HSPI The Open Access Publisher

JPRR JOURNAL OF PULMONOLOGY AND RESPIRATORY RESEARCH
ISSN 2639-9954

Thesis

Inhalation Technique among Patients with Chronic Obstructive Pulmonary Disease Visiting a Teaching Hospital, Chitwan

Chahana Bogati[1]* and Dipendra Kandel[2]

[1]Master of Nursing Program in Adult Health Nursing from School of Nursing, Chitwan Medical College, Nepal

[2]Bachelor of Medicine and Bachelor of surgery, Medical Officer and Project Lead at Green Pastures hospital and Rehabilitation Centre, Nepal

More Information

***Address for correspondence:** Chahana Bogati, Master of Nursing Program in Adult Health Nursing from School of Nursing, Chitwan Medical College, Nepal, Email: cbogati@gmail.com

Submitted: December 11, 2023
Approved: August 07, 2025
Published: August 08, 2025

How to cite this article: Bogati C, Kandel D. Inhalation Technique among Patients with Chronic Obstructive Pulmonary Disease Visiting a Teaching Hospital, Chitwan. J Pulmonol Respir Res. 2025; 9(2): 037-052. Available from: https://dx.doi.org/10.29328/journal.jprr.1001072

Keywords: Dry Powder Inhaler; Inhalation Technique; Patients with COPD; Rotahaler

Abstract

Background: Chronic Obstructive Pulmonary Disease (COPD) is a major cause of illness and death worldwide, and inhalers are often used to manage its symptoms. However, patients' ability to use inhalers correctly is crucial for the effectiveness of treatment. Incorrect technique can lead to poor management of the disease and limit the effectiveness of the medication. This study aimed to assess the inhalation technique of patients with COPD who visited a teaching hospital in Chitwan.

Methodology: A descriptive cross-sectional study was conducted among patients with COPD who had been using a dry powder inhaler through a rotahaler device for at least 1 month and were attending the Medicine and Respiratory OPD of the teaching hospital in Chitwan. A convenience sampling technique was used to select a total of 103 participants. An observational checklist was used to assess inhalation technique, and a structured interview schedule was used to collect socio-demographic information. Descriptive statistics were used to analyze the obtained data in SPSS version 20 for Windows.

Findings: The mean age of the 103 respondents was 70.1 ± 9.56 years, and 62.1% of them were female. While 78.6% had observed a demonstration of the inhalation technique, only 5.8% of the respondents performed the inhalation technique correctly, and 94.2% performed it incorrectly. Only 22.3% of the participants were able to perform at least one critical step of the inhalation technique. The most commonly observed errors included placing the mouthpiece between the lips and teeth (20.4%), breathing out through the mouth (21.4%), and inhaling the powder forcefully and deeply (26.2%).

Conclusion: Patients with COPD attending the teaching hospital in Chitwan exhibited incorrect inhalation technique, which can affect the effectiveness of medication and disease management. Healthcare providers should emphasize critical steps and common mistakes to ensure that patients receive maximum benefit from their medication.

Introduction

Background

Noncommunicable disease (NCDs) kills 41 million people each year, equivalent to 71% of all deaths globally. Each year, more than 15 million people die from an NCD between the ages of 30 and 69 years. Seventy-seven percent of all NCD deaths are in low- and middle-income countries. Chronic Obstructive Pulmonary Disease (COPD) is the third leading cause of death worldwide, causing 3.23 million deaths in 2019. Nearly 90% of COPD deaths of under 70 years of age occur in low- and middle-income countries (LMIC) [1].

COPD is a common, preventable, and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases and influenced by host factors, including abnormal lungs development {Global Initiative for Chronic Obstructive Lung Disease [2].

COPD is the major cause of chronic morbidity and is predicted to be in the 7th rank of global burden of diseases in 2030 [3]. The estimated prevalence of COPD is 4% - 20% worldwide in adults over 40 years of age and 6.3% in the Asian

population. In addition, it is considered as 4th most common cause of hospitalization and the most economic burden among chronic diseases in elderly patients [3]. Hospital-based prevalence showed that COPD comprises 43% of non-communicable diseases and 2.56% of all hospitalizations in Nepal [4].

In both developed and developing countries, smoking is the leading cause of COPD. Ninety percent of people who have COPD are smokers or former smokers, where 20 to 30% of people are chronic smokers [5] Along with cigarette smoke, houses in developing countries are frequently under-ventilated, putting families at risk of inhaling fumes from burning fuel for cooking and heating. There could also be a genetic predisposition to COPD. A protein called alpha-1-antitrypsin deficiency affects up to 5% of persons with COPD [6].

The three cardinal symptoms of COPD are dyspnea, chronic cough, and sputum production, and the most common early symptom is exertional dyspnea. Less common symptoms include wheezing and chest tightness. However, any of these symptoms may develop independently and with variable intensity [7]. Approximately 62% of patients with moderate to severe COPD report variability in symptoms (e.g., Dyspnea, cough, sputum, wheezing, or chest tightness) over the day or week-to-week; morning is typically the worst time of day [8]

COPD is a progressive illness that cannot be cured completely; however, therapeutic management can delay its progression [9]. Inhaled long-acting bronchodilators, beta-agonists, and/or muscarinic antagonists, whether or not they are combined with inhaled steroids, have been suggested in treatment guidelines to avoid COPD exacerbations [10]. Inhaled medication offers significant advantages over oral therapy because it permits active molecules to be delivered directly to the site of action. They allow for high drug deposition in the lungs while lowering systemic bioavailability, lowering the risk of systemic adverse drug reactions [11]. The patient's inhalation flow, the aerosol velocity, and the inhaled medication particle size are the three most critical parameters that determine inhaled drug deposition within the airways, which influence the amount of medicine delivered to the target site [12].

The most often utilized inhaler devices for drug administration in the treatment of COPD are pressurized metered dose inhalers (pMDIs) and dry powder inhalers (DPIs) [13]. Bell and colleagues developed the first DPI in 1971 to provide therapy to COPD patients. Since then, a variety of DPI devices for the treatment of COPD patients have become available, each with its unique set of instructions and 'bespoke' inhaling maneuver. DPIs are divided into three groups based on their design: single-dose, multiple-dose, and 'active' or power-assisted DPIs. DPIs have the benefit of not requiring coordinated activation [14].

The devices that are generally used for the inhalation of drugs among COPD patients in Nepal are dry powdered inhalers (DPIs), pressurized metered-dose inhalers (pMDIs), and mist inhalers. DPIs commonly used in Nepal include rotahaler, diskus, and revolizer. The use of DPI for its treatment without appropriate consideration of the patients' ability to use it correctly has become a critical challenge for effective treatment [15].

Correct use of an inhalation device is an important part of managing COPD and also a major factor in attaining better clinical control and a higher quality of life [16-18]. Adhikari Baral [15] has shown that 77 % of patients undergoing inhalation treatment through the use of a DPI do not use the correct inhalation technique. Poor inhaler technique remains a significant problem with several contributing factors, including the device itself, the patient, the healthcare provider, technology, and policy [17]. Patients may face challenges in using DPI because of age, comorbid conditions, personal perceptions, and beliefs about therapy [19].

Incorrect inhaler use is a major issue for COPD therapy since it can reduce therapeutic impact, resulting in poor symptom control, in poor drug delivery, decrease inhaler use [20-23], while patients may receive treatment, the therapeutic value is poor due to a lack of correct breathing technique teaching and training [19]. Though inhaler technique is crucial, it is poorly recognized and instruction is not given adequately, resulting in suboptimum control of disease [24]. In patients with COPD, improper inhaler technique is linked to a 50% higher risk of hospitalization, more emergency department visits, and more oral corticosteroid use. Regardless of the device's type, user errors are common [25].

Statement of problem

COPD is the third leading cause of death worldwide, accounting for 3.23 million deaths in 2019 [1]. The death rate for COPD has sharply grown in recent years, notably in elderly women, with a threefold increase among women under 75 years [26]. COPD is primarily managed with inhaled drugs, with inhaler devices serving as the primary delivery method for these medications [21,27].

Correct inhalation technique and medication adherence are considered the cornerstone in the management of COPD, as it is a chronic illness [28]. Inhaler devices require the patient's understanding and maintaining their proper use to ensure consistent optimal drug delivery into lower respiratory airways [21,27].

Poor inhaler technique remains a significant problem with several contributing factors, including the device itself, the patient, the healthcare provider, technology, and policy [17], the patient's age [29], sex [30], education [31], the type of inhaler used [20], or the use of multiple inhalers [32].

Incorrect use of inhaler devices is linked to worsening

health outcomes, including a higher risk of hospitalization and inadequate disease control [33-35]. The effectiveness of drug administration may be impacted by errors in device use, resulting in far less treatment of COPD, which can trigger multiple episodes of acute exacerbation, which are linked to several morbidities and mortalities [36].

Understanding and assessing their device-use errors are considered essential in the management of COPD, as they help with an effective patient intervention, and also new devices can be developed to prevent typical mistakes related to the regular use of inhalers and to fully deliver inhaled medication [28]. Hence, evaluation of inhalation technique is essential.

Few studies have been conducted in Nepal which are in Pokhara [15,37], Dhulikhel [38], Chitwan [39] and Kathmandu [24] where only 3.9%, 7.7%, 11.4%, 5.7%, 37% patients performed correct inhalation technique respectively which showed most of the patients performed inhalation technique incorrectly. Hence, to understand the common errors that patients make while using their inhalers and develop strategies to improve technique for the effectiveness of the medications, a researcher has shown interest in assessing inhalation technique among patients with COPD.

Objectives of the study

General objective: To assess the inhalation technique among patients with COPD visiting a teaching hospital in Chitwan.

Specific objectives: To find out the status of inhalation technique among patients with COPD.

To determine the factors associated with the inhalation technique among patients with COPD.

