing so based on the advice of his own doctor, he stated that he would nebulise the salbutamol solution first, then shake anything remaining in the chamber after use, before filling the budenoside preparation.

> I said to the doctor when I went up and saw him for something or another and I said - is it alright to mix them? And he said no, use them separately.
>
> Male, 75 yrs old, used a nebuliser for 2yrs

Drug – nebuliser compatibility

Information about the class of drugs being used by the patients, and the type of nebulisers they used were gathered in this study and previously reported in Chapter 3. Most jet nebulisers are suitable to nebulise bronchodilators, however, certain nebuliser chambers (such as the Sidestream), and ultrasonic nebulisers are not suitable to nebulise corticosteroid suspensions. Based on the manufacturer's recommendations for the types of nebulisers used by patients in this study, the suitability of the nebuliser to be used for the drug preparation was investigated for all patients. All patients were using jet nebulisers, and the majority of patients were using bronchodilators; beta 2 agonists (all patients were prescribed salbutamol) (n= 47), and anticholinergics (all patients were prescribed

ipratropium bromide) (n= 24). Few patients were using corticosteroids (budenoside) (n = 3) and only one patient was using an antibiotic (colcimycin). With regard to the compatibility of the drug preparation with the nebulisers being used in this study, and based on the manufacturer recommendations for the type of nebulisers being used, all patients were found to be using an appropriate nebuliser. However, there is little evidence to believe that this was a planned step. Information from a healthcare professional or technical advice on the type of the nebuliser system was rarely communicated to the patient prior to purchase. This will be discussed further in section 4.4. For instance, one female patient who was prescribed budenoside nebules mentioned that her healthcare team never enquired about her nebuliser. However, she was found to be using the Ventstream nebuliser (Medix, UK) and according to the manufacturer's recommendation was suitable to nebulise corticosteroids.

> No they've never mentioned (the nebuliser); they don't even know that I've got one. They never said do you want one, or can we get you one. It's never been mentioned and we had to pay for it. I was told I couldn't get it on the National Health, so we had to pay and nobody every queried...
>
> Female, 76 yrs old, used a nebuliser for 2.5 yrs

Nebuliser – compressor compatibility

The nebuliser design and compressor model was noted for all patients in this study and a photo was taken to assist in identifying uncommon types and models which were used by some patients. Additionally patients were asked whether the nebuliser chamber was the original one supplied with the equipment, or in cases where it has been replaced, they were asked if it was identical to their original one. The findings were validated with the photos. Leading nebuliser system manufacturers recommend that their compressor is used with the marketed nebuliser. The reason for this is that the majority of the quality control tests conducted by the manufacturer are based on this combination. Therefore, using a different nebuliser means that the amount of the nebulised dose reaching the airways is unknown. The nebulisers and the compressors used by the patients in this study were described in Chapter 3. In terms of nebuliser – compressor compatibility, half of the patients were using a nebuliser – compressor combination which was different than the one recommended/marketed by the manufacturer. When patients were asked whether they thought using a different nebuliser than the original one mattered, there was lack of understanding on that aspect.

I'm not sure, can't say whether that would [make a difference] without having one. It would probably be similar... I mean it's similar to the size that they got in the hospital you know, because they just put the oxygen onto it in the hospital. But it's a possibility I don't know I never looked at that.

Male, 78 yrs old, used a nebuliser for half a year

4.3.2. Problems occurring during inhalation of the nebulised dose

All patients (50) were asked to demonstrate and describe their inhalation technique. The patients were asked to demonstrate how they: fitted the facemask on their face or in case the patient was using a mouthpiece; they were asked how they held the mouthpiece in their mouth and inhaled their nebulised dose. The patients were observed by the researcher while they demonstrated their inhalation technique, and recorded the steps performed incorrectly by the patient in a step-by-step checklist developed for the purpose of this study (Chapter 2). The problems encountered by the patients while performing these activities are given in Table 4.7. The themes identified from the patients accounts are described in relation to: the patient/device interface, leakage of drug fluid during nebulisation, concerns about the safety of aerosol cloud and feeling claustrophobic from the facemask, drug loss to the surrounding atmosphere, poor inhalation technique and breathing pattern, the duration of the nebulisation session and defining an end point for nebulisation.

Table 4.7: The problems encountered by COPD patients during inhalation of the nebulised dose

Theme	Description of step performed incorrectly	N (50)
Patient/device interface	Failure to fit the face mask/holds the mouth piece *	6
Inhalation technique	Failure to sit in an upright position *	2
	Failure to breathe in from the mouth *	17
Breathing pattern	Failure to breathe in slowly *	23
	Failure to breathe in as deeply as possible *	28
	Failure to hold breath for few seconds before exhaling *	39
NT	Failure to define an end point to stop nebulisation	5

Steps highlighted in **BOLD** are essential steps and are likely to result in a reduced drug output (*).

The patient/device interface

The patient is required to fit the facemask by tightening securely it around the face, or when using a mouthpiece, by placing it in the mouth, holding it between the teeth, with the tongue positioned under the mouthpiece, and the lips sealed around it. Failure to perform this step correctly results in drug aerosol escaping to the surrounding atmosphere which reduces the amount of inhaled dose and potentially the effectiveness of the medication. Additionally, a loose fitting facemask can result in aerosol deposition on the face and in the eyes causing side effects. As previously described (Chapter 3), 40 patients were using facemasks in this study, while 10 were using mouthpieces. With regard to fitting the facemask, six patients were identified as experiencing problems with this task. Of those, two patients attached the mask inverted on the nebuliser cap, and consequently could not fit it properly on their face. Holding the facemask with the hand instead of fastening it securely on their face was identified in three cases. Holding the facemask in the hand was

regarded easier in one case, while in two cases, the patient was using a facemask with a missing elastic band which secures the mask to the head. Moreover, the elastic band was found to be stretched in another case, which can be explained by inadequate replacing of the disposable parts, and one patient was using safety pins to repair an over-stretched band and secure the mask on his face.

In terms of the patients' preference to the type of interface, five patients preferred using the mouthpiece, for their relative ease of use and the ability to synchronise their breathing with aerosol output compared to the facemask.

> I find even the oxygen's a menace, because you can't control it. What happens is it's pumping into your mouth all the time, whereby with this you are breathing it in and out. This one you can control, the facemask you can't. And it's the same with the oxygen. You can't control the oxygen.
>> Male, 77 yrs old, used a nebuliser for 15 yrs

Some patients preferred the facemask and gave similar reasons (n = 6). Other reasons for preferring the facemask were: feeling more secure with the mask on, and a more natural way to breathe.

> I just feel more secure with it over. I just didn't feel as though it was doing me any good at all, just in the mouth.
>> Female, 59 yrs old, used a nebuliser for 1 year

Accordingly, healthcare professionals should take the patients' preference and ease of use into consideration and patients should be given a choice of accessory to use with their nebuliser.

Leakage of drug fluid during nebulisation

Some patients described suffering leakage during nebulisation which affects the amount of drug available for inhalation. Leakage occurred at the medication chamber/ tubing (n = 3), or the medication chamber/cap joint (n = 3). Leakage at the chamber/tubing joint can be explained by using over-stretched tubing, while leakage at the medication chamber/cap joint can be explained by using a cracked nebuliser cap or incorrect assembling of the parts.

> Well it tends to stretch at the end and it goes too far do you know what I mean onto the chamber so you get a leakage.
>> Female, 76 yrs old, used a nebuliser for 3 yrs

> If you over tighten it or once it's split then while you're using it, it tends to go over the top and run down and you end up with a pool on the floor and it's less efficient that way.

> Male, 60 yrs old, used a nebuliser for 1.5 yrs

Additionally, two patients described incidents of the tubing popping out during nebulisation (n = 2), which can be explained in both cases by the use of over-stretched tubing.

Concerns about the safety of the aerosol cloud and feeling claustrophobic

Ill-fitting facemasks can result in drug being deposited on the face and in the eyes causing side effects, which is a particular concern when inhaled steroids or when anticholinergics are prescribed for a patient with glaucoma. Some patients expressed concerns about the safety of the aerosol cloud depositing on the face and getting into the eyes (n = 3).

> I can't use a face mask... I use a mouth piece... I was allergic and my eyes come up and my face comes up, so I use the mouth piece.
> Female, 76 yrs old, used a nebuliser for 10 yrs

Another problem reported was feeling 'closed in' and claustrophobic with the facemask covering the entire face (n = 3).

> I didn't' like using it very much... I found it a bit claustrophobic on your face.
> Female, 77 yrs old, used a nebuliser for 1 yr

Drug loss to the atmosphere

Drug loss to ambient environment can considerably reduce the amount of drug available for inhalation and is a major disadvantage of nebulisers with constant output designs. Breath-enhanced and dosimetric nebuliser designs offer advantage over conventional nebuliser designs by enhancing drug output during inhalation and minimising drug loss to the atmosphere (Chapter 1). The majority of patients in this study were using conventional nebuliser designs which constantly emitted aerosol (n = 36). Consequently, concerns about drug escaping to the atmosphere and drug loss was expressed by some patients (n = 6).

These patients adopted strategies to minimise drug loss by turning the machine on and off, or using their fingers to stop vapour escaping the medication chamber during exhalation.

> One of the things that does concern me, of course, is every time you breathe out you are throwing half the medication away, but then, whether you are using the one at the hospital or otherwise, when you breathe in you are getting it, when you breathe out you are breathing all that out as well, unless you try to stop it, which is difficult to do. Occasionally I put my finger over this (the opening of the nebulise cap)
>
> Male, 80 yrs old, used a nebuliser for 10 yrs

Only two patients were using nebulisers incorporating a manual interruption valve which can be used by the patient to interrupt nebulisation if necessary.

> If it's coming out too fast for me to handle it, I regulate it with this valve. It's got a little valve there, and the more you shut it the slower it goes.
>
> Female, 58 yrs old, used a nebuliser for 20 yrs

Inhalation technique and breathing pattern

To maximise drug deposition in the lungs, the patient is required to sit in an upright position and breathe from the mouth. Nose breathing results in drug being deposited in the nasal airway which may reduce the amount of drug reaching the lung. Taking deep breaths and breathing at a slower rate increases drug deposition. Conversely, a shallow breathing pattern reduces the amount of drug deposited in the lung. Moreover, holding the breath for few seconds, if possible, before exhaling increases drug deposition in the lungs. With regard to inhalation technique, all patients except for two, reported sitting in an upright position during inhalation of the nebulised dose. Despite doing so, these patients did not seem to have a clear understanding of the importance of this technique other than being more comfortable in this position. One patient described trying different manoeuvres to enhance inhaling the medication.

> I tend to sit in an easy chair, more like that, because I am more relaxed, but as it comes towards the end there's more, you can get more by either sitting up, or even moving forward a bit. So initially I am very pleased to sit back and relax, and then move forward, because then it seems to be more effective to get it out.
>
> Male, 80 yrs old, used a nebuliser for 10 yrs

Only six patients who were using facemasks were mouth breathing, while the majority were either nose breathing (n = 17) or breathing through mouth and nose (n = 18). Clearly, patients who were using a mouthpiece were breathing through their mouth. However, in

one case, the patient was found to be breathing from his nose despite using a mouthpiece which resulted in not getting any of his nebulised doses. A few patients recognised the advantage of mouth breathing over nose breathing.

> Going through the nose isn't as good as the mouth, because you've got all those millions of little hairs up there that filter the air when you breathe. I mean, if you are out in the desert, for instance, or anywhere like that, on a dusty day, and you breathe in, then your nose is a filter, you breathe in through your nose. They say, if it's dusty, don't breathe through your mouth, and your nose is a filter. So it's best, when you are using that, not to have a filter. So I breathe through the mouth.
>
> Male, 75 yrs old, used a nebuliser for 2 yrs

With regard to the breathing pattern, only a few patients reported breathing slowly (n = 12). The patients explained that breathing at a slower rate is not always possible, especially when their chest is tight.

> The first couple of minutes you are gasping, so you are breathing fast, and then you've got to learn to regulate your breathing. That's what I've been trained to do by the physiotherapist, and the doctors.
>
> Male, 68 yrs old, used a nebuliser for 4 yrs

A significant number of patients reported breathing deeply (n = 20), although in most cases the patients were not instructed on how to breathe, the patients still recognised the importance of deep breathing.

> The other thing I try to do, normally, although I breathe normally, I do at the beginning try to breathe well out and take a very deep breath and hold on to it.... Nobody ever said do so, it just seems to me that if you breathe very shallowly there's some part of the lung that isn't getting the medication, and it probably ought to.
>
> Male, 80 yrs old, used a nebuliser for 10 yrs

Holding the breath prior to exhalation was only performed in a few cases (n = 6). The majority of patients reported experiencing difficulties with holding their breath especially during severe attacks.

> It depends if my chest is tight, if my chest is tight then I do (hold breath) momentarily, but I can't always hold it very long you know so yes sometimes but not always.
>
> Female, 67 yrs old, used a nebuliser for 10 yrs

The duration of the nebulisation session

Ideally and depending on the volume used in the nebuliser chamber, the nebulisation session should last between 10 – 15 minutes; nebulisation times up to 20 minutes are usually acceptable to the patient. Longer nebulisation times can affect compliance and are usually associated with inadequate compressor maintenance and might indicate compressor malfunction. With regard to the duration of nebulisation, the time reported by the patients ranged from 2 minutes to 40 minutes. Most commonly, the patients reported a nebulisation time between 10 and 15 minutes (n= 21). In some instances a long nebulisation time of > 20 minutes was reported (n=4). Moreover, some patients interrupted their nebulisation and resumed the session at a different point in time (n= 8). The time taken before the session was resumed varied from 2 hours to 24 hours. Interruption was mainly due to the inconvenience of a long nebulisation session (n = 3).

> It's a nuisance, sometimes; you have to sit so long with it you know. I could be doing so-and-so-and-so-and-so. And if they want to go out or something (the dogs) or they are trying to get out in the garden, it's a damn nuisance. But I just stick it on there and turn it off and let them out, and then come back and put it on again.
>
> Female, 76 yrs old, used a nebuliser for 5 yrs

Other reasons given by the patients for interrupting the session were: coughing (n = 1), suffering a blocked nose (n = 1) and forgetting to come back on the nebuliser after a brief interruption (n = 1).

> Well, I tend to use it on and off rather than in one straight go because I find that after maybe a minute or half a minute using it then I have to clear my throat and my nose because at the same time as the emphysema I suffer, my nose blocks up very quick which makes it difficult for breathing so until I clear my nose I can't clear my chest so I have to use it in small doses probably over a 20 minute period.
>
> Male, 60 yrs old, used a nebuliser for 1.5 yrs

The patients identified factors which impacted on the time taken to nebulise the dose such as; the volume of the drug fluid used. This was described in terms of the number of formulations being used (n= 3), or whether the formulation was diluted, which in turn increase the volume of fluid need to be nebulised (n = 1), the condition of the compressor (n = 4), the condition of the facemask (n = 1), the breathing pattern (n = 1), and the weather (n= 1).

<u>Defining an end point for the nebulisation session</u>

The patients were required to define an end point at which they should end their nebulisation, which is usually guided by the sputtering sound which occurs towards the end of nebulisation. At this point, the patients had to tap the chamber a few times to get the remaining fluid in the chamber, and stop the session when the vapour stops. With regard to defining an end point for nebulisation, the majority of patients identified an end point to stop the nebulisation session (Table 4.8). However, a few patients mentioned they would tap the medication chamber towards the end of the session (n= 7).

> Because the fluid inside, it goes in here, because it throws it up all over the place, so if you knock it you'll get all the fluid down. So I knock it and knock it and knock it hold it on one side, and if there's no fluid in the bottom I'm finished. If there's any fluid in the bottom I just keep doing it until it's all gone.
>
> Female, 58 yrs old, used a nebuliser for 20 yrs

Table 4.8: End points defined by the patients to stop the nebulisation session

End point to stop the nebulisation session	Number of patients (N)*
On emptiness	30
Sputtering sound occurs (change in sound)	15
Vapour stops	8
Knows when/had timed it before	3

* In some cases more than one endpoint was defined by one patient.

4.3.3. Problems occurring after inhaling the nebulised dose

All patients (50) were asked to demonstrate and describe how they dismantled, cleaned, and dried the nebuliser parts after nebulisation. Additionally, they were asked to indicate the frequency with which they replaced the nebuliser parts and serviced the compressor. The patients were observed by the researcher while they demonstrated their cleaning and drying techniques, and recorded the steps performed incorrectly by the patient in a step-by-step checklist developed for the purpose of this study, comprising steps required to be performed correctly to accomplish each activity (Chapter 2). The problems encountered by the patients while performing these activities are given in Table 4.9. The themes identified from the patients' accounts are described in relation to activities: dismantling the nebuliser parts, discarding the remaining residual liquid, cleaning the nebuliser system, maintaining the nebuliser system, and problems encountered with other types of nebuliser systems.

Table 4.9: The problems encountered by COPD patients after inhaling the nebulised dose

Theme	Description of step performed incorrectly	(N)
Dismantling	Failure to switch off the compressor	0
	Failure to detach the nebulizer from the tubing	9
	Failure to dismantle the nebuliser (cap/medication tank/vaporiser head)	14
Cleaning	Failure to wash hands before handling the drug	45
	Failure to run the machine for some time with saline/empty *	44
	Failure to rinse the parts (except the tubing) under hot water after use *	31
	Failure to disinfect the parts (except the tubing) with a suitable disinfectant once a day *	46
	Failure to wipe the compressor and tubing at least once a day with a damp cloth	34
	Failure to discard the remaining drug solution *	16
	Failure to re-assemble and place the nebuliser in a clean bag/tubing placed inside compartment	28
	Failure to close the lid when not in use	15
Drying	Failure to leave the parts to dry on a clean tissue	20
	Failure to run the machine until no moisture remained in the tubing	42
	Failure to hang the tubing to dry	32
Equipment misuse	Failure to place the equipment on a flat surface	16
	Failure to place the equipment at least 4 inches away from any other equipment	27
Maintaining	**Failure to replace the tubing according to manufacturer's recommendations ***	36
	Failure to replace the nebuliser according to manufacturer's recommendations *	37
	Failure to replace the face mask/ mouth piece according to manufacturer's recommendations *	36
	Failure to check the filter monthly and to replace it according to manufacturer's recommendations *	37
	Failure to service the equipment annually and to check it for any electrical fault *	39

Steps highlighted in **BOLD** are essential steps and are likely to result in a reduced drug output (*).

Dismantling the nebuliser parts

After inhaling the nebulised dose and upon completion of the nebulisation session, the patients should switch off the compressor, dismantle the components of the nebuliser system by disconnecting the nebuliser chamber from the tubing, and disconnecting the components of the nebuliser chamber (facemask/mouthpiece, nebuliser cap, vaporiser head). Dismantling the different parts of the nebuliser chamber is necessary to ensure

adequate cleaning of the parts. Failure to clean the parts properly results in drug residue being left in the chamber and around the vaporiser head, which affects the nebulisation of the drug in subsequent nebulisation sessions, consequently leading to treatment failure due to sub-therapeutic dose being delivered to the patient's lungs. With regard to dismantling the parts, a third of the patients did not dismantle their nebuliser chamber after use (n = 14). Most of those patients would clean the nebuliser kit as a unit by running water through the opening of the mask or the nebuliser cap, shaking it, and emptying of water (n= 11). Manual dexterity was the commonest reason given by the patients for failing to dismantle the parts.

> I had terrible trouble because this (tubing) used to pop off. My hand wasn't strong enough to push it together and so now that's it's on I don't wash this at all. I found once it comes off, I find it hard to get back on.
>
> Female, 75 yrs old, used a nebuliser for 10 yrs

Discarding the remaining residual liquid

After dismantling the nebuliser chamber parts, any remaining residual liquid should be discarded by the patient and never kept or re-used again. Depending on the nebuliser chamber used, the amount remained in the chamber after nebulisation varies. Most modern nebuliser designs had a residual volume < 1ml (Chapter 1). The majority of patients were using a nebuliser chamber design of specifications < 1ml of residual volume. In most cases patients stated that they ran the nebulisation session until dryness was reached and no residual volume was left in the chamber. However, in instances where some residual liquid was found after visually inspecting the chamber, the patient resumed the nebulisation session until no more liquid was left in the medication chamber. Instances identified where the residual liquid remained in the chamber are shown in Table 4.10.

> There's generally no liquid left in there. If it's not completely empty I put it back on again and switch the machine back on again until it is empty.
>
> Male, 83 yrs old, used a nebuliser for half a year

Table 4.10: Instances of residual liquid remaining in the nebuliser chamber

Instances	Patients (N)
Patients using a nebuliser chamber design with unknown RV.	18
Patients fail to tap the nebuliser chamber towards the end of the nebulisation.	7
Patients fail to define an end point for nebulisation/ interrupt nebulisation session, and resume it at a different point in time.	5
Patients using a nebuliser chamber design with > 1ml RV.	1

Many patients reported not discarding the remaining residual liquid (n= 16). Moreover, as previously described, some patients interrupted the nebulisation session for one reason or another (n = 8). This action resulted in the patient using a medication that has been in the nebuliser chamber for a time which ranged from 2 hours to 24 hours in two cases, which may affect the stability of the drug formulations and can be a risk for contamination. In one case, the patient recognised the importance of discarding any remaining liquid despite admitting re-using the residual liquid in the past.

> Because you are not supposed to use this stuff, once you've used it you are supposed to empty it. You are not supposed to keep on using it, the same stuff, don't know enough about it, but that seems to be the case. They warn you, don't use, once you've used it, discard it.
>
> Female, 76 yrs old, used a nebuliser for 5 yrs

Cleaning the nebuliser system

After dismantling the parts, and discarding the remaining liquid in the nebuliser chamber, the patients should follow the manufacturer's cleaning instructions. Inadequate cleaning and drying affect the performance of the nebuliser and can lead to sub-therapeutic outcomes as well as being a risk for infection. Most manufacturers recommend the parts be cleaned after each use with warm soapy water and are disinfected/boiled at least once a week. Some manufacturers recommend the nebuliser is run empty or with saline for some time after use. However, the majority of the patients did not adhere to the manufacturer's recommendation with regard to washing the parts in warm soapy water after each use (n = 34) (Tables 4.11- 4.12). The majority of the patients never disinfected the nebuliser parts (n = 46) (Table 4.13), and only a few patients ran the machine empty or with saline for some time after use.

Table 4.11: Frequency of cleaning

Frequency	Patients (N= 50)		
	Facemask/mouthpiece	Chambers	Tubing
After each use	19	20	18
*Daily	10	7	-
Alternate days	2	2	-
Twice weekly	4	5	-
Weekly	9	9	-
Monthly	3	4	-
Never	3	3	32

* Daily refers to the patients who reported cleaning their nebuliser by the end of the day, which depending on their dosage frequency either be after 2, 3 or 4 uses (n = 7, 1, and 1).

Table 4.12: Method of cleaning

Method of cleaning	Patients (N = 50)
Warm soapy water	16
Tap water	9
Warm water	6
Cold water	2
Hot water	4
Boiling water	4
Tissue	3
Never cleaned it before	3

Table 4.13: Method of 'sterilisation'

Method of sterilisation	Patients (N = 50)
Boil it	2
Using lime scale tablets	1
Detergent or commercial disinfectant solution	1
Never sterilised it before	46

After cleaning the parts, they should be left to dry naturally, and packed away in a clean bag. With regard to the tubing, it should be air blown with the compressor after each use to get rid of retained moisture. However, many patients never dried the parts after cleaning (n = 15) (Table 4.14), less than half of the patients packed away the nebuliser parts in a clean bag after use (n = 22), and only a few patients dried the tubing by air blowing it with the compressor (n = 8).

> And that's dry, but inside there, that is misty, inside, where the tube goes. And if you do that it doesn't clear, but if you go the other way you can blow it all down and clear it and dry it. You can blow it out with the nebuliser; you can blow it out and dry it with the nebuliser.
>
> Male, 75 yrs old, used a nebuliser for 3 yrs

Table4.14: Method of drying the disposable parts

Method of drying	Patients (N)
With a cloth or tissue	5
Drain it or leave it to dry naturally	27
Blow it or air dry it with the compressor	3
Never dried it before	15

The manufacturer recommends that the compressor should be wiped with a damp cloth and kept closed when not in use. However, only a third of the patients wiped the compressor after use (n = 16), and less than half of the patients closed the compressor lid when not in use (n = 21). Additionally, the majority of the patients never washed their

hands prior to handling the drug (n = 45), and three patients shared the nebuliser with another member of the family.

As a result of inadequate cleaning, dirty masks (n = 12), medication chamber with evidence of crystallisation inside (n = 5), blocked tubing (n = 3) and stained compressors (n = 19) were identified (Figures 4.1 -4.4).

Figure 4.1: Dirty facemask
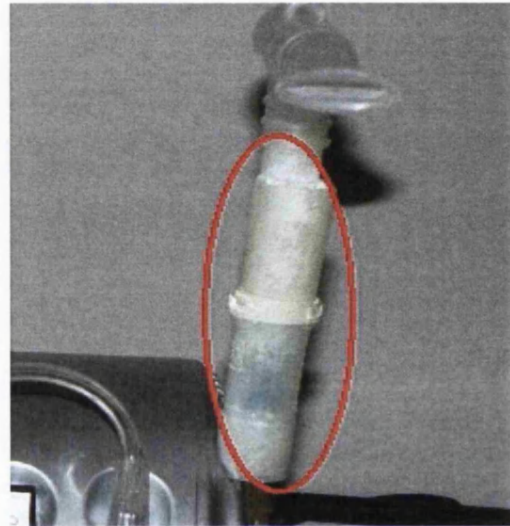
Figure 4.2: Residues in medication chamber
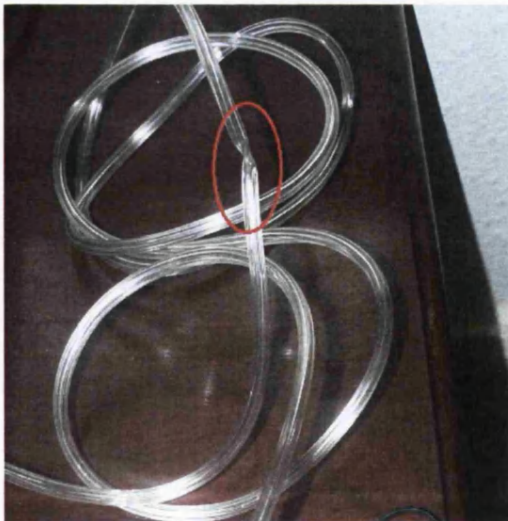
Figure 4.3: Blocked tubing
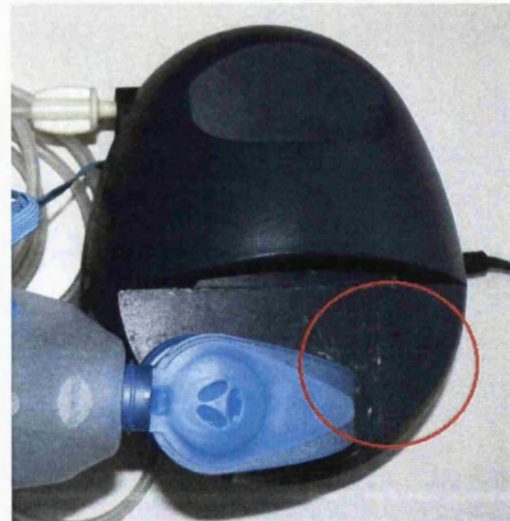
Figure 4.4: Stained compressor

<u>Maintaining the nebuliser system</u>

Inadequate maintenance of the nebuliser parts affects performance and may lead to sub-therapeutic treatment outcomes. Most nebuliser manufacturers recommend that the facemasks/mouthpieces, and the tubing are replaced every 3 months with daily use. Disposable nebuliser chambers should be replaced every 3 months, while durable chambers can last up to a year if adequately cleaned. The filters should be checked monthly and replaced if discoloured, and the compressor should be serviced annually and checked for electrical fault.

The majority of the patients failed to adhere to the manufacturer's recommendation with regard to replacing the nebuliser parts (Table 4.15). Additionally, seven patients who were using the Sidestream (Clement & Clarke, UK) disposable nebuliser failed to replace the nebuliser every 3 months as recommended. Additionally, as previously shown (Section 4.3.2) some patients had a long nebulisation time which can be a sign of compressor malfunction as a result of inadequate servicing (Table 4.15).

Table 4.15: Frequency of replacing parts and servicing the compressor

Frequency	Patients (N)*				
	Facemask/mouthpiece	Chambers	Tubing	Filter	Compressor
Weekly	-	-	-	-	-
Monthly	2	2	2	2	-
3 monthly	6	5	4	3	-
6 monthly	4	4	3	1	-
Annually	3	3	3	-	9
Discoloured/damaged	10	9	13	11	2
Never	24	26	21	31	39

* 1 patient will replace the all the parts after 2 or 3 uses, and 1 patient was found to be using the nebuliser system without the outlet/inlet filter.

Different reasons were articulated by the patients for adopting inadequate maintaining procedures.

> I'm happy with it. Well I can't see the need to change it when it's working I mean are there more modern ones they give a better (flow).... I mean nobody tells me that.

> Female, 75 yrs old, used a nebuliser for 5 yrs

I've never done the filters, I must admit. I've never bothered a great deal with them because there seems to be a flow you know, a good flow of air, but I realised that it should be something that I looked at, because I've got no instructions on the thing because it doesn't belong to me (not supplied by healthcare system).

Male, 83 yrs old, used a nebuliser for half a year

Well, I haven't used it enough to worry about. I've only had the one session and then I've left it, and this is the second time. The air products people tell you that that it should be replaced If you use it all day and every day. It should be replaced every month.

Male, 75 yrs old, used a nebuliser for 1 year

As a result of inadequate maintaining, the patients either over-used some parts or used damaged parts which may affect the performance of the nebuliser system. Damaged or overused parts identified were: facemasks with overly stretched elastic bands (n = 5), compressors with a broken lid (n = 2), cracked nebuliser cap (n = 2), damaged/discoloured tubing (n = 13), damaged/discoloured mask (n = 5), damaged/discoloured chamber (n = 9) and discoloured filters (n = 11) (Figures 4.5 – 4.8).

Self-repair of damaged parts was attempted by some patients. Instances identified such as: repairing the compressor lid by fastening it with a string (n = 1), wrapping adhesive tape around a cracked nebuliser cap or chamber (n = 2), cutting off the damaged part of the tubing (n = 2) and using pins to secure the elastic band of facemasks (n = 1). Wrapping tape around the nebuliser cap or the chamber resulted in inadequate cleaning of the part, cutting the tubing resulted in failing to connect it back to the compressor, and using pins can result in an ill-fitting facemask. Additionally, there was evidence of equipment misuse in the data such as: the equipment not placed 4 inch away from other objects (n = 27), the compressor being used on the floor/couch to minimise noise (n = 16), the compressor being covered with a blanket during use (n = 3), the compressor is 'holed' to reduce operating noise (n = 1). Photographs showing signs of inadequate maintaining and equipment misuse are given in Figures 4.9 – 4.12.

Figure 4.5: Compressor with a broken lid
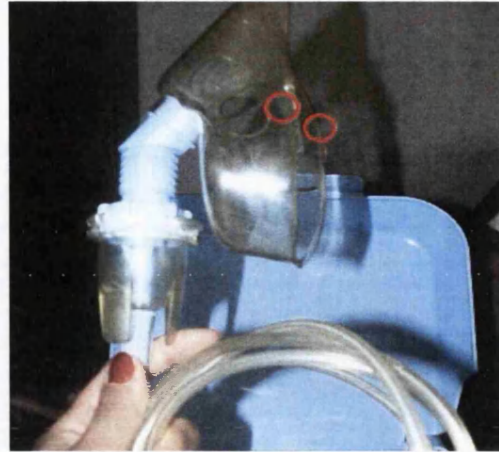
Figure 4.6: Facemask with missing elastic band
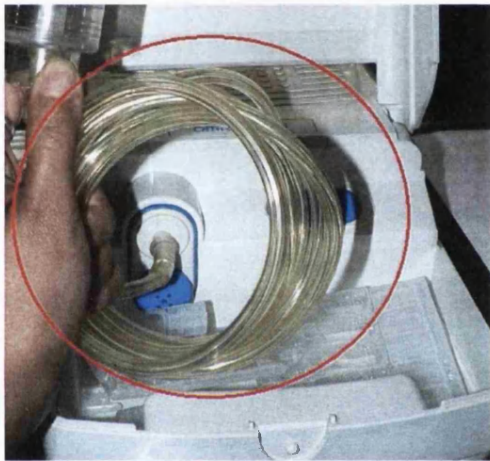
Figure 4.7: Discoloured tubing

Figure4.8: Discoloured nebuliser chamber

Figure 4.9: Use of safety pins to repair band

Figure 4.10: Use of tape to repair nebuliser
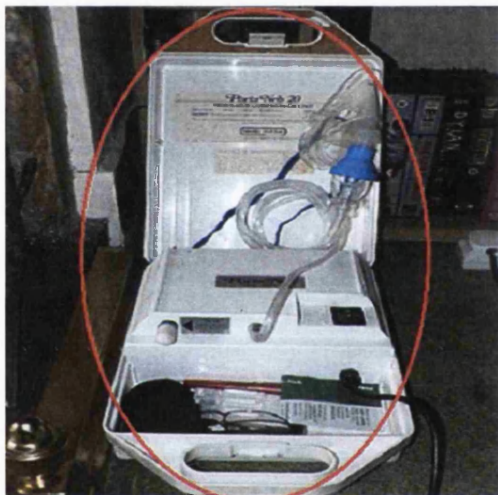
Figure 4.11: Compressor placed on the floor
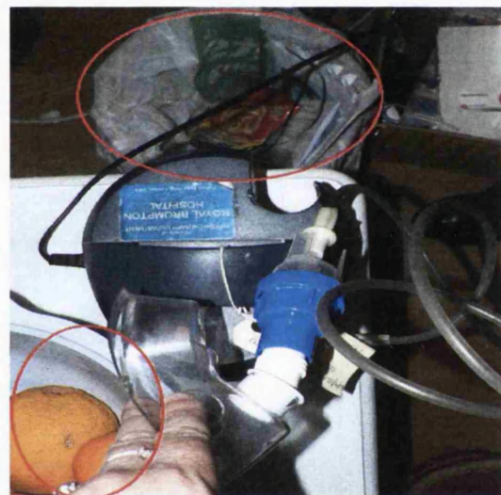
Figure 4.12: Compressor placed close to other objects

Problems encountered with other types of nebuliser system

In addition to the problems identified with conventional nebuliser systems which uses compressed air as the driving force to nebulise drug fluid, problems were also reported in relation to other types of nebuliser systems such as those incorporating vibrating mesh technology or using high frequency (ultrasonic nebulisers) as the driving force to nebulise the drug fluid (n = 3).