Significance of the study

The result of this study could be a guide to health care providers to improve their instruction and demonstration on dry powder inhalation with more focus on frequently committed errors.

This result would be helpful for hospitals to develop and enforce a health teaching protocol for COPD patients, which includes clear instructions and demonstration and re-demonstration on the use of the DPI.

The findings of the study would be used as a source of baseline for future researchers to conduct research in different places.

Research question

What was the inhalation technique adopted by patients with COPD visiting a teaching Hospital of Chitwan?

Conceptual framework

Figure 1 shows the theoretical framework for the study,

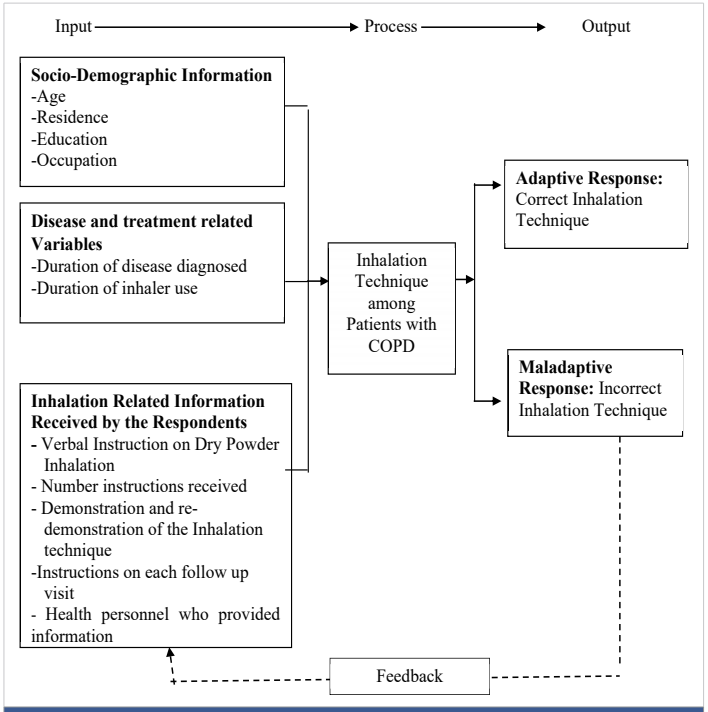

Figure 1: Conceptual Framework on Inhalation Technique among Patients with COPD based on Roy Adaptation Model.

which is based on modified Roy's Adaptation model. This model views a person as an open system who responds to environmental stimuli such as focal, contextual, and residual. Focal stimuli represent an immediate and confronting cause, contextual stimuli are the other stimuli of the human system identified as having a positive or negative influence in a situation, and the residual stimuli are those internal or external factors whose current effects are unclear. In humans, there are two sub-systems, i.e., regulator and cognator, within the coping mechanism & four modes (physiological, self-concept, role function, and interdependence). These two sub-systems constitute adaptive modes for coping with the different stimuli (focal, contextual & residual) through the help of chemical, neural &endocrine activities as well as by learned, experienced. Outputs of the human adaptive system are the behavioral responses that can be both external and internal and become feedback to the system and to the environment. The output responses of the system can either be adaptive responses or ineffective responses [40].

In this framework, the researcher considered patients with COPD as an adaptive system that had input, process, and output. Patients interact and respond to environmental stimuli. Patients' environment had focal stimuli such as disease condition and treatment related variables (duration of disease diagnosed, duration of inhaler use, follow up), contextual stimuli such as inhalation related information related factors (verbal instruction on dry powder inhalation, demonstration and re-demonstration on inhalation technique, number of demonstration/re-demonstrations received, source of inhalation instruction) and socio-demographic variables (age, sex, residence, education, occupation) that contribute to the

effect of focal stimuli. The residual stimuli, such as medication adherence, family support, have not been studied and included in the study.

When patients react to their stimuli, the coping process often gets stimulated, and behavioral responses to inhalation medications are reflected. The status of inhalation technique has been observed in terms of output, such as adaptive and maladaptive responses. If COPD patients adapt to their stimuli, they perform correct inhalation technique, whereas if maladapted, incorrect technique is observed. The maladaptive response will send feedback to the stimuli again and will trigger the stimuli to act upon the system and improve inhalation technique among patients with COPD, thus improving sufficient drug delivery to the lungs.

Variables

Research variable: Inhalation Technique

Influencing variables:

Socio-demographic variables:

Age

Sex

Residence

Education

Disease and treatment variables

Duration of Disease Diagnosed

Duration of inhaler use

Inhalation related information received factors

Verbal Instruction on Inhalation Technique

Demonstration and re-demonstration on the Inhalation technique

Number of instructions received

Instructions on each follow-up visit

Health personnel who provided information

Operational definitions

COPD patients: Those patients who were clinically diagnosed to have COPD (Forced expiratory volume in 1 second (FEV1)/forced vital capacity (FVC) ratio of less than 0.7 on spirometry) according to GOLD criteria, receiving inhaler for minimum of one month and visiting General medicine and Respiratory Unit of Chitwan Medical College-Teaching Hospital (CMC-TH).

Inhalation technique: It refers to step-wise performance of the dry powder inhalation technique through a rotahaler device by patients with COPD. It was assessed using an observational checklist consisting total of 11 steps (3 critical steps and 8 general steps). Each statement was rated to 0 to 1, where 0- incorrectly performed and 1-correctly performed. Total score ranged from 0 to 11.

Status of inhalation technique: It was defined as the measurable performance of an individual's inhalation technique during the administration of a prescribed medication, as assessed by a healthcare professional. The total score was calculated by summing the scores of all items and was further classified into two categories according to Poudel et al. [39] as:

Correct technique (Performing at least 90% of total steps, including 3 critical steps)

Incorrect technique (Performing less than 90% of total steps)

Literature review

Introduction

This chapter presents the literature on the status of inhalation technique among patients with COPD. Online as well as manual searches were made to locate the relevant literature. In this literature review, various sources were used by the researcher. The electronic databases PubMed and Google Scholar were searched to gather the most recent related literature. The reviewed literature is presented and organized in chronological order.

Review of related literature

COPD is a complex, slowly progressing condition [41] that reduces airflow and causes disruption of the pulmonary tissue as a consequence of chronic inflammation [36,42]. Any patient who exhibits symptoms of cough, sputum production, or dyspnea, as well as a history of exposure to risk factors for the condition, should be evaluated for COPD. Spirometry provides proof of the diagnosis. A partially irreversible airflow limitation is confirmed by the existence of a postbronchodilator FEV1 of 80% of the expected value and a FEV1/FVC 70% [43].

Inhalation of harmful particles has an impact on the pathogenesis of COPD [44] and may result in persistent inflammation that worsens the prognosis for COPD [45]. Both epithelial cells and alveolar macrophages are activated by these chemicals, and they release proinflammatory cytokines and proteases such as neutrophil elastase and matrix metalloproteinases (MMPs), which are involved in inflammation. Degradation of elastin and disintegration of the alveolar wall result from neutrophil elastase release [44].

Chest tightness, dyspnea, and a protracted and productive cough are the hallmarks of the COPD clinical course [41]. The existence of life-threatening systemic problems [41], such as stroke and ischemic heart disease [46], which are

linked to a progressive reduction in lung function and can significantly affect quality of life, as well as an aggravation of the disease's symptoms, are characteristics of the disease's progression [47]. Patients who continue to experience exacerbations despite receiving either dual bronchodilator therapy or a LABA/ICS combination are advised to use triple inhaled therapy, according to GOLD [48]. Three medications are used in triple inhalation therapy: an inhaled corticosteroid (ICS), a long-acting β2-agonist (LABA), and a long-acting muscarinic antagonist (LAMA). Budesonide/ Formoterol/ Glycopyrronium, Beclometasone/Formoterol/ Glycopyrronium, and Fluticasone Furoate/ Vilanterol/ Umeclidinium are the three ICS/LABA/LAMA fixed-dose combinations (FDCs) that are currently offered [2].

High drug deposition may be achieved in the lungs through inhalers, thus leading to more effectiveness and decreased systemic effects [49]. It promotes high bioavailability of the therapeutic drug (10 - 200 times better than gastrointestinal delivery) and is unaffected by dietary variation, extracellular enzymes, and patient-to-patient metabolic variations; hence, direct delivery of pharmaceutical therapy via inhalation is a promising strategy in pulmonary illnesses [50]. However, patient- and particle-related factors, including airway size, particle density, pathological changes affecting airway lumen patency, respiratory patterns, and lung clearance systems, can influence the deposition of medication molecules into the lungs. As a result, these elements may have an impact on how effectively inhaled medicines provide treatment [51].

Patients' improper inhaler technique remains a problem [52], and even experienced patients frequently mishandle their device [34]. Errors in inhaler handling and non-adherence might influence drug delivery and reduce the effects of treatment [21,53]. Inhaler mistakes were linked to worse disease outcomes in individuals with asthma or COPD. Studies have shown that poor adherence and inhaler misuse were linked to poor disease control and a higher risk of hospitalization, ER visits, oral steroids, and antibiotics [54].

A descriptive cross-sectional study was conducted among 300 asthma/COPD patients to evaluate inhaler techniques in order to identify common errors in Turkey. Out of 300 patients, 70.2% used their inhaler incorrectly. The most common mistake found was 'failing to breathe out before inhalation' for all types of devices (for MDI: 66.7%, and for DPI: 71.1%). The study concluded that the misuse of inhalers was high. Hence, the study concluded that all medical professionals should focus on those factors that affect inhaler use and should evaluate inhalation technique at each follow-up visit [55].

A study was conducted to determine the prevalence and possible determinants of incorrect inhaler technique in COPD subjects with common inhalers in Egypt, among 180 COPD subjects, which showed that incorrect inhaler techniques were highly prevalent among COPD subjects (80%). Lack of experience, certain inhaler types, female gender, and older age are found to be the significant factors for incorrect technique [56].

An institutional-based, prospective study was conducted among 250 COPD patients in India to compare the techniques of inhalational device use before and after training the patients suffering from COPD, which revealed that most patients used their inhaler devices inappropriately regardless of pMDI or DPI, although the majority (92.4%) of the participants were confident in using their inhaler device. Only 7.8% of Rotahaler® patients and 4.5% of Revolizer® patients were able to complete all of the steps correctly. This study further discovered that patients with more education performed the inhaler device technique more correctly [57].

A cross-sectional study aimed to assess knowledge and practice of dry powder inhalation among 100 patients with COPD in the Bihar region showed that a minority (4%) of the patients demonstrated the use of the rotahaler correctly, while most (96%) of them performed the steps incorrectly. The most commonly performed error among Rotahaler users was not exhaling before inhalation, followed by the inability to hold one's breath for 10 seconds. The study concluded that there is importance of health care personnel for demonstration and re-demonstration of the technique for dry powder inhalation to the patients at each follow-up visit to ensure the correct inhalation technique [58].

A hospital-based cross-sectional study was conducted among 120 participants to evaluate the technique of use of metered dose inhaler and dry powder inhaler technique among bronchial asthma and COPD patients attending a tertiary health care center in South India. Findings showed that only 8.64% of respondents performed all the steps regarding the proper technique of inhaler use. The common errors performed were holding the breath for 10 seconds or for as long as breathing out fully (61.14%), followed by placing the mouthpiece between teeth (33.3%) [59].

A cross-sectional interventional study was conducted by Thakkar, et al. [60] in India to determine the effectiveness and outcomes of educational inhaler technique counselling in India among 120 patients attending a respiratory OPD. Findings showed that 11.67% of patients had poor inhaler technique, 58.33% had moderate inhaler technique, and only 30% had good inhaler technique. The majority of the DPI patients made an error while breathing out and placing their lips around the mouthpiece tightly and breathing in deeply through the device (34.38%) and holding the breath for 5-10 sec, and then breathing out (28.13%).

A cross-sectional study was conducted among older patients with asthma or chronic obstructive pulmonary disease among 130 patients in Portugal to assess the inhaler technique in older patients, which showed that poor inhalation

technique among the respondents. The study showed that 71.6% of them performed the inhalation technique in the wrong way, with 31.1% not performing critical steps. Hence, the study concluded that while assessing risk assessment in old-aged groups, focus should be on inhalation technique (focusing on dose activation and end pause) and adherence, smoking, respiratory comorbidities, and cognitive impairment [29].

Sanauallah, et al. [61] conducted a cross-sectional study to assess the steps of inhalation technique; satisfaction, preferences, perception, and practice of different types of inhalers among 765 patients with COPD in Pakistan, which showed that there is poor practice of inhalation technique among COPD patients. Only 6.3% of patients could perform seven correct steps of inhalers. The most frequently performed errors were breathing out, fully and gently (88.4%), followed by breathing out from the mouthpiece (94.7%). The study concluded that poor inhaler technique was highly present among the respondents, and the errors were not significantly associated with types of inhaler devices (MDI *vs.* DPI).

Adhikari Baral [15] conducted a cross-sectional study in Pokhara, Nepal, to assess knowledge and practice of dry powder inhalation among COPD patients, which showed that only a few of the respondents correctly practiced the inhalation technique (3.9%) (n = 204). The least correctly performed steps were exhaling to residual volume, keeping the mouthpiece between teeth and lips, breathing in again, and holding breath for 10 seconds (4.9%). Almost all (99%) respondents had received verbal instructions on inhalation technique. However, only 13.2% of the respondents had observed a demonstration of the dry powder inhalation technique from health care professionals.

Suthar, et al. [62] conducted a prospective interventional study on "Assessment of inhalation techniques in 60 COPD and asthma patients using metered dose inhaler and rotahaler" in India, which showed that more than half (58.35%) of the COPD patients and 53.39% of the asthma patients failed to use the inhaler device correctly. Among them, rotahaler was found to be mostly used inhaler device (68.3%), and there was a significant improvement in rotahaler use after providing intervention education to the participants (p = 0.04).

A descriptive observational study was conducted among 66 patients to assess inhalation technique and to evaluate the need for pharmaceutical intervention in respiratory pathologies in Spain. Findings revealed that about half of the patients performed the inhalation technique incorrectly, despite the fact that 88.5% had already received training on inhalation technique. Older patients had a poorer inhaling technique. The medical staff's inhalation technique training appears insufficient, since it is critical to create awareness about the importance of health education for patients and their use of inhalers, which requires a scheduled follow-up and technical feedback acquired from the patient assessment [63].

A descriptive study was conducted in Manipal Teaching Hospital, Pokhara, among 101 patients with COPD or Asthma to assess the correct technique of rotahaler inhalation. Only 29.7% of the patients receiving rotahaler demonstrated all steps correctly, while 70.3 of % patients made at least one error during inhaler technique. Despite the fact that rotahaler use is more common and easier than other inhaler devices, the study showed that incorrect rotahaler use is common among COPD patients. It indicates that patients on long-term inhaled medicine should be examined and instructed on how to utilize their inhaler regularly [37].

A pre–post interventional study was conducted by Poudel, et al. [39] in a teaching hospital of Nepal among 174 asthma and COPD patients to evaluate the benefit of hospital pharmacy intervention on the current status of the dry powder inhaler (Rotahaler) technique and the factors associated with the correct use. Findings showed that only 5.7% of the patients performed the correct Rotahaler technique, and the most common errors observed were failure to breathe out gently before inhalation (98.8%) and failure to hold breath for about 10 seconds after inhalation (84.8%). Factors affecting appropriate technique were found to be age, previous instruction, patient's education level, and sources of instruction.

A descriptive cross-sectional study was conducted to assess rotahaler inhalation technique among 100 patients with COPD in Kathmandu University Teaching Hospital using rotahaler for at least one year by Sapkota and Amatya [24]. Findings showed that only 37.0% of the respondents performed the correct inhalation technique. The commonest error performed by respondents was not exhaling fully (61%), 59% failed to hold their breath after inhalation, and one quarter (25%) of respondents were unable to breathe in through the mouth deeply. This study has highlighted the importance of implementing health education initiatives that focus on commonly recognized faults. To guarantee proper inhaler technique, arrangements should be made for the health personnel to regularly participate in training and re-demonstrations.

A quasi-experimental research conducted in Dhulikhel Hospital, Nepal by Shrestha, et al. [38] to evaluate the inhalation technique among 100 COPD patients using dry powder device and the effect of patient education on it showed that majority (88.6%) of patients who utilized dry powdered inhaler (DPI) devices used their inhaler incorrectly, performing at least one important step incorrectly and more than half of the patients (58.33%) did not get instruction on inhalation technique with a DPI device.

A prospective interventional study was conducted among 50 patients with COPD and asthma to evaluate the effectiveness of the inhalation techniques of Rotahaler in Nepal. The study showed that only 4 % of the patients could perform critical errors. The most incorrectly performed step was holding the

breath for 5 seconds (16%), followed by breathing out fully (20%). The most correctly performed steps were found to be holding the rotahaler at the base with one hand, pulling back the mouthpiece (98%), followed by closing the mouthpiece of the rotahaler firmly (90%). The study has concluded that intervention on inhaler technique has a significant effect on patients' knowledge that helps for a better therapeutic outcome [64].

Roggeri, et al. [65] conducted a real practice study to estimate the potential economic impact on the Italian National Health Service (INHS) due to inhalation errors in patients switching devices without adequate training among 200 COPD patients and 200 asthma patients. The findings of the study showed an increase in health-care resource consumption associated with inhaler misuse, including 11.5 hospitalizations, 13 ER visits, 19.5 antimicrobial courses, and 47 corticosteroids per year. The study concluded that inhaler device misuse is linked to a decrease in disease control and an increase in healthcare resource consumption and expenses due to insufficient training or non-consented switching of inhaled drugs.

Capanoglu, et al. [66] conducted a study in Turkey among 171 respondents to evaluate inhaler technique, adherence to therapy, and their effect on disease control using metered dose or dry powder inhalers. Findings showed that 57.8% were using their inhaler device correctly. Frequency of correct use was higher among males, for younger patients, and for patients who got training 3 times or more. The most frequent errors for DPI were exhale to residual volume (51.9%) and holding the breath for 10 seconds when inhalation is complete (32.6%). The study concluded that repetitive training about device usage may contribute to an improvement in inhaler technique.

A prospective cross-sectional study conducted to evaluate inhaler use technique in COPD patients in Thailand by Pothirat, et al. [31] found that almost two-thirds of patients (74.8%) performed at least one step incorrectly (n = 103). Inhalation technique in COPD patients without face-to-face training was mostly unsatisfactory, especially in patients with low education levels. Face-to-face inhalation technique training significantly increased the compliance for the inhalation technique.

Pun, et al. [67] conducted a study in Nepal to assess the inhalation technique in 100 COPD patients using Metered-Dose Inhaler and Rotahaler at a Tertiary care Hospital. Findings revealed that 84% of them do not use their Rotahaler correctly, whereas only 9% successfully utilized their MDI and 14.0% correctly used their Rotahaler. This study also showed the significant relationship between age (p = 0.049), educational status (0.002), occupation (0.032), and experience with rotahaler inhalation use (0.048). The most common mistakes performed by rotahaler users were not exhaling to residual volume (84% and not holding breath for 5 seconds (69%). Hence, this study concluded that the right use of inhalers is critical to the effectiveness of COPD therapy, which can be achieved through training, verbal instruction, technique assessment, and reassessment.