> When you switch them on (ultrasonic nebuliser) a light comes on to say they are working, but when you switch them on now the light doesn't come on and no vapour comes out.
>
> Male, 80 yrs old, used a nebuliser for 10 yrs

> You put the medication in the plastic cone, and I'm not sure that the plastic cone would be enough to take both of those (the nebules), I think it will only take the single dose.
>
> Male, 80 yrs old, used a nebuliser for 10 yrs

4.3.4. Predictors of the problems encountered by COPD patients with the use of nebuliser therapy

Data obtained from the checklist for all patients (50) were entered into SPSS, version 18, and analysed descriptively. The frequency of the problems encountered with using nebuliser therapy was estimated and reported for the three stages: prior to inhaling the nebulised does, during inhalation of the nebulised does, and after inhaling the nebulised does. The association between various demographics and clinical characteristics (collected from the patients' medical records and during the interviews) and the frequency of problems was investigated using bivariate analysis. The one way analysis of variance ANOVA was used for > two categorical variables, the independent T-test was used for two categorical variables, and the simple linear regression test was used for continuous variables. To meet the assumptions of normality, it was necessary to transform certain variables before applying the statistical test (Chapter 2). Relevant significant variables (p value < 0.05) from bivariate analysis were entered into a multiple regression model to investigate the variables which predicted the overall problem score. Preliminary assumptions were tested and met before conducting multiple regression model (Chapter 2).

The frequency of the problems

The analysis of the checklist revealed that all patients failed to perform one or more steps correctly (50/50, 100%), and ten patients failed to perform half of the steps correctly (10%, 10/50). The total number of steps performed incorrectly by the patients ranged from 5 to 25 (Mean 15). The frequency of the problems for the overall process of nebulisation and for each stage in relation to the inhalation of the nebulised dose is shown in Table 4.16. Only three patients assembled and filled the drug correctly (prior), seven inhaled the drug correctly (during), while none adhered to cleaning and maintaining their nebuliser system (after).

Table 4.16: The frequency of problems encountered at each stage of inhalation

Stage of inhalation	N	Minimum	Maximum	Mean	Std. Deviation
Prior	50	0	4	2	1
During	50	0	5	2	1
After	50	3	19	11	4
Total	50	5	25	16	5

The factors associated with the problems

Only 4 variables out of 31 variables tested reached statistical significance indicating association with the total problem score: patients with higher number of hospital admissions had a higher problem score (r = 0.27, 95% CI = -0.0 to – 3.37, p = 0.05), patients with higher impact score reflecting greater impairment of quality of life had significantly more problems (r = 0.27, 95% CI – 0.00 to 0.14, p = 0.05), patients who used facemasks had significantly more problems than their counterparts who used mouthpieces (95% CI – 7.13 to - 0.61, p = 0.02) (Figure 4.13), and patients treated in practices with higher number of doctors had significantly more problems compared to the ones treated in practices with smaller number of doctors (r = 0.28, 95% CI -0.004 to 1.19, p = 0.05).Table 4.17.
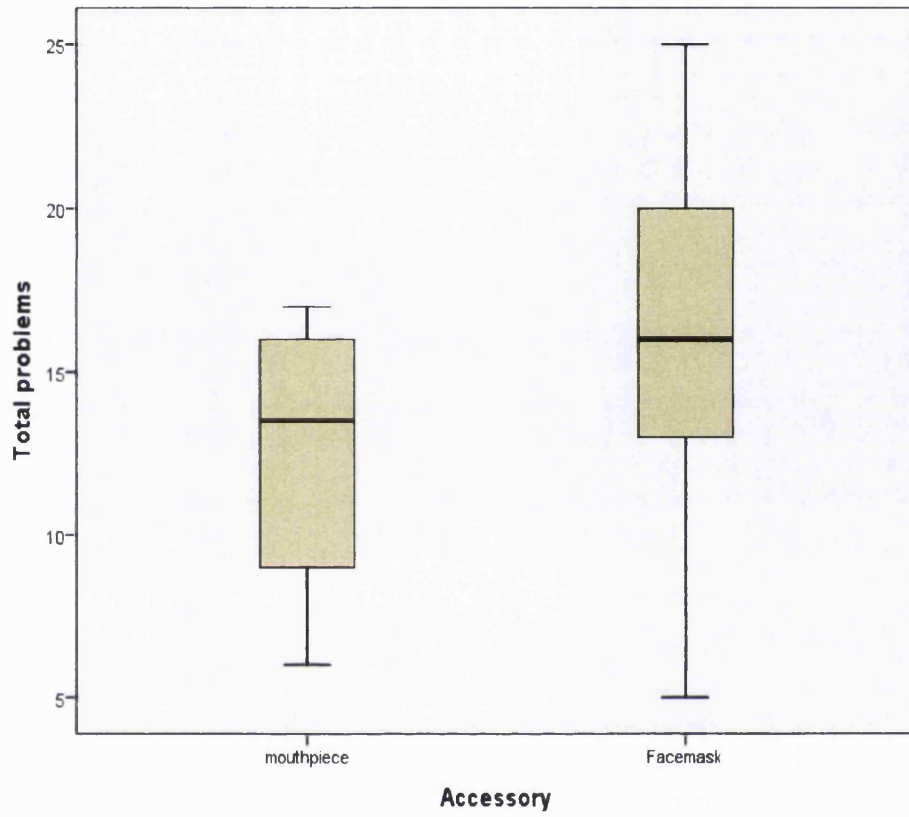
Figure 4.13: Comparison of the problems between patients using facemasks and mouthpiece

Table 4.17: Associations between various patient characteristics and total problem score

Independent variables	N	Test	P value
Patient characteristics			
Age	50	Simple linear regression	NS
Gender		Independent T-test	NS
Male	21		
Female	29		
Ethnicity		Independent T-test	NS
White	41		
Non white	9		
Smoking		One way ANOVA	NS
Ex-smoker	34		
Current smoker	3		
Never smoker	13		
Activity		One way ANOVA	NS
Retired	42		
Employed	4		
Housewife	4		
Education		Independent T-test	NS
Yes	20		
No	30		
Qualification		Independent T-test	NS
Yes	16		
No	34		
Living arrangement		Independent T-test	NS
Alone	18		
With others	32		
Have a carer		Independent T-test	NS
Yes	15		
No	35		
Disease characteristics			
BMI	46	Simple linear regression	NS
Co morbidity	50	Simple linear regression	NS
Hospital admissions	50	Simple linear regression	0.05*
Self reported health status score	50	Simple linear regression	NS
Symptom score	50	Simple linear regression	NS
Activity score	50	Simple linear regression	NS
Impact score	50	Simple linear regression	0.05*
Overall health status score	50	Simple linear regression	NS
Mobility score		One way ANOVA	NS
Level 1	4		
Level 2	45		
Level 3	1		
Self care score		One way ANOVA	NS
Level 1	25		
Level 2	20		
Level 3	5		
Usual activity score		One way ANOVA	NS
Level 1	8		
Level 2	31		
Level 3	11		
Pain and discomfort score		One way ANOVA	NS
Level 1	10		
Level 2	28		
Level 3	12		
Anxiety and depression score		One way ANOVA	NS
Level 1	22		
Level 2	23		
Level 3	5		
Characteristics of nebuliser therapy			
Duration of therapy	49	Simple linear regression	NS
Nebulised medication		Independent T-test	NS
Mono therapy	25		
Combined therapy	25		
Nebuliser model		One way ANOVA	NS
PortaNeb	10		
CompAir	9		
AC 4000	9		
Others	22		
Accessory		Independent T-test	0.02*
Mouthpiece	10		
Facemask	40		
Other technology		Independent T-test	NS
Yes	22		
No	28		
Pattern of use		Independent T-test	NS
Intermittent	24		
Continuous	26		
Received instruction		Independent T-test	NS
Yes	19		
No	30		
Source of nebuliser		Independent T-test	NS
Privately obtained	40		
Loaned from healthcare provider	10		
Respiratory medication	50	Simple linear regression	NS
Hand held inhalers	50	Simple linear regression	NS
Number of doctors	49	Simple linear regression	0.05*

The factors predicting the problems

The significant independent variables: number of doctors, number of hospital admissions, and the use of facemask were used to create a regression model (Table 4.18), 25% of variance in the total problem score is explained by this model (R Square = 0.25)(Table 4.19). The combination of these variables significantly predicted the total problem score (p = 0.00 < 0.05) (Table 4.20). After conducting multivariate analysis, all variables predicated the total problem independently, the use of facemasks was the strongest predictor (B = 0.33, p = 0.01), then the number of treating doctors (B = 0.26, p = 0.04) and finally, the number of hospital admissions (B = 0.24, p = 0.06) (Table 4.21).

Table 4.18: Descriptive statistics of the predictor variables and total problem score

Variables	Mean	Std. Deviation	N
Total problems	15.60	4.802	50
Number of doctors	5.73	2.196	49
Log Hospital Admissions	1.1961	0.78967	50
Facemasks	0.80	0.404	50

Table 4.19: The model summary of the predictor variables and total problem score

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
0.500ᵃ	0.250	0.200	4.295	0.250	5.001	3	45	0.004

Predictors: (Constant), Accessory, log Hospital admissions, Number of doctors

Table 4.20: The result of ANOVA for the predictors and the total problem score

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	276.787	3	92.262	5.001	0.004ᵃ
Residual	830.152	45	18.448		
Total	1106.939	48			

Predictors: (Constant), Accessory, log Hospital Admissions, Number of doctors

Table 4.21: Coefficients of the predictors of the total problem score

Variables entered	Coefficient	95% CI		P value	Standardised coefficient
		Lower	Upper		
Number of doctors	.580	0.008	1.153	.047	0.265
Hospital admissions	1.476	-0.116	3.067	.068	0.243
Facemask	3.965	0.872	7.058	.013	0.334

4.4. Current services and support available for COPD patients using nebuliser therapy

This section fulfils the fourth objective of the study and describes the provision of nebuliser therapy, the current services available for COPD patients using nebulisers through their hospital and local GP surgery. The actions taken in the event of experiencing treatment failure will also be outlined in this section. The gaps in service provision will be identified providing healthcare professionals opportunities for interventions. For example, highlighting potential information and service needs from the perspective of the patients.

4.4.1. Decisions on obtaining nebuliser therapy

All patients (50) were asked during the interviews about decisions made to obtain nebuliser therapy. Decisions to supply nebuliser therapy should be based on objective and/or subjective response to nebuliser therapy after conducting a home trial where different treatment options are tried by the patient for a period of time (Chapter 1). Although for the majority of the patients in this study, the decision to start nebuliser therapy was made by their treating doctor (n = 35), it was clear from the patients' accounts that this was not based on a proper assessment, taking into consideration the patient's objective and subjective response to different treatment regimens over a certain period. It was also clear from the patients' accounts that no form of assessment was performed prior to the supply of the nebuliser therapy in all cases. Instead the patients merely received a suggestion from a member of their healthcare team to use a nebuliser. Some patients mentioned that their doctor was very reluctant to recommend a nebuliser (n = 3).

> The first time that I had an asthma attack I was in hospital for 3 weeks; nearly died and they would not give me a nebuliser at home. It was only when I had the second and third attack after a period in hospital that Dr. X decided I could have a nebuliser at home they were extremely reluctant to do it.
>
> Male, age 80, duration of use 7 yrs

At other times, the decision to obtain a nebuliser was made by the patient, which in many cases was made after a history of nebuliser use in hospital or at the surgery. The inconvenience of making trips to the surgery and the long waiting times before a nebuliser was available for use were other factors identified which influenced the patients' decisions to obtain a nebuliser themselves.

Because you see what happened when I was put on the nebuliser I used to have to go to the surgery and there'd be a wait and sometimes it might be out of order or something and I've had to go to maybe the hospital and queue, this can be for ages, one time I went at 10 AM and I didn't get one until 4 PM.

Female, age 82, duration of use 3 yrs

I mean, if you can imagine being in pain, in your chest, and not being able to breathe properly, and I couldn't get the bus to my doctors, it was a walk, I had to walk straight across the park to my doctors, I had to actually walk there to get there, and that used to be murder. I used to end up at my doctors in a right old state, nearly a state of collapse, and they would just see me come through the door, and say oh has it happened again? Into the treatment room, on with the nebuliser, then go and get the doctor, because it happened so often.

Female, age 58, duration of use 20 yrs

4.4.2. The routes of obtaining nebuliser therapy and source of funding

All patients (50) were asked during the interviews about the route of obtaining their nebuliser system, and the source of funding. If nebuliser therapy is indicated for the patient after a home trial, a nebuliser system should be supplied by the NHS, the patient should not be encouraged to purchase their own equipment, if this was the case, the assessment should be performed with this equipment. There are various nebuliser systems available on the market, the choice of a suitable device should be based on the cost, ease of use, maintenance and the performance of the system (Chapter 1). The data revealed that the majority of the patients obtained their nebuliser system on their own through different routes (Table 4.22). Only 11 patients were supplied with nebuliser system directly, while the majority obtained their nebuliser through other routes. The nebuliser system was sometimes purchased from the internet (n = 6). In this case the nebuliser system was not necessarily purchased from a known or a reputable manufacturer which may have implications on the effectiveness of therapy and the amount of dose delivered the patient's lungs.

Table 4.22: The routes of obtaining nebuliser system, as reported by COPD patients

Source of nebuliser	Frequency
Pharmacy	23
GP/Hospital	11
Friend/Family	7
Internet	6
Manufacturer	3

In most cases, the doctor was not involved in choosing the nebuliser system, and the patient was only told to get a nebuliser. In these cases, the involvement of the treating doctor did not go beyond prescribing the nebulised medication.

> I was just given the prescription for these, told to get a nebuliser, and use it when you need it. Which, looking back, is not a very good way, not very helpful.
>
> Male, age 67, duration of use 1.5 yrs

The source of funding for nebuliser systems is given in Table 4.23. In most cases, the patient purchased the nebuliser at their own expense; financial constraints were expressed with this regard by many patients (n = 20).

> I don't dare think how much they are now. This was £119, then you know well worth the money I'm not complaining about that, but I just haven't got that money now. I've been widowed since..... And I just couldn't do it now you know so I'm terrified of it breaking down to be quite frank with you.
>
> Female, age 67, duration of use 10 yrs

As a result, some patients sourced the nebuliser system through other routes such as borrowing it from a friend or a family member (n = 7).

> A friend of mine, I said to her about I'm going to have to get one of these, I'm going to need one. This was about eighteen months ago. Don't worry, she said, I've got one upstairs that my son, when he was little had, but he doesn't need it anymore, as he grew up he grew out of it. So she gave it to me.
>
> Male, age 67, duration of use 1.5 yrs

Table 4.23: The source of funding of nebuliser, as reported by COPD patients

Source of funding	Frequency
Privately purchased	33
Loaned from hospital/GP	10
Gift/Borrowed family or friend	7

A discount was offered in a few cases, either through the GP, or in the form of claiming the VAT back.

> The nurse gave us a form to send of which she signed to say that I was eligible because it was a half price offer at the time so we sent off. I can't remember the address at the moment but we sent off and I think it was £40.
>
> Male, age 76, duration of use 0.5 yrs

I had to go through the doctor because of the VAT element. I think she had to sign something so I didn't have to pay the VAT as well, something like that.

Female, age 70, duration of use 10 yrs

Additionally, in two cases the doctor assisted the patient in sourcing the nebuliser through liaison with charities or other organisations.

He said I've heard of this charity called NARA the Breathing Society. And he wrote off to them and said would they consider accepting me, and they get to phone me at home and I didn't deal with it, because I was ill at the time, my ex-husband did. And within, I think, four days of that telephone call, the man turned up with and brought me one (nebuliser).

Female, age 58, duration of use 20 yrs

4.4.3. The availability of a nebuliser therapy loaning service for COPD patients

All patients (50) were asked whether a loaning service was available through their local surgery or hospital. The data revealed that loaning was only available for 10 patients, while the majority of the patients responded that this service was either not available, or was not offered.

They've never mentioned it. They don't even know that I've got one. They never said do you want one or can we get you one, it's never been mentioned and we had to pay for it. I was told I couldn't get it on the National Health so we had to pay and nobody every queried, nobody ever said anything to me.

Female, age 76, duration of use 1.5 yrs

In one case, a loaning service was available in the local hospital but the patient was refused due to shortage of equipment.

My doctor applied to the hospital to get me one, and he was refused. He said they told him I needed to be under the care of one of their consultants, which I was already under, and that they didn't have any spare ones.

Female, age 58, duration of use 20 yrs

This patient was profoundly distressed and blames the healthcare system for the worsening of her condition.

> I was actually in the hospital, and I was put straight on to the consultant, and, if, at that point, they had given me a nebuliser, I would not have had five years of pneumonia, I would not have had so much scarring, and I would not have had so much damage. That is the only regret I've got, that if I had been put on a nebuliser a few years earlier I wouldn't have such damaged lungs, but the fact that we couldn't get one, you know, there wasn't one available.
>
> Female, age 58, duration of use 20 yrs

Additionally, for some patients, a loan was only available for a short term.

> They left it (nebuliser) here for a week you know and they said that's there in case you use it. If you use it let us know when we come tomorrow, and they said but we got to take it away because the National Health can't supply them.
>
> Male, age 78, duration of use half a year

4.4.4. The supply of nebulised medication

If two formulations are prescribed for the patient, the prescribing doctor should ensure that the two formulations are compatible, and the drug is compatible with the nebuliser device used by patient. No instances were identified of drug incompatibility, or drug – nebuliser incompatibility. However, there was no evidence from the data to suggest that these issues were checked prior to supplying the nebulised medication to the patient. All patients had their nebulised medication supplied on repeat prescription through their local surgery. A few patients expressed concerns with regard to their nebulised medication such as: confusion about the names of formulations being prescribed especially when a change was made by the doctor, medication falling off repeat prescription if not ordered for a period of time, and the need to stay vigilant to avoid interruption of supply.

> I've got one left so when I start to use, open that (nebules), I then order my next lot which goes through my GP. I order through him and so forth.
>
> Female, age 62, duration of use 30 yrs

> The hospitals ones now they have a different name on them with a small square box. They're the ones they give you all the time in hospital, a blue box, Steri-neb.
>
> Female, age 74, duration of use 10 yrs

There is a slight problem, that after two months, if you haven't drawn anything it drops off your automatic thing, and you have to go back to the doctor and say will you put me back on it again? So many, many times, I've had twenty of those, they've lasted me, perhaps, for two years. They didn't on this occasion, because I had to get them about every fortnight, or no, more often than that, not, probably. But they fall off the prescription, and then when I want them I go and explain to the manager at the health centre, and she said oh that's very annoying they drop off, I'll have a word with the doctor and get them put back on again (the nebules).

Male, age 80, duration of use 10 yrs

4.4.5. The supply of disposable parts for nebuliser systems

All patients (50) were asked whether they had access to disposable parts through their local surgery or hospital. Patients prescribed nebuliser therapy in the home should have access to two sets of nebulisers and tubing initially and regularly every 3 months thereafter (some durable types of nebulisers can last up to a year). Failure to replace the disposable parts regularly may affect the performance of the nebuliser and potentially might lead to sub-therapeutic outcomes. It was previously shown that patients had inadequate replacing procedures (Section 4.3.3). This can be explained by poor access to disposable parts, for the majority of the patients this option was not available through their local surgery or hospital. Additionally, one patient was profoundly distressed over being diverted from one place to another before being refused and told to buy his own supplies.

It was a long time sorting out, a long time sorting out, this. Because I had to go to the hospital four or five times, I couldn't get filters for this (compressor). And the doctor sent me to the hospital, and the hospital sent me to the pharmacy, the pharmacy then sent me back to my own doctor, my own doctor sent me to the chemist. And then I rang up the social services, and the social services got back on to the doctors and everybody, and finally the flipping doctor said no, you must buy yours yourself.

Male, age 58, duration of use 0.5 yr

Only a few patients reported they were supplied with disposable parts through their local surgery or the hospital. In one case the patient obtained the supplies through a charity. The patients reported getting the parts very sparingly through their local surgery or hospital, and it was evident from the patients' comments that there was no organised system in place to supply the disposable parts. Instead, the supply occurred rather opportunistically with most patients indicating that they would bring back home used nebuliser kits after being treated in hospital or the surgery.

> This (nebuliser chamber) didn't come with this. Every time I go to the medical
> centre, and I use it, I always say to the nurse may I have it, and all she does is put it
> in the bin, so she just puts it in a bag and gives it to me.
>
> Male, age 80, duration of use 10 yrs

Due to the limited availability of spare parts, it was obvious from the patients' accounts that the patients were very grateful to healthcare professionals who could spare them a few parts and considered it a big favour. The patients also talked about forming links with medical staff or even sweet talking them just to get some parts.

> It's funny, anything to do with those (spare parts). What I would normally do, is I
> phone a lady called A, she works up in the sleep study, she is my link. I got to
> know her when I first, after I had my operation, and she was absolutely brilliant.
> And she remembers me every time. So I say - A, it's X here. Hi, how are you
> doing? You know, it's that sort of rapport. Anna, this isn't working. Oh, bring it
> in, I'll organise an ambulance for you. She does all that for me, she's lovely. So
> she's my little link, my lifeline.
>
> Female, age 59, duration of use 1 yr

It was previously shown that almost half of the patients were using nebuliser chambers which were different from the ones recommended by the manufacturer of the compressor and vice versa. This can be explained by patients obtaining their nebuliser system privately, and getting replacements through the hospital or local surgery, which were not necessarily compatible with their own compressor. Therefore, some patients were reluctant about obtaining nebuliser kits through the hospital or their local surgery which might be different from the original kit supplied by the manufacturer.

> Not really (get spare parts through the doctor), because I don't know whether they
> do the same as this (nebuliser chamber), but I may when I go and see him I'll ask
> him and see what he says. Possibly if it was like the one that the National Health
> use it is a possibility that I could, but this isn't anything that they use
>
> Male, age 78, duration of use 0.5 yr

A small proportion of patients stated that they purchased their supplies privately through a company. However, these patients expressed concerns about the cost of spare parts and the fact that the purchase was only available in wholesale quantities. Consequently, one patient was found to have her supplies flown over from India at additional costs and inconveniences for her family. Moreover, the patients encountered difficulties in obtaining supplies privately form companies as firms went out of business, or models were discontinued.

The company that sells the spares for that (compressor) is in England, you can phone them through, explain to them, give them the model number (compressor), and they send you the spare parts. I've already spoken to them not because I wanted spare parts, but because now and then things get out of date, firms come and firms go in this climate, but they're still there and I've spoken to them.

Male, age 78, duration of use 0.5 yr

4.4.6. The availability and access of servicing and repairs in the event of equipment breakdown

All patients (50) were asked whether they had access to servicing and repairs if their equipment broke down. Annual servicing and electrical safety checks should be performed on all compressors, the filters should be replaced at that time, and the patient should be given a replacement compressor to be used while their equipment is retained for servicing. Failure to service the compressor may affect the performance of the compressor. It was previously shown that the patients had inadequate maintenance procedures (Section 4.3.3). The data revealed that a servicing option was only available for those patients who had their nebuliser loaned through the hospital or their local surgery, and in one case through a charity. However, for the majority of patients who obtained their compressor privately servicing was not available. A few of these patients had experienced equipment breakdown.

Because I go to the hospital I will get this done (serviced) ,but the people who don't have the hospital's will not get serviced. I mean my other machine wasn't serviced for a long time, like you said that filter needs changing now you see so I think it's a good idea.

Female, age 60, duration of use 5 yrs

Moreover, some patients were reluctant to take their nebuliser back to the hospital or local surgery for annual servicing for fear of it being replaced with a less efficient compressor.

If I take it back (the compressor), what I gets is the old one, so they give me the old one back. They change it, and then they give me a very, very old, and those are not so effective at all, because it's very, very old.

Male, age 63, duration of use 8 yrs

Patients with privately obtained compressors either took their compressor back to the company, the manufacturer, or the community pharmacy for servicing. However, this was not always the case due to experiencing difficulties such as: service only available through

selected pharmacies, the cost of the service, the cost of the postage required to send the compressor back to the company, the inconvenience of travelling to the company or manufacturer site.

> The only thing is, most probably, I would like to get it serviced, but I don't know how much that will cost also. Now postage is another thing and everything you can't pay out now because before I used to go out and get my paper, now I can't, so I have to pay for that. So everything, a bit here, a bit there, so having worked I don't get any benefit from this government, because my pension, they say, is quite enough.
>
> Female, age 77, duration of use 10 yrs

> I wanted to get it cleaned up and I was told again by my daughter that the pharmacy will do it but they won't, um well I thought they'll take it and send it away if you understand. I don't know whether they do it, but they no longer do it.
>
> Female, age 77, duration of use 1 yr

> It's such a performance. I can't easily get to chemists or to post offices and that I have to rely so often on other people you know and it's the thing of packaging it up so carefully; oh it seems as if, it's a terrible thing to say, but it's how I feel and I just have to tell you the truth you know.
>
> Female, age 67, duration of use 10 yrs

Some patients were reluctant to take their compressor for servicing for fear of being without a nebuliser or being given a less efficient one.

> And the shop the chemist Lloyds the chemist gave me a loan one but that they had it away for weeks that I had to beg to get it back. I thought I'd never get my original back again...
>
> Female, age 74, duration of use 10 yrs

4.4.7. Access to services and actions taken in the event of treatment failure

All patients (50) were asked during interviews whether they had accessed health services in the last year in relation to their COPD, and the nature of the previous contact with medical care. The patients were also asked whether they experienced any treatment failures, and the actions they would take in the event of experiencing a treatment failure. The data revealed that the majority of the patients had accessed services in relation to their condition in the previous year. The patients accessed a range of primary, secondary, and community

services for COPD. For the majority of the patients the GP surgery was their most recent contact with the healthcare services, suggesting that COPD is primarily managed in primary care. However, many patients accessed emergency services, indicating that for these patients, an opportunity for healthcare professionals to intervene was available. The reasons for accessing COPD services identified are given in Table 4.24.

Table 4.24: Services accessed by COPD patients

1. Physician Consultation
+++ Cough/Sputum/SOB
Exacerbation of COPD
Referral to specialist
Referral to services (PRP, LTOT)
2. Nurse Consultation
Diagnostic testing
Inhaler technique
Flu vaccination
Smoking cessation
Follow up/Review appointment
3. Hospital Visit
Annual review
A&E
Inpatient stay/Hospital admission
Outpatient clinic
4. Supply of medication
Repeat medication
Antibiotics and Steroids
Nebuliser medication
Other respiratory medication
5. Home visit
Hospital at home
Assisted discharge scheme
Emergency visit

SOB: Shortness of Breath, PRP: Pulmonary Rehabilitation
Programme, LTOT: Long Term Oxygen Therapy.

A few patients were housebound and can only request a home visit when their breathing deteriorates. However, for these patients the nebuliser aspect of care is often overlooked.

> I can't go in to them and they are not allowed to come in to me. So this is where we are in a fixed circle, really. It would help if someone could come to me, because I can't go to them. I can get a doctor out, but I can't get the nebuliser lady out, they are not allowed to come out. So that bit, I think, is a bit poor.
>
> Female, age 62, duration of use 5 yrs

Avoiding unnecessary hospital admission was previously reported as one of the benefits of using nebuliser therapy at home. When the patients were asked if they had ever experienced treatment failure after using the nebuliser therapy, the majority of the patients indicated that they could not recall a time where this had occurred. However, a few patients

indicated that despite using nebuliser therapy, they ended up in hospital. However, when this happened, the patients often stressed that it only occurred infrequently or very rarely. One patient added that even when the nebuliser therapy failed to bring relief, or prevent a hospital admission, the improvement it brings assists in allowing to call for help when required.

> It will always bring you round to where you could phone an ambulance if you needed if you're getting desperate then you have to phone an ambulance.
>
> Female, age 65, duration of use 10 yrs

According to national and international guidelines on nebuliser use, the nebuliser can be used to a maximum of four times daily (Chapter 1). After which the patient is advised to initiate emergency medication with antibiotic and steroid or contact a healthcare professional. When patients were asked about what would they do if the nebuliser therapy failed to relieve their symptoms, several actions were revealed by the patients. Most frequently, the patients reported that they would access medical services such as: contacting the treating doctor, dialling an ambulance, or contacting the HART (Healthcare and Rehabilitation Team based at the hospital).

> If I know it's not working then normally you phone the doctor and he will either put you on antibiotics and you know that would do, but if he thinks you're really bad then he'll give you steroids as well if it's really bad. Then he sends you to the hospital. Or if I can't get the doctor then its hospital and they put you on high dose oxygen which I can't do myself because they say that's dangerous.
>
> Female, age 75, duration of use 5 yrs

However, there were instances where delay in accessing healthcare services in the event of an emergency occurred. Failing to seek help in a timely way may result in further delay in recovery and complicate treatment. This is manifested in instances where the patients stated that they doubled the nebulised dose or repeated the nebulisation session when adequate relief was not gained after their usual dose. Additionally, doing nothing if their nebuliser treatment fails to bring a relief to their breathlessness was one of the answers the patients gave. Furthermore, some patients would try many options before making the decision to contact their doctor or access emergency services or starting a course of antibiotics and steroids they stocked at home as an emergency medication. For instance trying alternative treatment options such as the use of oxygen therapy or the use of their regular reliever medications (hand held inhalers). Delay in seeking help in an emergency was more explicitly expressed by one female patient.

> I think the trouble is it could be partly my fault, I may let it go too long, you know?
> So that I start panicking, and it makes it worse, it does make it worse.
>
> Female, age 62, duration of use 2.5 yrs

Additionally, some patients were very confident at self managing themselves at home; in their view they were already taking what would be given to them if they choose to go into the hospital.

> Well there's nobody can do anything more than what I already do, even if I go into Accident and Emergency they do exactly the same things as what I do at home. So there's nothing, really, that anybody can do. They do increase the dosage and that, and it does make you feel better, but, you know, you are laying in Accident and Emergency from nine o'clock in the morning until ten or eleven o'clock at night, before they let you come home. They lay you on a bed and they just pump stuff into you.... Really I would prefer not to go up there, rather than that, so treat myself at home.
>
> Male, age 77, duration of use 15 yrs

By contrast, some patients felt there was nothing much that could be done to help them due to the stage of their condition.

> There's no point in me talking to a doctor or anybody because they can't help me and I understand that, you know, this is the best that we could do.
>
> Female, age 76, duration of use 3 yrs

4.4.8. Information received and following up in relation to the use of nebuliser therapy

All patients (50) were asked during the interviews whether they received information from their healthcare team on the use of nebuliser therapy (on dosage, setting up, cleaning, maintaining and action plan in event of treatment breakdown). According to national and international guidelines on nebuliser use, all patients prescribed nebulised therapy in the home should be given verbal and written information on dose, frequency of dosage, setting up, cleaning and maintaining (Chapter 1). The patients should be followed up, and reassessed after 3 months of commencing nebuliser therapy and regularly thereafter. The components of the assessment should include: assessing the need of therapy, side effects, and their technique should be checked. They should also be given a clear action plan on what to do in emergencies with contact details.

The data revealed that only 19 patients reported receiving instructions from a member of the healthcare team on the use of the nebuliser therapy. In most cases, the information was in relation to the dosage frequency (n = 12). Information on how to use and clean the nebuliser was rarely given (n = 7). Additionally, none of the patients reported receiving information on how to inhale the nebuliser medication, or who to contact in the event of an emergency. The source of information on the use and cleaning of the nebuliser was either the treating doctor (n = 3), or the respiratory nurse (n = 5). In all cases, the information was only given initially, and patient was never followed up. Although the patients had review visits every 6 months at the surgery and annually at the hospital, it was only restricted to spirometry testing, whereas the nebuliser therapy rarely formed a component of this review. Additionally, some patients mentioned they were only followed up after being discharged from hospital, when an opportunity to prevent re-admission is often missed.

> I can't remember the last time anyone mentioned that (nebuliser therapy). I think they said to me when I'm in hospital, have you got a nebuliser? you know, when I come out you know when I'm going to come out and they say to me you know you've got a nebuliser, and I say yes, but that's as far as it goes really.
>
> Female, age 75, duration of use 5yrs

The majority of the patients hadn't had any instructions on the use of the nebuliser from any member of their healthcare team (n = 31).

> Since I've got one the National Health Service haven't done anything with it, as regard even coming to look at it, or having to service it. It's as if my nebuliser doesn't exist to them. Even when I go into the hospital I take it with us, they don't use mine, and they use their own. Mine stays in the bag by the bed.
>
> Female, age 58, duration of use 20 yrs

These patients mentioned they learned how to use their nebuliser through 'trial and error', or from previous use in hospital and surgery. For the majority of patients, the instruction booklet was the only source of information (n = 14), which is usually read at the beginning.

> It certainly came with instructions, which I would have read, and I will have taken notice, but I now do it from experience, bearing that in mind, and what I've learnt at the medical centres, or hospitals, as the case may be.
>
> Male, age 67, duration of use 1.5 yrs

Although some patients did not receive enough information on the use of the nebuliser therapy, they did not feel this was a problem.

> Well I don't know what they can tell me, you know I can load it up and I can use it. As I say it's more or less my own nebuliser, no one provided it to me, no one gave me any instruction on how to clean it or do anything like that.
>
> Male, age 83, duration of use 0.5 yr

Lack of information was evident in all aspects of nebuliser use, and information needs were expressed by the patients in relation to many aspects of nebuliser therapy (Table 4.25).

Table 4.25: Information needs, as reported by COPD patients

Aspect of care	Example
Nebuliser models	No, my only thing would be I have no way of knowing whether this model now, because it's quiet old is any less effective than a modern day one. Well I don't think there's that much difference, so I have no complaint about this but I just wondered if they're any different today because I have nowhere, I don't know anybody who has an up to date one you see what I mean. That's really all I wanted to know I wonder if you could tell me that. Patient 10
Instruction on dosage frequency	Well, nobody's ever told me to. When I first started, yes, I did, obviously, but then it sort of got under control, and nobody's ever really told me to do it since. So I don't, no. Patient 46
Setting up	Do you know what, nobody ever told me. I didn't know that was supposed to be moved. So what I do, I put it in there. You see I've had no... I think one of the reasons you've come is to find the lack of information that we do get. I didn't know it needed servicing. I didn't know that thing in the top, is that supposed to be down or loose. Patient 25
Cleaning	No, the only thing I would like to know how do I sterilise the mask, you shouldn't boil that type of thing or does it need sterilising, just wash in warm water, is that it? Patient 33
Breathing technique	Nobody actually showed me how to use it you know. Nobody said you should hold your breath hold it in for a moment and exhale slowly I just do it how I do it maybe if there is a way of doing it maybe I should have been shown or told. Patient 10
Information on maintenance	If they've done a quick reference guide, what they call a quick reference guide and believe me they were the best because they're dealing with the things that you deal with every time every day so if you do like a quick what I call a quick reference you give somebody a big manual they're not going to read it. I haven't got time for that, but a quick reference guide will, with the pictures... yeah and then a little checklist about when to replace when you tubing are going blacky. Patient 32
Contact in event of equipment breakdown	Till now I have no problem, and if I have any problem I don't know what to do. I take it to the pharmacy or to the company to ask but I never had a problem yet. Patient 35

4.5. The roles of carers in assisting COPD patients with the use of nebuliser therapy

This section fulfils the fifth objective of the study and describes the range and extent of assistance provided by carers in relation to the use of nebulisers, the difficulties encountered by carers, and the partnerships between COPD patients and their carers in the context of using nebuliser therapy at home. Fifteen carers were identified by the patients as providing assistance with the use of the nebuliser; one carer did not consent to take part in the study and was therefore excluded. There were 10 female and 4 male carers (11 spouses, and 3 daughters), with a mean age of 61 years (range 26–79). All carers were living with the patient (Chapter 3). It is worth mentioning that other patients who live with family also received some assistance from family members despite not being recognised as 'carers' by the patients (Chapter 5). Understanding the range and amount of assistance provided by the carers in relation to the use of nebuliser therapy is essential to support and empower carers in fulfilling their roles and to ensure effective use of medications and optimise health outcomes for COPD patients.

4.5.1. The range of activities and extent of assistance provided with the use of nebuliser therapy

This section describes the range of activities with which the carers provide assistance, and the extent of this assistance in terms of the number of activities and time spent providing assistance. The carers (14) were asked during the interviews to indicate whether they provided assistance with a total of 10 activities related to the use of nebulisers. Additionally, they were asked about the duration of time they had been assisting with the use of nebulised therapy, and the duration of time they spent providing this assistance on a weekly basis. The data revealed that the carers in this study provided a substantial amount of assistance. On average the carers provided assistance with 6 activities, with a range from 2 to 9 activities. The carers assumed responsibilities across a range of vital activities, some of which were practical tasks while others required a clinical judgment to be made on behalf of the carer (Table 4.26). On average, the carers had assisted with the use of nebuliser therapy for about 4.5 years, and spent around 3.5 hours per week providing nebuliser-related activities (range 1 to 10.5 hours per week). The assistance provided by the carers will be described in relation to each activity.

Table 4.26: The number of carers assisting with each activity

Description of activity performed by carer	Yes (n= 14)
Making decisions on the need to use the nebuliser	8
Supervising the nebulisation process	9
Setting up and operating the nebuliser	12
Assisting with inhaling the nebulised medication	3
Dismantling and cleaning the nebuliser	10
Maintaining supplies of disposables and condition of the nebuliser	9
Maintaining supply of nebulised medication	11
Making decisions to seek help in an emergency	8
Monitoring side effects of nebulised medication	11
Gathering information on the use or safety of nebuliser	8

Making decisions on the need to use the nebuliser

Eight carers described making clinical decisions regarding the use of nebuliser therapy. Giving advice on nebuliser use was discussed in relation to four contexts: advice was given on the need to initiate the therapy (n=6), advice given on adjusting the dosage of the nebuliser therapy (n=1) or advice given on withholding the dosage (n=1), or advice given on discontinuation of therapy (n=1). The carers stated that most of the time, the patient decided to initiate the therapy on their own, based on their symptoms. However, in some instances, they jointly decided on the need for therapy. The carers gave advice on the need to initiate therapy in response to noticing or hearing their relative having difficulties in breathing, or as a precautionary measure prior to an anticipated increase in physical activity, which might trigger an exacerbation of their condition.

> She's been out three times every Thursday for the last three weeks and yeah she's struggling, and I feel that this (nebuliser) could have helped her and she didn't ... I said I want you to prepare yourself to go out and you didn't do it.
>
> Female, 60 yrs old, assisting for 10 yrs

Decisions to withhold, adjust or discontinue therapy were expressed in relation to experiencing side effects, or in some cases, developing tolerance to therapy. In these cases both the carer and the patient jointly decided on the actions taken.

> We didn't want to have it (nebuliser therapy) because we think it's, he puts on a lot of weight, he fills with water, but he said – don't worry, it's better to start it straight away than to wait. We used to wait until he couldn't breathe at all, you see?
>
> Female, 74 yrs old, assisting for 4 yrs

<u>Supervising the nebulisation process</u>

Nine carers stated that they would supervise their relative while they performed the nebulisation process. In this context, the carers described making judgments based on their understanding of the patient, which determined the need or level of supervision required by the patient.

> He can't put the solutions in when things are bad, he doesn't understand which ones to put in. He couldn't tell the difference between the two, the antibiotic and the other one. So he does need somebody to make sure he is doing it properly.
>
> Female, 64 yrs old, assisting for 3 yrs

<u>Setting up and operating the nebuliser</u>

Twelve carers provided practical assistance with setting up and operating the nebuliser. The carers described practical steps required to assemble the different components of the nebuliser system. The carers described connecting the tubing to the nebuliser chamber at one end and to the compressor at the other, pouring drug fluid in the medication tank, screwing the cap back on the chamber, and connecting the facemask or the mouthpiece to the cap before giving the nebuliser to the patient to start inhaling the nebulised dose. This activity was described by the carers as mostly performed by the patient, with the exception of two patients who were totally dependent on the carer to perform this activity. However, some assistance was occasionally needed by the patient. In this case, the carer either performed the task for the patient or they worked as a team to accomplish the task.

> Well very simply you attach one end to the machine, the other end as you saw to the mouth piece, you then attach it to the bowl, and my wife then fills the bowl by holding it with one hand and pouring it with the other, screw the top and inhale.
>
> Male, 79 yrs old, assisting for 3 yrs

<u>Inhaling the nebulised medication</u>

Three carers assisted with inhaling the nebulised administration. This involved the carer guiding the patient through inhalation, fitting the facemask onto the patient's face, or instructing the patient to breathe. A clinical judgment was made on behalf of the carer to assess the whether this assistance was needed.

The only time, when she had an asthma attack a couple of years ago, I had to say to her go on, breathe it in and talk her through it. But that was a really bad asthma attack, she hasn't had many I think it was just one really bad one. And just talk her through it. But apart from that she just breathes it in on her own.

Female, 26 yrs old, assisting for 5 yrs

Dismantling and cleaning the nebuliser

Ten carers reported providing assistance with dismantling the different parts of the nebuliser system after use, and cleaning the parts. Performing this task is essential to ensure the safe and effective use of nebuliser therapy. Failure to clean the nebuliser may affect the performance of the device. In addition, inadequate cleaning may lead to microbial colonisation of equipment and is a risk of infection to the patient. The carers described washing the nebuliser parts with warm soapy water, wiping the compressor and disinfecting the parts with commercial detergent. This activity was reported to be mostly performed by the carers, while on some occasions the patient was responsible for this activity but still received some assistance. The over-reliance on carers for performing this activity led to the nebuliser parts being unwashed while the carer was away.

I have been away at my daughter's, that's why it hasn't been done (cleaning) for the last couple of days.

Female, 64 yrs old, assisting for 3 yrs

Maintaining supply of disposable parts and servicing the equipment

Nine carers reported replacing the nebuliser parts and servicing the compressor. This task is essential to ensure effectiveness of therapy. The carers described being involved in activities such as purchasing or obtaining the disposable parts, taking the compressor for annual service appointments, booking service appointments to check for defects, or calling a dedicated team at the hospital in the event of equipment breakdown. This activity was always performed by the carers.

What I do is whenever she has a hospital appointment, we know before, so what I do is I ring the service people and tell them my wife is coming in on a particular day, and I'll come with her, so I'll bring the nebuliser. And then they service it. It takes half an hour for them to do it, but if they know we are going to take it in they will do it then.

Male, 61 yrs old, assisting for 3 yrs

Maintaining supply of medication for nebulisation

Eleven carers reported maintaining supplies of nebulised medication. Activities described by the carers included: calling the pharmacy or surgery to order a repeat prescription, collecting a repeat prescription from the surgery, dropping off the prescription at the pharmacy, and collecting medication from the pharmacy. This activity was mostly performed by the carers.

> I go to the surgery, drop off prescription to do the repeats; I collect medicines from pharmacy...

> Female, 42 yrs old, assisting for 6 yrs

Making decision on the need to seek help in an emergency

Eight carers reported making clinical judgments about the need to seek medical help in the event of treatment failure. The carers stated they would seek help when nebulised therapy failed to relieve the patient's breathlessness. The actions taken in the event of treatment failure were: contacting the doctor, or calling for an ambulance. The carers reported that they were mostly responsible for performing this activity, while occasionally both the carer and the patient jointly decided on the need for additional help.

> I will book her a doctor's appointment if she feels unwell... if she looks unwell; I will ask her "how are you feeling, are you OK?"... If she tells me she feels unwell, I often take her temperature... I go through her symptoms with her, and say "right, I think you need to see a doctor".
>
> Female, 26 yrs old, assisting for 5 yrs

Monitoring the side effects of nebulised medication

Eleven carers reported monitoring side effects of nebuliser therapy. Side effects recognised by the carers are those which can be easily noticed by the carer such as: tremor, which is a common side effect of beta$_2$ agonists, and disorientation.

> I mean, some days he looks like he's got the shakes for that is the Ventolin^{TM} anyway because that does make you shake because I've been on that myself in the past and yeah... that wears off doesn't it after a while, but he does, I just leave him to sit quiet I watch him, he doesn't always know that I'm watching him.
>
> Female, 66 yrs old, assisting for 5 yrs

> She gets disorientated. She took her nebuliser while I was out and she done a double dose... so I said to the emergency doctor I didn't call anyone because I'll see how she gets on... I didn't call anyone I thought I'll just watch her to see how she goes...
>
> Female, 60 yrs old, assisting for 10 yrs

Gathering information on the use and safety of nebuliser therapy

Eight carers described having an advocacy role with healthcare professionals. The carers actively sought information on different aspects of nebuliser use, such as: how to use the nebuliser and the side effects of nebuliser therapy. Additionally, various sources were used to obtain information: GPs, manufacturer instruction manuals, medication leaflets and family members with medical backgrounds. Some carers consulted healthcare professionals for approval to initiate nebuliser therapy upon worsening of the patient's symptoms.

> I've asked the doctor. When we've gone to see them, you know, is it OK? They say it's fine to use it up to four times a day. None of them has really said that using it a lot is going to have any major adverse effect on her.
>
> Female, 26 yrs old, assisting for 5 yrs

4.6. The difficulties encountered with assistance provided with the use of nebulisers

This section describes the difficulties encountered by the carers while providing assistance with nebuliser therapy. Identifying difficulties provides healthcare professionals with valuable information to support carers in their roles, reduce their burden and optimise health outcomes for patients. All carers (n = 14) were asked whether they encountered any difficulties with a total of 10 activities related to the use of nebuliser therapy. The carers' accounts were examined to identify difficulties encountered with assistance provided with nebuliser use, which may prevent them from fulfilling their roles adequately and which may lead to suboptimal health outcomes for the patients. Good examples and positive experiences will also be highlighted in the context of the activities conducted should they arise from the carers' accounts. The difficulties reported by the carers will be described in detail in relation to each activity.

4.6.1. The range of difficulties encountered by carers

The data suggests that carers encountered difficulties with all activities. On average, the carer encountered 3 difficulties, which ranged from 0 (only one carer did not report any difficulties with care) to 9 difficulties. The number of carers reporting difficulties with each activity is given in Table 4.27. Most frequently, difficulties encountered were associated with practical assistance such as setting up the nebuliser (n = 8), dismantling and cleaning the nebuliser parts (n = 7), as well as maintaining disposable parts and servicing the compressor (n = 6).

Table 4.27: The number of carers reporting difficulties with each activity

Description of activity performed by the carer	N(14)
Making decisions on the need to use the nebuliser	4
Supervising the nebulised medication use	4
Setting up and operating the nebuliser	8
Assisting with inhaling the nebulised medication	1
Dismantling and cleaning the nebuliser	7
Maintaining supplies of disposables and condition of the nebuliser	6
Maintaining supply of nebulised medication	4
Making decisions to seek help in an emergency	3
Monitoring the side effects of nebulised medication	3
Gathering information on the use or safety of nebuliser	2

Difficulties reported with making decisions on the need to use the nebuliser

The carers made decisions in the context of their own beliefs regarding the need for nebulised therapy. Concerns about safety or developing tolerance to nebulised medication were other views which shaped the carers' decisions with regard to the use of therapy (Section 4.5.1). Therefore, carers should have the necessary information to support them in this role. However, this was not the case for carers in this study, as carers expressed difficulties with regard to knowing when to initiate therapy and the frequency of dosage (n = 4). Deficiencies in the knowledge and understanding of the carers are illustrated well in one case, where a daughter carer described her five month ordeal where lots of confusion was created with regard to the frequency of dosage.

When she was going through the five months they were telling me right you know take it up to five (times a day/nebuliser) and then bring it down. So I'll bring it down but that didn't work, we're back at A&E, then she was one time in hospital again and it was like so that was going up to five down to four three two then up again ....But since then, since from that time we had no real instructions on it no not really.

Female, 60 yrs old, assisting for 10 yrs

As a result of knowledge deficiencies, making clinical decisions was viewed by some carers as a burden. Feelings of guilt were expressed, especially if harm was caused to the patient. Discontinuation of care and seeking a placement in residential care were actions which could be taken by carers as a result of this burden. The carers expressed the need for respite care and more support.

I'm not a doctor and I'm not a nurse and they mustn't view me as that, and I think that's true it's so easy for them of course it is to depend on the carer. They are used to it but at the end of the day they must remember we are not doctors, and we are not nurses, and we are not pharmacists, so you know that is got to be at the back of their minds. I think if they can keep it like that, and say yeah okay they've got experience. Yes they can do this, but at the end of the day we got a feel because if something bad happened to her, I would say is that me? Did I do that? See, we've got to keep that in mind and make sure that the responsibility doesn't become too much of a burden on the carer otherwise what happens is that the carer thinks that she's doing it wrong, and could say well, I can't do this anymore she's going to have to go on a home, because that's how I was thinking at the end of the five months, so the support needed to be there maybe take her in hospital for a week, give the carer a break, because its tiring, five months, so they got to recognise, hold on a minute, yeah we haven't got any beds but these carers been battling at home for four three months, maybe we need to give them a break, and have them in hospital for a week.

Female, 60 yrs old, assisting for 10 yrs

Difficulties reported with supervising the use of nebuliser therapy

Four carers discussed difficulties in relation to the critical nature of the condition and the level of vigilance required on the carers' behalf and preparedness to take over any task whenever needed.

The most important thing to understand in my view with people with this condition is the tendency to panic when things go wrong because you can understand this it's such a vital function and if there's any worry I think this is a general theme with people with this condition. There's a tendency to panic, and so they need people there with little things even for example the connection can come off you know you just need to be available to help with anything that would turn up actually.

Male, 79 yrs old, assisting for 6 yrs

Competing demands were discussed in relation to supervising nebuliser use and other responsibilities. Doubling of the nebulised dose occurred while the carer was out doing the shopping. Fortunately the situation did not result in any harm to the patient but the carer was profoundly distressed over the incident. Burden was expressed by the carer as a result of complex dosage regimen. Medication reviews and simplifying drug regimens benefited one carer.

I said quite frankly I could never go through those 5 months because putting her on nebulisers they wanted five nebulisers a day. I couldn't get out to do the shopping. Then steroids you know I've got another 85 year old here I've got osteoarthritis myself this is impossible I could never go through that again and I said to him I am one on my own here, you got an army of nurses, cleaners, everything you know. I can't do this so let's sit down. So the district nurse said right I'm bringing the community pharmacist, we sit down we go through all the medication we discuss all side effects and how to counteract them...

Female, 60 yrs old, assisting for 10 yrs

Difficulties reported with setting up and operating the nebuliser

Eight carers described experiencing difficulties with setting up the nebuliser system (n = 8). Three carers mentioned that assembling the nebuliser was a lengthy process; the time taken to set up the nebuliser was of a particular concern for a wife carer during an emergency when the patient needs the medication quickly. Reported lack of information on the use and maintenance of the nebuliser system parts was well represented in the data and resulted in experiencing technical difficulties, in particular those related to the use of an over-stretched tubing which was frequently blown out during nebulisation, as well as being uncertain whether a dilution was required.

No sometimes this does come off (tubing), it is sort of blows off you know and we have to keep pushing it back on and that doesn't stay in there too well. But apart from that and the fact that this takes a little longer you know if my husband is really bad and he needs it quite quickly and it does seem a little bit fiddly with this.

Female, 67 yrs old, assisting for 4 yrs

I'm not very good at that (setting up the nebuliser), he does it mainly, so. I mean that's the bit that we're not sure about because sometimes he uses distilled water, sometimes he doesn't put any water in and I don't know if that's right.

Female, 29 yrs old, assisting for 10 yrs

Choosing a suitable nebuliser device which fits into the lifestyle of both carer and patient eliminates inconvenience and enhances social life. In this context, some carers were profoundly distressed by the noise of operating the nebuliser, the weight of the compressor, and not being able to use the nebuliser in the event of a power cut as the nebuliser was not equipped with a battery or a power source.

It's just that if you don't have electricity you can't use it, that's the only problem. Say if we had a power cut and she had an asthma attack while we had the power cut, I couldn't set it up, it couldn't, do you know what I mean? It doesn't have its own power source. That's the only thing I would say about it, or if I was, say on a train, and she had an asthma attack, I couldn't use it then, because there's no power socket, I couldn't plug it in to use it, so there's no way I could use it.

Female, 26 yrs old, assisting for 5 yrs

To overcome the problem with the noise, the carer described how her mother covers the nebuliser with a duvet to silence it if she had to use it during the night. The weight of the compressor was a particular concern during day trips; this problem was solved by using a trolley.

Difficulties reported with inhaling the nebulised medication

With regard to inhaling the nebulised medication, the data suggest patients were mostly responsible for inhaling their medication, while occasionally received assistance by the carers during an emergency. One female carer was concerned about the effectiveness of the nebulised medication due to poor inhalation technique. The carer repeatedly gave advice on breathing technique.

Although I have to say I don't think he does enough deep breathing when that's on (whispering). If a doctor tells him ... I can't do it because he won't listen to me (whispering). Well I mean you know I come out her and I'm... I said come on breathe in and breathe out. I am I am I am...

Female, 75 yrs old, assisting for 0.5 yrs

Difficulties reported with dismantling and cleaning the nebuliser

Seven carers described difficulties with performing this activity. Manual dexterity as a result of arthritis, and the lack of maintaining the nebuliser parts resulted in two carers experiencing technical difficulties with dismantling. In both cases, the carer described incidents where the tubing was stuck and could not be detached from the nebuliser chamber. Additionally, two other carers expressed concerns over the use of blocked tubing which could not be cleaned properly.

I don't know what kind of cleaning is good for that (tubing), because it's a bit difficult. That's something you have to get a genius to work that out, how to clean this, you got to go to an engineer or something.

Female, 60 yrs old, assisting for 10 yrs

Difficulties reported with maintaining nebuliser parts and servicing the compressor

Six carers expressed difficulties in relation to this activity. Poor access to disposable parts through the hospital or the local surgery was a difficulty expressed by the carers. In one case the carer described having arguments with surgery staff over the supply of disposable parts.

Don't get me wrong, but I've had loads of rows and rows over the years, because we have to pay for our nebuliser, but I said no, I'm not paying for tubes and masks, I mean at least you have the decency to give us those. I had terrible rows with PCT over that 'get it yourself and all that business....I had terrible rows with them.

Female, 60 yrs old, assisting for 10 yrs

However, the nursing staff at the hospital seemed to have more appreciation for carers, but the lack of an organised system being in place for the supply of disposable parts had the nursing staff to be cautious while giving out supplies to carers.

> I had a nurse come up to me at A&E, and said 'we know how valuable you are....
> Carers... Take these; she gave me mask... tubes... quite a bunch, she done it carefully
> so that no one could see she said 'come here, take these'... So the accessories need
> to be looked at because you're now again its chaotic do we provide them or don't
> we provide them?
>
> > Female, 60 yrs old, assisting for 10 yrs

The non-availability of a nebuliser service unit through the local hospital, and the lengthy procedures for obtaining a nebuliser through loaning services were expressed by the carers. Additionally, the lack of information received on maintaining the nebuliser system, and fears of being left without a nebuliser in the event of equipment break down was a major concern for some carers.

> We never thought about it touch wood. So far it's been okay but it's something we
> should find out. We're lost without it. And when things are now you can't rush out
> and buy a new one I don't know how much they are now.
>
> > Female, 65 yrs old, assisting for 5 yrs

On the other hand, carers who purchased the disposable parts privately through a company expressed concerns over the cost. Only wholesale quantity was available to purchase through the company with lots of other parts which were not needed.

> We bought packages from the company and you get loads of stuff you don't need.
> You know you couldn't buy the tubes without, you know on their own, and that
> kind of things you like paying £20 for a package with loads of stuff you don't use.
>
> > Female, 60 yrs old, assisting for 10 yrs

The inconvenience of making long trips to the manufacturer site to service the equipment was another difficulty expressed in this context.

> Take it to the manufacturer's agent; the nearest is in .... so that's where it gets
> serviced. You could send it by post but then you're without it, this way we book an
> appointment and it's about an hour and a half. You leave it and then we pick it up.
>
> > Male, 79 yrs old, assisting for 3 yrs

<u>Difficulties reported with maintaining supply of nebulised medication</u>

Four carers described difficulties with regard to this activity. The level of vigilance exercised on behalf of the carer to ensure uninterrupted supply of medication was one of the issues raised in this regard.

> I need to check that he's got enough because with the repeat prescription it takes 5-10 days so you need to keep a check on how many, make sure that it's enough in the house because, sometimes I think last week the chemist made a mistake and he was down to the last five so that was a bit worrying yeah... yeah I've got to make sure he's got enough in. He can't be to the last one before...
>
> Female, 56 yrs old, assisting for 10 yrs

Delivery services offered by the local pharmacy were described as a positive experience by one carer.

> Basically, we don't have to do anything except phone them (the pharmacy), ask them for what we want, and then in two days go and pick it up. And quite often, I will go and pick it up for her, yes. But before this, before our pharmacy did this, yes, I would quite often say to her do you need a repeat? I've got to put mine in. I will take it up, put it in, pick up the repeat, and then bring it back to the pharmacy. But now they've got this really nice system we don't have to worry about it.
>
> Female, 26 yrs old, assisting for 5 yrs

Difficulties reported with making decisions on the need to seek help in an emergency

Three carers described difficulties with performing this activity. The inability of the carer to recognise symptoms of an exacerbation and to distinguish it from other symptoms related to age was described by carers. Conflicting information received from healthcare professionals complicated this task further.

> I go really exhausted you see. They say to me like the receptionists, the nurses were alright, but the receptionist says to me 'do her lips go blue', well her lips don't always go blue. A one point they ask me is her lips blue and..., and I said no and then we got an emergency doctor in he took her oxygen levels and said oh my god she's got to go to a hospital immediately, they're so low, and I said blue lips is not an indication necessarily because she lives on low oxygen levels anyway...
>
> Female, 60 yrs old, assisting for 10 yrs

Difficulties reported with monitoring side effects of the nebulised medication

Three carers expressed difficulties with performing this task. The lack of information received regarding what side effects to expect with the use of nebulised medication, and the need for constant monitoring were described by some carers. The side effect itself, and

medication errors introduced by the system were described as a major source of stress. The carer needed to stay vigilant to detect these errors which complicate their monitoring role.

> She's gone to the clinic, and the clinic had given her something else, changed the inhaler, but didn't make it clear it was instead of another inhaler, so they were doing double, so when she went in the clinician ward, the pharmacist come up to the warden, but they're saying it to her, not me, you're duplicating, you got to do something about it. Then the day she came out, the pharmacist come up again, and said look, I'm concerned about it; you're duplicating, and so then we got the thing from the hospital, and found it was still duplicating, so I rang the doctor, and I said you know, the pharmacist was quite insistent that there's a duplication here, that the old medication she was on have been changed at the clinic, but you haven't taken it off, and haven't made it clear that it was instead of. So she looks it, and she oh yeah god, yeah a duplication, so she'd been duplicating, so there was all this sort of confusion.
>
> Female, 60 yrs old, assisting for 10 yrs

<u>Difficulties reported with accessing information from healthcare professionals on the use and safety of nebuliser therapy</u>

Two carers expressed a need for information with regard to different aspects of nebuliser therapy such as; the frequency of dosage, cleaning and maintaining of nebuliser, and what actions to be taken in the event of treatment failure or equipment break down. The use of multiple inhaler devices was a source of confusion for some carers.

> My husband is on three different inhalers, so we weren't entirely sure how they really work, and it did take us a while to actually find out how that (nebuliser) happened you know, how they work you know. He was told to take them, but we weren't really sure what we were supposed to be doing.
>
> Female, 67 yrs old, assisting for 4 yrs

4.5.3. The partnership between carers and COPD patients

This section describes the partnership between carers and COPD patients in the context of using nebuliser therapy in the home. All carers (14) were asked during the interviews to indicate how often they provided assistance with a total of 10 activities related to the use of nebuliser therapy. They were also asked about the reasons for their assistance. The carers' accounts were examined closely to gain a deep understanding of the partnership which

existed between the carers and the patients. Analysis of the data revealed the extent of carer involvement, the dynamics of the partnership, and the factors affecting the partnership. Understanding how carers and COPD patients divide tasks and share responsibilities of the use of nebuliser therapy provides healthcare professionals with vital information to optimise medication use and health outcomes for patients and their carers. Knowledge about the factors which lead to increased carer input can assist in targeting carers who are in need for support.

The extent of involvement

Three types of partnership between the carers and the patients were identified from the data which occurred in the context of using nebuliser therapy: the patient is mostly responsible for using the nebuliser while occasionally receiving some assistance, the patient and the carer shared responsibility for using the nebuliser, and the carer is mostly responsible for using the nebuliser.

The patient mostly responsible for nebuliser use

The carers reported that the patient was mostly responsible for making decisions on the need to use the nebuliser (n = 4), setting up and operating the nebuliser (n = 6), and inhaling the nebulised medication (n = 3). However, assistance was still occasionally received from the carer.

> Yes, she does it mostly herself (setting up and operating the nebuliser), but whenever she needs help, you know, it's difficult to put a time factor to it. Because I rather she can do things herself than rely on me all the time.
>
> Male, age 61 yrs old, assisting for 3 yrs

The patient and carer shared responsibilities of nebuliser use

Sharing responsibilities was described by the carers in the context of many activities such as: making decisions on the need to use the nebuliser (n = 4), setting up and operating the nebuliser (n = 4), dismantling and cleaning the nebuliser (n = 2), maintaining supplies of disposable parts and servicing the compressor (n = 3), making decisions to seek help in an emergency (n = 3) and gathering information on the use of nebuliser (n = 2). Sharing

responsibilities was described in terms of always being responsible for doing certain tasks while the patient was responsible for others, or in terms of always performing tasks together with the patient.

> I dismantle it and clean it, wash it properly, but I don't reassemble it, because she would normally want to put the medicines inside. She would reassemble it. But I can reassemble it, it's not a problem.
>
> Male, age 61 yrs old, assisting for 3 yrs

The carer fully responsible for nebuliser use

The carers reported that they were mostly responsible for performing tasks such as: supervising the nebuliser use (n = 7), dismantling and cleaning the nebuliser (n = 6), maintaining supplies of disposable parts and servicing the compressor (n = 6), maintaining supplies of nebulised medication (n = 11), making decisions to seek medical help in an emergency (n = 5), monitoring side effects of nebulised medication (n = 11) and gathering information from healthcare professionals on the use or safety of nebuliser therapy (n = 6). It is worth mentioning that the partnership was not always described as being harmonious or teamwork. There was evidence that this partnership was sometimes strained. Conflicting views with regard to the need for therapy, or beliefs about the safety of nebulised medication were expressed by the carers.

> Well, when she's bad she'll use it up to four times a day, when she's good maybe only once or twice. So she tries not to use it, she's stubborn; she tries the hardest not to use it.
>
> Female, 26 yrs old, assisting for 5 yrs

Additionally, there were instances where the carer felt that the patient was demanding more assistance than what was really needed.

> He calls me and he said - you prepare it. I said I want to show you, it's so easy, it's very easy, you break the top and you just squeeze it in. You do it. I can't do it. I said - you look here, you can see here there is one, two, three, you can see there is nothing there. You can see if it's empty.
>
> Female, 74 yrs old, assisting for 4 yrs

Some carers were mindful not to 'over-care' or compromise the autonomy of the patient, these carers explained the importance of the patient to stay independent and do things for themselves as long as they could. However, they indicated that they would step in at any time they felt that their assistance was needed. One carer saw herself as a standing-by person who would step in when needed.

> We are like a standing by person do you understand I'm standing by watching to see when they need to be supported... they can be taken away that bit of independent to their patients they could be over caring you know and that's not right either you have to get a balance.

> Female, 60 yrs old, assisting for 10 yrs

Factors affecting the extent of assistance provided

The data demonstrated that the assistance provided by the carers was dynamic and responsive to patient needs. The carers were actively involved in observing the patient and continuously reviewing and adjusting their level of contribution to match the needs of the patient. Accordingly, the data were searched for factors which affected the contribution of the carers. The reasons for assistance, as reported by the carers, are also shown in table 4.28.

Table 4.28: The reasons for the assistance provided, as reported by carers.

Reason	N(14)
Confusion about medication	1
Difficulty in breathing	5
Coordination problems	1
Disorientation	2
Feeling Pain/Discomfort	1
No reason	3
Panicking	1

The timing and complexity of the regimen

One of the factors that emerged during analysis was the timing of the therapy, as some carers indicated that the patient only required the assistance in the beginning when nebuliser therapy was first started, and that the patient no longer needs this assistance.

When we first bought it, we went through the instructions and they showed him everything and all that and since that time I haven't really helped him with it. So he mainly assembled it himself... So he does it mainly on his own, so I'm not really familiar with assembling and everything now, but I mean I know about the medication that the GP told him to stop now... and that's all.

Female, 29 yrs old, assisting for 10 yrs

Additionally, it emerged from the carers' accounts that the number of formulations prescribed for the patient to be used with the nebuliser determined the amount of the assistance provided by some carers.

Because sometimes he cannot do, sometimes he doesn't know how much he has to take, and how many times a day, and which one to put in, etc, etc. Probably confusion, I don't know because he doesn't understand, but it's just the one (one drug), so that's why he does it better himself now. But when he has got the two (drugs), and sometimes it was three times a day, and then from three times it went down to two times, then down to one time at one stage. Well, he can't do it then, he can't put the solutions in when things are bad, he doesn't understand which ones to put in, he couldn't tell the difference between the two, the antibiotic and the other one. So he does need somebody to make sure he is doing it properly.

Female, 64 yrs old, assisting for 3 yrs

Exacerbation of symptoms and presence of co morbidities

One of the most frequently quoted reasons for providing assistance by the carers was an exacerbation of symptoms. Co-morbidities and other problems the patient had were other reasons commonly articulated by carers as reasons for assistance.

When she has a bad asthma attack she can't think straight, she gets very confused, she looks at it, she has the ampoule in her hand, looks at it and goes 'what am I doing now'. And I usually go that goes in there, Mum, there you go, put it on. But I think the last time I had to do that was a couple of years ago now, because she's not had a bad asthma attack for a while.

Female, 26 yrs old, assisting for 5yrs

In summary, this chapter described the use of nebuliser therapy by COPD patients and their carers in the home. The pattern of use was shown to be influenced by the patients' and carers' own experiences and views on the effectiveness and safety of the therapy. The study provided further evidence on the effectiveness and safety of nebuliser therapy from the perspectives of COPD patients with a range of disease severity levels and duration of nebuliser use. The contribution of the carers and the assistance provided with the use of nebulisers was shown to be crucial for the overall management of COPD patients in the home. A range of problems was encountered by patients and carers with the use of nebuliser therapy which might lead to suboptimal treatment outcomes, impaired quality of life, and increased carer burden. Deficiencies in the knowledge of patients and carers, lack of services and support provided in relation to the use of nebuliser therapy were evident in this study. The patients and carers expressed many concerns and information needs which should be addressed if therapy is to succeed and health outcomes are to be improved.

This chapter discusses the findings of the study. It is divided into five sections: Section 5.1 discusses the impact of the methods employed and the response rate achieved on the generalisability, validity and reliability of the study findings; Section 5.2 discusses the key findings of this study in relation to contemporary research in the field, Section 5.3 discusses the findings of the study in relation to current government policies and health targets, Section 5.4 discusses the potential impact of the study findings to improve health outcomes and Section 5.5 discusses the contribution of this study findings to existing knowledge and identifies directions for future research.

5.1. Methodological issues

5.1.1 Sampling and recruitment

The patients were sent a recruitment pack which asked them to identify a person who provided assistance with the use of nebuliser therapy (Section 2.3.4). Only 15 carers were identified through the patients, and one did not consent to participate due to time constraints (Section 3.2). The amount of assistance required to meet the inclusion criteria of the study was not specified, and carers with minimal input were encouraged to take part. Despite this, carers providing some assistance failed to recognise the significance of their contribution to the study. This is likely to have resulted in underestimation of the carers' providing assistance with the use of nebuliser therapy. Higher numbers might have been achieved if carers were recruited from carer organisations, however the degree of representativeness of these carers would have been questionable. However, the carers included in this study represent those who were providing assistance to a representative sample of COPD patients (Section 5.1.2), and therefore findings obtained from carers can be of relevance to other carers.

Although the recruitment of the surgeries was a smooth process, identification of the patients from the databases was not straightforward. The diagnosis of COPD was recently introduced in the database system of the surgeries and previous to this COPD cases were recorded as asthma. This created a challenge in identifying some COPD patients and a review of various clinical variables was required before the researcher was confident that the case was one of COPD. This was done by considering factors such as the age of the patient, the history of smoking and record of spirometry testing. Thus, the identification

process was time consuming. This resulted in a few patients being recruited who identified themselves to the researcher during interviews as asthmatics (n= 6). Nonetheless, the views of these patients were consistent with those obtained from other patients with a confirmed diagnosis of COPD which suggests that findings from this study have some relevance to asthmatics. This is not surprising given the overlapping nature of symptoms of the two conditions. However, some issues explored were not relevant to asthmatics. This is evident in the data in the context of the pattern of nebuliser use, with asthmatics only requiring their nebuliser occasionally, during attacks.

Due to ethical considerations and criteria set out by the local ethics committee, the process of identification was carried out mostly by the collaborator. It is expected that doctors would not have the time to carry out this process if collaborators were not involved. Moreover, recruitment from other routes such as support groups and retail pharmacies was not feasible given that the clinical parameters were not accessible. Another challenge was the different database system employed in different surgeries which meant different methods were required to identify the clinical parameters. In the majority of cases the QOF indicators were consulted to obtain a list of all COPD patients on the register. However, this was conducted alongside reviewing asthma patients (as described above) to provide a comprehensive list of the patients who were likely to have COPD and were using nebulisers in their home and thus, were eligible to take part in the study. In this study 180 patients were identified as meeting the inclusion criteria, however, the number of patients identified varied across the surgeries (Mean 5, Range 0 – 13), and in two surgeries none of the patients matched the criteria for the study. Identification of eligible patients from intermediate care was relatively straightforward, as these patients were already known to members of the HART and were on a form of register. The patients identified through this approach yielded 20 more cases. The recruitment and the identification of patients from intermediate setting were carried out in parallel to that in primary setting. The patients identified through intermediate care were also identified through the GP surgeries, which was anticipated, as both settings served the same population. However, the inclusion of these patients was necessary to ensure representativeness of the disease severity level.