Arora, et al. [68] conducted an observational study among 300 COPD patients to evaluate and analyze the technique of use of the inhalation device in India. Findings revealed that only 7.7% were using the devices properly without any errors. Maximum errors were observed in those using MDI (94.3%), followed by DPI (82.3%) and MDI with Spacer (78%), while 70% users of Nebulizer committed the least number of errors. The most common errors of DPI users were insufficient acceleration (52.31%), followed by not inhaling deeply enough (36.92%) and poor seal around the mouth (29.23%). This study concluded that health care providers' education plays a significant part in enhancing inhaler technique and compliance. Competent device handling training may not only greatly enhance symptom control but may also enable dose reduction and, in the long run, a reduction in overall prescription costs.

Luiza, et al. [69] conducted a study on knowledge and technique for using inhalation devices among 60 asthma patients and 60 COPD patients in Brazil. The findings of the study showed that the majority of the patients claimed to understand how to use inhalation devices; however, 94.2% made at least one error, which indicates that their method was ineffective and highlights a gap between knowledge and practice. As a result, simply asking patients if they know how to utilize inhalation devices is insufficient. To reduce errors and improve therapy, practical actions should be taken.

A descriptive cross-sectional study was conducted in the Netherlands to determine the prevalence and determinants of an incorrect inhalation technique among 558 primary care patients with asthma and COPD. Findings showed 24.2% of patients made at least one critical error in their breathing method. Patients who used Rotahaler/ Spinhalers were more likely to have an incorrect inhalation technique (37.1%) than those who used Diskhalers (3.8%) or Cyclohalers Inhaler Ingelheim (10.5%) and Turbuhalers (31.4 %), and MDI users (30.0%). The type of inhaler used was the most powerful predictor of the wrong inhaling technique. Treatment in a group practice and a poor emotional quality of life were also significant predictors [20].

Beerendonk, et al. [70] conducted a descriptive cross-sectional study in the Netherlands among 316 patients suffering from asthma or COPD to evaluate how patients utilized their metered-dose inhaler (MDI) or dry powder inhaler (DPI), showing that 88.9% made at least one mistake in the inhalation technique. The most common skill error performed was not inhaling medicine slowly after activation of the canister (69.6%). The study concluded that education

and checkups of inhalation technique should be provided by health care personnel and should be considered as a standard and routine procedure.

Summary of reviewed literature

Aerosol therapy is preferred in the treatment of COPD. The ability of patients to correctly perform the inhalation techniques determines the therapeutic success. Incorrect inhalation technique has been a major issue in COPD, as the therapeutic value is poor due to incorrect breathing technique and training, causing a 50% higher risk for hospitalization, exacerbations, and frequent hospital visits. Various studies in different settings have shown that the majority of patients with COPD perform the inhalation technique incorrectly. Similarly, only a few studies have been conducted in the central region of Nepal to determine inhalation technique among COPD patients. Patients' practices might vary according to their region and geographic areas. Many COPD patients from different geographical areas are referred to Chitwan for further treatment. Hence, the study has focused on determining the correct inhalation technique status among patients with COPD to bridge the gaps.

Research methodology

Study design

A descriptive cross-sectional research design was adopted to assess inhalation technique among patients with COPD visiting a Teaching hospital in Chitwan. This design is appropriate to measure the practice of inhalation technique among patients with COPD in broader aspects.

Study setting

This study was conducted in Chitwan Medical College -Teaching Hospital (CMC-TH), Bharatpur, Chitwan. This is a tertiary care, 750-bedded hospital where the medicine department provides general and specialized services. This hospital has advanced health infrastructure with specialized doctors in pulmonology and internal medicine.

Study population

The population of the study was those patients diagnosed with COPD and visiting the outpatient department of Medicine and the Respiratory unit of CMC-TH. There were 129 outpatients diagnosed with COPD attending the Medicine and Respiratory OPD from 2022/03/01 to 2022/06/01.

Inclusion criteria

Those COPD patients who were clinically diagnosed to have COPD according to GOLD criteria (FEV1/FVC ratio of < 0.70), using dry powder inhalation through a rotahaler device for a minimum of 1 month and visiting at medicine and respiratory unit of CMC-TH were included in the study.

Exclusion criteria

Those COPD patients who did not give consent and patients who were severely ill and mentally unstable were excluded from the study.

Sampling

Sample size: A needed sample size was calculated using Cochrane formulae [71] taking 37% prevalence ($p = 0.37$) of the study entitled "Assessment of rotahaler inhalation technique among patients with chronic obstructive pulmonary disease in a teaching hospital of Nepal" [24], population correlation coefficient ($q = 1\text{-}0.37 = 0.63$), 95% confidence level ($z = 1.96$), allowable errors 5% ($d = 0.05$), and the total number of COPD patients in the last 3 months ($N = 129$). For the initial sample size (n0), following Cochran's formulae [71] was used:

$n_o = (Z_{\alpha/2})^2\, pq/d^2$ [71]

$= (1.96)^2 x\ (0.37)\ x\ (0.63)/\ (0.05)^2$

$= 358.19 = 359$

Furthermore, for a definite population following formulae were used:

$$n = \frac{n_o}{1+\frac{n_0 1}{N}}$$

where N number of patients with COPD

n_o = Initial sample size

Now,

$$n = \frac{359}{1+\frac{(359\text{-}1)}{129}}$$

Sample (n) = 95.09 = 95

8% non-response error = 8% = 8.24 = 8

Total required sample = 103

Sampling technique: Non-probability convenience sampling technique was used to select the desired sample. Those patients who met the study criteria during the data collection period were taken as the study sample.

Research instrument

A structured interview schedule and observational checklist were developed by the researcher herself based on an extensive literature review. The research instrument consisted of two parts:

Part I consisted of questions related to socio-demographic information, disease & treatment-related variables, and health care providers-related variables (**Appendix**).

Part II consisted of an observational checklist to assess the inhalation technique among patients with COPD. An observational checklist was constructed based on guidelines developed by GINA and manufacturer Cipla Pvt Ltd, Mumbai, India. It consisted of a total of 11 steps (3 critical steps and

8 general steps). Total score was 0 - 11. Each statement was rated to 0 to 1, where 0- incorrectly performed and 1-correctly performed (**Appendix**).

Content validity of the instrument was established by an extensive literature review and consultation with the research advisor and subject experts. Firstly, the instrument was developed in the English language. Then it was translated into Nepali version with the help of language experts, and again was translated into English version through third-person translation.

Pre-testing of the instrument was done to test the feasibility of the tool among 13 patients with COPD attending the Medicine and Respiratory OPD of CMCTH, who were excluded from the final study. The research instrument was modified and finalized on the basis of the pretesting results. Treatment-related factors were modified on the basis of pretesting results. Questions like the number of medications taken daily, medications taken daily, and understanding the disease condition by family members were excluded on the basis of pretesting results.

Ethical considerations

Proposal approval was obtained from the Thesis Committee of the School of Nursing, Chitwan Medical College (P) Ltd, and ethical approval was taken from Chitwan Medical College-Institutional Review Committee (CMC-IRC). Administrative approval for data collection was also taken from the hospital director of Chitwan Medical College-Teaching Hospital by submitting a request letter from the School of Nursing.

Written informed consent was taken from each respondent before data collection to ensure their willingness to participate in the study. Dignity was maintained by giving the option to discontinue from the research study at any time without any penalty. Privacy was maintained during data collection by interviewing them in a separate room or corner of the OPD using a curtain or screen. Confidentiality was maintained by not disclosing the information to others and giving a code number instead of a name. In addition, participants received demonstrations and re-demonstrations of inhalation technique after completion of data collection, one by one.

Data collection procedure

First of all, respondents were identified through their OPD tickets. The objectives of the study and the data collection process were explained to them to gain their cooperation. The respondents were assured of the confidentiality of their information, and they were informed that their information would be kept confidential and would only be used for the study purpose.

Data were collected by the researcher herself from 19th June, 2022 AD to 19th July, 2022 AD using an interview schedule in Nepali language using the Nepali version instrument. An observational checklist was used to observe the inhalation technique among respondents. Data were collected before respondents visited their doctor. Each respondent was observed one by one. The average time for each respondent was about 10 - 15 minutes. Data was collected during OPD time (8 am - 4 pm). The hospital number was also used as the responder's identification number to avoid repetition of data during the data collection period.

Privacy was maintained during data collection by interviewing them in a separate room or corner of the OPD using a curtain or screen. First, socio-demographic characteristics, disease and treatment, and health care provider-related information were collected using an interview method. Then, respondents were asked to demonstrate their inhalation technique through their rotahaler device. The Rotahaler device was brought by respondents themselves or else provided at the hospital if not self-bought. Placebo rotacaps developed by the Cipla company were provided to them. The inert substance used in placebo rotacaps was typically lactose powder (15 mg), which was a commonly used substance in the pharmaceutical industry and has a long history of safe use [72,73]. Those placebo rotacaps were produced by an intention for demonstration through Rotahaler/ Revolizer only and were not to be swallowed. The placebo rotacaps were accepted to provide patient education on inhalation technique by the ethical board committee of CMC-TH, which had been using them at CMC-TH for 6 years.

Data analysis procedure

All the collected data was checked, reviewed, and organized daily for its completeness, consistency, and accuracy. The collected data were coded and entered into IBM SPSS 20.0. The data was analyzed by using descriptive statistics in terms of frequency, percentage, mean, median, standard deviation, and inter-quartile range for the socio-demographic information, disease and treatment related variables, health care related information, and practice regarding inhalation technique.

Findings of the study

This chapter deals with the analysis and interpretation of the data collected. A descriptive cross-sectional study was conducted among patients with COPD using the Rotahaler device attending a teaching hospital, Chitwan. A total of 103 samples were selected using a convenience sampling technique. Data were collected using an observational checklist and structured interview schedule.

The obtained data were analyzed using descriptive statistics and interpreted on the basis of the objectives of the study. The findings are presented in Tables 1-7. Socio-demographic information, disease and treatment-related information, and rotahaler device-related information are presented in Table 3. Inhalation-related information received and related variables are presented in Table 4. Stepwise practice of the inhalation technique of patients with COPD and the status of inhalation technique is presented in Tables 5,6.

Table 1: Socio-demographic Information of the Respondents.

Variables	Number	Percent
Age Group in Years		
Young adulthood (19 to 39)	1	1.0
Middle adulthood (40 to 64)	21	20.4
Old adulthood (65 and above)	81	78.6
Mean (±S.D) =70 .19 (± 9.56), Minimum=34 years, Maximum = 92 years		
Gender		
Male	39	37.9
Female	64	62.1
Place of Residence		
Urban	46	44.7
Rural	57	55.3
Ethnicity		
Brahmin/Chhetri	65	63.1
Janjati	19	18.4
Others*	19	18.4
Religion		
Hindu	97	94.2
Other than Hindu **	6	5.8
Marital Status		
Married	65	63.1
Widow/Widower	32	31.1
Divorced	6	5.8
Family Type		
Nuclear	33	32
Joint	70	68
Educational Status		
Literate	13	12.6
Illiterate	90	87.4
Educational level (n=13)		
Basic education	9	69.2
Secondary education	4	30.8
Previous Occupation		
Household chores	46	44.7
Agriculture	42	40.8
Service & Business	15	14.5
Involved in Work Currently		
Yes	57	55.3
No	46	44.7
Smoking Status	14	13.6
Smoker (>100 cigarettes and smoked in the last 28 days)		
Ex-smoker (>100 cigarettes and not smoked in the last 28 days)	72	69.9
Non-smoker (Has not smoked 100 cigarettes in their lifetime and currently does not smoke)	17	16.5

*Muslim, Yadav, Kurmi, Baniya, Sunar, Pariyar, ** Buddhist, Christian & Islam

Table 2: Disease and Treatment Related Information of Respondents.

Variables	Number	Percent
Duration of disease diagnosed		
<1 year	2	2.0
1-5 years	47	45.6
≥5 years	54	52.4
Duration of inhaler use		
<1 year	13	12.6
1 to 3 years	54	52.4
≥3 years	36	35
Difficulty in taking inhaled medications		
Yes	23	22.3
No	80	77.7
Experience with the side effects of medicine		
Yes	4	3.9
No	99	96.1
Perceived benefits of treatment to improve the condition		
Yes	89	86.4
No	14	13.6
Presence of co-morbidities		
Yes	64	62.1
No	39	37.9
Type of co-morbid conditions (*n* = 64)		
Diabetes Mellitus	30	46.8
Hypertension	42	65.6
Hypothyroidism	10	15.6
Pneumonia & Prostatomegaly	5	5.0
Follow-up visit	103	100

Table 3: Rotahaler Device Related Information of the Respondents.

Variables	Number	Percent
Substance used to clean a rotahaler		
Detergent	4	89.3
Soap	7	6.8
Tap Water	92	3.9
Frequency of cleaning the Rotahaler device		
Once a week	51	49.5
Once a month	43	41.7
Once every 6 months	4	3.9
Once a year	5	4.9
Storage of Rotahaler		
Cool place away from moisture	92	89.3
Direct sunrays	11	10.7

Table 4: Inhalation Related Information Received by the Respondents.

Variables	Number	Percent
Instructions on DPI technique received	103	100
Number of instructions received on inhalation technique to date		
One time	24	23.3
Two or more times	79	76.7
(Median = 2, IQR = 4-2, Maximum = 10 times, Minimum = 1 time)		
Received demonstration of inhaler technique from health personnel		
Yes	81	78.6
No	22	21.4
Re-demonstration of inhalation technique in front of health personnel		
Yes	54	52.4
No	49	47.6
Regular instruction is received on each follow-up visit		
Yes	35	33.9
No	68	66.1
Person from whom information on inhalation was received		
Doctors	89	86.4
Nurses	4	3.9
Pharmaceuticals	10	8.7

Table 5: Stepwise Practice of Inhalation Technique among the Respondents.

S. N	Steps	Correct Performance	
		Number	Percent
01	Hold the Rotahaler vertically such that the fin is not directly below the rotacap hole. *	96	93.2
02	Insert the rotacap in the rotacap hole with the transparent end facing down such that the top end of the rotacap is level with the top of the rotacap hole.	99	96.1
03	Hold the mouthpiece firmly with one hand and rotate the base with the other hand such that the fin separates the two halves of the rotacap. *	88	85.4
04	Breath out through the mouth.	22	21.4
05	Place the mouthpiece between the lips and the teeth; keep the tongue from obstructing the mouthpiece.	21	20.4
06	Close the lips tightly around the mouthpiece.	62	60.2
07	Inhale powder forcefully and deeply. *	27	26.2
08	Remove the Inhaler from your mouth and hold your breath for 10 seconds.	45	43.7
09	Breathe out away from the mouthpiece of the inhaler slowly.	83	80.6
10	Open the inhaler and discard the empty capsules.	77	74.8
11	Rinse your mouth with water after using of inhaler.	49	47.6

*Critical steps

Table 6: Status of Inhalation Technique among Respondents

Status of Inhalation Technique	Number	Percentage
Correct (≥90% with 3 critical steps)	6	5.8
Incorrect (<90%)	97	94.2
Total	103	100

Table 1 reveals that out of 103 respondents, most (78.6%) of the respondents were 65 years and above age group with a mean age of 70.19 (± 9.56) years. Majority of respondents (62.1%) were female, nearly two third (63.1%) were Brahmin/Chhetri ethnicity, 94.2% followed Hinduism, 63.1% were married and only 12.6% of respondents were literate (12.6%). Nearly half of the respondents' occupation was homemaker (44.7%), followed by agriculture (40.8%), whereas nearly half of the respondents (44.7%) were not involved in any kind of occupation recently. In addition, the majority of the respondents were ex-smokers (69.9%), and 13.6% were still smoking cigarettes.

Table 2 shows that more than half of the respondents (52.4%) were diagnosed with COPD for more than 5 years, and 52.4% of them had been receiving Rotahaler as their treatment for 3 years. Most (77.7%) of the respondents reported that they did not experience any difficulties in taking inhaled medicines. Almost all of them did not experience any side effects with medicine (96.1%), and 86.4% had perceived the treatment benefits. Majorities (62.1%) of the respondents had co-morbidities, among which the common co-morbid conditions were hypertension (65.6%) and diabetes mellitus (46.8%). The majority (83.5%) of the respondents had their health insurance.

Table 3 shows that most of the respondents stored their rotahaler device in a cool place (89.3%) and also cleaned their device with tap water (89.3%). Only half of the respondents (49.5%) cleaned this device every week.

Table 4 shows that cent percent of the respondents reported that they received instructions on inhalation technique, the maximum number of instructions received was 10 times, and a minimum of 1 time. Most (76.7%) of the respondents received instructions two or more times on inhalation technique, and 78.6% of the respondents observed a demonstration of inhalation technique performed by health personnel. Just more than half (52.4%) of the respondents re-demonstrated the inhalation technique by self in front of the health care personnel. The respondents received information on inhalation from doctors (86.4%), whereas the least (3.9%) received information from nurses.

Table 5 reveals that almost all of respondents performed the step of holding the rotahaler vertically (93.2%) and inserting rotacap into the rotacap hole correctly (96.1%) Most of the respondents performed the step of holding and rotating the base such that the fin separates the two halves of the rotacap (85.4%) and breathing out away from the mouth piece slowly (80.6%). Less than half (43.7%) of the respondents removed the inhaler and held breath for at least 10 seconds, and 47.6% rinsed their mouth with water after inhaler use. However, the least respondents carried out the steps like placing the mouthpiece between the lips and teeth (20.4%), breathing out through the mouth (21.4%), and inhaling powder forcefully and deeply (26.2%).

Table 6 shows that only 5.8% of the respondents demonstrated the inhalation technique correctly, whereas 94.2% performed an incorrect inhalation technique.

Discussion, conclusion and recommendations

This chapter deals with the summary of the findings, discussion, conclusion, limitations, implications, and recommendations of the study. The major findings are discussed in this chapter with comparison to other studies identified from a review of the literature's findings. It also deals with the recommendations for future use in light of the limitations of the study.

Discussion

This study was designed to assess the rotahaler inhalation technique among patients with COPD visiting the Medicine and Respiratory OPD of CMC-TH.

Socio-demographic and health related information: Regarding socio-demographic information, majorities (78.6%) of patients were 65 years and above (78.6%), female (62.1%), and belonged to Brahmin/ Chhettri ethnicity (63.1%). Nearly two-thirds (63.1%) of them were married, and still 13.6% were current smokers. Most of the respondents (87.4%) were illiterate, and nearly half (44.7%) had not been involved in any occupation recently.

On disease-related information, just half of the respondents (52.4%) had suffered from COPD for more than 5 years, 35% had been using an inhaler for more than 3 years, and the majority (77.7%) felt difficulty in taking inhaled medications. This finding is consistent with the findings of the study done by Poudel, et al. [39] in Nepal, which showed that 76.3% felt easy to use COPD medicines through an inhaler. Two-thirds (62.2%) of the patients had co-morbid conditions, and the most common conditions were hypertension (65.6%) and diabetes mellitus (46.8%). These study findings are from the study conducted by Suthar, et al. [62] in India, which also showed hypertension as the commonest comorbid condition in COPD (44%), followed by diabetes mellitus (13%).