5.1.2. Response rate and participants' characteristics

Although this study employed a small sample size (n = 50) owing to the predominantly qualitative nature of the study, it included patients with a range of clinical characteristics

(disease severity and duration of nebuliser use), achieved through sampling from two levels of care, which are considered to be important and might influence the issues explored in this study. A similar proportion of males and females were recruited. However, the majority of patients were recruited from the white ethnic group, with a smoking history, and had lower education. These characteristics can be seen as a function of the prevalence of COPD in susceptible groups with known risk factors rather than a response bias. The greater number of severe patients recruited reflected the under-diagnosis of mild and moderate disease which are usually asymptomatic and less likely to present themselves in primary care and are unlikely to be prescribed a nebulised therapy.

One of the reasons for declining to participate was residence in a nursing home. This study did not include any patient from a nursing home. However one patient was in a care home. Patients in a nursing home might be too unwell to participate and it is unknown whether these patients would have fewer problems as they will have access to professional help. Further research is needed to investigate the nebuliser use among this group of patients.

It was noted during the interviews that a motivation of respondents in this study was the patients' and carers' desire to learn about their nebuliser therapy, which mirrored the lack of information revealed during the interviews. Participation in the study was seen as an opportunity to access information about issues relevant to their healthcare, especially in circumstances where the patient was isolated or housebound. Other drivers for participation identified were isolation of the patient and the desire to speak to someone about their health.

Although there is some evidence of self-selection and response bias, the methods employed achieved a sample with a wide range of demographics and clinical characteristics suggesting that the study findings can be of relevance to a wider COPD population.

5.1.3. Data collection

In health services research, triangulation is used to serve three main purposes: to provide different perspectives of an issue, to validate data obtained on an issue or to obtain different data to serve an objective or a research question (Smith, 2002). Social researchers have argued that triangulating data obtained from different methods strips the data from the influence of the contexts in which these data were collected (Smith, 2002). In this

study, the data were collected at the same time and were concerning the same sample of patients. Different methods were used and a reflection on each method and the extent to which using this method achieved the objectives of the study is outlined below:

The process of the interview

The effect of the presence of the researcher to influence participants' views should be considered when interpreting findings obtained from the interviews. It is likely that the presence of the researcher, the medical background, and other characteristics would influence the findings. Conducting the interviews in the patient's home provided a private and relaxed environment for the patient to 'open up' about their health and discuss sensitive issues. Overall, the patients and the carers were open and relaxed with discussing issues related to their health with the researcher which is reflected in the wide range of sensitive issues revealed in this study. However, it was noted that the participants varied in the degree of their openness and willingness to disclose details on some issues despite reassurance given on the confidentiality of the information collected. This is reflected in the variations in the durations of interview between participants, and the amount of information obtained from each participant. This may be because certain issues were more relevant to some patients or that some patients had more experience to share on some matters. This variation was noted within the same participant where some issues were more extensively discussed than others. This means that the data available for analysis differed for the issues explored. Nonetheless, none of the interviews lasted less than 20 minutes, which suggests adequacy of the information obtained. Overall, the interviews went smoothly. However, some interruptions occurred due to the telephone or door bell ringing. When this occurred, on resuming, the researcher always followed up the issue previously being addressed.

In adherence with the requirement of the ethics committee, the researcher carried a badge with photograph as an aid in identifying herself to the study participants (Section 2.6.1). It was noted that this was often interpreted as the researcher being a member of the healthcare team and therefore, participants were reluctant to give negative views on issues concerning the care they received. This was overcome by the researcher by stressing the confidentiality of the data collected, and disassociating herself from the healthcare team. Doing so, led the participants to be more open to the researcher, which was evident from the negative views they gave on particular aspects of their care. Some patients were inclined

to ask for information with respect to particular issues where this was lacking. In this context, information was frequently sought by the participants on many aspects of their care such as: the frequency of cleaning and replacing the nebuliser parts, the cleaning method and information on places to service the compressor. This information was of particular importance to achieving the study objectives. Therefore, whenever this occurred, the researcher gave the information after the interview so as not to influence the participant's responses on related issues. There is evidence that some issues had not been thought about previously by the participants, who were stimulated to form a view or opinion when confronted with a question.

Conducting separate interviews with carers and patients was not always feasible in this study. However, the interaction between the patient and the carer served to validate the data collected; in particular variance of views were resolved after a brief discussion, especially in instances where the patient had to recall events which occurred in the past. Conducting separate interviews would not have allowed for such verification and could have resulted in conflicting views between the patient and the carer, which are not necessarily accurate. Asking the questions in the same order was not always possible, due to the nature of qualitative research and the importance of following up issues raised by the participants, which were not necessarily anticipated and accounted for in the interview schedule. In addition some participants wished to discuss certain issues with the researcher which they considered a priority to them, and were seen by them as central to their care or use of nebuliser therapy. This approach represented a more natural way to elicit information and was seen as more friendly than a rigid protocol approach. There was a need to collect consistent data on certain issues to validate findings. Whenever this occurred the researcher reminded the participants of the previous point and followed with the next question. The missing responses in the results section resulted from when the researcher was not able to follow the issue.

The non-participant observations

The use of non-participant observation in this study validated and complemented the findings obtained from the interviews in providing a detailed investigation of the problems encountered by COPD patients using nebulisers in their homes. By observing the patients while they set up and operated their nebuliser, the researcher identified the steps which

were incorrectly performed during this process. Such data would not have been achieved if interviews were the only method used for data collection, in particularly, the problems which are not known to the patient would have been missed. However, interviewing techniques served to provide explanations and additional details of the problems (how and why they occurred?). Additionally, the use of a checklist as a mean of standardisation ensured that the information obtained was consistent across all patients, and provided a way of quantifying the problems. However, a major limitation of the use of observations is the Hawthorne effect, which is the effect of the presence of the researcher influencing the behaviours of participants (Smith, 2002). There were many ways in which researchers have attempted to minimise this effect such as: spending some time with the participants before collecting the data, discarding the data collected in the early stages, or withholding the research objectives from participants. Due to the limited time allocated to data collection, and ethical obligations none of these measures could have been undertaken and therefore the extent to which the Hawthorne effect influenced the findings in this study could not be ascertained. However, in the light of the high frequency of problems identified in this study, it seems likely that this effect was minimal.

The clinical data obtained from surgery databases

All patients who were interviewed agreed to share the information required with the researcher and a visit to the surgery where the patient was treated was made. Some points relating to the procedures employed in collecting the clinical information together with their limitation are discussed to give an indication of the usefulness of the parameters. Missing data were scattered across the cases. However, no clinical data were available for one patient who was registered with a surgery which was not within the PCT (this patient was identified through the hospital). Although the surgery which held the patient record was part of the strategic health region covered by the approval granted by the local ethics committee, a further approval was required from the PCT which would have hindered the flow of the study.

Overall data collection was time consuming and challenging due to the poor recording of information at some practices. In addition some parameters required different searches and to consult multiple sources required several visits depending on the number of patients and the availability of a desk. Due to inconsistencies and shortcomings in some surgeries' information records, some variables were not complete for all patients and in some cases

the researcher made a clinical judgement. In particular to the disease severity level. Ethnicity was another variable which could not be extracted from surgery databases, and in this case the researcher made a subjective judgment based on the appearance and accent of the patient. Although in this study none of these variables were associated with the occurrence of problem, they should be interpreted with caution. Additionally, it was not always possible to ascertain that recruited patients had a diagnosis of COPD due to shortcomings of endorsing information at the surgeries. This resulted in some issues being less relevant in instruments and during interviews. In particular inconsistencies in responses obtained on some interview items regarding the pattern of use (occasional use was more related to asthma while regular use was related to COPD), and items in SGRQ concerning the frequency of exacerbations. However, overall there was an agreement among the participants with regard to interview and questionnaire data. Additionally, the inconsistencies only occurred with regard to a few cases while these patients shared many characteristics suggesting that study findings can be generalised to other conditions with similar clinical presentations.

<u>The use of the quality of life instruments</u>

The instruments used in this study demonstrated good practicality, validity and reliability in the study sample. The practicality of the SGRQ in this study was somewhat better than that reported by other researchers who used the SGRQ in a similar population (COPD) in terms of the time taken to complete the questionnaire (Stahl et al., 2003), and the number of missing items (Molken et al., 1999). The use of the SGRQ and the EQ-5D appears to be practical in this study. Both questionnaires were easy to administer and were completed in a relatively good time (Section 3.5.1, 3.5.2). The SGRQ had more items and was expected to take longer time to administer than the EQ-5D. However, none of the patients seemed to be fatigued by the process. The shorter time taken to complete the SGRQ and the lower rate of missing responses can be related to the method employed in administering the questionnaire in this study (interviewer-administered compared to self-completion). Additionally, other measures taken in this study to facilitate data collection among COPD patients included the use of a large font and reprinting the questions on laminated papers, reading the questions aloud to the patients, and audio-recording the responses (Section 2.6.3). These measures facilitated the administration of the questionnaire and led to better acceptability by the patients. In the light of these findings healthcare professionals and researchers are recommended to use a similar approach when considering using a long

quality of life questionnaire in COPD patients or other vulnerable group of patients. The completion rates were also good for all the domains included in the SGRQ, with the exception of the symptom domain where some patients expressed some difficulties in answering some of the items. This led to the missing items which were all clustered in this domain. The difficulty expressed by the patients can be explained partially by the fact that some of the items corresponding to the symptoms were less applicable to asthmatic patients. Asthmatics differ from COPD patients in terms of symptoms on a day to day basis, and the short recall period may have accounted for the missing values among those who were asthmatics. It is difficult to distinguish the two and on many occasions the researcher had to make a judgement on whether to include the patient in the study. This may have resulted in the inclusion of some asthmatics who found some of the symptom items not applicable to them. The developer stated that the scale was appropriate for use among asthma, COPD and other respiratory conditions (Jones et al., 2003). The overall understanding of the patients was good for the SGRQ and excellent for the EQ-5D. However, some patients expressed difficulties in answering some of the questions in particular those with dichotomous responses (True/False) of the SGRQ. As for the practicality of the carer burden scale, the carers were asked to complete the ZBI at the end of the interview. The use of the ZBI in this study proved to be appropriate and practical to administer for the 15 carers assisting COPD patients with the use of the nebuliser therapy at home. In terms of the practicality and ease of administration of the scale, the carers completed the questionnaire in a relatively short time (Mean = 7 minutes) (Section 3.5.3).

As reported in the literature, both the EQ-5D and the SGRQ were shown to have a good validity and reliability when used among COPD patients. Findings from this study are consistent with those previously described by other researchers with regard to the good psychometric properties for both questionnaires (Jones et al., 1991; Hazell et al., 2003; Brazier et al., 2004). As for the content validity, all instruments had good content validity which was supported by the issues raised by the participants during the interviews. The construct validity in this study was achieved by comparing the health status scores obtained from both scales. The results obtained from validity testing using Spearman's correlations in this study suggests that the EQ-5D was only poorly related to the symptom score from the SGRQ indicating that the two instruments cannot be used interchangeably (Appendix XXV). This finding is not surprising as the two scales were developed to measure different aspects which would impact on the quality of life of the patient and the symptom subscale comprised items related to the chest condition which were not addressed by the generic

EQ-5D. It was also possible to compare the scores from both instruments which lend the questionnaires evidence for convergent validity. Additionally, both questionnaires had good disciminant validity and were successful at differentiating between patients with different disease severity levels (Appendix XXVI and XXVII). The ability of the SGRQ and the EQ-5D to differentiate between disease severity levels was previously described in the literature (Stahl et al., 2005; Rutten-van Molken MP et al., 2006). With regard to the reliability of the instruments, previous researchers used Cronbach's Alpha as a measure of the internal consistency to demonstrate the extent to which the items in the scale are measuring the same phenomenon and noted good results for the all SGRQ domains except for the symptom scale which showed a lower value (Jones et al., 1991). A similar observation was noted in this study with excellent reliability for all domains except for the symptom domain (Appendix XXIV). In the literature, the reliability of the EQ-5D questionnaire was assessed using a test-retest method as it is more suited for scales with less than 10 items, as in the case of the EQ-5D which comprises only five items and would therefore be expected to have a low Cronbach's Alpha value. However, due to the cross-sectional design employed in this study it was not possible to re-test the EQ-5D and the Cronbach's Alpha was calculated instead (Appendix XXV). The ZBI scale demonstrated excellent reliability (Appendix XXV) which was consistent with previous studies (Zarit et al., 1987).

5.2. Key findings of the study

5.2.1. The use of nebuliser therapy in the home

Pattern of use

The findings from this study identified regular and occasional patterns of nebuliser use among COPD patients (Section 4.1.1). A significant proportion of patients were found to be using their nebuliser therapy occasionally and in some instances the last time the nebuliser therapy was used exceeded a year. This finding is in line with previous studies documenting the patterns of nebuliser use among COPD patients in the community (Mansfield, 1996; Godden et al., 1998; Melani et al., 2001; Boyter and Carter, 2005). However, the proportion of patients who use their nebuliser occasionally was greater in this study compared to three previous studies (Mansfield, 1996; Godden et al., 1998; Boyter

and Carter, 2005). This difference can be explained by methodological differences between this study and the previous studies. In the latter only patients who derived an apparent subjective or objective benefit were included in the studies and would therefore be expected to be more motivated to use their nebuliser. In addition, these patients received proper instructions on the use of the nebuliser and were followed up for the period of study. The infrequent use identified in our study should be a cause of concern for healthcare professionals and reflects a lack of proper assessment of these patients. The cost of one unit salbutamol (5mg) and ipratropium bromide (0.5mg) from a nebuliser four times a day has been estimated to be more than 10 fold greater per person per year for the equivalent dose delivered by a metered-dose inhaler (O'Driscoll, 1991). The prescription of nebuliser therapy might not be cost-effective in these cases. Healthcare professionals should assess the need for therapy, and identify cases where the nebuliser therapy is infrequently used to avoid unnecessary costs.

Dosage frequency and dosage interval

The dosage and the frequency of dosing have not been established in previous trials, however drug regimens currently recommended in the guidelines for nebuliser use are: 2.5 – 5 mg salbutamol, or 250 – 500 mcg ipratropium bromide, or a combination of the two formulations to be administered 'as needed' up to four times a day, although in practice the four times a day regimen is mostly used by patients (British Thoracic Society, 1997). In this study, the majority of patients used the nebuliser therapy less than four times a day, over a third of patients used it four times a day and only a few patients were using their nebuliser more than four times a day (Section 4.1.1). This variation in use was previously noted in other studies of nebuliser use (Murphy and Holgate, 1989; Hosker et al., 1995; Godden et al., 1998; Melani et al., 2001; Barta et al., 2002; Boyter and Carter, 2005). The lack of a clear consensus on the dose of the nebulised medication to be used in clinical practice explains the variation noted in these previous studies and in this study. In the majority of cases, the patients made their own judgment on the need to use the nebuliser and the dosage required to control their symptoms. The BTS guideline for nebuliser therapy clearly indicates that there should be a four hour gap between nebulised doses. In this study the majority of the patients, with the exception of four patients, adhered to the four hour rule between doses. Godden et al (1998) showed considerable confusion about the time interval considered safe to re-administer the nebulised dose among COPD and asthmatic patients (time ranged

from 0.5 to 12 hours) and what to do in the event of treatment failure. This information is readily accessible from the patient information leaflet. However, the non-adherence to this rule in our study can be improved with reinforcing these instructions by healthcare professionals.

To our knowledge no previous study described how patients determined their dose requirements. Based on patients' reports, the decision to initiate nebuliser therapy and the dosing frequency were symptom dependent, the next dose was often determined by a worsening of symptoms, with the majority of patients aiming for the longest period of being symptom-free. On a few occasions, the patients administered a prophylactic dose in response to certain known triggers which they anticipated, through past experience, would result in a worsening of their symptoms. Additionally, some patients worked out a dosing schedule which fitted best into their daily routine and lifestyle.

According to current recommendations, the suitability for long term nebuliser therapy requires a period of trial conducted using patients' subjective reports and objective peak inspiratory flow rate (PEFR): an improvement in symptoms or lung function is a prerequisite to the supply of the nebulised bronchodilators (Boe et al., 2001; The National Institute for Clinical Excellence, 2010). However, there is evidence suggesting that there is little value in using a peak flow meter in monitoring the response to treatment in COPD patients, and recently a study showed that there was little difference in PEFR between an intermediate dose bronchodilator delivered by pMDI and a spacer and high dose nebulised bronchodilator (Brophy et al., 2008). Findings from this study support the lack of usefulness of using a peak flow meter as a monitoring tool in COPD (Section 4.1.3). Based on reports from interviews, the peak flow meter did not correlate with the patients' symptoms, and was inconsistent in one case. In addition, compliance with the use of the peak flow meter was shown to be low in this study. Poor compliance was attributed to worsening bronchoconstriction caused by the deep inspiration required for its use in one previous study (Murata et al., 1998). Similarly, the patients in this study had difficulties in achieving a measurement on the device, which was attributed to the degree of airflow limitation.

5.2.2. The impact of using nebuliser therapy on condition management in daily life

Perceived effectiveness of nebuliser therapy

Based on findings obtained from the interviews, the majority of the patients in this study perceived nebuliser therapy to be effective (Section 4.2.1). The effectiveness was attributed to improving symptoms of COPD such as: relieving breathlessness, aiding in expectoration of mucus, alleviating congestion symptoms, increasing activity levels, improving sleep and having a calming effect. Other benefits were attributed to increasing the level of self confidence and psychological wellbeing. These findings are supported by previous studies assessing the role of domiciliary nebuliser therapy from the perspectives of COPD patients (Murphy and Holgate, 1989; Godden et al., 1998; Melani et al., 2001; Barta et al., 2002).

Increasing independence as a result of avoiding unnecessary hospital admissions was reported by the patients; the patients in this study indicated that using nebuliser therapy prior to accessing emergency services prevented hospital admissions most of the time, while only a few patients reported that despite using their nebuliser, they ended up in hospital. However, these patients stated that such incidents only happened occasionally. This finding was supported by a previous study where using a nebuliser just before an emergency hospital admission helped the majority of patients in avoiding hospital admission (Murphy and Holgate, 1989). A common misconception is to perceive nebuliser therapy more effective than other forms of inhalational therapy (pMDIs and DPIs). Findings from this study suggest that patients perceived their nebuliser therapy as more effective than their regular hand held inhalers (Section 4.2.2). However, when compared with oxygen therapy, the latter was perceived more effective than nebuliser therapy. This finding is contradictory to that reported in clinical trials comparing the effectiveness of the nebulisers to hand held inhalers (Brocklebank et al., 2001). However, these studies often included patients recruited from primary care presenting with severe disease, and excluded patients with poor inhaler technique. Several studies have shown nebuliser therapy to be superior to conventional pMDIs in terms of subjective and objective benefits (Jenkins et al., 1987; Mestitz et al., 1989; Morrison et al., 1992; O'Driscoll et al., 1992). Currently, the role of nebulised therapy in mild and moderate disease is not fully established. This study included patients with a range of disease severity levels, and demonstrated that benefits were perceived across all disease severity levels, which suggests a possible value of domiciliary nebuliser therapy in mild and moderate disease states, although more research is needed to fully determine this.

Most of the previous studies reporting the efficacy of the domiciliary nebuliser therapy identified in the literature employed structured questionnaires. These studies assessed different aspects of nebuliser use with a simple question on efficacy, or required patients to select the benefits from a pre-defined list. The advantage of conducting a qualitative study was to gain a deeper insight into the patients' perceptions of the role of the nebuliser therapy in the management of their condition, without imposing any restrictions or limiting their input. By analysing the patients' qualitative accounts it was possible to gain insights into the extent of benefits attained by the patients, and to identify factors which have attributed to the effectiveness of the nebuliser therapy. Such details would have not been achieved without using an in-depth approach. Although the majority of patients in this study reported the relief of breathlessness, the extent of the relief was described by the majority to be only marginal, and temporary, which reflected the severity of their condition and indicated the need for repeated dosing (Section 4.2.2). Nonetheless, this small effect was greatly appreciated by the severely impaired patients interviewed in this study. The importance of this slight improvement in symptoms in this group of patients is consistent with one previous study (Brophy et al., 2008). Currently, the value of supplying domiciliary nebuliser therapy for patients on the grounds of attaining a subjective benefit in the absence of a clear objective benefit is greatly debated by healthcare professionals and guidelines on the nebuliser use requires the clinician to make a clinical judgment (British Thoracic Society, 1997; Boe et al., 2001).

Several factors have been identified in this study which impacted on the patients' perception of the effectiveness of nebuliser therapy (Section 4.2.1). The findings from this study suggest that the effectiveness of nebuliser therapy was considered by the patients to be dose dependent; more benefits were attained with increasing dose (using two formulations together, higher strength of formulation or increasing the dosage frequency). However, in terms of the duration of use needed before any benefits were attained from nebulised therapy, the patients in this study gave mixed views; some patients attributed benefits to the frequent use of the nebuliser, whereas for others, nebuliser therapy was only needed occasionally during times of an exacerbation. However, some patients reported a decline in the effectiveness of nebuliser therapy over time, which was attributed to disease progression; the extent of relief gained from the nebuliser was described as being more profound in the beginning due to disease progression (Section 4.2.2). Godden et al. (1998) proposed a similar explanation in a previous study assessing the effectiveness of nebuliser therapy. Currently, nebuliser therapy is only indicated in severe COPD. In the light of the

findings from this study, commencing nebuliser therapy early might play a role in managing COPD patients and slowing the progression of disease, although more studies are needed to ascertain the exact role of nebuliser therapy in milder disease. Developing tolerance to nebulised medication with frequent use was another factor reported by the patients to contribute to the decline in the effectiveness of nebuliser therapy (Section 4.2.2). Tolerance to long term inhaled beta agonists is well described in asthma, but not until recently has this issue been investigated in COPD. Previous researchers believed that, short term tolerance to beta agonists existed only in laboratory settings but was less relevant with prolonged use in clinical setting (O'Driscoll and Bernstein, 1996). However, recent evidence suggested that this tolerance is apparent for beta agonists alone, but not when anticholinergics are used (Salpeter, 2007). Based on this finding, it was recommended that treatment guidelines for COPD should be revised to recommend anticholinergics as the first line treatment for COPD (Salpeter, 2007). A lack of effectiveness in this study was attributed to the severity of symptoms prior to using the nebuliser (Section 4.2.2). For example, one male patient indicated that benefits were not gained as he did not feel unwell prior to using the nebuliser. By contrast, one female patient stated she had not gained benefits during flare ups. This in turn shows that the response to nebulised therapy might be subjective to the individual patient, and indicates a need for an individualised treatment plan for each patient. Some patients in this study had low expectations of outcomes from their nebuliser therapy which impacted on the perceived effectiveness. For example, one male patient felt there was nothing that could be done to help him unless he went through lung transplantation. This finding differ from a previous study where patients had higher expectations of their nebuliser therapy at the beginning which did not match their subjective benefits after 2 months of use (Simpson et al., 1998). Furthermore, some patients in this study were uncertain about the exact effect of the nebulised therapy which was due to continuous use such that benefits could not be ascertained unless the patient refrained from using the nebuliser for some time to notice the difference (Section 4.2.2). The lack of using any form of subjective or objective assessment to monitor the response to therapy was another factor which hindered the patient from forming an opinion on the effectiveness of the nebuliser therapy. The uncertainty of the exact effect of the nebuliser was explained by some patients as their being on multiple medications or suffering from multiple conditions, which prevented them knowing the contribution of the nebuliser per se to their wellbeing (Section 4.2.2). Such issues complicated the management of COPD patients in clinical practice; assessing the effectiveness to nebuliser therapy is useful and

increased the patient confidence in their therapy and should therefore be undertaken by healthcare professionals.

Perceived safety of nebuliser therapy

The findings from this study were in line with previous studies investigating the safety of domiciliary nebuliser therapy from the perspective of COPD patients (Murphy and Holgate, 1989; Godden et al., 1998; Barta et al., 2002; Boyter and Carter, 2005). Although, side effects such as: tremor, dizziness, palpitations, eye problems, and mouth ulcers were reported by a number of patients in this study. Tremor, dizziness and palpitations appear to occur occasionally, be dose dependent, and disappeared with persistent use (Section 4.2.2). Godden et al. (1998) previously found that side effects were dose dependent (Godden et al., 1998). However, in one previous study, half of the patients reported one or more side effects after 3 years indicating that these patients did not develop tolerance to side effects, however the side effects were minor and less significant compared to their breathlessness (O'Driscoll and Bernstein, 1996). On the other hand, mouth ulcers and eye problems were related to the use of steroids and the use of anticholinergics with face masks respectively.

In the literature, concerns have been previously expressed over the increased mortality among asthmatic patients using home nebulisers (Ebden et al., 1987; Burrows and Lebowitz, 1992; Mullen et al., 1993). However, studies investigating mortality among COPD nebuliser users are currently lacking. Nonetheless, O'Drischoll and Bernstein (1996) investigated the mortality from high dose bronchodilators delivered using either pMDI and a large volume spacer device or a nebuliser among COPD patients and asthmatics during a five year follow up period. They found that the survival rates were similar in both groups, and that deaths were related to the age and the FEV_1 as measured at entry to the study. They concluded that mortality among nebuliser users was a marker of disease severity rather than an effect of the nebuliser. This study was a cross sectional design and did not intend to investigate mortality and survival rates among COPD patients using nebulisers, in the light of the few randomised controlled trials which investigated this issue, the need for more research is clearly warranted.

Impact of perceived efficacy and safety on decisions to use nebuliser therapy

Findings from this study can be considered in the context of the wider literature of adherence to therapy and beliefs about medications. Adherence to inhalational therapy among COPD patients was previously found to be influenced by their own beliefs, effectiveness of therapy and side effects experienced (Restrepo et al., 2008) Findings from this study suggest that this theory is applicable to the decisions made to use nebuliser therapy, which were largely influenced by the patients' own views and experiences about nebuliser therapy (Section 4.2.1, 4.2.2). It emerged from the data that perceptions of the effectiveness and safety of nebuliser therapy influenced the decisions made by the patients with regard to the use of therapy The patients were found to be more likely to use their nebuliser if it was perceived to be effective. On the other hand, fear of developing tolerance was associated with limiting their use of the nebuliser. The patients in this study regarded the side effects as being minor and stated that it did not stop them from using their nebuliser, although changes in dosage regimen were necessary in some cases. Reducing the frequency of dosage in response to side effects, and fear of developing tolerance was previously reported in the literature (Dolce et al., 1991; Barta et al., 2002). Four cases of discontinuation of therapy were identified in this study (two as a result of ineffectiveness, two as a result of side effects). Previous studies did not report cases of discontinuation of nebuliser use. The use of a nebuliser was part of the inclusion criteria in those previous studies, while in this study a prescription for a nebulised medication was the only criteria for participation. This in turn resulted in identification of those patients who were prescribed nebulised medication but were not using their nebuliser.

Compliance to therapy is of paramount importance to achieve therapeutic outcomes in patients and COPD patients fall at a great risk of non-compliance with their medication due to: the chronicity of their condition, they are likely to be prescribed multiple drug regimens and different inhaler devices, the period of symptom remission, and the concurrent therapy prescribed for other co-morbidities (Steinman et al., 2006; Krigsman et al., 2007a). Compliance to medication has been shown to be poor among COPD patients (Krigsman et al., 2007b), and significantly lower compared to asthmatics (Haupt et al., 2008). The non-compliance with the nebuliser therapy reported by previous researchers was 27% (Melani et al., 2001) to 56% (Bosley et al., 1996; Corden et al., 1997). However, differences between compliance levels reported in these studies were due to discrepancies

in the definition of the compliance used and the method of assessing the compliance. Previous studies assessing the impact of compliance with the nebuliser therapy on the quality of life yielded conflicting results (Turner et al., 1995; Bosley et al., 1996; Corden et al., 1997; Osman et al., 1997). Compliance with the use of the nebuliser therapy has been shown in two previous studies to improve the quality of life in COPD patients (Bosley et al., 1996; Corden et al., 1997), whereas in other two it was not the case (Turner et al., 1995; Osman et al., 1997). Moreover, few previous studies have identified the factors associated with non-compliance to nebulised therapy (Turner et al., 1995). Further research should identify the factors associated with adherence to nebuliser therapy in order to develop interventional programmes to optimise medication use.

Healthcare professionals should be aware of the factors underlying how patients use their nebuliser and should address all patients' concerns during the initial consultation when the nebuliser therapy is being considered. Increasing the dose might achieve better control of symptoms but will also result in more side effects. Similarly, although side effects were better tolerated with time, reduced effectiveness was reported as a result of developing tolerance to the effect of medication with frequent use. This association between the effectiveness and safety of nebuliser therapy led patients to weigh up the risks and benefits of using the nebuliser. This further emphasises the need for healthcare professionals, with patients to rationalise the use of the nebuliser therapy and optimise outcomes.

5.2.3. The impact of using nebuliser therapy on the quality of life of COPD patients

The goal of therapy in COPD is mainly palliative, aiming at relieving symptoms (Osman et al., 1997). Assessing the patients' views on their therapy is an important factor to be considered by healthcare professionals aiming to optimise health outcomes for patients with COPD. The limitations of lung function parameters in predicting the perceived benefits to nebuliser therapy among patients with COPD have been expressed recently (Brophy et al., 2008), and has led to the increasing use of quality of life measures. The use of a multidimensional quality of life questionnaires have been described in a few studies of nebuliser therapy. Moreover, these studies have assessed the impact of the nebulised medication (i.e. they have compared monotherapy to combination therapy in terms of an additional class of medication, or the use of an additional inhaler device), rather than the impact of the use of the nebuliser device. Only a few studies have assessed the impact of

adhering to domiciliary nebuliser therapy on the quality of life of COPD (Turner et al., 1995; Bosley et al., 1996; Corden et al., 1997; Osman et al., 1997). One of the objectives of this study was to examine the role of the nebuliser therapy in the daily management of COPD patients. The generic EQ-5D and the disease specific SGRQ were used to assess the impact of using nebuliser therapy on the quality of life of the patients. It has been suggested that a generic instrument would not be sensitive enough to detect changes in quality of life related to a specific disease state, and therefore, incorporating both measures is more beneficial (Jones et al., 1994).

In terms of the health status as measured by the generic EQ-5D instrument, the mean self-reported health status, minimum score, and the mean VAS score in this study were: 0.42 (SD = 0.35), – 0.36, and 50% respectively (Section 3.5.1). However, the health status of the patients in this study was worse than those reported in one previous study conducted in the UK (Punekar et al., 2007) which can be explained by the proportion of patients with severe disease included in this study compared to those included in the previous study. Additionally, this study included more patients who were: older, with a smoking history and who needed a carer, than those in the previous study. However, the health status in this study was somewhat better than that reported in another previous study conducted in the UK by O'Reilly et al., (2007); mean health status and mean VAS were - 0.08 and 26% respectively. The percentage of patients who had negative health status (interpreted as health status worse than death as valued by the general population) were more in the previous study (61%) compared to this study (14%). Additionally, the percentage of patients who had moderate or extreme problems with their mobility and usual activity domain in the previous study were marginally higher than this study (98% and 88% compared to 92% and 84%). The difference in the health status between this study and the previous study and the greater impairment noted in the previous study can be explained by the fact that patients were recruited during hospital admission to assess the impact of exacerbations on health status and utility of services (O'Reilly et al., 2007). Moreover, Punekar and colleagues aimed in their study to compare the health status of COPD patients as measured by the EQ-5D in five western countries including the UK. In their study, they showed that the health status was similar between the UK, the US, France, Germany and Spain, but different to Italy. The authors warned of extrapolating the results to countries beyond the study scale where healthcare systems and access to COPD management and treatment might be more advanced (Punekar et al., 2007). In support of this argument, the health status as measured by EQ-5D in our study was worse than that

reported in two previous studies conducted in the Netherlands (Stavem and Jodalen, 2002; Rutten-van Molken et al., 2006) and another conducted in Sweden (Stahl et al., 2005). However, the mean health status score and the mean VAS score in our study was similar to that reported for the severe disease group (GOLD IV) in two of the studies which stratified the patients into disease severity (Stahl et al., 2005; Rutten-van Molken et al., 2006). This suggests that the greater impairment in health status which was noted in our study is more likely to be attributed to the severity of the disease in our sample of patients rather than differences in the healthcare system or access to COPD services and treatment between countries. In addition, Punekar et al., (2007) also compared health status patients in primary care and speciality care and showed no difference between the two. Although in this study the patients were not compared based on the level of care, in the light of the findings from the previous study there is no reason to assume that the patients from the two levels would have been different in terms of their health status, but further research is needed to confirm this. In terms of the quality of life as measured by the disease specific SGRQ, the patients had a mean symptom score of 68, activity score of 86, impact score of 56, and an overall score of 68 (Section 3.5.2). These findings were consistent with those reported in previous studies assessing the impact of nebuliser therapy on the quality of life of COPD patient (symptom score 65 – 68, activity score 82 – 87, impact score 53 – 54, overall score 64 – 65) (Bosley et al., 1996; Corden et al., 1997).

The inclusion criteria for patients in this study were those with a diagnosis of COPD, who had a history of spirometry, had a smoking history, and were over 40 years of age. This limited recruitment to those patients with moderate or severe disease who had symptoms and presented for treatment and might have excluded those who were otherwise asymptomatic and therefore remained undiagnosed and unlikely to be prescribed nebulised therapy. Consequently, an improvement in the health status is expected to be shown if more patients with mild disease were included in this study. Nonetheless, the patients in this study were recruited from two levels of care: a primary trust and an acute hospital in a strategic health authority region in the UK. The population of this region was in line with the national population on many health indicators. Moreover, there is an underestimation of the prevalence of COPD in the study setting which was consistent to other parts of the country (for every patient diagnosed with COPD, a further four remained undiagnosed), which suggests that patients with mild COPD are more likely to remain undiagnosed as they not yet have presented to the GP (Howe, 2010). This suggests that findings from this study can be of relevance to other settings with similar prevalence of COPD in the UK.