In this study, cent percent of the patients had received at least one verbal instruction, and this is almost consistent with the study done by Poudel, et al. [39] in the same institution, which revealed that almost all (95.4%) of the respondents had received instructions from a health care professional. The increase in the percentage of respondents receiving verbal instructions in inhalation technique is due to the efforts of health workers and institutions over the years to educate each

respondent on inhalation technique [39]. An individualized educational intervention using hands-on inhalation technique demonstrations helps patients to use their inhalers more effectively [74]. However, only 78.6% of them had observed a demonstration on the inhalation technique performed by health personnel. Nearly half (47.6%) of the respondents did not get the opportunity for re-demonstration in front of health personnel. In addition, the majority (66.6%) of the patients reported that they were never rechecked on their inhalation technique during their follow-up visits. Furthermore, the study reported that repetition, demonstration, and simplification form the foundation of effective inhaler training [75]. It is vital to frequently review technique and reinforce education because inhaler technique might deteriorate once instruction has been completed [76]. This current study shows the actual status of inhalation technique and the most frequently committed errors by patients, hence, highlighting the importance of regular assessment and reinforcement of correct inhalation technique for successful inhaler usage.

Rotahaler inhalation technique: The present study findings on inhalation technique are quite concerning, as they revealed that only 5.8% of the respondents used their inhaler correctly. This might be due to patients' lack of curiosity or learning attitude, and their negligence or inability to read the instruction pamphlet given with the drug package. This finding is consistent with a study conducted by Shrestha, et al. [38] in Nepal, where only 11.4% of users use their inhalers correctly. Dry powder inhalation is widely used in clinical practice; however, several studies have shown that a minority of patients use inhalers correctly, with figures ranging from 5.7% [39] to 37% [24]. Evidence also showed that increased drug consumption, adverse events, frequent exacerbations, and hospital admissions can be consequences of improper inhalation technique, causing more difficulty in controlling the disease [77]. Although cent percent of the respondents received instructions from health personnel in this present study, almost all of the respondents demonstrated incorrect inhalation technique, which might indicate the inadequate instructions provided by the health providers.

In this study, 94.2% of the patients used the rotahaler device incorrectly by performing at least one critical step error. Among 11 steps, the least performed steps identified were placing the mouthpiece between the lips and teeth (20.4%) and breathing out through the mouth (21.4%). Similarly, a study done by Poudel, et al. [39] showed that only 23.5% of the users were able to exhale residual volume [39]. In contrast, the study conducted by Maya and Shakya [37] in Nepal showed that the most common errors performed were removing the rotahaler from the mouth and holding breath for 5 - 10 seconds (53.5%). The discrepancies in the findings might have been attributed to the respondent's socio-demographics, different instrumentation, and sample size. The failure to exhale before inhalation hinders the forceful and deep inhalation, resulting in insufficient drug release and low lung deposition [39]. Sapkota and Amatya [24] showed that only 41% of the respondents hold their breath after inhalation. Similar findings were observed in the current study, where 43.7% hold their breath for 10 seconds. This result can be attributed to poor instructions, lack of supervision, and follow-up checks by health care providers. Only 47.6% of the respondents rinsed their mouth with water after using of inhaler. Similar findings were reported by Sapkota and Amatya [24], where 51% of the users did not rinse their mouth after inhaler use.

In regard to critical steps, more than three-fourths (77.7%) of the respondents could not perform one or more of the critical steps. Moreover, only 22.3% of them performed all critical steps, in which the most performed step was holding the rotahaler vertically (93.2%) and holding the mouthpiece firmly with one hand and rotating the base with the other hand (85.4%), whereas the least performed step was inhaling powder forcefully and deeply (26.2%). This result was contradictory to the former study by Pun, et al. [67], which showed that more than half (58%) of the respondents inhaled powder forcefully and deeply. This inconsistency might be due to the quality of instruction given by health care providers and their emphasis on item skills. Instructions regarding inhalation technique should always be given by healthcare personnel, as patients' improper inhaler usage may be a direct result of the healthcare providers' insufficient teaching [34]. Hence, health care personnel must possess adequate knowledge and skill in inhalation technique for the proper delivery of instructions to the patients.

The expertise and skills of the medical staff have a significant impact on the educational outcomes of the patients [78]. However, a study showed that prescribers' knowledge of inhalers and inhalation techniques remains poor in Spain, where only 14.2% of physicians had adequate knowledge of inhaled therapy [79]. Hence, the focus should also be directed at educating health professionals regarding correct inhaler use [12]. In addition, errors in inhalation technique are more common in people ≥ 60 years old [80,81]. In the current study majority (87.4%) of the respondents were illiterate. Patients' physical and cognitive limitations, a lack of preference for the right inhalation devices for them, as well as educational and sociocultural disparities, could be the main reasons for inappropriate inhalation device use. Inhalation technique can be improved by focusing on the errors performed by patients, and sessions should be repeated frequently because repetition always makes learning easier. An efficient method for enhancing inhaler technique is a checklist-based assessment and correction of the step-by-step procedure.

This study also revealed that most of the patients were unaware of how to properly maintain their rotahaler devices, including storage of rotahaler in a cool place (89.3%) and cleaning them weekly (49.5%), and cleaning with tap water (89.3%). This research has underlined the need and necessity

of teaching interventions focusing on both inhaling technique and rotahaler device maintenance.

Strength

One of the strengths of this study is the observation method of data collection using an observational checklist, which provides a real picture of the inhalation technique of patients with COPD.

Limitations

This study was a cross-sectional study conducted among COPD patients attending OPD who were using inhalers in a single setting only. Hence, the result has limited generalizability.

This study could not explore the factors associated with the inhalation technique of COPD patients because almost all patients with COPD are using an inhaler device incorrectly.

Conclusion

Based on the findings, it is concluded that very few patients with COPD are using their inhalers correctly, whereas most of them are using inhalers incorrectly. The most frequently performed errors on the steps are the inability to put the mouthpiece between the lips and teeth, followed by breathing out through the mouth and inhaling powder forcefully and deeply. Regular assessment and reinforcement of correct inhalation technique by health care personnel is essential for the effectiveness of the therapy and improved symptom control.

Implications

The result of the study has generated information on the status of inhalation technique of the respondents, hence it can be used as a guide by health care providers for organizing an effective instruction program on inhalation technique.

Recommendations

The findings of the study showed only 5.8% of the respondents follow the correct inhalation technique, so health professionals need to be aware of it, and periodic education should be provided to all the patients using inhalers, including demonstration and re-demonstrations in order to provide effective instructions on correct inhaler use.

Further studies are recommended to evaluate the reason for incorrect inhalation technique and also to assess the knowledge and practice of health professionals in the proper use of inhalers.

A similar study can be conducted in multiple centers so that the findings can be generalized.

Acknowledgement

This study has been completed with the support, suggestion, guidance, supervision, and co-operation of many individuals and organizations. It is a pleasure, delight, and contentment to show gratefulness to individuals and organizations who helped throughout the research period.

First of all, with great pleasure, I'm delighted to express sincere thanks to Chitwan Medical College, School of Nursing, for providing an opportunity to conduct this study as partial fulfillment of the Master of Nursing (MN) program.

I would like to express sincere, profound gratitude and heartfelt thanks to thesis advisor Professor Dr. Kalpana Sharma for her continuous encouragement, guidance, constant support, supervision, valuable suggestions, and constructive feedback during the research period.

I extend my special thanks to Professor Raj Kumar Mehta, Head of the Department of Research, and members of the Nursing Thesis Committee for their valuable feedback throughout the study. Moreover, I'm also thankful to the Institutional Review Committee (CMC-IRC) of Chitwan Medical College for providing ethical clearance for conducting the research study.

I'm very grateful to the Vice Principal of Chitwan Medical College (CMC), School of Nursing (SON), Professor Basanta Thapa. I would also like to express heartfelt thanks to all the staff of the medicine and respiratory OPD for their support throughout the research. I would like to mention my special appreciation towards all the respondents who made this study possible. Without their cooperation, this study wouldn't have been completed successfully.

I express my sincere gratitude to Assistant Professor Jaya Prasad Singh, statistician, for providing expert advice and statistical knowledge for strengthening the thesis. Last but not least, I would also like to express heartfelt thanks to the staff of the library of Chitwan Medical College for making availability of literature available.

References

1. World Health Organization. Chronic Obstructive Pulmonary Disease (COPD). Geneva: World Health Organization; 2022. Available from: https://www.who.int/news-room/fact-sheets/detail/chronic-obstructive-pulmonary-disease-(copd)
2. Global Initiative for Chronic Obstructive Lung Disease (GOLD). Global Initiative for Chronic Obstructive Lung Disease Pocket Guide to COPD Diagnosis, Management, and Prevention: a Guide for Health Care Professionals. 2021. Available from: https://goldcopd.org/wp-content/uploads/2020/11/GOLD-2021-POCKET-GUIDE-v1.0-16Nov20_WMV.pdf
3. Bousquet J, Dahl R, Khaltaev N. Global Alliance against Chronic Respiratory Diseases. Eur Respir J. 2007;29(2):233–239. Available from: https://doi.org/10.1183/09031936.00138606
4. Bhandari GP, Angdembe MR, Dhimal M, Neupane S, Bhusal C. State of non-communicable diseases in Nepal. BMC Public Health. 2014;14(1):23. Available from: https://doi.org/10.1186/1471-2458-14-23
5. Prasad B. Chronic Obstructive Pulmonary Disease (COPD). Int J Pharm Res Technol. 2020;10(1):67. Available from: https://www.ijprt.org/index.php/pub/article/view/122

6. Hogg JC. Pathophysiology of airflow limitation in chronic obstructive pulmonary disease. Lancet. 2004;364(9435):709–721. Available from: https://doi.org/10.1016/S0140-6736(04)16900-6

7. Rennard S, Decramer M, Calverley PMA, Pride NB, Soriano JB, Vermeire PA, Vestbo J. Impact of COPD in North America and Europe in 2000: Subjects' perspective of Confronting COPD International Survey. Eur Respir J. 2002;20(4):799–805. Available from: https://doi.org/10.1183/09031936.02.03242002

8. Kessler R, Partridge MR, Miravitlles M, Cazzola M, Vogelmeier C, Leynaud D, Ostinelli J. Symptom variability in patients with severe COPD: a pan-European cross-sectional study. Eur Respir J. 2011;37(2):264–272. Available from: https://doi.org/10.1183/09031936.00051110