Another aim of incorporating the quality of life instruments was to consider the findings obtained from the instruments alongside those obtained from patients during the interviews as a mean of validating the findings. Accordingly, analysis of the SGRQ results sought to assess the impact of using nebuliser therapy on the quality of life of patients in terms of their symptoms, activities, psycho-emotional, and social life. The SGRQ included four items assessing the role of medication on the quality of life which were adapted during the administration of the instrument by asking the patients to respond to these items with specific consideration of nebuliser therapy. The responses obtained from the patients on the specific items were compared with those obtained during interviews to validate and explain any differences in relation to efficacy, safety, and impact of the nebuliser therapy on quality of life. Generally there was an agreement between the qualitative interviews and the patients' responses to items concerning their nebulised medication. The findings from the qualitative and quantitative data were consistent in terms of the perceived efficacy, the perceived safety and the enhancement of life style (evident from the patients' responses to the items encompassing the impact component of the SGRQ). In terms of the perceived efficacy of nebulised therapy, the qualitative interviews identified that the majority of the patients perceived their nebuliser therapy to be effective in relieving their symptoms (Section 4.2.1). Similarly, responses to the item "My medication does not help me very much" revealed that for the majority of the patients this statement was false (Section 3.5.2). In terms of the impact of nebuliser therapy on the quality of life of the patient, the interviews identified that the nebuliser was portable equipment which enhanced their lifestyle by allowing them to leave the house and visits friends and family. The equipment did not impose any difficulties for the patients and they were not embarrassed to use the nebuliser in the presence of other people (Section 4.2.1). This was supported by their responses to the item "I get embarrassed using my medication in public" which the majority of the patients responded to as false (Section 3.5.2). Similarly, the responses of the patients to the item "My medication interferes with my life a lot" mostly indicated that this statement was false (Section 3.5.2). In terms of the safety of nebulised therapy, the qualitative interviews identified that more patients experiencing side effects than those identified from the item assessing side effects in the SGRQ. This discrepancy could be due to the fact that some patients who experienced side effects from nebuliser therapy did not regard them as troublesome. The interviews provided more information on this aspect as the patients were allowed to express their views on the issue without restriction. In addition, the interviews allowed the researcher to follow up the patients who indicated experiencing side effects during interviews with a question about their perception on the

severity of the side effects which showed that these side effects were considered minor and insignificant. This led to the discrepancies noted between the two methods. Furthermore, the item assessing side effects from the SGRQ specified that the side effects were unpleasant which did not necessarily represent the views of the patients regarding these side effects.

Overall, patients responded positively with regard to the questions on medication, indicating nebuliser therapy impacted positively on their quality of life (Section 3.5.2). This finding was consistent with reports from patients during interviews where patients indicated that the nebuliser therapy had a positive impact on their symptoms, level of activities, emotional state and enhanced social wellbeing (Section 4.2.1). Therefore, the interview data were more informative than the SGRQ and provided more meaningful information. However, the use of both methods in this study proves advantageous, allowing the researcher to develop explanations for issues of uncertainty. It has been argued that the omission of relevant information from instruments investigating a particular concept or phenomenon results in incomplete representation of this concept (Smith, 2002). Other issues identified from the interviews in relation to the use of nebuliser therapy and were omitted from the SGRQ, which could impact on the quality of life of the patients were related to advantages of using the therapy such as: a sense of self-confidence, and disadvantages such as time issues, technical issues, and dependency (Section 4.2.1). Incorporation of these factors which are relevant to the use of a nebuliser, a common therapy prescribed for patients with COPD within the items encompassing the question regarding the use of medication would prove invaluable in providing a comprehensive assessment of the quality of life for COPD patients. The SGRQ scale proved to have a good content validity manifested in many emergent issues during interviews which were part of the scale.

5.2.4. The problems encountered with the use of the nebuliser therapy in the home

This study used interviewing techniques, in instances where the patient had omitted a step or had performed it incorrectly, the researcher inquired about it and an explanation was sought to understand why this step was omitted/performed incorrectly by the patient. Additionally, the patients were asked to comment on the perceived ease of performing each activity from a total of 10 activities, and any difficulties they had encountered previously.

Interview transcripts were analysed to generate in depth descriptive accounts of the problems encountered. The patients' accounts obtained during interviews supplemented the data collected by observation and provided further details on the problems and identified the factors contributing to their occurrence. In some instances additional problems were identified. An integrated approach to data analysis was employed and the identified problems from observations were considered alongside the patient's comments pertaining to the same problem/step during the interviews to further understanding of the problem. The problems relating to the same activity were grouped together; this approach allows deeper analysis to be conducted for each activity. Analysing the patients' accounts on how they performed these activities assisted in identifying how and why these problems occurred. The activities were then grouped under higher order categories in relation to the inhalation of the dose. These findings are presented in relation to three stages prior to, during, and after inhalation of the nebulised dose.

<u>Problems encountered prior to inhaling the nebulised dose</u>

In relation to the problems encountered prior to inhaling the nebulised dose, this study confirmed findings reported in a previous study which identified problems during assembling the nebuliser parts and filling the drug solution (Teale et al., 1995). However, this study extends these findings by investigating these problems in greater detail (Section 4.3.1). Incorrect assembling of the parts pertained to situations where the patient has used a nebuliser with: an inverted facemask, a loosely fitted nebuliser cap, or a missing piece (vaporiser head). Fitting the facemask inverted would likely result in drug loss to the surrounding atmosphere during use and deposition of aerosol on the face, consequently reducing the amount of drug available for inhalation and the effectiveness of the inhaled dose. Similarly, a reduced effectiveness of the dose would result from a loosely fitted nebuliser cap permitting leakage of drug fluid during nebulisation. In instances where the vaporiser head was missing, no aerosol would be produced during nebulisation. Manual dexterity, having a poor grip, lack of understanding regarding the function of some component parts and the mechanism of operation of the nebuliser were factors identified to contribute to these problems. Additionally, the unpredictable pattern of breathlessness led a few patients to keep their nebuliser system set up at all times, to eliminate panic during the onset of the attack by ensuring the nebulised dose could be administered quickly. Thus, a significant number of patients failed to ensure the vaporiser head was freely moving prior to filling the drug formulation, which might affected the nebulisation

of the drug fluid and the dose delivered to the patient. Problems with filling the drug formulation pertained to difficulties in opening vials and confusion about the drug formulation to be used. Poor grip, eye sight problems and a lack of understanding were factors identified as contributing to these problems. Confusion about the amount of saline required to dilute the drug formulation, the use of date-expired saline solution or the use of alternative liquids to dilute the drug formulation (such as boiled water or wound irrigation solution) were other problems identified with filling the drug formulation. Substituting isotonic saline with water is hazardous and produces hypotonic solution which may cause bronchoconstriction (Mann et al., 1984). Moreover, there was a considerable confusion as to whether a dilution was necessary or not, and in one case a patient who was using a nebuliser design with a residual volume > 1ml failed to dilute the drug formulation which resulted in receiving a much reduced nebulised dose. This finding is in line with a previous study where a similar problem was identified among COPD patients who used their nebuliser in the home (Mansfield, 1996). Healthcare professionals should therefore educate patients on how to use their nebuliser and ensure that they understand the basic principle of how a nebuliser system works. Additionally, they should give the patient clear information on whether a dilution is required and the amount of saline needed to be used.

This study addressed compatibility issues in three contexts: drug-drug compatibility, drug-nebuliser compatibility and nebuliser-compressor compatibility. In terms of drug-drug compatibility, none of the patients who were prescribed combination therapy were found to be using incompatible drug formulations. Currently, guidelines on compatibility of nebulised drugs are unavailable. However, a few papers have addressed this issue and therefore prescribing doctors and dispensing pharmacists should consult available information prior to prescribing combination therapy to the patient (Joseph, 1997; Kamin et al., 2006; Burchett et al., 2010). Whenever possible (combination is tolerated by the patient and no side effects experienced) the patient should be advised to mix the two drug formulation, which reduces nebulisation time and improves compliance. Similarly, in terms of drug-nebuliser compatibility, all nebuliser designs used by the patients in this study were found to be suitable to nebulise the prescribed drug formulation. However, there is evidence in this study that this occurred by chance as healthcare professionals were rarely involved in helping the patient to choose a suitable nebuliser system. Healthcare professionals are advised to consult the manufacturer's datasheet to check the suitability of the nebuliser design to nebulise the prescribed drug formulation. Leading nebuliser manufacturer recommend the use of nebuliser chambers which are marketed with their

compressor equipments. Failure to use a compatible nebuliser-compressor combination results in an unknown amount of drug reaching the patient's lung. Unless the combination used has been tested, the patient should be discouraged to use un-recommended combinations. In this study, half of the patients were found to be using nebulisers which were different from the original design marketed with the compressor. More disturbingly, when the patients were asked whether using a different nebuliser design than the one supplied by the manufacturer made any difference, it was realised that the majority were not aware of this issue.

Problems encountered during inhalation of the nebulised dose

The problems encountered during inhalation of the nebulised dose pertained to the fitting of the facemask, concerns about drug loss, incorrect inhalation technique and breathing pattern, long nebulisation time, leakage of drug fluid from the chamber and tubing popping out during nebulisation. Ill-fitting facemasks were attributed to either: fitting the mask incorrectly on the patient's face, holding the facemask in the hand during nebulisation for easiness or due to using a facemask with a missing elastic band. This might result in drug escaping to the surrounding atmosphere, potentially reducing the effectiveness of the inhaled dose, or the drug aerosol being deposited on the patient's face or in the eyes which may cause side effects. Aerosol deposition in the eyes and on the face was previously shown in one study (Sangwan et al., 2004) and was proposed to cause glaucoma following bronchodilator therapy (Mulpeter et al., 1992; Hall, 1994). Preferences for one type of interface (facemask, mouthpiece) varied between patients. Some patients perceived breathing through the mouthpiece to be easier than the facemask due to the ability of the patient to synchronise their breathing pattern with aerosol output. Feeling claustrophobic with the mask on the face, and concerns about safety of the vapour depositing on the face made the mouthpiece a favourable option for patients. Nevertheless, some patients perceived breathing through the mask as a more natural way to breathe. These findings emphasise that healthcare professionals should give the patient the option to choose the type of interface that he/she finds more comfortable and easiest to use, prior to commencing nebuliser therapy. It is also necessary that all patients supplied with a mouthpiece keep a facemask in case of an emergency.

Drug loss to the atmosphere and not being able to interrupt the aerosol output was a cause of concern for many patients in this study and some patients used their finger to stop the

aerosol escaping to the surrounding environment during exhalation. There are different nebuliser designs available on the market which overcomes drug loss during exhalation (breath-actuated nebulisers, dosimetric nebulisers and nebulisers with a manual interruption valve). Patients in this study did not receive any advice from healthcare professionals prior to obtaining their equipment. Therefore, healthcare professionals involved in the care of respiratory patients should be aware of the different nebuliser designs and their features and offer advice to patients when nebuliser therapy is prescribed.

This study showed that patients had poor understanding of the correct inhalation technique, which mirrored the lack of instructions received from healthcare professionals on this particular aspect. Breathing technique is thought to be less relevant when nebuliser is used, compared to pMDI or a DPI, where coordination of breath and a slow inspiration flow is a prerequisite for a correct dose to be delivered to the site of action. COPD is characterised by airway constriction (Hasegawa and Nishimura, 2007), this results in a limited deposition pattern into the lung and in particular into the smaller airways (Lin and Goodwin, 1976). The deposition pattern in COPD was found to be patchy and non-uniform (Santolicandro and Giuntini, 1979), related to the degree of airflow constriction with lower FEV_1 values correlating to lower penetration indices indicating lower deposition in the lung periphery (Greening et al., 1980). Body posture can affect the area of drug deposition and trying out certain body manoeuvres can help in targeting poorly ventilated airways. The patients in this study might benefit from trying different manoeuvres. The majority of patients were found to be nose breathing in this study. Heyder et al., (1986) determined the total and regional deposition of mono-disperse particles during nose breathing in healthy adult volunteers and found that only 3% of particles between 1 – 5 μm deposit in the bronchial airways during nose breathing. They argued that a larger amount of aerosol is needed to compensate for the loss in the nose. Breathing deeply through the mouth at a slower rate and holding breath for few seconds (when possible) before exhalation can increase the amount of drug deposited in the airways by at least two folds compared to normal tidal breathing as shown in one study (Smaldone, 2002). Although deep breathing, holding breaths for few seconds and slow breathing may be ambitious and not always possible, especially for patients with severe disease. Slow and deep inspiration is beneficial when possible.

There were considerable variations between the patients in this study with regard to the duration of nebulisation. Similarly, Godden et al., (1998) found that there was a lack of

understanding of the time required to complete nebulisation among patients with asthma and COPD using nebulisers at home(Godden et al., 1998) whereas 35% of the patients were found to exceed the maximum recommended 10 min nebulisation time in another study (Melani et al., 2001).

Problems encountered after inhaling the nebulised does

The problems encountered by the patients after inhaling the nebulised dose were related to dismantling, cleaning and maintaining nebuliser therapy (Section 4.3.3). The problems identified were related to the cleaning and maintaining of the nebuliser parts and the compressor. The patients in this study had inadequate cleaning and maintaining procedures. Moreover, some patients re-used the residual fluid remaining in the nebuliser chamber at the end of the nebulisation and there was evidence of drug crystallisation within the medication chamber. Similarly, it was revealed in a previous study that a significant number of patients (12%) used the residual solution again at varying times and 6% of patients reported the presence of macroscopic residues in the tubing or the reservoir (Melani et al., 2001). The patients in this study expressed difficulties with regard to cleaning some parts especially the tubing. A previous study showed that patients had difficulty in cleaning their nebuliser (Teale et al., 1995). Conversely in another study among home nebuliser users conducted by Barta et al., (2002), the majority of COPD patients did not have any problems in keeping their nebuliser clean. With regard to maintaining the nebuliser and compressor, the infrequent replacement of the disposable parts of the nebuliser system; nebuliser chamber, the mouthpiece/facemasks, the tubing, and the filters were in line with those documented in previous studies (Murphy and Holgate, 1989; Melani et al., 2001; Boyter and Carter, 2005). In this study discoloured filters were found in some cases. Blockage of inlet filters was found to affect compressor performance in one study (Godden et al., 1998). Moreover, the lack of servicing of the compressor was a particular omission of patients in this study. The lack of servicing was found to be associated with the compressor malfunctioning in a previous study, where less than half of the compressors developed the desired flow rate recommended by the manufacturer (Godden et al., 1998). Adherence to manufacturers' cleaning and maintaining instructions are essential for the correct operating of the equipment (Wilson and Muers, 1997). Inadequate cleaning procedures have previously been linked with nebuliser contamination and respiratory tract colonisations in patients with cystic fibrosis (Jakobsson et al., 2000).

This study set out to investigate the problems encountered with the use of compressor nebulisers which are the most commonly used type of nebulisers by patients in their home. However, a few patients were found to be using newer technological nebuliser devices which offer advantages over the conventional type in terms of their portability and shorter treatment time, such as the ultrasonic and the mesh nebulisers. These patients expressed difficulties with the use of these devices. Therefore, researchers wishing to investigate the problems with the use of nebulisers should address other types of nebulisers as they become increasingly common to use.

The frequency of the problems encountered with using the nebuliser and the factors predicting the problems

This study quantified the problems encountered by COPD patients during the course of using their nebuliser in their home. Findings from this study showed that all the patients encountered problems with the use of their nebuliser suggesting a higher prevalence rate (100%) than that previously predicted (Section 4.3.4). Teale et al. (1995) estimated a 50% prevalence of problems with nebuliser use among elderly patients with COPD. This lower prevalence rate can be explained by the sampling strategy employed by Teale et al. (1995) which included patients who had been prescribed a nebuliser through a hospital and received proper instruction on their use prior to inclusion in the study. However, this study provided a more naturalistic clinical situation where most patients acquired their nebuliser through the pharmacy or another route other than the hospital (80%), and in the majority of cases no instructions were given on the use (61%). Although Teale et al. (1995) used similar methods (observations) to identify the problems, no details were provided on how the data were collected and whether a structured, highly detailed checklist was used to provide some means of standardisation.

Some previous studies have used survey methods and relied on self-reports by the patients (Teale et al., 1995; Barta et al., 2002; Boyter and Carter, 2005). This study employed a cross-sectional design. Thus, the frequency of the problems represents only that point in time, when data were collected, and the frequency is likely to change if the patients received instructions to improve their use. Accordingly, re-assessing the frequency of the problem is recommended. The problems encountered after inhaling the nebulised dose were more frequent compared to the problems encountered prior and during inhalation. This finding is in line with previous studies conducted by Teale, et al. (1995) and Boyter and Carter

(2005) which both showed that problems with cleaning were the most frequent (40%) compared with filling the reservoir and assembling (18% and 13% respectively).

To our knowledge, this study is the first to investigate the relationship between several factors and the frequency of the problems encountered with the use of nebuliser therapy by COPD patients in the home (Section 4.3.4). A range of demographic and clinical factors obtained from medical notes and during interviews were explored. It was previously shown that nebuliser therapy could prevent hospital admissions in patients with less severe disease (Godden et al., 1998) and it is generally agreed that hospital admissions occur as a result of treatment failure which can be a consequence of incorrect use of nebuliser therapy. This study confirmed this finding by demonstrating a positive linear relationship between previous hospital admissions and the occurrence of problems ($r = 0.27$, 95% CI = -0.0 to – 3.37, $p = 0.05$). Findings from previous studies showed that greater impairment in quality of life resulted in more inhalation mistakes with pMDIs (Hesselink et al., 2001). This finding can be extended to patients using nebulisers in the home as this study showed that greater impairment in quality of life (as measured by the SGRQ impact score) was associated with more frequent problems ($r = 0.27$, CI – 0.00 to 0.14, $p = 0.05$). Moreover, this study demonstrated that patients treated in practices with a larger number of doctors encountered more problems with the use of their nebuliser ($r = 0.28$, 95% CI -0.004 to 1.19, $p = 0.05$). This finding is consistent with a previous study conducted by Hesselink et al. (2011) which found that patients treated in a group practice had more inhalation mistakes with pMDIs. The authors argued that lack of continuity of care may have resulted in inadequate instructions and follow up for these patients (Hesselink et al., 2001). This may also be the case in this study. The use of facemasks was another factor found to be associated with the occurrence of problems (95% CI – 7.13 to - 0.61, $p = 0.02$) (Figure 4.13). Patients who were using facemask had more problems prior to inhaling the nebulised dose. This association can be explained by information obtained from the patients during interviews which showed that patients who were using facemask to be more likely to breathe through their nose, while it was more obvious for those who used a mouth piece that they should only breathe through their mouth. Finally, this study failed to show an association between the number of inhaler devices used and the total problem score ($p > 0.05$). Conflicting findings on the relationship between the number of inhaler devices used and inhalation errors was previously shown with pMDI and DPI (Wieshammer and Dreyhaupt, 2008; Rootmensen et al., 2010). Knowledge of these factors is pivotal for healthcare professionals to ensure effective medication use and optimal health outcomes.

The factors predicting the incorrect inhaler use were demonstrated by previous researchers for other inhalational devices (pMDIs, DPIs). However, to our knowledge no study has been conducted which elucidated the factors predicting the occurrence of problems during the course of using nebulised therapy. Only one study has shown that age, gender, and education levels can predict the problems encountered with nebuliser therapy (Melani et al., 2001). Knowledge of the factors predicting the problems experienced with the use of the nebuliser therapy is pivotal for healthcare professionals aiming to optimise medication use by COPD patients in the community. Effective use of nebulisers in the homes should effectively lead to patients remaining independent and reduce utilisation of healthcare services. Healthcare professionals should be aware of the factors predicting the problems; such knowledge should help them to target patients who are more likely to use their nebuliser incorrectly. Based on findings from this study the number of hospital admissions (B = 0.24, p = 0.06), the number of treating doctors (B = 0.26, p = 0.04) and the use of facemasks (B = 0.33, p = 0.01) were found to be predictive of the occurrence of problems. The use of facemask was the strongest predictor of the problems (Table 4.21). However, the number of cases included in this study allowed for a maximum of five variables to be included in the regression model, to be tested for their ability to predict the problem score. In this context, a study with a larger sample size is recommended.

5.2.5. The current services and support available for COPD patients using nebuliser therapy in the home

Decisions, assessment and supply of nebuliser therapy

The decision to supply nebuliser therapy should be made by the treating doctor after a period of a home trial in which different treatment options are tried by the patient, and based on attaining objective and/or subjective response to nebulised therapy (Boe et al., 2001). However, findings from this study revealed that none of the patients received a formal assessment prior to being prescribed nebuliser therapy (Section 4.4.1). A survey conducted among respiratory physicians in a health authority in the UK showed a surprising degree of inconsistency in the management of COPD with regard to the trials, methods used to assess response to treatment, and whether an objective improvement was required prior to recommending supply of nebuliser therapy (Bennett and Swinburn, 1996).

Moreover, this study revealed that the decision to commence on nebuliser therapy was not always made by the doctor as the patient often requested to be supplied with nebulised medication based on a previous positive experience attained during the use of therapy in hospital or the surgery. The inconvenience of making trips to the surgery was another factor which influenced the patients' decisions on obtaining the therapy. However, reluctance by the doctor to prescribe nebulised medication was often expressed by patients and was perceived negatively (i.e. the patients felt that delay in prescribing nebulised medication accelerated the decline in their lung capacity).

If nebulised therapy is prescribed for the patient, arrangements should be made by the treating doctor to source a nebuliser system for the patient, the choice of the nebuliser system should be made by the prescribing doctor and patients should be discouraged from purchasing their own equipment (Boe et al., 2001). Findings from this study indicated that nebulisers were only offered to a few patients through loaning services from their local surgery or hospital (Section 4.4.2). The majority of the patients obtained their nebuliser system privately through different routes (community pharmacy, friends, internet and manufacturer). Funding was not available in many cases except for a fraction of the price in the form of a discount or a claim for reimbursement of the VAT. In two cases, the doctor liaised with local charities to source a nebuliser system for the patient. Hosker et al., (1995) have reported a considerable variation among respiratory physicians in the provision and funding of domiciliary nebuliser. They suggested that a consensus on nebuliser provision would result in more uniform delivery of service. More studies are required to establish the current provision of nebuliser therapy.

The study identified the range of nebuliser equipment currently in use by COPD patients in their home (Portaneb, Compair, Medix AC 4000, Pulmostar, Actineb, etc) ((Section 3.2, Table 3.2). Findings from this study indicated that prescribing doctors were rarely involved in choosing a suitable nebuliser system for the patient (Section 4.4.2). This finding is consistent with that reported in a previous survey conducted in Italy, where decisions to obtain a nebuliser therapy were often made by the patient, and resulted in the choice being based on the minimal characteristics required to achieve effective treatment rather than technical issues (Melani et al., 2001). Moreover, when the nebuliser was supplied according to the advice of a healthcare professional, this was often based on marketing and technical issues were overlooked, while some professionals left choice entirely to the patient (Melani et al., 2002). The choice of the ideal nebuliser system should take into consideration the performance of the system, as well as patient characteristics and lifestyle (Stevens, 2003).

However, difficulties in comparing the performance of different nebuliser systems available on the market are mainly due to the diversity of the methods used in their evaluation. This has led to the development of the European Standard for nebulisers which facilitated the evolution and development of in vitro testing methodologies which were described in the European Respiratory Society clinical guidelines on the use of nebulisers published in 2001 (Boe et al., 2001). The guidelines aimed at improving efficacy and safety of nebuliser systems by calling on manufacturers to provide evidence for the performance of their nebuliser system using a standard method, and on clinicians to choose a suitable nebuliser system for each clinical indication based on the standardised information supplied by the manufacturers. Until this option becomes available in clinical practice, clinicians are encouraged to prescribe one nebuliser system for a specific clinical indication. This way, the effectiveness can be related to the individual patient (pattern of use, handling of device, and disease state) rather than related to the type of nebuliser system being used (Boe et al., 2001).

Access to services, information received and actions taken in the event of treatment failure

Patients in this study often referred to their condition as asthma, which indicated the lack of knowledge of these patients regarding their condition. The lack of awareness of the term 'COPD' among patients and the mislabelling of the condition as 'asthma', on diagnosis by healthcare professionals was highlighted in a previous survey conducted by the British Lung Foundation (British Lung Foundation, 2006). The patients in this study accessed a range of primary, secondary and community services offered through their local GP surgery or hospital (Section 4.4.7). However, these services were related to overall COPD management such as: consultations with the GP or the nurse, obtaining a supply of medication and regular review appointments. However, services were lacking in relation to nebuliser therapy and the patient technique rarely formed a component of a regular review appointment (Sections 4.4.3, 4.4.5 and 4.4.6). The European Society Guidelines on the use of nebulisers clearly states that the supply of nebuliser therapy should be accompanied with sufficient support to assist patients and their carers with the use (Boe et al., 2001). The findings from this study showed that only a few patients (38%) received instruction on the use of the nebuliser (Section 4.4.8). The instruction was often given to the patient by the respiratory nurse or the prescribing doctor, and was in most cases with regard to the dosage frequency. Instructions on setting up, cleaning and maintaining the nebuliser were

rarely communicated to the patient. The patients indicated that they learned how to use their nebuliser through 'trial and error', previous use at the hospital or surgery, and reading the information manual supplied with the equipment. The latter was usually only read at the beginning, and in many cases was not available especially if the nebuliser was obtained through a friend. Moreover, supply of disposable parts and servicing was only available to those who were offered a nebuliser system on loan. This finding links back to the use of damaged parts and the long nebulisation time reported by some patients in this study (Section 4.3.3). Some patients expressed difficulties in obtaining disposable parts or servicing their compressor due to using an outdated nebuliser model or due to firms going out of business.

It was previously noted that nebuliser therapy prevented hospital admissions for the majority of the patients if used prior to accessing emergency services. However, this finding must be interpreted with caution; there is evidence from the current study suggesting delay in accessing emergency services by COPD patients using their nebulisers at home (Section 4.4.7). The patients did not have a clear action plan in the event of treatment failure. Although the majority of the patients would seek professional help (contact the doctor, dial an ambulance), some would try other treatments (oxygen therapy, hand held inhalers, emergency medication), or even do nothing. Murphy et al., (1989) and Godden et al., (1998) identified similar actions taken by COPD and asthmatic patients in the event of treatment failure. However, in one of those studies, more patients would use different treatment options compared to those who would contact their doctor in the event of treatment failure (Godden et al., 1998) indicating a greater reliance on nebulisers than that noted in this study. In the light of the limited studies in this regard, more studies are recommended.

The data provided two explanations for taking such actions: the concept of the 'expert patient' has emerged during interviews as some patients expressed confidence in treating their symptoms in the home, or patients expressed lack of trust in healthcare team and the treatment offered at the hospital. Additionally, there were three cases identified where they would either: double the dose, or re-use their nebuliser for at least a few days before seeking professional help. This is a cause of concern as such actions are unsafe and would result in a delay in treating the exacerbation. Evidence suggests that treating exacerbations early result in faster recovery, better quality of life and fewer hospital admissions (Wilkinson et al., 2004). Over-reliance on nebulisers and the danger of delaying help was expressed in the literature for asthmatic patients using domiciliary nebulisers (Laroche et al., 1985) and the same has been suggested to apply to COPD patients (Murphy and

Holgate, 1989; O'Driscoll, 1997). However, results from these studies were inconclusive. In the light of the few studies investigating this issue, more research is warranted. However, the evidence from the current study implies that healthcare professionals should provide all COPD patients who are using nebulisers at home with a clear written action plan on when to contact their healthcare team if their treatment fails.

5.2.6. The roles of carers in assisting COPD patients with the use of their nebuliser therapy

<u>The range of activities and the extent of assistance</u>

Medicines-related activities are known to be an integral part of the caring process and many patients with long term illness often depend on a carer for the use of their medicines. The contribution of carers in the delivery of care for COPD patients is widely recognised in the literature. Patients with COPD are often prescribed domiciliary nebuliser therapy as part of a disease management plan (British Thoracic Society, 1997; The National Institute for Clinical Excellence, 2010). However, little is known about the assistance provided by the carers with nebuliser therapy, the problems encountered and the impact of this assistance on their daily lives. Documenting the extent of assistance provided by the carers and identifying the difficulties encountered with this assistance is prudent to enable healthcare professionals to support carers in their roles, reduce their burden and optimise health outcomes for their patients.

This study recognises the contribution of the carers in assisting COPD patients with nebulised therapy by demonstrating that about a third (15/50, 30%) of the patients received assistance from a carer in this context (Section 3.2). Only one previous study was identified in the literature which acknowledged that elderly people often depended on a carer when using nebuliser therapy (Teale et al., 1995). In agreement with the study presented in this thesis, one third of the patients in the previous study sometimes required assistance with their nebuliser, while one in six were always dependent on a carer for administration. However, the assistance in the previous study was restricted to practical activities such as assembling the component parts, using the nebuliser and cleaning the nebuliser. Moreover, the extent of assistance provided with each activity was not investigated. Therefore, conducting this study was crucial as the contribution of carers in

relation to the use of nebulisers has never been extensively described in the literature before.

This study extends existing knowledge with regard to the assistance provided with the use of nebulisers by identifying the number and range of activities for which the carers assumed responsibilities. In this study, the carers assisted with an average number of six activities, and the number of activities performed ranged from 2 to 9 activities (Section 4.5.1). This amount of assistance is similar to that previously reported by Francis et al., (2002) in a study that documents the roles of informal carers in the management of medications for older care-recipients. The number of activities was shown to be correlated with carer strain. Findings from this study shared some general features with previous qualitative studies investigating the medication roles of carers and therefore findings from these studies can be extended to carers assisting COPD patients with the use of their nebuliser therapy in their home. In common with previous studies, activities performed by carers spanned across organisational/practical tasks and tasks requiring the carer to make a clinical judgment. As expected, similar activities to those identified in previous studies documenting medication roles were undertaken by the carers in this study, such as maintaining the supply of medication, assisting with taking or using medication, reminding when to take medication and deciding how much/how often the medication should be taken and noticing and managing side effects from medication (Travis and Bethea, 2001; Francis et al., 2002). In addition, other activities were specific to the use of the nebuliser therapy such as assembling and setting up equipment, mixing of medicines, operating the equipment, dismantling and cleaning the nebuliser parts after use, and maintaining the disposable parts and the condition of the equipment, which were similar to those previously reported by Teale et al., (1995).

In agreement with Francis et al. (2002), the carers in this study described communicating with healthcare professionals to obtain information concerning different aspects of the patient's medication. The carers in this study described actively seeking information from doctors on basic information about medication (dosage frequency, side effects) and more specific advice on the need to initiate or discontinue the medication in the event of worsening of symptoms or experiencing side effects. Similarly, Travis and Bethea (2001) identified that family members used primary (physicians, pharmacists) and secondary (internet, information hotlines, nurses, more experienced carers, family members with health backgrounds) sources of information to help them in making decisions about

medication administration for dependent elderly family members (Travis and Bethea, 2001).

<u>The difficulties encountered by carers with assisting with the use of the nebuliser therapy</u>

In agreement with previous qualitative studies documenting the problems encountered by informal carers with medication management roles (Travis et al., 2000; Smith et al., 2003), the carers in this study encountered a wide range of difficulties with all aspects of assistance provided. On average the carer encountered 3 difficulties with providing care in the context of using nebuliser therapy (Section 4.6.1). Smith et al. (2003) found that carers experiencing more problems had higher levels of carer strain (Smith et al., 2003). Similar issues such as: concerns about overdosing, difficulties in determining the correct dose, reluctance on the part of the care-recipient to take medication, perceived need for more information from healthcare professionals, worries about disruption in medication supply, difficulties in scheduling doses, and the level of vigilance required to monitor care-recipient condition were identified in this study.

In addition some difficulties identified in this study were specific to the nebuliser use such as: Inconvenience, technical problems, overreliance on the carers and resistance from the patient. The costs of disposable parts and maintaining the equipment accompanied by poor access to disposable parts and lack of services for maintaining the nebuliser resulted in overuse of some parts and the occurrence of technical difficulties. The lack of information was expressed with respect to many aspects of use, such as dosage frequency, cleaning and maintaining the nebuliser, side effects and identifying an emergency and when to seek help. Other worries identified were development of tolerance, side effects, and fears over equipment failure. In most cases these difficulties can be resolved by improving the provision of information between healthcare professionals and between healthcare professionals and carers/patients. The issues identified in this research could inform components of an educational program for carers who are assisting with nebuliser and medication use. Optimal health outcomes for patients with COPD often depend on the effective use of nebulisers; and many patients may depend on a carer for vital assistance. The responsibilities that may be assumed by carers and the problems and concerns they experience are hugely varied. Support must be directed to carers if therapy is to be effective, and their needs and perspectives are to be addressed.

The partnership between COPD patients and their carers

The extent of involvement of carers has been highlighted in previous studies documenting the medication roles of the carers (Goldstein and Rivers, 1996; Francis et al., 2002). Francis et al. (2002) identified carers to have three levels of involvement with regard to medication management, which ranged from taking full responsibility to providing assistance with particular aspects when required. This study identifies similar levels of involvement of carers providing assistance to COPD patients with the use of nebulisers in the home (Section 4.5.3).

Sudden and gradual change in the patient health status (Francis et al., 2006) and the patient's physical and cognitive ability (Goldstein and Rivers, 1996) have previously been suggested to impact on the type of partnership that exists between the carer and the care-recipient. Similarly, an exacerbation of symptoms and existing co-morbidities were factors identified in this study to affect the level of involvement of the carers.

Ranelli and Hansen (1994) found that carers delivered their responsibilities in terms of promoting independence and autonomy of their care-recipient, and that they observed the care-recipient determined their level of responsibility before undertaking remaining tasks (Ranelli and Hansen, 1994). This issue was similar to that identified in this study where carers were mindful not to over-care or compromise the patient's autonomy. The carers in this study shared a general view of the importance of the patients staying independent as long as they could, at the same time they did not mind helping when needed. Issues of autonomy concerning sharing information on medication were raised in another qualitative study by Francis et al., (2006) which revealed evidence that the care-recipient's autonomy was compromised by the carer. However, this was not apparently an issue in this study.

In addition to the factors previously proposed to affect the type of partnership, this study identified additional factors such as the timing and complexity of the medication regimen to impact on the amount of assistance required by the patient. This finding emphasises the role of healthcare professionals in providing support at the appropriate time for patients and their carers, especially when nebuliser therapy is first started and in simplifying medication regimens for patients to increase patients' independence and to help carers and reduce their burden. It also emphasises that healthcare professionals should be aware of how carers and patients share responsibilities for the use of the nebuliser at home, work closely with them and continually assess their needs in order to support them in the best way. This study was based on reports from only 15 individuals, who were able to identify

themselves as carers. Nonetheless, diverse opinions and views were expressed with regard to issues explored in this study, but more studies should be conducted to confirm and refine these findings.