9. Agustí AGN. Systemic effects of Chronic Obstructive Pulmonary Disease. Proc Am Thorac Soc. 2005;2(4):367–370. Available from: https://doi.org/10.1513/PATS.200504-026SR

10. Kempker JA, Abril MK, Chen Y, Kramer MR, Waller LA, Martin GS. The Epidemiology of Respiratory Failure in the United States 2002–2017: A Serial Cross-Sectional Study. Crit Care Explor. 2020;2(6):e0128. Available from: https://doi.org/10.1097/cce.0000000000000128

11. Dolovich MB, Dhand R. Aerosol drug delivery: developments in device design and clinical use. Lancet. 2011;377:1032–1045. Available from: https://doi.org/10.1016/s0140-6736(10)60926-9

12. Bonini M, Usmani OS. The importance of inhaler devices in the treatment of COPD. COPD Res Pract. 2015;1(1):1–9. Available from: https://doi.org/10.1186/S40749-015-0011-0

13. Cochrane MG, Bala MV, Downs KE, Mauskopf J, Ben-Joseph RH. Inhaled corticosteroids for asthma therapy: patient compliance, devices, and inhalation technique. Chest. 2000;117(2):542–550. Available from: https://doi.org/10.1378/chest.117.2.542

14. Bell JH, Hartley PS, Cox JSG. Dry powder aerosols I: a new powder inhalation device. J Pharm Sci. 1971;60(10):1559–1564. Available from: https://doi.org/10.1002/jps.2600601028

15. Adhikari Baral M. Knowledge and practice of dry powder inhalation among patients with Chronic Obstructive Pulmonary Disease in a regional hospital, Nepal. Int J Gen Med. 2019:12–31. Available from: https://doi.org/10.2147/IJGM.S165659

16. Ilic AD, Zugic V, Zvezdin B, Kopitovic I, Cekerevac I, Cupurdija V, et al. Influence of inhaler technique on asthma and COPD control: a multicenter experience. Int J Chron Obstruct Pulmon Dis. 2016;11(1):2509. Available from: https://doi.org/10.2147/COPD.S114576

17. Price DB, Román-Rodríguez M, McQueen RB, Bosnic-Anticevich S, Carter V, Gruffydd-Jones K, et al. Inhaler errors in the CRITIKAL study: type, frequency, and association with asthma outcomes. J Allergy Clin Immunol Pract. 2017;5(4):1071–1081.e9. Available from: https://doi.org/10.1016/j.jaip.2017.01.004

18. Global Initiative for Asthma (GINA). GINA Main Report. Global Initiative for Asthma; 2022. Available from: https://ginasthma.org/gina-reports/

19. Lavorini F, Magnan A, Dubus JC, Voshaar T, Corbetta L, Broeders M, et al. Effect of incorrect use of dry powder inhalers on the management of patients with asthma and COPD. Respir Med. 2008;102(4):593–604. Available from: https://doi.org/10.1016/j.rmed.2007.11.003

20. Hesselink AE, Penninx BWJH, Wijnhoven HAH, Kriegsman DMW, van Eijk JTM. Determinants of an incorrect inhalation technique in patients with asthma or COPD. Scand J Prim Health Care. 2001;19(4):255–260. Available from: https://doi.org/10.1080/02813430152706792

21. Molimard M, Raherison C, Lignot S, Depont F, Abouelfath A, Moore N. Assessment of handling of inhaler devices in real life: an observational study in 3811 patients in primary care. J Aerosol Med. 2004;16(3):249–254. Available from: https://doi.org/10.1089/089426803769017613

22. Diamond SA, Chapman KR. The impact of a nationally coordinated pharmacy-based asthma education intervention. Can Respir J. 2001;8(4):261–265. Available from: https://doi.org/10.1155/2001/380485

23. Lenney J, Innes JA, Crompton GK. Inappropriate inhaler use: assessment of use and patient preference of seven inhalation devices. Respir Med. 2000;94:496–500. Available from: https://doi.org/10.1053/rmed.1999.0767

24. Sapkota D, Amatya YR. Assessment of rotahaler inhalation technique among patients with chronic obstructive pulmonary disease in a teaching hospital of Nepal. J Kathmandu Med Coll. 2017;5(1):11–17. Available from: https://doi.org/10.3126/jkmc.v5i1.18259

25. Usmani OS. Choosing the right inhaler for your asthma or COPD patient. Ther Clin Risk Manag. 2019;15:461. Available from: https://doi.org/10.2147/TCRM.S160365

26. National Institutes of Health, National Heart, Lung, and Blood Institute. Morbidity & Mortality: 2012 Chart Book on Cardiovascular, Lung, and Blood Diseases. 2012. Available from: https://www.astrazeneca.com/content/dam/az/media-centre-docs/article_files/articles-2015/Documents/2012_ChartBook_508.pdf

27. Sanchis J, Gich I, Pedersen S. Systematic review of errors in inhaler use: has patient technique improved over time? Chest. 2016;150(2):394–406. Available from: https://doi.org/10.1016/j.chest.2016.03.041

28. Miravitlles M, Soler-Cataluña JJ, Alcázar B, Viejo JL, García-Río F. Factors affecting the selection of an inhaler device for COPD and the ideal device for different patient profiles: Results of EPOCA Delphi consensus. Pulm Pharmacol Ther. 2018;48:97–103. Available from: https://doi.org/10.1016/j.pupt.2017.10.006

29. Maricoto T, Santos D, Carvalho C, Teles I, Correia-de-Sousa J, Taborda-Barata L. Assessment of poor inhaler technique in older patients with asthma or COPD: a predictive tool for clinical risk and inhaler performance. Drugs Aging. 2020;37(8):605–616. Available from: https://doi.org/10.1007/S40266-020-00779-6

30. Goodman DE, Israel E, Rosenberg M, Johnston R, Weiss ST, Drazen JM. The influence of age, diagnosis, and gender on proper use of metered-dose inhalers. Am J Respir Crit Care Med. 2012;150(5):1256–1261. Available from: https://doi.org/10.1164/AJRCCM.150.5.7952549

31. Pothirat C, Chaiwong W, Phetsuk N, Pisalthanapuna S, Chetsadaphan N, Choomuang W. Evaluating inhaler use technique in COPD patients. Int J Chron Obstruct Pulmon Dis. 2015;10:1291. Available from: https://doi.org/10.2147/copd.s85681

32. Palen J, Klein JJ, van Herwaarden CLA, Zielhuis GA, Seydel ER. Multiple inhalers confuse asthma patients. Eur Respir J. 1999;14(5):1034–1037. Available from: https://doi.org/10.1183/09031936.99.14510349

33. Calzetta L, Aiello M, Frizzelli A, Ritondo BL, Pistocchini E, Rogliani P, et al. Impact of sex on proper use of inhaler devices in asthma and COPD: a systematic review and meta-analysis. Pharmaceutics. 2022;14(8). Available from: https://doi.org/10.3390/pharmaceutics14081565

34. Melani AS, Bonavia M, Cilenti V, Cinti C, Lodi M, Martucci P, et al. Inhaler mishandling remains common in real life and is associated with reduced disease control. Respir Med. 2011;105(6):930–938. Available from: https://doi.org/10.1016/j.rmed.2011.01.005

35. Virchow JC, Crompton GK, Dal Negro R, Pedersen S, Magnan A, Seidenberg J, et al. Importance of inhaler devices in the management of airway disease. Respir Med. 2008;102(1):10–19. Available from: https://doi.org/10.1016/j.rmed.2007.07.031

36. Singh D, Agusti A, Anzueto A, Barnes PJ, Bourbeau J, Celli BR, et al. Global strategy for the diagnosis, management, and prevention of chronic obstructive lung disease: the GOLD science committee report 2019. Eur Respir J. 2019;53(5):1900164. Available from: https://doi.org/10.1183/13993003.00164-2019

37. Maya R, Shakya N. Assessment of Rotahaler inhalation technique among patients with COPD or asthma at Manipal teaching hospital, Pokhara. Int J Nurs Educ. 2018. Available from: https://www.researchgate.net/publication/327489535_Assessment_of_rotahaler_inhalation_technique_among_patients_with_COPD_or_asthma_at_Manipal_teaching_hospital_Pokhara

38. Shrestha S, Shrestha S, Baral MR, Bhandari S, Chand S, Tamrakar R, et al. Evaluation of inhalation technique in patients using a dry powder device (DPI) at the chest clinic in Dhulikhel Hospital – Kathmandu University Hospital, and the effect of patient education on it. Clin Med (Lond). 2019;19(Suppl 3):64–66. Available from: https://doi.org/10.7861/clinmedicine.19-3s-s64

39. Poudel RS, Piryani RM, Shrestha S, Prajapati A. Benefit of hospital pharmacy intervention on the current status of dry powder inhaler technique in patients with asthma and COPD: a study from the Central Development Region, Nepal. Integr Pharm Res Pract. 2017;6:7–13. Available from: https://doi.org/10.2147/iprp.s119202

40. Roy C. The Roy adaptation model: the definitive statement. Norwalk (CT): Appleton & Lange; 1991.

41. Duncan D. Chronic obstructive pulmonary disease: an overview. Br J Nurs. 2016;25(7):360–366. Available from: https://doi.org/10.12968/bjon.2016.25.7.360

42. Barnes PJ. Chronic obstructive pulmonary disease. N Engl J Med. 2000;343(4):269–280. Available from: https://doi.org/10.1056/NEJM200007273430407

43. Anthonisen N, Bailey WC, Barnes PJ, Clark T, Fabbri L, Fukuchi Y, et al. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. Am J Respir Crit Care Med. 2001;163(5):1256–1276. Available from: https://doi.org/10.1164/AJRCCM.163.5.2101039