5.2.7. The impact of assisting COPD patients with the use of nebuliser therapy

Previous studies assessing the impact of caring for COPD patients were mostly quantitative, aiming to explore whether one factor was predictive of the carer burden. Few qualitative studies were available in the literature assessing the impact of caring for patients with COPD (Bergs, 2002; Kanervisto et al., 2007; Simpson et al., 2010). Moreover, the impact of medication burden was assessed in the context of the overall management of COPD and none of the studies aimed to assess the impact of the medication role or use of nebuliser therapy, which are central in the management of COPD patients in the home environment. This study takes into consideration the impact of using nebuliser therapy on carer-burden. Data obtained from interviews were considered alongside the data obtained from the ZBI scale to relate the impact of assisting with the use of the nebuliser to the carer-burden. Although the carers in this study provided a substantial amount of assistance with nebulised therapy and reported a number of problems experienced with performing activities (Section 4.5.1), it did not seem to impact heavily on the carers (as indicated by their overall burden score). The carers in this study had a mean burden score of 22 (Section 3.5.3) indicating mild to moderate burden according to burden classification proposed by Zarit and Zarit (1987), which is consistent with that reported in one previous study (Schreiner et al., 2006). However, this finding contradicts that reported in a previous study by Cossette and Levesque (1993) examining the type, number, amount of disturbance and the adequacy of social support as predictors of mental health in wives of men with COPD, which found that the number of supervision tasks performed was predictive of mental health outcomes (Cossette and Levesque, 1993). Similarly, Schreiner et al. (2006) argued that more objective measures of caregiver stress such as hours of care-giving or types of tasks performed were not related to the negative carers' outcome, while subjective measures such as the Zarit Burden Interview (ZBI) were strongly related to these outcomes (Schreiner et al., 2006).

Additionally, the impact of providing assistance with the use of nebulised therapy on the carer's perceived level of burden was determined in this study by analysing the carers'

responses to the individual items of the Zarit Burden Interview. The carers gave positive responses (in terms of the frequency of problems reported) to the majority of the items with the exception of the item relating to the dependency of the patient and the concerns they had for their relative, to which many carers responded negatively (may reported a high frequency of problems with this item) (Section 3.5.3). Although the use of a nebuliser increased the workload of the carers (due to the additional activities needed to be performed), it may well be that the benefits of the nebuliser use have obviated the negative impact of the associated workload. This observation was noted previously in families using long term oxygen therapy, where family dynamics and functionality was found to be better than in those families not using the complex therapy (Kanervisto et al., 2003).

This study is an exploratory descriptive study and the number of carers included did not permit further analysis to confirm the associations between the factors identified from the data and the burden scores. Further studies with a larger sample size are necessary if any conclusions are to be drawn on the factors impacting on carer burden. However, this study provided a theoretical framework suggesting that several factors might impact on the carer's life, some of which have been described in previous research and thus validate findings from this study. Other factors identified need to be further investigated. Future studies can use findings from this study to further refine or elaborate. It is also likely that the caring experience will change over time as circumstances surrounding the carer/care-recipient change, and consequently so does the level of burden. It is therefore recommended that further assessment of carer burden should be conducted regularly to account for these changes and provide the necessary support.

The carer sample in this study was confined to 15 people who identified themselves as carers, and therefore consented to take part in this study. It is likely that there were instances where the carers felt not compelled to take part on the grounds that they considered the care they provided was minimal, with a possibility that more carers undertaking such roles have excluded themselves from the study on the basis that their minimal contribution did not warrant their participation. Also, this study did not include patients from residential homes or other community day care services and thus carers responsible for these patients have not been included in this study. It is also possible that carers who are likely to experience the highest levels of burden might not have been well represented in this study, as they might be more reluctant to participate due to time constraints.

5.3. Consideration of the study findings in context of current policy

The findings of this study were in line with several government and health policies. Some of the key initiatives relevant to the study findings are discussed below:

- The care of the chronically ill is shifting towards the community with a need for a continuity of care and more support for patients and their carers (Department of Health, 2008b). 'The National Service Framework for Older People' published in 2001 has set out standards among which it highlighted the importance of older people remaining as independent as possible in the community. Findings from this study demonstrated that nebuliser therapy can achieve this goal as patients reported that one of the benefits of this therapy was to avoid unnecessary hospital admission.

- Medicines formed a major component of the NSF plan, which stated that older people and their carers must be supported in taking their medication to gain the maximum benefit from their medication to maintain or increase their quality and duration of life and to not suffer unnecessarily from illness caused by excessive, inappropriate, or inadequate consumption of medicines (Department of Health, 2001b). To achieve this another document was published to specifically address the medicines component of the standards (Department of Health, 2001a). In this document, the practical aspect of medication use was emphasised in any medication review. However, findings from this study showed that patients and carers frequently experienced practical problems with the use of nebulisers.

- The guidelines of the management of COPD published by NICE clearly states that nebuliser therapy should not be continued in the absence of a clear benefit to the patient. Two cases were identified where nebuliser therapy was not perceived effective by the patient. These cases should be investigated. Also, the supply of nebuliser therapy should be accompanied with ongoing support and servicing which was not the case in this study (The National Institute for Clinical Excellence, 2010).

- COPD is under researched and recent initiatives have advocated raising the profile of this debilitating disease (British Lung Foundation, 2006; British Lung Foundation, 2007). Moreover, reducing hospital admissions and the costs of

hospitalisation from exacerbations of COPD is a priority for the NHS. One way of achieving this goal is to ensure the safe and effective use of medication in the home. This study gave insights into the use of nebuliser therapy in the home which will provide opportunity for healthcare professionals to optimise the use of medication and health outcomes. Moreover, COPD is one of the national target patient groups for Medicines Use reviews (MURs) and one of the initial diagnoses which will be included in a New Medicines Service (NMS) set out to improve adherence to medication. The nebuliser therapy can form a component of this assessment.

- Conducting this study was timely with the recent publication of 'An Outcomes Strategy for COPD and Asthma in England' (Department of Health, 2011) aimed at ensuring high quality care for people with COPD. One of the objectives set out in the strategy was to ensure that COPD patients across all social groups receive safe and effective care, which minimises progression, enhances recovery and promotes independence. The outcome strategy calls for an active partnership between healthcare professionals and COPD patients to be partners in care, self-manage their condition and to exercise choice in the treatment they receive. As well as receiving evidence-based treatment for all pharmacological interventions tailored to their choice and linked to regular reviews. However, findings from this study showed that this was rarely the case.

- One of the priorities set out in 'The Carers' Strategy' is to support those with caring responsibilities to identify themselves as carers at an early stage and to recognise the value of their contribution. The carers in this study did not demonstrate a good understanding on the value of their contribution.

- This study is in line with recent initiatives advocating the provision of community care and the development of services which are more responsive to carers' needs (Department of Health, 2008a). Findings from this study identified the concerns and needs of carers to allow healthcare professionals and stakeholders to develop services to support carers in their roles in the best possible ways, which is a priority for the UK government (Department of Health, 1999; Department of Health, 2010b).

5.4. Implications of the study findings and recommendations for healthcare professionals

The true value of conducting this study is to communicate relevant findings from the perspective of the patients and carers to healthcare professionals to optimise health outcomes. Recent health initiatives advocate commissioning new services incorporating the views of service users (Department of Health, 2010a). The value of this is to develop services which are more responsive to patients' and carers' needs. This section applies the findings of this study to inform healthcare professionals of the needs and concerns of COPD patients and their carers. Recommendations for healthcare professionals will be made in the light of the study findings to optimise the health outcomes of COPD patients using nebuliser therapy in the home, and their carers.

- **Healthcare professionals to consider wider use of nebuliser therapy**

Reports from the patients during the interviews indicated that nebulised therapy was perceived to be effective by the majority of patients and across disease severity levels. This finding was further supported by data obtained from the SGRQ which showed that nebuliser therapy was perceived to impact positively on the quality of life of the patients. However, the effectiveness was perceived to decline with disease progression, and some patients described the reluctance of their doctor to prescribe nebulised medication until at a very late stage of their disease. Currently, nebuliser therapy is only indicated in severe disease due to the limited evidence supporting its value in mild and moderate COPD. In the light of the findings obtained in this study, healthcare professionals should be encouraged to consider wider application of nebuliser therapy to include mild and moderate disease. However, in the light of paucity of studies assessing the impact of therapy in these groups of patients, more studies are needed to confirm findings from this study.

- **Healthcare professionals to assess the need for nebuliser therapy**

The findings from this study showed that in two cases the patients perceived their nebuliser as being ineffective or even to worsen their condition. This could be due to the fact that these patients did not receive a formal assessment prior to the supply of nebulised therapy. A proper assessment should exclude patients who do not attain benefits from the use of

nebuliser therapy. The first step to ensure the patient derives benefit from nebulised therapy is to consider conducting a home trial where different treatment options are tried prior to prescribing nebuliser therapy. In this study, a few patients did not perceive their nebuliser therapy to be effective and it is worth reconsidering the supply of nebulised medication for these patients. Although other factors could have contributed to the lack of effectiveness such as: the handling of the device by the patient. A comprehensive assessment of the need for therapy as well as the patient's nebulisation technique is worth undertaking in these cases. Additionally, some patients used their nebuliser therapy very sparingly which raises questions over the need for such expensive therapy in this group.

- **Healthcare professionals to engage in the process of choosing a suitable nebuliser system**

The findings of this study indicated that for the majority of patients, healthcare professionals were not involved in the process of choosing the right nebuliser system purchased by the patients. Consequently, the cost was usually the only determinant factor which was considered by the patient in making their choice. Healthcare professionals are recommended to engage with the patient once nebulised therapy is being considered for the patient and should consider their lifestyle and match their expectations. For healthcare professionals to be able to carry out this role, educational workshops should be conducted for health personnel involved in the care of respiratory patients. The choice should be based on technical characteristics and performance of the equipment ensuring that the system is effective and acceptable to the patient. The aerosol output and the effectiveness of the inhaled dose depend on the gas flow rate and the pressure generated by the compressor which determines the aerosol size and drug delivery. The latter is determined by testing the compressor and the nebuliser which is usually determined by the manufacturer using marketed nebuliser/compressor combinations.

The lifestyle of the patient should be taken into consideration when choosing a particular nebuliser system for a specific patient. Nebulisation time was a concern for patients in this study, and although long nebulisation time can be explained by the lack of servicing of the compressor which affects its performance, different nebuliser systems varied considerably in the time taken to nebulise an effective dose. A nebulisation time up to 20 minutes is usually regarded acceptable to most patients. Similarly the weight and the noise produced varied between different compressors and should be taken into consideration. The patients expressed concerns about drug loss during nebulisation and this factor should be

considered when choosing a nebuliser design (breath enhanced and dosimetric designs minimise drug loss compared to conventional constant output designs). The compatibility of the nebuliser design with the prescribed drug formulation is another factor which should be considered when choosing a nebuliser system for the patient. The patients should be offered a choice of a mouthpiece or a facemask to use with their system. Findings indicated that some patients preferred and perceived easier of one type of interface. Costs were also of concern to the patients and should be considered accordingly.

- **Healthcare professionals to assess the perceived efficacy and safety of the nebuliser therapy**

The perceived effectiveness of nebulised therapy was reported by the patients in this study to decline over time and therefore there is a need to continually re-assess the role of the therapy in these patients. Assessment should ideally be performed before considering the supply of the nebuliser therapy, and at regular intervals thereafter. Follow up assessment should be carried out 3 months after commencing nebuliser therapy and at least periodically thereafter. It should include assessment for unwanted side effects and a review of the dosage taking into consideration other medications taken by the patients. This study provides healthcare professionals with insights into how patients worked out their dosing schedules, and thus enables them to work closely with the patients to optimise treatment outcomes. The perceived effectiveness and safety was shown to influence the decisions to use the nebuliser in this study. These concerns should be addressed by healthcare professionals and sufficient information should be communicated to the patients with regard to expected side effects from therapy. Rationalising therapy and weighing risks and benefits might be necessary in some cases. Moreover, there is great variation in the dosage frequency between patients in this study and some evidence that patients were exceeding the recommended daily dose. These patients should receive clear instructions on the maximum daily dose.

- **Healthcare professionals to use quality of life questionnaires in their routine assessment of COPD patients using nebuliser therapy**

The use of the SGRQ was shown to be valuable in assessing the impact of nebuliser therapy in this study and findings from the instrument were consistent with those obtained directly from patients during interviews, and therefore, it can be used in routine

assessments of patients using nebuliser therapy in clinical practice. Alternatively, healthcare professionals can ask the patients about their concerns about the effectiveness and safety of their nebulised medication.

- **Healthcare professionals to encourage the use of symptom diaries to monitor response to therapy instead of the use of peak flow meters**

Based on the findings of this study, peak flow meters were often prescribed for patients to monitor their response to therapy. However, patients in this study reported their limited usefulness as a monitoring tool. Accordingly, the use of symptom diaries should supplement or replace the use of peak flow meters for monitoring the response to therapy in the home. The effectiveness of the therapy is an important factor which influences the use of therapy and increases self confidence of the patients.

- **Healthcare professionals to educate patients on the proper use of nebuliser therapy**

Deficiencies in the patients' knowledge were shown with regard to the frequency of dosage, assembling the nebuliser system, filling and diluting the drug formulation, fitting the facemask, breathing pattern and the inhalation technique, cleaning and maintaining the equipment. Healthcare professionals should provide patients who are using nebulisers in their homes with clear verbal and written instructions on the frequency of dosing, clearly indicating the time interval before the next dose is administered. Teaching elderly patients how to use their pMDI has been shown to be beneficial in previous studies (Hammerlein et al., 2011). This can only be achieved by ensuring that healthcare professionals have the necessary skills and knowledge on the use of nebulisers. However, this does not always happen in real practice, as a previous study showed deficiencies in nebuliser operation techniques on a hospital wards, with limited improvement after issuing and reinforcing of guidelines for nebulisation by a pharmacist led tutorials (Caldwell and Milroy, 1995).

- **Healthcare professionals to be alert to overreliance on the nebuliser and delay in accessing emergency services**

The findings of this study identify a small number of patients who would re-use the nebuliser or even do nothing in the event of experiencing treatment failure. Healthcare

professionals should provide a clear action plan both verbally and in writing to all patients using nebulisers at home, giving clear instructions on actions if the nebuliser therapy failed to relieve their breathlessness. The plan should include usual baseline symptoms and symptoms of exacerbations, clear information on when to seek medical help should be included in the plan as well as an emergency contact number. The data revealed that delay in seeking help was due to the lack of information the patients had received in these areas.

- **Healthcare professionals to direct resources to patients susceptible to poor inhaler technique**

The findings presented in this study identified several factors contributing to the practical problems experienced with the use of nebulised therapy which may impact on effectiveness and safety. Based on multiple regression methods employed to predict the characteristics of the patients more prone to make mistakes when using their nebuliser therapy, patients with more frequent hospital admissions, seen in practices with higher number of treating doctors, and using facemasks were found to be more likely to make mistakes when using nebulisers. Accordingly, healthcare professionals should be aware of these factors and resources should be directed to target patients at high risk of making errors. The majority of the patients in this study last accessed healthcare via primary care services suggesting that GP surgeries can offer a good point to implement interventional programmes to optimise the use of nebuliser therapy.

- **Healthcare professionals to develop a nebuliser service unit within their local surgery**

The findings from this study indicated that the provision of services for nebuliser therapy was suboptimal and lacking, which was linked to the problems encountered by patients. Loaning services were not available for the majority of patients in this study. Poor access to disposable parts and servicing has led to the use of damaged components and attempted self repairs by the patients. Moreover, the patients raised concerns about the cost of the parts and servicing of the compressors, the inconvenience of travelling to manufacturer sites and the use of out dated models. This warrants the development of a nebuliser service unit for patients using nebuliser therapy in their home. The loaning of nebulisers, supply of nebuliser parts, servicing and a 24 hour emergency contact point in the event of equipment breakdown should be made available for all patients prescribed nebulised medication.

- **Healthcare professionals to recognise the contribution of carers in assisting with the use of nebulisers**

This study recognised the vital roles of carers in assisting with the use of nebuliser therapy and the greater dependency on carers which was reflected in interviews and responses of ZBI scale. Healthcare professionals should recognise this role and be aware of the partnership existing between COPD patients and their carers. This study identified factors which affected the level of contribution of the carers; this information will assist healthcare professionals in targeting carers with vital contribution. The study findings suggested that carers often accompanied patients to their consultation; this presents healthcare professionals with an opportunity to assess the carers' contribution and address their concerns. Findings from this study indicated that carers often experienced difficulties while assisting with the use of nebuliser therapy and these should be addressed by healthcare professionals to empower carers in undertaking their roles.

5.5. Contribution to existing knowledge and implications for future research

This thesis is an original contribution as it is the first study to set out to describe the experiences of patients and their carers with the use of nebuliser therapy in the home, using semi-structured interviews, non-participant observations and survey methods to provide a detailed assessment. Also, it is the first study to explore the carers' contribution to assisting with the use of nebulisers. The study contributes to the fields of medication use in the home by the following:

- It has documented the pattern of domiciliary nebuliser use among COPD patients and identified the factors underlying the decisions to use the nebuliser.

- It has demonstrated the perceived effectiveness and safety of nebuliser therapy in controlling symptoms of COPD, promoting independence and enhancing confidence and psychological wellbeing.

- It has demonstrated that problems are frequently encountered by COPD patients with the use nebulisers in the home, and has identified the range of the problems and their contributory factors.

- It has recognised the extent and importance of the carers' contribution and assistance provided with the use of nebulisers (30% of the patients depended on carers) which spanned organisational and practical activities. The study has also identified factors which may hinder or facilitate the carers' roles.

- It has described the partnership which existed between patients and their carers and showed different perspectives between them which will have future implications for healthcare interventions. It has also described the level of involvement and carers' input which was shown to be dynamic.

- Patient related factors such as co-morbidities, disease severity, exacerbations, timing and complexity of dosage regimen were shown to require a greater level of involvement by carers. Knowledge of these factors will allow healthcare professionals to effectively target assistance and provide necessary support.

- It has made recommendations to healthcare professionals to optimise nebuliser use among patients and carers in the home. Hence, potentially improving therapy and health outcomes for COPD patients and their carers.

Based on findings presented in this thesis, further research is recommended with respect to the following:

- Factors affecting adherence to nebuliser therapy to inform interventional programmes. Based on this study several factors were shown to affect decisions to use the nebuliser. There are limited studies on adherence in COPD in general and on the use of inhalation device in particular. Hence, more research is needed.

- The role of nebuliser therapy in mild and moderate disease should be explored in future studies. Currently, this role is unclear. In this study, therapy was perceived as effective and safe among patients with a range of disease severity levels but further research is warranted to fully establish this.

- The cost-effectiveness of using nebulisers should be explored further. Reports from patients during interviews suggest that nebuliser therapy might have a role in reducing hospital admissions. Some evidence exists that nebulisers can indeed reduce hospital admissions. However, the impact of using nebuliser therapy on the rate of hospital admission has not been fully investigated and therefore further studies are recommended. Also, there was some evidence in this study of over-reliance on nebulisers and delay in accessing timely help in emergencies. This issue has previously been described for asthma patients but is rarely investigated in COPD. Thus, more research is needed to explore this issue.

- Based on reports from the patients, several factors were attributed to effectiveness of nebulised therapy. Tolerance was one of the factors raised in this respect and

studies have recently linked this to the use of beta agonists but not to anticholinergic drugs. However, this issue should be investigated further.

- This was a cross-sectional study and it was not possible to explore the long term safety of using nebuliser therapy. Mortality has previously been linked to use of nebulisers in asthma but this has not been investigated in COPD. Therefore, research is recommended to establish the long term safety of nebulisers in COPD.

- Tools to assess inhaler techniques with pMDIs and DPIs have been described by previous researchers. To our knowledge, no tools have been developed to assess how patients use their nebuliser. Findings from this study will be valuable in this context; a range of problems and their contributory factors were identified. Qualitative research is useful to provide a theoretical framework for larger scale quantitative studies. Findings from this study can be incorporated and developed into a generic tool and tested to confirm findings from this study and to assess the magnitude of the problems in clinical practice.

- The study has described the experiences of COPD patients and identified the problems with the use of compressor type, jet nebulisers. Some of the issues are likely to be of relevance to other inhaler or technological devices used by patients having COPD or other respiratory conditions. Future research can extend to include other nebuliser users such as people with a diagnosis of asthma or cystic fibrosis. Also, this study did not include patients from residential homes or nursing homes. This is an area which can usefully be explored further.

- Findings from this study suggest a link between quality of life and poor nebuliser technique. However, this study was of a small scale and a study with a larger sample size may yield more conclusive findings. The relationship between poor nebuliser technique and maintenance and admission rate or utilisation of healthcare resources (surgery visits, hospital admissions, prescribed medications to treat symptoms of exacerbations, etc.) can also be investigated in future studies. Although a number of clinical parameters were collected, the study was predominantly qualitative and descriptive; the number of cases did not allow testing of these variables for their power to predict the problems. This study has revealed several factors associated with poor nebuliser use. Future research can confirm the association of these factors in a larger sample of patients or focus on studies with an interventional design, aiming at improving nebuliser use and assessing the impact on health outcomes, such as the quality of life.

- Future work can focus on the use of nebuliser therapy from the healthcare professionals' perspective or investigate the knowledge of healthcare professionals involved with the provision of nebuliser therapy. This study revealed great variations in the provision of nebuliser therapy; discrepancies and inconsistencies in services and support received.

- Studies investigating the contribution of carers are recommended to firmly establish the roles and assistance. This information is necessary from the point of view of policy makers to inform resource allocation to support carers. This study describes the partnership that exists between carers and patients, the level of carers' involvement and has identified factors which affected that input. However, more research is recommended so appropriate support can be provided in this context.

- This study was based on reports from only 15 individuals who provided assistance with the use of nebulisers. Nonetheless, diverse views and experiences were revealed. Although the carers provided substantial amount of assistance, overall they had a low perceived burden score. The number of the cases did not permit identification of the factors associated with the burden. However, this study provided a theoretical framework. Some factors which impacted on the carer's life were described previously, others need to be confirmed. Also, this study did not include carers from residential homes.

- The study was a cross-sectional design and therefore the views and experiences of patients and carers and the data obtained on the patients' quality of life and the care burden represented those at the time of the study. These are likely to change if interventional measures were applied to improve the patients' techniques and practices, the carer burden or if the circumstances of the patient, or the care changed as a result of further decline in lung function and should therefore be re-assessed.

- The use of the SGRQ, EQ-5D and ZBI scales in this study augmented the interview data and were shown to be usable and acceptable among COPD patients and their carers. However, measures taken to improve administration of the scales to older people were undertaken and proved valuable and therefore, researchers are recommended to adopt these measures in any future research involving frail older people.

5.6. Conclusion

Nebuliser therapy was perceived as safe and effective by patients with COPD. The perceived effectiveness was manifested in patients' ability to control their symptoms, increased independence and improved quality of life. However, achieving optimal health outcomes depends on the appropriate use of these devices by patients and carers, and the support available from their healthcare professionals. The findings from this study showed that these were often suboptimal.

A holistic approach to promoting the effective and safe use of therapy among older people and their carers, in their own homes, is a health policy priority. This study has enabled recommendations to inform the development of services for COPD patients, who are prescribed nebuliser therapy, and their carers to promote optimal therapy and improved treatment outcomes.

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Appendix I

THE SCHOOL OF PHARMACY
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29/39 Brunswick Square, London, WC1N 1AX

The use of nebulisers at home

(Interview with the patient)

Notes to Interviewer
Bold: To be spoken out loud to respondent
Italics: Prompts to be used when needed
Standard: Directions to the interviewer

Before we start the interview, I am going to tell you a little bit about the study.

A lot of people like you are using nebulisers to manage their condition at home. We do understand that this can be a complicated task to do.

We would like to know more about you/your caregiver's experience with nebulisers, any practical aspects you want to raise, any care issues related to the nebuliser use and how using your nebuliser affects your health and everyday life.

Request permission to tape-record.

Request permission to take photo of the nebulizer system.

Ensure consent form is completed.

Start time of interview: End time of interview:

Section1: Basic information about your nebuliser:
   1) **Let's start with some information about your nebuliser, would you mind showing me your nebuliser?**

   Record details about nebulizer type, model,

Nebulizer system	Chamber *:		Compressor*:	
Accessories	Mouthpiece		Face mask	
Type	Disposable		Re-usable	
Gas	Compressed air		Oxygen	
Nebules	Drug:		Drug:	
Diluent				
Volumes				
Jet	Ultrasonic		Mesh	
Duration of use				

*Manufacturer & Model, consider taking a photo if not clear.

2) **Where did you obtain your nebuliser?**

   Prescribed by GP or lent by hospital
   Bought from pharmacy or manufacturer
   Borrowed from a friend or a relative
   Gift

3) **How often do you normally use your nebuliser?**

   When I feel I need it (as required)
   Four times a day
   Less than four times a day
   More than four times a day
   Not used

4) **How long have you been using a nebuliser for?**

   <6mnths,
   6mnths-1 yr,
   1yr-5yrs,
   >5yrs

5) **Do you use any other inhaled medications?**
   DPI
   pMDI
   DPI & pMDI

Section 2: Information about technical issues related to the use of your nebulizer:
Setting up and operating your nebuliser
I would like to know more about your part in the different aspects of taking your medicine:

6) **Would you like to tell me which of the following activities you carry out:**

   Assembling
   Diluting
   Mixing
   Filling
   Operating the machine
   Disassembling of the equipment
   Cleaning the equipment

7) I would like to you to describe how would you assemble your nebuliser?

8) I would like to know about your experience of this step?

9) Any additional comments you may wish to add?

10) I would like you to describe how you dilute the drug solution?

11) I would like to know about your experience of this step?

12) Any additional comments you may wish to add?

13) I would like you to describe how you mix the drug solution?

14) I would like to know about your experience of this ste

15) Any additional comments you may wish to add?

16) I would like you to describe how you fill the solution in your nebuliser chamber?

17) I would like to know about your experience of this step?

18) Any additional comments you may wish to add?

19) I would like to know about operating your equipment.

20) I would like to know about your experience of this step?

21) I would like to know about your technique for inhaling your nebulised drug?

22) I would like to know about your experience of this step?

23) Any additional comments you may wish to add?

24) I would like to know how you dismantle your the equipment?

25) I would like to know about your experience of this step?

26) Any additional comments you may wish to add?

27) How long does your nebulisation usually last?

28) When would you stop nebulisation?

Spluttering
Dryness
Tapping

29) **What would you do with any residual liquid/drug left in the nebuliser chamber?**

Re-use it
Discard it (how? / where?)
Rinse it

Monitoring of your response using peak flow meter

30) **Do you monitor your therapy or condition using a peak flow meter?**

31) **How often do you use it?**

32) **When do you use it?**

Section3: Information about cleaning and maintenance of the nebuliser:

33) **How often do you clean your nebuliser chamber?**

After each use
Daily
Weekly
Monthly
Never cleaned

34) **Would you explain to me how you clean it?**

Warm soapy water, then rinse
Water only
Sterilize
Dry with a cloth
Dry naturally

35) **Have you got any additional comments in relation to cleaning your nebuliser?**

Haven't experienced any problems
Find it very difficult to clean

36) **How often would you replace your**

Frequency	Chamber	Tubing	Filters	Facemask	Mouthpiece
Weekly					
Monthly					
1-3 months					
4-6 months					
7-11 months					
Annually					
More than 12 months					
When damaged					
Never					

37) **How often do you get your compressor serviced?**

Once annually
More than once annually
Less than once annually
When damaged
Never

38) **Has anyone else used this nebuliser with you?**

39) **Comments on general condition of the nebuliser.**

40) **Comments on the general condition of the compressor.**

41) **Have you ever experienced a mechanical failure of the equipment?**

Mechanical failure
Power failure

42) **If so what action did you take?**

Alternative (Nebules / pMDI)
HART team

Section 4: Information about care and support across the interface of primary intermediate care:
I would like to know about your experience of the last contact you had with medical care in relation to your chronic bronchitis or emphysema.

43) **Would you like to tell me when did you last access medical care?**

44) **Would you like to tell me what was the nature of your last access?**

GP visit
Hospital visit through referral or Accident and Emergency
Outpatient appointment
In patient stay
Discharge

45) **What was the reason for this last visit?**

Worsening of condition
Review appointment
Supply of medication
Other reasons

46) **Would you like to tell me more about your experience of this visit?**

47) **How would you describe your visit?**

Do you feel it's easy to get access to medical care when needed?
How do you feel about your relationship with your healthcare professional?
Do you feel you were properly managed?

*Have your healthcare professional reviewed your condition/therapy/
supplies/technique check?
Have you received enough information and instruction about the
use/cleaning/maintenance of your therapy? (Who from?, when?, where? Any
updates?)
Have you been given a peak flow meter and taught on how to monitor your
response to therapy?
Have you been given an action plan in case of emergency?
Have you been left uncertain about anything regarding your condition or
treatment?
Have you been followed up since discharge?
Do you feel that care is properly coordinated between your healthcare team?
Any medical help at home or visits from healthcare professionals?*

48) Would you like to add anything else?

Section 5: Information about receiving help from your relative or friend:

**49) Do you receive any help or assistance from anybody in taking your
medicine?**

Ask for reasons before proceeding to question 2.

....
....
....
....

50) Who provide you with this help?

> *Spouse,*
> *Friend,*
> *Neighbour*
> *Family member*

Would you mind if I contact that person?

**I would like to know more about the role this person in assisting/helping you with
taking your medicine by a nebuliser:**
I would like you to tell me which of the following activities he/she carries out:

a. Assembling:

51) How much time does he/she spend doing this task?

52) How often does he/she assist with this task?
/day
/week
/month

b. Diluting:

53) How much time does he/she spend doing this task?

54) How often does he/she assist with this task?
/day
/week
/month

c. Mixing:

55) How much time does he/she spend doing this task?

56) How often does he/she assist with this task?
/day
/week
/month

d. Filling:

57) How much time does he/she spend doing this task?

58) How often does he/she assist with this task?
/day
/week
/month

e. Operating the equipment:

59) How much time does he/she spend doing this task?

60) How often does he/she assist with this task?
/day
/week
/month

f. Disassembling of the equipment:

61) How much time does he/she spend doing this task?

62) How often does he/she assist with this task?
/day
/week
/month

g. Cleaning the equipment:

63) How much time does he/she spend doing this task?

64) How often does he/she assist with this task?
/day
/week
/month

I would like to know more about decisions made with regard to your taking your medicine and failure of therapy.

65) Have you ever advised on the need for medication, how much, how often or when it is needed?

66) Have you ever had concerns about the effectiveness of the medication?

67) What would you do in that case?
Call a doctor,
Report to hospital,
Repeat nebulization
Do nothing

68) Who would decide on that action?

69) Have you ever had concerns about the use of the nebuliser or side effects from medication?

Section 6: Health status and impact on daily life:

Administer the EuroQol questionnaire and the St. George's Respiratory Questionnaire (SGRQ).

Section 7: Information about the patient:

Age

Sex

Educational background

Additional information to be completed by the researcher:
Complete end time on page 1

Was anyone present at the interview?   Yes/No

If Yes, who?
Please make comments about their participation in this interview

Was this interview taped? Yes/No

If yes write the code of the interviewee on the tape

If no, give reasons below

Other comments you wish to add

.

Appendix II

THE SCHOOL OF PHARMACY
UNIVERSITY OF LONDON
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The use of nebulisers at home

(Interview with the carer)

<table>
<tr><td>

Notes to Interviewer
Bold: To be spoken out loud to respondent
Italics: Prompts to be used when needed
Standard: Directions to the interviewer

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</table>

Before we start the interview, I am going to tell you a little bit about the study.

A lot of people like you are using nebulisers at home. We do understand that this can be a complicated task to do.

We would like to know more about you/your caregiver's experience with nebulisers, any practical issues you want to raise, any care issues related to the nebuliser use and how assisting with the use of nebuliser affects your health and everyday life.

Request permission to tape-record.

Ensure consent form is completed.

Start time of interview: End time of interview:

Section1: Information about the assistance or help you give to your relative/friend:

I would like to know a bit more about the help you give to your relative/friend:

1) What's your relationship to this person?

Spouse,
Friend,
Neighbour,
Family member

2) How much time do you spend caring for [   ] each week?

3) How often do you see [   ] during the week?

4) How long have you been assisting [   ]?

I would like to know more your role in assisting/helping with taking the medicine using a nebuliser:

5) Have you ever helped or assisted [   ] in taking their medicine using a nebuliser?

Ask for reasons before proceeding to question 6.

....
....
....

6) In general how much time you spend in assisting him/her in taking medication weekly?

7) In general how often you assist her/him in taking medication during a week?

Section 3: Information about using the nebuliser:
Setting up and operating the nebuliser

8) Would you like to tell me which of the following activities/tasks you are involved in?

Assembling
Diluting
Mixing
Filling
Operating the machine
Disassembling of the equipment
Cleaning the equipment

a. Assembling:

9) How much time do you spend doing this task?

10) How often do you assist with this task?

/day
/week
/month

11) Would you like to describe to me how you assemble the nebuliser?

12) I would like to know more about your experience of doing this task?

13) Any additional comments you may wish to add?

b. <u>Diluting:</u>

14) How much time do you spend doing this task?

15) How often do you assist with this task??

/day
/week
/mont

16) Would you like to describe to me how you dilute the drug solution if you do?

17) I would like to know more about your experience of doing this task?

18) Any additional comments you may wish to add?

c. <u>Mixing:</u>

19) How much time do you spend doing this task?

20) How often do you assist with this task??

/day
/week
/month

21) Would you like to describe to me how you mix the drug solution?

22) I would like to know more about your experience of doing this task?

23) Any additional comments you may wish to add?

d. <u>Filling:</u>

24) How much time do you spend doing this task?

25) How often do you assist with this task??

/day
/week
/month

26) Would you like to describe to me how you fill the solution in the nebuliser chamber?

27) I would like to know more about your experience of doing this task?

28) Any additional comments you may wish to add?

e. <u>Operating the machine:</u>

29) How much time do you spend doing this task?

30) How often you do you assist with this task??

/day
/week
/month

31) Would you like to describe to me how you operate the equipment?

32) I would like to know more about your experience of doing this task?

33) Any additional comments you may wish to add?

f. <u>Dismantling of the equipment:</u>

34) How much time do you spend doing this task?

35) How often do you assist with this task??

/day
/week
/month

36) Would you like to describe to me how you dismantle the nebuliser?

37) I would like to know more about your experience of doing this task?

38) Any additional comments you may wish to add?

g. <u>Cleaning the equipment:</u>

39) How much time you spend doing this task?

40) How often you assist with this task?

/day
/week
/month

41) Would you like to describe to me how you clean the nebuliser?

42) I would like to know more about your experience of doing this task?

43) Any additional comments you may wish to add?

I would like to know about role of your relative/friend in taking his/her medicine?

44) Would you like to tell me which of the following activities he/she carries out:

Assembling
Diluting
Mixing
Filling
Operating the machine
Disassembling of the equipment
Cleaning the equipment

I would like to know more about decisions made with regard to taking the medicine and failure of therapy

45) Do you provide any other help/assist in any other medication?

46) Would you like to tell more about this help?

47) Do you ever advise on the need for medication, how much, how often or when it is needed?

48) Have you ever had concerns about the effectiveness of the medication?

49) What would you do in that case?
Call a doctor,
Report to hospital,
Repeat nebulisation
Do nothing

50) Who would decide on that action?

51) Have you ever had concerns about the use of the nebuliser or side effects from medication?

52) How long the nebulisation lasts?

53) When would you stop the nebulisation?

Spluttering

Dryness
Tapping

54) What would you do with the residual volume left in the nebuliser chamber?

Re-use it
Discard it (how?/where?)
Rinse it

<u>Monitoring his/her response using peak flow meter</u>

55) Do you assist your relative/friend in monitoring his/her response using a peak flow meter?

56) Would you like to describe this help?

57) How often do you do this?

58) When do you do it?

<u>Section4: Information about cleaning and maintenance of the nebuliser:</u>

59) How often do you assist your relative/friend in cleaning his/her nebuliser chamber?

After each use
Daily
Weekly
Monthly
Never cleaned

60) Would you explain to me how you clean it?

Warm soapy water, then rinse
Water only
Sterilize
Dry with a cloth
Dry naturally

61) Have you got any additional comments in relation to cleaning his/her nebuliser?

Haven't experienced any problems
Find it very difficult to clean

62) How often would you replace the following

Frequency	Chambers	Tubing	Filters	Facemask	Mouthpiece
Weekly					
Monthly					
1-3 months					
4-6 months					
7-11					

months					
Annually					
More than 12 months					
When damaged					
Never					

63) **How often would you service the compressor?**

Once annually
More than once annually
Less than once annually
When damaged
Never

64) **Has anyone else used this nebuliser with him/her?**

65) **Comments on general condition of the nebuliser.**

66) **Comments on the general condition of the compressor.**

67) **Have you ever experienced a mechanical failure of the equipment?**
Mechanical failure
Power failure

68) **If so what action did you take?**

Alternative (nebules/pMDI)
HART team

Section 5: Information about care and support across the interface of primary intermediate care:
69) **Have you ever been involved in any of the following activities in relation to his/her chronic bronchitis/emphysema:**

- contacting medical care.
- accessing medical care.
- accompanying him/her to a GP visit.
- accompanying him/her to a hospital outpatient appointment.
- accompanying him/her during his inpatient stay.
- picking him up following discharge from a hospital.

I would like to know about your experience on the last contact you had with the medical care for his/her condition
70) **Would you like to tell me when did you last access medical care?**

71) **Would you like to tell me what was the nature of your last access?**

GP visit
Hospital visit through referral or Accident and Emergency

Outpatient appointment
In patient stay
Discharge

72) What was the reason for this last visit?

Worsening of condition
Review appointment
Supply of medication
Other reasons

73) Would you like to tell me more about your experience of this visit?

74) How would you describe your visit?
Do you feel it's easy to get access to medical care when needed?
How do you feel about his/her relationship with his/her healthcare professional?
Do you feel he/she were appropriately managed?
Did the healthcare professional review his/her condition/therapy/ supplies/technique check?
Did he/she receive enough information and instruction about the use/cleaning/maintenance of his/her therapy? (Who from, when?, where? Any updates?)
Has he/she been given a peak flow meter and taught on how to monitor their response to therapy?
Has he/she been given an action plan in case of emergency?
Has he/she been left uncertain about anything regarding his/her condition or treatment?
Has he/she been followed up since discharge?
Do you feel that his/her care is properly coordinated between the healthcare team?

75) Would you like to add anything else?
<u>Section 6: Health status and impact on daily life:</u>
Administer the Zarit Burden Inventory (ZBI) and the EuroQol (EQ-5D) questionnaire.
<u>Section 7: Information about carer:</u>
Age
Sex
Educational background

Additional information to be completed by the researcher:
Complete end time on page 1

Was anyone present at the interview?   Yes/No

If Yes, who?
Please make comments about their participation in this interview

Was this interview taped? Yes/No

If yes write the code of the interviewee on the tape

If no, give reasons below

Other comments you wish to add

Appendix III

Problems	Number	Step	Description	Yes/No	Comments
Prior to inhaling NM	1	Settingup_Item1	The nebuliser cap is removed from medication tank?		
	2	Settingup_Item2	The vaporisation head is removed prior to filling the drug solution?		
	3	Filling_Item1	The patient is using the correct nebuliser for the drug?		
	4	Filling_Item2	The patient stores the drug correctly?		
	5	Filling_Item3	The patient uses the drug at room temperature?		
	6	Filling_Item4	The patient washes hand before handling the drug?		
	7	Filling_Item5	The patient prepares the drug immediately prior to use?		
	8	Filling_Item8	The medication tank is filled with the drug solution?		
	9	Settingup_Item3	The vaporisation head is re-inserted in the medication tank?		
	10	Settingup_Item4	The nebuliser cap is re-connected to the medication tank?		
	11	Settingup_Item5	The facemask/mouth piece is fitted on the nebuliser cap?		
	12	Settingup_Item6	The tubing is connected to the medication tank from one end and to the compressor from the other?		
	13	Operating_Item1	The compressor is switched on?		
During inhalation of NM	14	Inhalation_Item1	The patient fits the face mask/holds the mouth piece correctly?		
	15	Inhalation_Item2	The patient is sitting in an upright position?		
	16	Inhalation_Item3	The patient breathes in from the mouth?		
	17	Inhalation_Item4	The patient breathes in slowly?		
	18	Inhalation_Item5	The patient breathes in as deeply as possible?		
	19	Inhalation_Item6	The patient holds breath for few seconds before exhaling?		
	20	Inhalation_Item7	The patient defines an end point to stop nebulisation?		
After inhaling NM	21	Dismantling_Item1	The compressor is switched off?		
	22	Dismantling_Item2	The nebuliser is detached from the tubing?		
	23	Dismantling_Item3	The nebuliser is dismantled (cap/medication tank/vaporisor head)?		
	24	Cleaning_Item1	The machine is run for some time with saline/empty?		
	25	Cleaning_Item2	The parts (except the tubing) are rinsed under hot water after use?		
	26	Cleaning_Item3	The parts (except the tubing) disinfected with a suitable disinfectant once a day?		
	27	Cleaning_Item4	The parts are left to dry on a clean tissue?		
	28	Cleaning_Item5	The machine is run until no moisture is remained in the tubing?		
	29	Cleaning_Item6	The tubing are hung to dry?		
	30	Cleaning_Item7	The compressor and tubing is wiped at least once a day with a damp cloth?		
	31	Cleaning_Item8	The patient discards the remaining of the drug solution?		
	32	Storage_Item1	The nebuliser is re-assembled and placed in a clean bag/ tubing placed inside compartment?		
	33	Storage_Item2	The lid is kept closed when not in use?		
	34	Storage_Item3	The equipment is placed on a flat surface?		
	35	Storage_Item4	The equipment is at least 4 inches away from any other equipment?		
	36	Maintaining_Item1	The tubing are replaced according to manufacturer recommendations?		
	37	Maintaining_Item2	The nebuliser is replaced according to manufacturer recommendations?		
	38	Maintaining_Item3	The facemask/ mouth piece replaced according to manufacturer recommendations?		
	39	Maintaining_Item4	The filter is checked monthly and replaced according to manufacturer recommendations?		
	40	Maintaining_Item5	The equipment is serviced annually and checked for any electrical fault?		

Appendix IV

EQ-5D (UK English version)

By placing a tick in one box in each group below, please indicate which statements best describe your own health state today.

Mobility
I have no problems in walking about □
I have some problems in walking about □
I am confined to bed □

Self-Care
I have no problems with self-care □
I have some problems washing or dressing myself □
I am unable to wash or dress myself □

Usual Activities (*e.g. work, study, housework, family or leisure activities*)
I have no problems with performing my usual activities □
I have some problems with performing my usual activities □
I am unable to perform my usual activities □

Pain/Discomfort
I have no pain or discomfort □
I have moderate pain or discomfort □
I have extreme pain or discomfort □

Anxiety/Depression
I am not anxious or depressed □
I am moderately anxious or depressed □
I am extremely anxious or depressed □

To help people say how good or bad a health state is, we have drawn a scale (rather like a thermometer) on which the best state you can imagine is marked 100 and the worst state you can imagine is marked 0.
We would like you to indicate on this scale how good or bad your own health is today, in your opinion. Please do this by drawing a line from the box below to whichever point on the scale indicates how good or bad your health state is today.

Your own health state today

Best
imaginable
health state

100

9 0

8 0

7 0

6 0

5 0

4 0

3 0

2 0

1 0

0

Worst
imaginable
health state

Appendix V

ST. GEORGE'S RESPIRATORY QUESTIONNAIRE

ORIGINAL ENGLISH VERSION

ST. GEORGE'S RESPIRATORY QUESTIONNAIRE (SGRQ)

This questionnaire is designed to help us learn much more about how your breathing is troubling you and how it affects your life. We are using it to find out which aspects of your illness cause you most problems, rather than what the doctors and nurses think your problems are.

Please read the instructions carefully and ask if you do not understand anything. Do not spend too long deciding about your answers.

Before completing the rest of the questionnaire:

Please tick in one box to show how you describe your current health:

Very good	Good	Fair	Poor	Very poc
☐	☐	☐	☐	☐

St. George's Respiratory Questionnaire

PART 1

Questions about how much chest trouble you have had over the past 4 weeks.

Please tick (✓) *one box for each question*:

	most days a week	several days a week	a few days a month	only with chest infections	not at all
17. Over the past 4 weeks, I have coughed:	☐	☐	☐	☐	☐
18. Over the past 4 weeks, I have brought up phlegm (sputum):	☐	☐	☐	☐	☐
19. Over the past 4 weeks, I have had shortness of breath:	☐	☐	☐	☐	☐
20. Over the past 4 weeks, I have had attacks of wheezing:	☐	☐	☐	☐	☐

21. During the past 4 weeks, how many severe or very unpleasant attacks of chest trouble have you had?

Please tick (✓) *one*:

more than 3 attacks ☐
3 attacks ☐
2 attacks ☐
1 attack ☐
no attacks ☐

22. How long did the worst attack of chest trouble last?
(Go to question 7 if you had no severe attacks)

Please tick (✓) *one*:

a week or more ☐
3 or more days ☐
1 or 2 days ☐
less than a day ☐

23. Over the past 4 weeks, in an average week, how many good days (with little chest trouble) have you had?

Please tick (✓) *one*:

No good days ☐
1 or 2 good days ☐
3 or 4 good days ☐
nearly every day is good ☐
every day is good ☐

24. If you have a wheeze, is it worse in the morning?

Please tick (✓) *one:*

No ☐
Yes ☐

St. George's Respiratory Questionnaire PART 2

Section 1

How would you describe your chest condition?

Please tick (✓) *one*:

The most important problem I have ☐

Causes me quite a lot of problems ☐

Causes me a few problems ☐

Causes no problem ☐

If you have ever had paid employment.

Please tick (✓) *one*:

My chest trouble made me stop work altogether ☐

My chest trouble interferes with my work or made me change my work ☐

My chest trouble does not affect my work ☐

Section 2

Questions about what activities usually make you feel breathless these days.

Please tick (✓) in *each box* that
applies to you *these days*:

	True	False
Sitting or lying still	☐	☐
Getting washed or dressed	☐	☐
Walking around the home	☐	☐
Walking outside on the level	☐	☐
Walking up a flight of stairs	☐	☐
Walking up hills	☐	☐
Playing sports or games	☐	☐

Section 3
Some more questions about your cough and breathlessness <u>these days</u>.

Please tick (✓) in *each box* that
applies to you *these days*:

	True	False
My cough hurts	☐	☐
My cough makes me tired	☐	☐
I am breathless when I talk	☐	☐
I am breathless when I bend over	☐	☐
My cough or breathing disturbs my sleep	☐	☐
I get exhausted easily	☐	☐

Section 4

Questions about other effects that your chest trouble may have on you <u>these days</u>.

Please tick (✓) in *each box* that
applies to you *these days*:

	True	False
My cough or breathing is embarrassing in public	☐	☐
My chest trouble is a nuisance to my family, friends or neighbours	☐	☐
I get afraid or panic when I cannot get my breath	☐	☐
I feel that I am not in control of my chest problem	☐	☐
I do not expect my chest to get any better	☐	☐
I have become frail or an invalid because of my chest	☐	☐
Exercise is not safe for me	☐	☐
Everything seems too much of an effort	☐	☐

Section 5

Questions about your medication, if you are receiving no medication go straight to section 6.

Please tick (✓) in *each box* that
applies to you *these days*:

	True	False
My medication does not help me very much	☐	☐
I get embarrassed using my medication in public	☐	☐
I have unpleasant side effects from my medication	☐	☐
My medication interferes with my life a lot	☐	☐

Section 6

These are questions about how your activities might be affected by your breathing.

Please tick (✓) in *each box* that applies to
you *because of your breathing*:

	True	False
I take a long time to get washed or dressed	☐	☐
I cannot take a bath or shower, or I take a long time	☐	☐
I walk slower than other people, or I stop for rests	☐	☐
Jobs such as housework take a long time, or I have to stop for rests	☐	☐
If I walk up one flight of stairs, I have to go slowly or stop	☐	☐
If I hurry or walk fast, I have to stop or slow down	☐	☐
My breathing makes it difficult to do things such as walk up hills, carrying things up stairs, light gardening such as weeding, dance, play bowls or play golf	☐	☐

My breathing makes it difficult to do things such as carry heavy loads, dig the
garden or shovel snow, jog or walk at 5 miles per hour, play tennis or swim

My breathing makes it difficult to do things such as very heavy manual work,
run, cycle, swim fast or play competitive sports

Section 7

We would like to know how your chest <u>usually</u> affects your daily life.

Please tick (✓) in *each box* that applies to
you *because of your chest trouble*:

	True	False
I cannot play sports or games	☐	☐
I cannot go out for entertainment or recreation	☐	☐
I cannot go out of the house to do the shopping	☐	☐
I cannot do housework	☐	☐
I cannot move far from my bed or chair	☐	☐

Here is a list of other activities that your chest trouble may prevent you doing. (You do not have to tick these, they are just to remind you of ways in which your breathlessness may affect you):

Going for walks or walking the dog

Doing things at home or in the garden

Sexual intercourse

Going out to church, pub, club or place of entertainment

Going out in bad weather or into smoky rooms

Visiting family or friends or playing with children

Please write in any other important activities that your chest trouble may stop you doing:

. . . .

. . . .

. . . .

. . . .

Now would you tick in the box (one only) which you think best describes how your chest affects you

It does not stop me doing anything I would like to do ☐

It stops me doing one or two things I would like to do ☐

It stops me doing most of the things I would like to do ☐

It stops me doing everything I would like to do ☐

Thank you for filling in this questionnaire. Before you finish would you please check to see that you have answered all the questions.

Appendix VI

BURDEN INTERVIEW

INSTRUCTIONS: The following is a list of statements, which reflect how people sometimes feel when taking care of another person. After each statement, indicate how often you feel that way: never, rarely, sometimes, quite frequently, or nearly always. There are no right or wrong answers.

1. Do you feel that your relative asks for more help than he/she needs?

   0. Never   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always

2. Do you feel that because of the time you spend with your relative you don't have enough time for yourself?

   0. Never   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always

3. Do you feel stressed between caring for your relative and trying to meet other responsibilities for your family or work?

   0. Never   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always

4. Do you feel embarrassed about your relative's behaviour?

   0. Never   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always

5. Do you feel angry towards your relative when you are around him/her?

   0. Never   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always

6. Do you feel that your relative currently affects your relationship with other family members or friends in a negative way?

   0. Never   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always

7. Are you afraid of what the future holds for your relative?

   0. Never   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always

8. Do you feel your relative is dependent upon you?

0.   1. Rarely 2. Sometimes 3. Quite Frequently 4. Nearly Always
Never

9.   Do you feel strained when you are around your relative?

0.   1. Rarely 2. Sometimes 3. Quite Frequently 4. Nearly Always
Never

10.   Do you feel your health has suffered because of your involvement with your relative?

0.   1. Rarely 2. Sometimes 3. Quite Frequently 4. Nearly Always
Never

11.   Do you feel that you don't have as much privacy as you would like because of your relative?

0.   1. Rarely 2. Sometimes 3. Quite Frequently 4. Nearly Always
Never

12.   Do you feel that your social life has suffered because you are caring for your relative?

0.   1. Rarely 2. Sometimes 3. Quite Frequently 4. Nearly Always
Never

13.   Do you feel uncomfortable about having friends over because of your relative?

0.   1. Rarely 2. Sometimes 3. Quite Frequently 4. Nearly Always
Never

14.   Do you feel that your relative expects you to take care of him/her, as if you were the only one he/she could depend on?

0.   1. Rarely 2. Sometimes 3. Quite Frequently 4. Nearly Always
Never

15.   Do you feel that you don't have enough money to care for your relative, in addition to the rest of your expenses?

0.   1. Rarely 2. Sometimes 3. Quite Frequently 4. Nearly Always
Never

16.   Do you feel that you will be unable to take care of your relative for much longer?

0.   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always
Never

17.   Do you feel you have lost control of your life since your relative's illness?

0.   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always
Never

18.   Do you wish you could just leave the care of your relative to someone else?

0.   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always
Never

19.   Do you feel uncertain about what to do about your relative?

0.   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always
Never

20.   Do you feel you should be doing more for your relative?

0.   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always
Never

21.   Do you feel you could do a better job in caring for your relative?

0.   1. Rarely   2. Sometimes   3. Quite Frequently   4. Nearly Always
Never

22.   Overall, how burdened do you feel in caring for your relative?

0. Not at All   1. A Little   2. Moderately   3. Quite a Bit   4. Extremely

Appendix VII

Dr. Gwen Sayers

Brent & Harrow Research Ethics Committee

Level 7

Maternity Block

Room 07N19

Northwick Park Hospital

Harrow

Middlesex

HA1 3UJ

Nebulizers in the management of COPD: A study with patients and carers

Dear Dr. Gwen,

Please find enclosed the ethics application form and the related documents for the above study for review by Brent & Harrow Research Ethics Committee on the 1st of September 2008.

Please do not hesitate to contact me if you require further information.

Yours Sincerely,

Ms Bothaina Alhaddad

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The School of Pharmacy,
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Appendix VIII

Harrow Research Ethics Committee

Room 019, Level 7 Maternity Block

Northwick Park Hospital

Watford Road

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Middlesex

HA1 3UJ

Telephone: 020 8869 3805

Facsimile: 020 8869 5222

12 September 2008

Ms Bothaina Alhaddad

PhD Research Student

School of Pharmacy

Department of Practice & Policy, School of Pharmacy

Mezzanine Floor, BMA House

Tavistock Square, London

WC1H 9JP

Dear Ms Alhaddad

Full title of study:	**Nebulizers in the management of COPD: A Study with patients and carers**
REC reference number:	**08/H0719/65**

The Research Ethics Committee reviewed the above application at the meeting held on 01 September 2008. Thank you for attending to discuss the study.

Documents reviewed

The documents reviewed at the meeting were:

Document	Version	Date
Application		08 August 2008
Investigator CV		08 August 2008
Protocol	1	08 August 2008
Covering Letter		08 August 2008
Peer Review		04 August 2008
Interview Schedules/Topic Guides	1	08 August 2008
Questionnaire: Non validated questionnaire		08 August 2008
Questionnaire: Zarit Burden Interview		
Questionnaire: EuroQol questionnaire		
Questionnaire: St. Georges' Respiratory questionnaire		
Letter of invitation to participant	1	08 August 2008
GP/Consultant Information Sheets	1	08 August 2008
Participant Information Sheet	1	08 August 2008
Participant Consent Form	1	08 August 2008
Meet the researcher poster	1	08 August 2008
Reply Slip	1	08 August 2008
Letter from Sponsor		08 August 2008
Summary CV for Prof Kevin Taylor		
Summary CV for Julia Smith		
Clinical information from medical notes	1	08 August 2008

Provisional opinion

The Committee would be content to give a favourable ethical opinion of the research, subject to receiving a complete response to the request for further information set out below.

The Committee delegated authority to confirm its final opinion on the application to the Chair.

Further information or clarification required

In discussion, the Committee noted the following ethical issues.

1. The committee asked whether the researcher was going to access the database for information and then go into the community. If this was the case then it was not ethical practice and would breach confidentiality as the researcher was not part of the clinical care team.
2. The committee requested that the Participant Information Sheet (PIS) should be rewritten using the NRES guidance -
   http://www.nres.npsa.nhs.uk/applicants/help/guidance.htm#consent
3. The committee asked whether patients would know what COPD meant or was it too technical.
4. The committee requested that a separate Information sheet should be submitted for carers.
5. The committee commented that the patient letter may cause upset to the recipient if it arrives by post informing them that they have a disease.
6. The committee asked whether the photograph of Ms Alhaddad provided to the participants could be of a better quality print.
7. The committee commented that the estimated time to take part in the study (30-45 minutes) may be understated as a member had carried out a test run of the questionnaires and 1-1.5 hours was a more realistic estimate. This information should be clearly stated on the PIS.
8. The committee did not approve the SSA-Exempt status as it felt that issues of causing upset to the patients, possible complaints about the research and safety of the researcher needed to be considered.
9. The committee pointed out two minor errors – "HAART" only has one "A" and "nebuliser" is spelt with and "s".

Ms B Alhaddad and Professor Taylor were invited to join the meeting and the Chair informed them that a letter would be sent following the meeting, which would set out the Committee's concerns and any amendments required to the documentation. The following points were discussed at the meeting:

A. The Chair informed Ms Alhaddad that lay members on the committee did not understand the term COPD and asked whether lay people recruited onto the study would understand it. Ms Alhaddad noted this point.
B. The Chair asked for the Participant Information Sheet (PIS) to be written in the standard NRES format.
C. The Chair asked what steps would be taken if a patient became distressed and advised Ms Alhaddad to get consent from them to refer them to the GP.
D. The Chair informed Ms Alhaddad that the recruitment process would breach confidentiality as she would be taking data that has not been collected for research purposes and suggested that the GP should send the letter to the potential participants. Ms Alhaddad noted this point. The Chair asked for this letter to be submitted to the committee for review.
E. The Chair informed Ms Alhaddad that a member of the committee had undertaken a test run of the questionnaires and interview schedule and a realistic time commitment would be 1-1.5 hours- this should be stated in the PIS. Ms Alhaddad noted this point.
F. The Chair informed Ms Alhaddad that the SSA-Exempt status had not been approved.

When submitting your response to the Committee, please send revised documentation where appropriate underlining or otherwise highlighting the changes you have made and giving revised version numbers and dates.

The Committee will confirm the final ethical opinion within a maximum of 60 days from the date of initial receipt of the application, excluding the time taken by you to respond fully to the above points. A response should be submitted by no later than 10 January 2009.

Ethical review of research sites

After consideration of the research procedures involved in the study, the Committee decided that an assessment should be made locally of the suitability of the investigator, site and facilities ("site-specific assessment"). The lead researcher at each site should be designated as the local Principal Investigator.

You should therefore arrange for the Site-Specific Information Form to be submitted to the Research Ethics Committee for each site (SSA REC), together with a copy of the local Principal Investigator's curriculum vitae, as soon as possible. In the case of research sites outside the NHS, the following should also be provided:

- A copy of the participant information sheet, as submitted to this Committee, on local headed paper and incorporating relevant site-specific information including contact points
- Evidence of the PI's professional registration.
- Evidence of insurance or indemnity cover for the PI and where applicable the Contract Research Organisation.

SSA RECs have 25 days in which to notify this Committee whether or not there is any objection on site-specific grounds. The Committee would then confirm the favourable ethical opinion for each site in writing to you.

Membership of the Committee

The members of the Committee who were present at the meeting are listed on the attached sheet.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

08/H0719/65	Please quote this number on all correspondence

Yours sincerely

Dr Gwen Sayers

Chair

Email: Mona.Shah@nwlh.nhs.uk

| Enclosures: | *List of names and professions of members who were present at the meeting and those who submitted written comments.* |

| Copy to: | Ms Maureen Boylan |

Chief Operating Officer and Secretary to Council

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The Heights, Fourth Floor
59-65 Lowlands Road
Harrow HA1 3AW
Tel: 020 8966 1001

Harrow Research Ethics Committee

Attendance at Committee meeting on 01 September 2008

Committee Members:

Name	Profession	Present	Notes
Ms Sara Barnett	Nurse/Midwife	No	
Mrs Renu Barton-Hanson	Senior Lecturer in Law	No	
Mr Owen Cock	Retired Aeronautical Engineer	Yes	
Mr Rahim Ghanbari	Audiologist	No	
Dr Moses Kapembwa	Consultant Physician in Genito-Urinary and HIV Medicine	Yes	
Mrs Trixie McAree	Research and Audit midwife; Safeguarding Lead Midwife	No	
Ms Hazel-Ann Munroe	Discharge Manager	Yes	
Ms Fatima Nathoo	Lay member	Yes	
Dr Dan Ornadel	Consultant Physician in Respiratory and General Medicine	Yes	
Dr Gwen Sayers	Clinical Ethicist	Yes	
Mr Alan Smith	High Court Judges Clerk	Yes	
Miss Stella Pik Shan Wan	Pharmacy Production Manager	Yes	
Mr David Wells	Head Biomedical Scientist	No	
Mr Jim Wood	Retired IT Consultant	Yes	

Also in attendance:

Name	Position (or reason for attending)
Mrs Mona Shah	Committee Co-ordinator

Appendix IX

Harrow Research Ethics Committee
Room 019, Level 7 Maternity Block
Northwick Park Hospital
Watford Road
Harrow
Middlesex
HA1 3UJ

10/11/2008

Re: Nebulisers in the management of COPD: A study with patients and carers

REC reference number: 08/H0719/65

Dear Dr. Gwen,

Thank you for your provisional letter dated on 12th of September. The research team has noted all the points rose by the Ethics Committee and have made all the necessary changes requested, as follows:

Further information and clarification:

1. The researcher confirms that she will not be accessing the patients' database for information and then go in the community. Please note that the "information letter to the GP" has been now changed to be an "invitation letter to the GP", in this letter the GP will be invited to take part in the study, and upon agreeing to take part (or a member of practice staff) will be asked to identify potential patients in their surgery who are currently using nebulisers. Once patients are identified, they will be asked to approach the patients they identified either by giving them the prepared information pack as they come in for their scheduled surgery visit or alternatively by posting the pack to their home address. The invitation letter for the participants will now be signed by the patients' GP or by the clinical care team on behalf of the GP.

    Similarly in intermediate care, the clinical care team will identify the patients who are admitted to hospital experiencing an exacerbation and have been using

nebulisers before admission or discharged from hospital with a nebuliser. They will be asked to give the patients the information pack just before discharge or alternatively during a routine home visit, or by post.

2. Version 2 of the participants' information sheet has prepared according to the guidance provided on the NRES website as requested by the Committee and submitted with this letter.

3. The research team has now renamed the word COPD to be less technical and more familiar to lay people and participants. We now use chronic bronchitis/emphysema instead. The two words will appear in all documents prepared for the participants including invitation letters, participants' information sheets, consent forms, reply slips, and will be read out during interviews.

4. A separate information sheet for carers is prepared according to the guidance on the NRES website and submitted for your review.

5. The invitation letter to participants is now re-written. The first paragraph is now:

Dear Participant,

"Nebuliser therapy is one way of managing a number of conditions which affect breathing and the airways. However, very little is known about the use of nebulisers at home, the problems experienced and the help received. The findings of this study will help in the development of future services"

The title of the invitation letter to participants is now also changed to read the following:

"The use of nebulisers at home"

Please note that the letter now does not inform the patients that they have a disease, rather that the participants in the study have been selected on the basis of their use of nebuliser therapy. Version 2 of the information letter has been re-written to emphasise and reflect this point. In addition the invitation letter to patients and their carers will now be signed by their GP or a member of their health care team on

behalf of their GP whom they will recognise as being involved with their health care as agreed during the committee meeting.

6. The photograph of the researcher will be a high quality colour image as requested. Please refer to the photograph submitted with this letter.

7. The research team discussed this point and taking into consideration the cognitive, physical, health status of the participants, and drawing from previous research in similar participants group, 60 min is considered a realistic estimate of the time taken for each participant to complete the interview. The time is now modified in the PIS and where relevant in all documents and application form to be <u>60 min.</u>

8. An SSI form is now filled in and submitted for Northwick park hospital with all the collaborators named in the form and a copy of their CV.

    However, as explained to the committee's co-ordinator Mrs Alka Bhayani during a telephone conversation, fulfilling this requirement for all surgeries within Harrow PCT would require the research team to know which surgeries are going to be recruited based on the numbers of potential participants within each surgery. It was understood during preliminary discussions with clinical staff from Harrow PCT that numbers of patients using nebulisers can be as low as 1 in some surgeries. Therefore, the research team felt that recruiting surgeries should be considered as part of the research process once it started. Therefore, "An invitation letter to the GP" was prepared to replace the "Information letter to the GP" which was previously prepared. The letters will be sent out to all GP surgeries within the Harrow PCT. The GP will be asked to nominate a member of their health care team to identify potential participants and approach them. They will be asked to sign the invitation letter to all participants from their surgery. The nominated member of the healthcare team would have their contact details printed on the PIS. In doing so, issues causing upset to the patients, possible complaints about the study and safety of the researcher will be addressed. Please refer to point 1.

9. The erroneous HAART has now been changed, where it appeared in all documents, to <u>HART</u>. Similarly, nebulizers have been changed to <u>nebulisers</u>.

Other points discussed in the meeting:

A. As outlined above in point 3, the word COPD has now been changed to chronic bronchitis/emphysema.
B. As outlined above in point 2, version 2 of the PIS is now written according to the NRES guidance and submitted for review.

C. The researcher has noted this point down and will ask patients for their consent to be referred to their GP if they become distressed during the interview.
D. As outlined in point 1 and 8, the invitation letter to participants will now be signed by their GP/HART. Please find enclosed with this letter version 2 of the invitation letter to patients and version 2 of the invitation letter to carers both will now be signed by the GP or the HART.
E. As outlined above in point 7, this has now been changed to 60 minutes.
F. As outlined above in point 8, An SSI form is now submitted for Northwick Park Hospital with the Collaborators' CV.

Please find enclosed with this cover letter the version 2 of the modified documents for your kind review. The changes are underlined.

An SSI form is now completed for Northwick Park Hospital with one page CV of the local principal investigator and the collaborator at the site.

Please do not hesitate to contact me if you require further information.

Yours Sincerely,

Ms Bothaina Alhaddad

PhD Research Student
The Department of Practice and Policy,
The School of Pharmacy,
Mezzanine Floor, BMA House,
Tavistock Square,
London,
WC1H 9JP.
Tel: 0 20 7874 1278
Fax: 0 20 7387 5693
Email: bothaina.alhaddad@pharmacy.ac.uk

Appendix X

National Research Ethics Service

Harrow Research Ethics Committee
Level 7, Room 7N019, Maternity Block
Northwick Park Hospital
Watford Road
Harrow
Middlesex HA1 3UJ

Telephone: 020 8869 3805
Facsimile: 020 8869 5222

01 December 2008

Ms Bothaina Alhaddad
PhD Research Student
School of Pharmacy
Department of Practice & Policy, School of Pharmacy
Mezzanine Floor, BMA House
Tavistock Square,
London WC1H 9JP

Dear Ms Alhaddad

Full title of study:	**The use of nebulisers at home: A study with patients and carers**
REC reference number:	**08/H0719/65**

The REC gave a favourable ethical opinion to this study on 11 November 2008.

Further notification(s) have been received from local site assessor(s) following site-specific assessment. On behalf of the Committee, I am pleased to confirm the extension of the favourable opinion to the new site(s). I attach an updated version of the site approval form, listing all sites with a favourable ethical opinion to conduct the research.

R&D approval

The Chief Investigator or sponsor should inform the local Principal Investigator at each site of the favourable opinion by sending a copy of this letter and the attached form. The research should not commence at any NHS site until approval from the R&D office for the relevant NHS care organisation has been confirmed.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

08/H0719/65	Please quote this number on all correspondence

Yours sincerely

Mrs Alka Bhayani
Committee Administrator

Email: alka.bhayani@nwlh.nhs.uk

Enclosure: *Site approval form*

Copy to: Ms Maureen Boylan
Chief Operating Officer and Secretary to Council
School of Pharmacy, University of London
29-39 Brunswick Square,
London WC1N 1AX

Dr Alan Warnes
NWLH NHS Trust, Level 7N022, Maternity Unit
Northwick Park Hospital, Watford Road
Harrow, Middlesex HA1 3UJ

Marie-Claire Sekeley
R & D Lead Advisor, Harrow PCT
The Heights, Fourth Floor
59-65 Lowlands Road
Harrow HA1 3AW

Appendix XI

Dear General Practitioner,

The use of nebulisers at home

We would like to invite you to take part in a study on nebuliser use among patients with COPD. The aim of the study is to find out about their views and experiences with using nebulisers in the home setting. Little is known about this, and findings from previous studies reveal suboptimal use and problems ranging from operation through to cleaning and maintaining the equipment.

We would like your help to identify COPD patients who are currently using nebulisers/prescribed nebules for their COPD. Taking part in this study would simply mean that you nominate a member from your practice team to identify potential participants and to give out the prepared information pack to the patients by posting them to their home address, or alternatively, as they come in the surgery for their appointment. We also need you to sign the prepared invitation letters to participants from your surgery. The nominated member of the team at your surgery will have their contact details printed on the information sheet. It is a requirement of the local Ethics Committee to have a contact point for all participants should they wish to refer to during the course of the study.

Patients and their carers will be invited to take part in an interview in their home. This should not interfere with the care of the patients during their attendance at your surgery. We are hoping that on completion of the study that we will be able to provide useful information about the needs and concerns from the perspective of patients and their carers that will lead to optimization of their care and support in the future.

The study is being run independently by researchers at the School of Pharmacy, University of London in collaboration with clinicians and pharmacists from Harrow PCT and Northwick Park Hospital. This study has been approved by the Local Ethics Committee (Ref ....) and the local R & D department, and is receiving no commercial funding.

We would be grateful if you could give the reply slip enclosed with this letter to a nominated member of your primary care team to fill in and return it in the pre-paid envelope provided.

If you require more information about the study, please do not hesitate to contact the researcher by email or on the numbers shown below:

Looking forward to hearing from you

The researcher's contact details: Dr. Tricia Robertson
Bothaina Alhaddad   Mobile:
07908213695
Mobile: 0751 5810 896
Tel: 020 7874 1278
Email: bothaina.alhaddad@pharmacy.ac.uk   Email:
tricia.robertson@nhs.net

Appendix XII

The use of nebulisers at home

Reply slip for practitioners

Name of doctor: (please print)...

Surgery address:

....

....

....

Please tick the appropriate box:

I would like to take part in this study of 'The use of nebulisers at home: A study with patients and carers'. Please give your contact details below.	
I would not like to take part in this study of 'The use of nebulisers at home: A study with patients and carers'. Please give reasons below.	

Name of the nominated member of practice team:

....

Tel number:

....

Number of patients receiving nebuliser therapy for COPD at your surgery:

....

Reasons for not taking part:

....

....

....

Please return this slip in the pre-paid envelope provided (no stamp is required)

Thank you very much for your time

Appendix XIII

Study of Nebuliser use by COPD Patients at Home: Quick Reference Guide

• What is the aim of the study?

To examine the place and experiences of using nebulisers in the home in the management of COPD from the perspectives of patients and their carers and to determine their needs and concerns to be able to support them most effectively.

• What will it involve for the patients?

Once patients and their carers return a reply slip expressing willingness to take part in the study they will be contacted by the Principal Investigator to arrange a convenient time for an interview in their home. Semi-structured interviews have been developed for the study. Patients and carers will be asked to complete validated questionnaires relating to the patient's quality of life and carer burden. Some relevant clinical and medicines use information will be taken from their medical notes.

• What will be the collaborator's involvement in each practice?

We need your help:

1. To identify COPD patients, using your surgery database, who are currently using nebulisers/prescribed nebules for their COPD.

2. To sign the prepared invitation letter to be sent to participants.

3. To have your contact details printed on the information sheet.

4. To post the prepared information pack to the patients or alternatively, give out the packs to patients as they come in the surgery for their routine visit.

5. Later on and after consent from patients has been obtained, the principal investagator would like to have access to patients medical notes to record information about; the medicines they are taking, any other condition they may have, any previous admissions to hospital, measures of their lung function and blood gases.

Please note: the Principal Investigator will be happy to assist in all preparatory tasks

• What are the benefits of the study?

The study will provide valuable information about the needs and problems experienced in the use of nebulisers at home from the perspective of COPD patients and their carers in Harrow PCT. It will establish current practices and experiences and inform future initiatives to optimise care. We will also be able to determine which patients would benefit from other interventions such as the Rescue Pack and the smoking cessation scheme.

• Who is organizing the study?

The study is being run independently by researchers (principal investigator: Bothaina Alhaddad) at the School of Pharmacy, University of London in collaboration with clinicians from the HART team at Northwick Park Hospital and Dr. Tricia Robertson and Dr Geoffrey Watman from Harrow PCT.

Appendix XIV

Dear Participant,

The use of nebulisers at home

Nebuliser therapy is one way of managing a number of conditions which affect breathing and the airway. However, very little is known about the use of nebulisers at home, the problems people experience and the help they receive. Findings of this study will help inform the development of future services

I would like to invite you to take part in this study which will involve an interview in your home about your use, views and experiences of using a nebuliser for chronic bronchitis/emphysema. We would also like to interview anyone who assists you in the use of your nebuliser. You will be asked to fill in a questionnaire that will tell us about your health. Overall, this will take about 60 minutes. If you are happy to take part, the researcher will contact you to arrange a convenient time to come and talk with you and this person at your home.

Enclosed with this letter you will find an information leaflet which will tell you more about the study. You may wish to read and decide if you would like to take part in this study.

If you receive help from anyone, we would like to speak to him/her. You will find enclosed a yellow letter and information sheet to give to any person who assists you in using your nebuliser.

All information will be kept strictly confidential. A copy of the consent form is also provided for you to read and keep it. You will be asked to sign this form by the researcher on the day of the interview. You will have the chance to ask any questions before deciding to do so.

Whether you are willing to take part or feel unable to do so, I would be most grateful if you would complete the reply slip attached to this letter and return it to me in the pre-paid envelope provided.

I have included a photo of the researcher for you to have a look at and know who you may expect when you are visited.

The study is being run independently by researchers at the School of Pharmacy, University of London in collaboration with your surgery in Harrow PCT and the HART team at Northwick Park Hospital.

If you would like to discuss taking part in this study further before you complete the slip, please feel free to contact the researcher on 0207 874 1278.

I look forward to receiving your reply slip.

Yours faithfully

Signed by the GP/or the HART

Appendix XV

INFORMATION SHEET

For patients

The use of nebulisers at home

Ref 08/H0719/65 Version 2 9/10/2008

You are being invited to take part in a research study. Before you decide whether to participate it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Part 1 tells you the purpose of this study and what will happen to you if you take part. Part 2 gives you more detailed information about the conduct of the study. Please contact us if there is anything that is not clear or if you would like more information.

PART 1

- **What is the purpose of the study?**

Nebuliser therapy is one way of managing a number of conditions which affect breathing and the airways. However, very little is known about the use of nebulisers at home, the problems experienced and the help people receive. The information will help in the development of future services.

- **Why have I been chosen?**

We are inviting all patients currently using nebulisers at home who are registered at selected surgeries in Harrow PCT and at Northwick Park Hospital to take part.

- **Do I have to take part?**

It is up to you to decide. This information sheet tells you about the study and you will have the opportunity to ask questions. If you agree to take part we will ask you to sign a consent form. You are free to withdraw at any time, without giving a reason. This would not affect the standard of care you receive.

- **What will happen to me if I take part?**

If you decide to take part in this study, a researcher will contact you to arrange to visit you at home on one occasion to talk to you about your use of your nebuliser and your chest. The researcher will also ask you to fill in a questionnaire about your health. We would like to audio-record the interview but if you do not want us to do this, we would still like you to take part. We may wish to take a photo of your nebuliser. The visit may take up to 60 minutes.

We would also like to take the following information from your medical notes:

- the medicines you are taking.

- any other condition you may have.

- any previous admissions to hospital.

- measures of your lung function and blood gases.

- **What are the possible disadvantages and risks of taking part?**

It is possible during the interview that you may recall some negative experiences or you may find the length of the

questionnaire inconvenient. However, if any of these arise you will be able to stop the interview at any point without giving any reasons. The researcher is also experienced at handling emotional situations. Should they arise you will be asked for your consent if you would like to be referred to your GP or your healthcare team.

- **What are the possible benefits of taking part?**

We cannot promise the study will help you but the information we get from this study will help improve the treatment of people using nebulisers in the future.

- **What if there is a problem?**

Any complaint about the study or any possible harm you might suffer will be addressed. The detailed information on this is given in Part 2.

- **Will my taking part in the study be kept confidential?**

Yes. We will follow ethical and legal practice and all information about you will be handled in confidence. The details are included in Part 2.

This completes part I.

If the information in Part 1 has interested you and you are considering taking part, please read the additional information in Part 2 before making any decision.

PART 2

- **What will happen if I don't want to carry on with the study?**

If you withdraw from the study, we will destroy all your identifiable data, but we will need to use the data collected up to your withdrawal.

- **What if there is a problem?**

If you have a concern about any aspect of this study, you should ask to speak to the researcher or a member of your healthcare team who will do their best to answer your questions (contact numbers are provided at the end of this sheet). If you remain unhappy and wish to complain formally, you can do this through the NHS Complaints Procedure (or Private Institution). Details can be obtained from the surgery/hospital.

- **What if there was harm?**

It is unlikely that this study will result in any harm to you; however, there is a small chance that during the conduct of the interview you may recall bad or negative experiences. If this occurs, you can stop the interview at any time without giving any reasons and without your care being affected. The researcher is also experienced at handling such events and will ask you for your consent if you would like her to inform your GP/healthcare team.

- **Will my taking part in this study be kept confidential?**

All information which is collected about you during the course of the research will be kept strictly confidential, and any information about you which leaves the hospital/surgery will have your name and address removed so that you cannot be recognised.

- **Involvement of the General Practitioner/Family doctor (GP)**

As you may already know your GP/Healthcare team is aware that you have been invited to take part in this study. However no information will be disclosed to your GP/Healthcare team without your consent.

- **What will happen to the results of the research study?**

The results from the study will made available to the public through publication and other leaflets. You will be asked if you would like to receive a copy of the information. No individual will be identifiable in any report of the study.

- **Who is organising and funding the research?**

The research is being carried out and funded by the School of Pharmacy, University of London. We are an independent establishment involved in education and research; we are not a commercial organisation.

- **Who has reviewed the study?**

The study has been independently approved by Harrow Research Ethics Committee [Ref no] and the research and development department at your Primary Care Trust/Hospital.

All research in the NHS is looked at by independent group of people, called a Research Ethics Committee to protect your safety, rights, wellbeing and dignity. This study has been reviewed and given a favourable opinion by Harrow Research Ethics Committee.It is a requirement by the Research Ethics

Committee that you have been given this information sheet and that you sign a consent before the start of the study.

- **Further information and contact details**

If you would like any further information about research, please visit the following website:

http://www.invo.org.uk/

However, if you need specific information about this research project, or advice as to whether you should participate, or even who should you approach if unhappy with the study, please do not hesitate to contact any member of the research team on their contacts as shown below:

Bothaina Alhaddad
SOP address
Tel: 020 7874 1278

Felicity Smith
SOP address
Tel: 020 7874 1288

Member of the Primary care
Practice address
Tel: ……………..

Roshan Silva
Hospital address
Tel: 0208 869 3654

THANK YOU FOR TAKING THE TIME TO READ THIS LEAFLET

Appendix XVI

Patient Identification Number:

The use of nebulisers at home

Consent form for patients

Please tick the boxes below: Researcher: Bothaina Alhaddad

1. I confirm that I have read and understood the information sheet dated 08/09/2008 (version 2) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected.	
3. I understand that relevant sections from my medical notes and data collected during the study may be looked at by the research team. Where it is relevant to my taking part in this study, I give permission for these individuals to have access to my records.	
4. I know that a request will be made to audio-record the interview, but agreeing to this is not a requirement to take part.	
5. I give permission to the researcher to take a photo of my nebuliser.	
6. I agree to take part in the above study.	

_____   _____   _____

Name of patient   Date   Signature

_____   _____

Name of person taking consent   Date   Signature

When completed, 1 for patient; 1 for researcher site file; 1 (original) to be kept in medical notes.

Appendix XVII

The use of nebulisers at home

Reply slip for patient

Name of patient: (please print)..

Please tick the appropriate box:

I would like to take part in this study of 'The use of nebulisers at home: A study with patients and carers'. Please give your contact details below.	

I may be contacted on

....

....

I prefer you contact me...

Address:

....

....

I would not like to take part in this study of the use of nebulisers at home: A study with patients and carers'. It would help if you gave a reason.	

Reasons for not taking part:

....

....

....

....

Please return this slip in the pre-paid envelope provided (no stamp is required)

Thank you very much for your time

Appendix XVIII

Dear Relative/Friend,

The use of nebulisers at home

Many people provide and receive help with their medication whether occasionally or regularly. However, very little is known about the help received by patient with chronic bronchitis/emphysema using nebulisers. This study is designed to find out about the help people give and receive in the use of nebulisers at home. If you provide any assistance however small, we would like to invite you to take part. The findings of this study will help inform the development of future services.

Taking part in this study involves an interview with you and your relative or friend about your views and experiences of using nebulisers at home. You will also be asked to fill in a questionnaire that will tell us more about your health and you experiences of providing assistance. Overall this will take about <u>60 minutes</u>. If you are happy to take part, the researcher would like to contact you to arrange a convenient time to come and talk with you.

Enclosed with this letter you will find an information leaflet which will tell you more about the study. You may wish to read this with your relative/friend and decide together if you would like to take part in this study. All information will be kept strictly confidential.

Whether you are willing to take part or feel unable to do so, I would be most grateful if you would complete the reply slip attached to this letter and return it to me in the pre-paid envelope provided.

The study is being run independently by researchers at the School of Pharmacy, University of London in collaboration with your local GP at Harrow PCT or the <u>HART</u> team at Northwick Park Hospital.

If you would like to discuss taking part in this study further before you complete the slip, please feel free to contact the researcher on 0207 874 1278.

I look forward to receiving your reply slip.

Yours faithfully   <u>signed by the GP/ or the HART</u>

Appendix XIX

INFORMATION SHEET

For carers

The use of nebulisers at home

Ref 08/H0719/65 Version 2 9/10/2008

You are being invited to take part in a research study. Before you decide whether to participate it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Part 1 tells you the purpose of this study and what will happen to you if you take part. Part 2 gives you more detailed information about the conduct of the study. Please contact us if there is anything that is not clear or if you would like more information.

PART 1

- **What is the purpose of the study?**

Many people provide and receive help with their medication, whether occasionally or regularly. However, very little information is known about the help people receive with the use of nebulisers at home. This study is designed to find out about the help people give and receive when using nebulisers. If you provide any assistance however small we would like to invite you to take part in this research. The information will help in the development of future services.

- **Why have I been chosen?**

We are inviting all people who are providing any assistance with the use of a nebuliser for patients who are registered at selected surgeries in Harrow PCT and at Northwick Park Hospital.

- **Do I have to take part?**

It is up to you to decide. This information sheet tells you about the study and you will have the opportunity to ask questions. If you agree to take part we will ask you to sign a consent form. You are free to withdraw at any time, without giving a reason.

This would not affect the standard of care your relative or friend receives.

- **What will happen to me if I take part?**

If you decide to take part in this study, a researcher will contact you to arrange to visit you at home to talk to you about the help you give with the use of the nebuliser. The researcher will also ask you to fill in a questionnaire about your quality of life. We would like to audio-record the interview but if you do not want us to do this, we would still like you to take part. The visit may take up to 60 minutes.

- **What are the possible disadvantages and risks of taking part?**

It is possible during the interview that you may recall some negative experiences or you may find the length of the questionnaire inconvenient. However, if any of these arise you will be able to stop the interview at any point without giving any reasons. The researcher is also experienced at handling emotional situations. Should they arise and you will be asked for your

consent if you would like to be referred to the GP or the healthcare team.

What are the possible benefits of taking part?

We cannot promise the study will help your relative or friend but the information we get from this study will help improve the care of people who use nebulisers in the future.

- **What if there is a problem?**

Any complaint about the study or any possible harm you might suffer will be addressed. The detailed information on this is given in Part 2.

- **Will my taking part in the study be kept confidential?**

Yes. We will follow ethical and legal practice and all information about you will be handled in confidence. The details are included in Part 2.

This completes part I.

If the information in Part 1 has interested you and you are considering taking part, please read the additional information in Part 2 before making any decision.

PART 2

- **What will happen if I don't want to carry on with the study?**

If you withdraw from the study, we will destroy all your identifiable data, but we will need to use the data collected up to your withdrawal.

- **What if there is a problem?**

If you have a concern about any aspect of this study, you should ask to speak to the researcher or a member of the heath care team who will do their best to answer your questions (contact numbers are provided at the end of this sheet). If you remain unhappy and wish to complain formally, you can do this through the NHS Complaints Procedure (or Private Institution). Details can be obtained from the hospital.

- **What if there was harm?**

It is unlikely that this study will result in any harm to you, however, there is a small chance that during the conduct of the interview you may recall bad or negative experiences. If this occurs, you can stop the interview at any time without giving any reasons and without your relative/friend care being affected. The

researcher is also experienced at handling such events and will ask you for your consent if you would like her to inform the GP/healthcare team.

- **Will my taking part in this study be kept confidential?**

All information which is collected about you during the course of the research will be kept strictly confidential, and any information about you which leaves the hospital/surgery will have your name and address removed so that you cannot be recognised.

- **Involvement of the General Practitioner/Family doctor (GP)**

As you may already know the GP/Healthcare team is aware that you have been invited to take part in this study. However no information will be disclosed to the GP/Healthcare team without your consent.

- **What will happen to the results of the research study?**

The results from the study will made available to the public through publication and other leaflets. You will be asked if you would like to receive a copy of the information. No individual will be identifiable in any report of the study.

- **Who is organising and funding the research?**

The research is being carried out and funded by the School of Pharmacy, University of London. We are an independent establishment involved in education and research; we are not a commercial organisation.

- **Who has reviewed the study?**

The study has been independently approved by Harrow Research Ethics Committee [Ref no] and the research and development department at the Primary Care Trust/Hospital.

All research in the NHS is looked at by independent group of people, called a Research Ethics Committee to protect your safety, rights, wellbeing and dignity. This study has been reviewed and given a favourable opinion by Harrow Research Ethics Committee.It is a requirement by the Research Ethics Committee that you have been given this information sheet and that you sign a consent to keep before the start of the study.

- **Further information and contact details**

If you would like any further information about research, please visit the following website:

http://www.invo.org.uk/

However, if you need specific information about this research project, or advice as to whether you should participate, or even who should you approach if unhappy with the study, please do not hesitate to contact any member of the research team on their contacts as shown below:

Bothaina Alhaddad
SOP address
Tel: 020 7874 1278

Felicity Smith
SOP address
Tel: 020 7874 1288

Member of the Primary care
Practice address
Tel: ……………..

Roshan Silva
Hospital address
Tel: 0208 869 3654

THANK YOU FOR TAKING THE TIME TO READ THIS LEAFLET

Appendix XX

Patient Identification Number:

The use of nebulisers at home

Consent form for carers

Researcher: Bothaina Alhaddad

Please tick the boxes below:

1. I confirm that I have read and understood the information sheet dated 08/10/2008 (version 2) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.	
3. I know that a request will be made to audio-record the interview, but agreeing to this is not a requirement to take part in the study.	
4. I agree to take part in the above study.	

_____   _____ _____

Name of carer   Date   Signature

_____   _____ _____

Name of person taking consent   Date   Signature

When completed, 1 copy for carer; 1 copy for researcher site file; 1 copy (original) to be kept in medical note

Appendix XXI

The use of nebulisers at home

Reply slip for carer

Name: (please print)……………………………………................................……..............……

Name of patient:

…………………………………………………………………………..…............…

Please tick the appropriate box:

I would like to take part in this study of 'The use of nebulisers at home: A study with patients and carers'. Please give your contact details below.	

I may be contacted on

…………………………………………………………………….................…

Preferred time for contact…………………………………………………………………………….…

Address:

………………………………………………………………………………....…..............…

…………………………………………………………………………………………………….…

……...........………………………………………………………………………………………….…

…………….........…………………………………………………………………………….........…

……………..........

I would not like to take part in this study of 'The use of nebulisers at home: A study with patients and carers'. It would be helpful if you gave a reason.	

Reasons for not taking part:

……

…………………………………………………………………………………………………….…

………...........…………………………………………………………………............………….…

………………........……

Please return this slip in the pre-paid envelope provided (no stamp is required)

Thank you very much for your time

Appendix XXII

The use of nebulisers in the home

Meet the Researcher

We would like to introduce Ms Bohaina Alhaddad; a researcher from the School of Pharmacy who is keen to know about your experience with using or helping with using a nebuliser. If you are willing to take part in the study she will contact you to arrange time for an interview. When she calls at your home as arranged we think it is important for you to know who to expect. She will be carrying an identification badge.

Thank you for taking time to read this page.

Appendix XXIII

Data-Unit	3.1. Details on nebuliser use	3.2. Perceived efficacy/benefits/advantages	3.3. Treatment failure	3.4. Monitoring of condition	3.5. Perceived problems/disadvantages
Case 40	Uses nebulise 5x a day. Patient knows when she should use it to keep a smooth flow going/ becomes breathless if didn't use nebuliser daily.	Frees chest up and ease it when it's tight. Relies on nebuliser/feels can't do without it.	Repeats the nebulisation if didn't get relief after using it. Thinks repeating nebulisation is a safe practice as long as it's a single dose at a time Felt encouraged to repeat nebulisation by seeing it done in hospital.	Don't normally monitor therapy with a peak flow meter but only has one because of participation in a trial. Doesn't know how to use it/need to ring the hospital and finds out.	Nebulisation time up to 20 min/ regarded too long by the patient/ describes it as hard work to empty nebuliser/ nuisance cannot carry on with work & had to stop it half way through & re-do it although she knows she is not suppose to. Admits not knowing awful lot about nebuliser but realises not suppose to re-use the nebules once opened.
Case 41	Normally uses one drug but when bad uses the two together. Only uses nebuliser in an emergency, and when he get to the point of using it every 4 hours for a couple of days starts on steroids and stops it. No clear idea when to use nebuliser. Reluctant to use the nebuliser/ hand shakes/ but need to write.	Reluctant to use nebuliser more than needed on the grounds of being less effective with more use.	Uses the nebuliser 4 x a day, one nebule at first then both , then start the pred for 3 days, get in touch with the doctor, continue for 5-10 days but only uses nebuliser in an emergency (during an exacerbation).	Monitors condition with a peak flow meter regularly on a daily basis. Feels a lot better in the afternoon after coughing up the phlegm but not reflected in peak flow meter score/inconsistency. Don't feel is a reliable tool, as it improved when not necessarily feels the same way. Unsure about effect of nebuliser /never uses the peak flow meter immediately after nebulisation.	Fills the medication chamber through the face mask because it's quick and easy, then he fits the masks on. Taps towards the end of nebulisation to get drug solution. NT last 8-10 min. Some RV left in chamber after nebulisation. Nebulisation stops when no more vapour comes out& after checking its empty. Prefers to use the face mask to breath both from his nose and mouth/ but breathes mainly through his nose with the face mask despite getting wet but feels it's not an issue /can wipe it. Not sure if effectiveness improved if breathe from his mouth/ the medication is intended for his lungs.
Case 42	Uses nebuliser only occasionally and not on a daily basis. Use increased during bad times. Patient uses her hand held inhalers up to 4 times a day but uses the nebuliser if she still needs extra. Patient uses her nebuliser in the early hour of the morning if she woke up uncomfortable. Patient knows she can have the nebuliser up to 6 times a day but doesn't want to become dependent on it. Patient reduces her dose back to normal if she recovers from an attack to preserve high doses for emergency when she needed them.	Patient feels the combination of her drugs and dosages (inhalers and nebuliser) seem to work well with her. Patient views her nebuliser is a compact little box which she can take with her	Patient thinks if it doesn't work from the first time it won't work if repeated. If had to use her nebuliser 4 times a day she'll see a doctor. If it didn't risen after nebulising she goes to hospital because it means her nebuliser is not coping with what she's doing	Has a peak flow meter which she uses every morning before she takes her medication and afterwards. Noticed her PF rises after using her inhalers but it doesn't stay up all day. The patient believes she can cough the phlegm out but her nebuliser helps her get the deep stuff out. Does her PF in the morning and when its above 200 she's happy. If her PF below and she need to nebulise, she repeats it afterwards to see if it has risen, then again and again before she goes to bed to make sure she's alright to go to sleep.	Not embarrassed using her nebuliser in public places but used to be in the past. Used to have a face mask / stopped using feels panicky and claustrophobic Feels gets more in when she uses the mouth piece. Holds the mouth piece by teeth and breathes in through mouth and out through her nose. Patient doesn't like to waste any medicine because it does her so much good /uses interruption valve to stop vapour output when not in use Doesn't wash chamber frequently as it has to be thoroughly dry so water doesn't get in her lungs so she only does it when she's well. Nebuliser kit apart immersed in bubbly soapy warm water and left it to soak including the tube, and then rinse it with cold fresh water. Needs to get a new tube / getting discoloured. Changes the tube annually. Didn't have to replace the mouth piece so far. Likes to keep a filter in reserve just in case it gets wet or anything. Replaces the chamber when it's damaged.

Appendix XXIV

CASE	SUMMARY	ELEMENTS/DIMENSIONS IDENTIFIED	CATEGORIES/CLASSES
Id: 6 Male 79 yrs Relationship to care-recipient: Spouse.	Watch over wife on occasion when having the nebuliser to help her if she needs, assembled the nebuliser on some occasions when wife had trouble getting it on or off. Feels his wife can manage the nebuliser herself and his help in needed in another aspect. Condition causes his wife to panic with even little things e.g. connection can come off and so need to be there the entire time ready for anything comes up. Also manages the portable nebuliser if used in the car. Discusses side effects with HCP to make sure safe use of NM. Involved in maintaining the equipment and taking it to the manufacturer or booking an appointment for servicing or when something goes wrong(at the moment makes funny noise/purchases the disposables when needed). Calls the ambulance in the event of emergency. Accompany wife to hospital visits/outpatient appointments.	Watch over wife	Supervising nebulisation
		Wife had difficulty getting tube on and off	Need for help/urgency
		Help on occasions when needed	Intermittent help
		Need for attending/being prepared	
		Assemble nebuliser/wife then fills it	Teamwork/working together
		Discuss side effects of NM	Gathering information on side effects
		Booking regular service slots with manufacturer	Maintaining nebuliser
		Taking nebuliser to manufacturer	Maintaining nebuliser
		Booking service slots when something goes wrong	Maintaining nebuliser
		Purchase the disposables	Marinating nebuliser
		Calls ambulance in emergency	Access medical help in emergency
		Accompany to trips to hospital/outpatient appointments	Accompany to hospital
Id: 8 Relationship to care-recipient: Spouse Time spent on caring: 24/7 Time spent on medication-related activities: Daily (2.5hr/weekly) Time spent on nebuliser-related activities: Some days Number of years providing care: 5 years Gives tables every night to her husband Help with the nebuliser is needed some days when husband is bad.	Hinting if husband need to use the nebuliser by asking him if he feels he needs it as he doesn't look well. Help is also received from daughter and grandchildren with shopping and the heavy items. Accompanies her husband to GP/hospital appointments and phoning for an appointment when he's not feeling well. Will assemble the nebuliser and do all the steps including dismantling and cleaning it afterwards the same way her husband do it. Provides other help such as giving the tablets and advice her husband on the need to see a doctor as he doesn't admit he's unwell and sometimes she even need to push him to see the doctor or get help in. NM causes her husband to shake but that doesn't worry her much as it wears off after some time/ she just sit quietly and watches him without him noticing that until it subsided. Asks the doctor on his behalf when going to GP about PFM and aspects related to his care. Happy that there is a good doctor whom she can talk with about her husband condition. Talk to HCP about his care. Access medical care in case of an emergency. Cleaning the nebuliser. Accompany him to shopping trips. If bad has to take antibiotics and steroids. Knows when husband is really bad and need to call for help/doctor sends him to hospital straight. Gives him his tablets at night/do the nebuliser when he can't manage it/help with medication on daily basis.	Dropping hints to use nebuliser when husband unwell	Advice on nebuliser use
		Accompany to GP/hospital	Accompany to GP/hospital
		Making appointments when unwell	Access medical care
		Assemble the nebuliser	Assembling
		Dismantle the nebuliser	Dismantling
		Clean the nebuliser	Cleaning
		Giving tablets to husband	Giving medicines
		Advice or even push husband on need to see doctor	Advice on seeking help
		Watches husband quietly until shakes subsided	Monitoring side effects
		Asks doctors about PFM	Gathering information on aspects of care
		Talking to HCP about care	Gathering information on aspects of care
		Has to take antibiotics and steroids if bad	Advice on need for medication
		Knows when husband is bad/doctor send him to hospital	Monitoring
		Help sometimes when unwell	Intermittent help
		Do the nebuliser when husband can't manage	Need for help/urgency
Id 9 Relationship to care-recipient: Spouse. Time spent on caring: 24/7 Number of years providing care: 4 years Time spent on nebuliser-related activities: 1hr/wk	Always set up the nebuliser and clean it for her husband. Advice husband on the need of nebuliser when he is not breathing properly and instructs him to do the nebuliser. Calls doctor in the event of emergency. Husband can do the nebuliser himself/No reason for help with doing the nebuliser/husband feels spoilt/lazy and that his wife cares about him. Does all medication/need to be taken at different times and set up the nebuliser when her husband needs it and observe him while taking it. Chronological steps on setting up, operating the equipment. Contacts the medical care/access the medical care/accompany him to a GP/hospital outpatient appointment/during his inpatient stay/picks him up following discharge. Watches how nebuliser is used in hospital. Advice him to take the emergency medication in the event of treatment failure. Monitors his condition and help with the use of PFM.	Always set up and clean nebuliser	Constant help
		Set up nebuliser	Setting up
		Clean nebuliser for husband	Cleaning
		Advice or instruct husband on need for nebuliser	Advice on need for medication
		Calls doctor in an emergency	Access medical care
		Help is not needed/husband feels lazy/spoilt/wife cares about him	Need for help/urgency
		Give the medication at different times	Giving medication
		Set up nebuliser	Setting up
		Observes husband taking nebuliser	Supervising nebulisation
		Access medical care	Access medical care
		Accompany husband to GP/hospital	Accompany to GP/hospital
		Watches how nebuliser done in hospital	Gathering information from HCP on nebuliser use
		Advice to take medication in an emergency	Advice on need for medication

Appendix XXV

Construct validity of SGRQ, and EQ-5D

The correlation coefficients between different scores from the EQ-5D and the SGRQ

Scores	HS-EQ-5D	VAS-EQ-5D
Symptom-SGRQ	-.09	-.25
Activity-SGRQ	-.62**	-.56**
Impact-SGRQ	-.60**	-.56**
Overall-SGRQ	-.58**	-.57**

**. Correlation is significant at the 0.01 level (2-tailed).

The reliability of SGRQ, EQ-5D, and ZBI

Subscale/Scale	(N)	Cronbach's Alpha	Mean Inter-Item correlations (Minimum – Maximum)
Symptom subscale*	33	0.60	0.14 (-0.47 - 0.64)
Activity subscale	50	0.80	0.30 (-0.07 – 1.00)
Impact subscale	50	0.81	0.16 (-0.27 – 0.75)
Overall scale*	33	0.80	0.14 (-0.47 – 0.71)
EQ-5D scale	50	0.65	0.29 (0.19 – 0.50)
ZBI	15	0.93	0.41 (-0.54 – 0.94)

* SPSS performed a listwise deletion for these two subscales based on all variables included in the procedure of those two subscales.

Appendix XVI

Discriminant validity of SGRQ

Descriptive statistics of the mean overall-SGRQ for different disease severity levels

Disease severity level	N	Mean(SD)	Difference (95% CI)	*P* value
Mild	10	60.74(4.34)	50.91 – 70.57	0.01
Moderate	16	62.65(4.47)	53.13 – 72.18	
Severe	24	75.06(2.50)	69.88 – 80.24	

Multiple comparisons of the mean overall score-SGRQ for different disease severity groups using Tukey test

Disease Severity		Mean Differenc e (I-J)	Std. Error	P value	95% Confidence Interval	
(I)	(J)				Lower Bound	Upper Bound
Mild	Moderate	-1.91	5.86	.943	-16.12	12.28
	Severe	-14.32*	5.47	.032	-27.58	-1.06
Moderate	Mild	1.91	5.86	.943	-12.28	16.12
	Severe	-12.40*	4.69	.030	-23.77	-1.03
Severe	Mild	14.32*	5.47	.032	1.06	27.58
	Moderate	12.40*	4.69	.030	1.03	23.77

*. The mean difference is significant at the 0.05 level.

Appendix XXVII

Descriptive statistics of the mean HS-EQ-5D for different disease severity levels

Disease severity level	N	Mean(SD)	Difference (95% CI)	*P* value
Mild	10	.51(.384)	.23 - .78	0.12
Moderate	16	.51(.356)	.32 -.70	
Severe	24	.31(.316)	.17 -.44	

Descriptive statistics of the mean VAS- EQ-5D for different disease severity levels

Disease severity level	N	Mean(SD)	Difference (95% CI)	*P* value
Mild	10	51.00 (17.12)	38.75 - 63.25	0.03
Moderate	16	60.31(19.01)	50.18 - 70.44	
Severe	24	43.17 (20.80)	34.38 - 51.95	

Multiple comparisons of the mean VAS-EQ-5D for different disease severity groups using Tukey test

Disease Severity		Mean Differenc e (I-J)	Std. Error	P value	95% Confidence Interval	
(I)	(J)				Lower Bound	Upper Bound
Mild	Moderate	-9.31	7.89	.471	-28.42	9.79
	Severe	7.83	7.37	.542	-10.00	25.67
Moderate	Mild	9.31	7.89	.471	-9.79	28.42
	Severe	17.14*	6.32	.025	1.85	32.44
Severe	Mild	-7.83	7.37	.542	-25.67	10.00
	Moderate	-17.14*	6.32	.025	-32.44	-1.85

*. The mean difference is significant at the 0.05 level.

Appendix XXVIII

orrelations

		Total_problems	Number of doctors	log_HospitalAdmissions	Accesso
Pearson Correlatio n	Total_problems	1.000	.280	.276	.3:
	Number of doctors	.280	1.000	.113	-.0:
	log_HospitalAdmission s	.276	.113	1.000	.0:
	Accessory	.326	-.039	.011	1.0(
Sig. (1-tailed)	Total_problems	.	.026	.026	.0:
	Number of doctors	.026	.	.220	.3(
	log_HospitalAdmission s	.026	.220	.	.4:
	Accessory	.010	.396	.470	
N	Total_problems	50	49	50	:
	Number of doctors	49	49	49	:
	log_HospitalAdmission s	50	49	50	:
	Accessory	50	49	50	:

Collinearity Diagnostics[a]

Mode l	Dimensio n	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	Number of doctors	log_HospitalAdmissions	Access(
1	1	3.530	1.000	.01	.01	.02	
	2	.257	3.708	.01	.01	.78	
	3	.164	4.642	.02	.36	.15	
	4	.050	8.409	.97	.62	.05	

a. Dependent Variable: Total_problems

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	10.24	20.06	15.59	2.417	49
Residual	-9.586	6.218	-.179	4.021	49
Std. Predicted Value	-2.234	1.856	-.006	1.007	49
Std. Residual	-2.232	1.448	-.042	.936	49

a. Dependent Variable: Total_problems

Appendix XXIX

Histogram

Dependent Variable: Total_problems

Mean =-0.04
Std. Dev. =0.936
N =49

Appendix XXX

Scatterplot

Dependent Variable: Total_problems
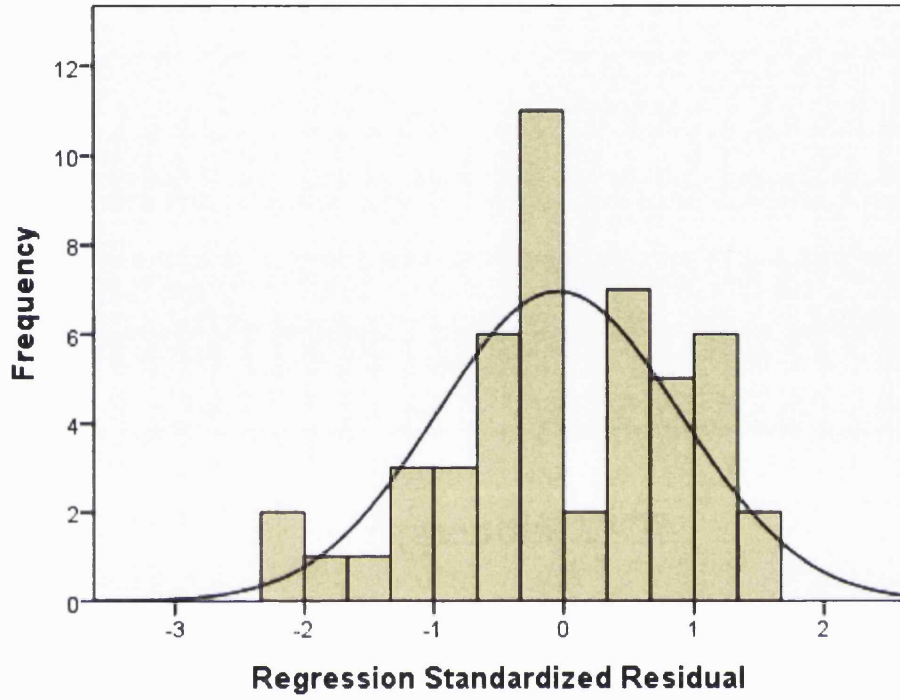
Appendix XXXI

Normal P-P Plot of Regression Standardized Residual

Dependent Variable: Total_problems