44. Hikichi M, Mizumura K, Maruoka S, Gon Y. Pathogenesis of chronic obstructive pulmonary disease (COPD) induced by cigarette smoke. J Thorac Dis. 2019;11(Suppl 17):S2129–S2140. Available from: https://doi.org/10.21037/JTD.2019.10.43

45. Wang Y, Xu J, Meng Y, Adcock IM, Yao X. Role of inflammatory cells in airway remodeling in COPD. Int J Chron Obstruct Pulmon Dis. 2018;13:3341–3348. Available from: https://doi.org/10.2147/COPD.S176122

46. Tkac J, Man SFP, Sin DD. Systemic consequences of COPD. Ther Adv Respir Dis. 2007;1(1):47–59. Available from: https://doi.org/10.1177/1753465807082374

47. Ritchie AI, Wedzicha JA. Definition, causes, pathogenesis, and consequences of chronic obstructive pulmonary disease exacerbations. Clin Chest Med. 2020;41(3):421–438. Available from: https://doi.org/10.1016/J.CCM.2020.06.007

48. Vogelmeier CF, Criner GJ, Martinez FJ, Anzueto A, Barnes PJ, Bourbeau J, et al. Global strategy for the diagnosis, management, and prevention of chronic obstructive lung disease 2017 report. Am J Respir Crit Care Med. 2017;195(5):557–582. Available from: https://doi.org/10.1164/rccm.201701-0218pp/suppl_file/disclosures.pdf

49. Borghardt JM, Kloft C, Sharma A. Inhaled therapy in respiratory disease: the complex interplay of pulmonary kinetic processes. Can Respir J. 2018;2018:1–11. Available from: https://www.hindawi.com/journals/crj/2018/2732017/

50. Labiris NR, Dolovich MB. Pulmonary drug delivery. Part I: physiological factors affecting the therapeutic effectiveness of aerosolized medications. Br J Clin Pharmacol. 2003;56(6):588–599. Available from: https://doi.org/10.1046/j.1365-2125.2003.01892.x

51. Labiris NR, Dolovich MB. Pulmonary drug delivery. Part II: the role of inhalant delivery devices and drug formulations in the therapeutic effectiveness of aerosolized medications. Br J Clin Pharmacol. 2003;56(6):600–612. Available from: https://doi.org/10.1046/j.1365-2125.2003.01893.x

52. Padmanabhan M, Tamilarasu K, Rajaram M, Batmanabane G. Inadequate inhaler technique, an everlasting problem, is associated with poor disease control – a cross-sectional study. Adv Respir Med. 2019;87(4):217–225.

53. Kaplan A, Price D. Matching inhaler devices with patients: the role of the primary care physician. Can Respir J. 2018;2018:1–9. Available from: https://doi.org/10.1155/2018/9473051

54. Kocks JWH, Chrystyn H, van der Palen J, Thomas M, Yates L, Landis SH, et al. Systematic review of the association between critical errors in inhalation and health outcomes in asthma and COPD. NPJ Prim Care Respir Med. 2018;28(1). Available from: https://doi.org/10.1038/s41533-018-0110-x

55. Çakmakli S, Özdemir A, Fırat H, Aypak C. An evaluation of the use of inhalers in asthma and chronic obstructive pulmonary disease. J Taibah Univ Med Sci. 2023. Available from: https://doi.org/10.1016/j.jtumed.2023.01.001

56. Harb HS, Ibrahim Laz N, Rabea H, Abdelrahim MEA. Determinants of incorrect inhaler technique in chronic obstructive pulmonary disease patients. Int J Clin Pract. 2021;75(6). Available from: https://doi.org/10.1111/IJCP.14073

57. Jain SRK. Impact of educational program on inhalational device usage techniques among the patients suffering from asthma. J Clin Diagn Res. 2021. Available from: https://doi.org/10.7860/jcdr/2021/51847.15601

58. Shankar DM, Shrivastava DPM, Kumar DS. Dry powder inhalation knowledge and practices among COPD patients in Bihar: a questionnaire-based study. Eur J Mol Clin Med. 2021;8(3):4576–4583.

59. Padmini AK, Basheer S. Evaluating metered dose inhaler and dry powder inhaler use technique among bronchial asthma and COPD patients attending a tertiary health care centre in South India. Int J Community Med Public Health. 2021;8(9):4545. Available from: https://doi.org/10.18203/2394-6040.ijcmph20213567

60. Thakkar K, Patel R, Abraham R, Shah A, Rajput H, Chandrakar V. A study on effectiveness and outcomes of educational inhaler technique counselling in the respiratory department by a clinical pharmacist. Indian J Pharm Pract. 2021;14(4):251–258.

61. Sanaullah T, Khan S, Masoom A, Mandokhail ZK, Sadiqa A, Malik MI. Inhaler use technique in chronic obstructive pulmonary disease patients: errors, practices, and barriers. Cureus. 2020;12(9). Available from: https://doi.org/10.7759/cureus.10569

62. Suthar J, Patel ZA, Shelat B. Assessment of inhalation techniques in COPD and asthma patients using metered dose inhaler and rota-haler. Indian J Pharm Pract. 2019;12. Available from: https://www.researchgate.net/publication/335931675_Assessment_of_Inhalation_Techniques_in_COPD_and_Asthma_Patients_using_Metered_Dose_Inhaler_and_Rota-haler

63. Tajes-González YM, Gulín-Dávila J, Castellano-Copa P. Inhalation technique assessment and evaluation for the need of pharmaceutical intervention in respiratory pathologies. Farm Hosp. 2019;43(6):202–207. Available from: https://doi.org/10.7399/FH.11296

64. Khan GM, Badri P, Parbati T, Anita D, Atul A, Deepak P, et al. Intervention on inhalation technique of rotahaler in patients with chronic obstructive pulmonary disease and asthma. Asian J Pharm Sci. 2016;11(1):81–82. Available from: https://doi.org/10.1016/j.ajps.2015.11.112

65. Roggeri A, Micheletto C, Roggeri DP. Inhalation errors due to device switch in patients with chronic obstructive pulmonary disease and asthma: critical health and economic issues. Int J Chron Obstruct Pulmon Dis. 2016;11(1):597. Available from: https://doi.org/10.2147/COPD.S103335

66. Capanoglu M, Dibek Misirlioglu E, Toyran M, Civelek E, Kocabas CN. Evaluation of inhaler technique, adherence to therapy, and their effect on disease control among children with asthma using metered dose or dry powder inhalers. J Asthma. 2015;52(8):838–845. Available from: https://doi.org/10.3109/02770903.2015.1028075

67. Pun S, Prasad GK, Bharati L. Assessment of inhalation techniques in COPD patients using metered-dose inhaler and rotahaler at a tertiary care hospital in Nepal. Int Res J Pharm. 2015;6(5):288–293. Available from: https://www.researchgate.net/publication/278770888_ASSESSMENT_OF_INHALATION_TECHNIQUES_IN_COPD_PATIENTS_USING_METERED-DOSE_INHALER_AND_ROTAHALER_AT_A_TERTIARY_CARE_HOSPITAL_IN_NEPAL

68. Arora P, Kumar L, Vohra V, Sarin R, Jaiswal A, Puri MM, et al. Evaluating the technique of using an inhalation device in COPD and bronchial asthma patients. Respir Med. 2014;108(7):992–998. Available from: https://doi.org/10.1016/j.rmed.2014.04.021

69. Luiza M, Souza M, Meneghini AC, Ferraz É, Oliveira Vianna E, Carvalho Borges M. Knowledge of and technique for using inhalation devices among asthma patients and COPD patients. Braz J Pulmonol. 2009;35(9):824–831. Available from: https://doi.org/10.1590/s1806-37132009000900002

70. Beerendonk I, Mesters I, Mudde AN, Tan TD. Assessment of the inhalation technique in outpatients with asthma or chronic obstructive pulmonary disease using a metered-dose inhaler or dry powder device. J Asthma. 1998;35(3):273–279. Available from: https://doi.org/10.3109/02770909809068218

71. Cochrane WG. Sampling techniques. 3rd ed. New York: John Wiley & Sons; 1977. Available from: https://www.scirp.org/reference/ReferencesPapers?ReferenceID=1390266

72. U.S. Food and Drug Administration. Safety testing of drug metabolites. 2016. Available from: https://www.fda.gov/regulatory-information/search-fda-guidance-documents/safety-testing-drug-metabolites

73. Bai S, Gupta V, Ahsan F. Inhalable lactose-based dry powder formulations of low molecular weight heparin. J Aerosol Med Pulm Drug Deliv. 2010;23(2):97–104. Available from: https://doi.org/10.1089/jamp.2009.0745

74. Bhushan B, Singh K, Abraham J, Goyal D, Bhatnager A, Chungath JT, et al. Role of educational intervention with practical demonstration in improving inhaler technique. Int J Adv Med. 2019;6(3):840. Available from: https://doi.org/10.18203/2349-3933.IJAM20192249

75. Broeders MEAC, Sanchis J, Levy ML, Crompton GK, Dekhuijzen PNR. The ADMIT series—Issues in inhalation therapy. 2) Improving technique and clinical effectiveness. Prim Care Respir J. 2009;18(2):76–82. Available from: https://doi.org/10.4104/pcrj.2009.00025

76. Crompton GK, Barnes PJ, Broeders M, Corrigan C, Corbetta L, Dekhuijzen R, et al. The need to improve inhalation technique in Europe: a report from the Aerosol Drug Management Improvement Team. Respir Med. 2006;100(9):1479–1494. Available from: https://doi.org/10.1016/j.rmed.2006.01.008

77. Rau LJ. Practical problems with aerosol therapy in COPD. Respir Care. 2006;51(2). Available from: https://pubmed.ncbi.nlm.nih.gov/16441960/

78. Keeley D. Ignorance about teaching inhaler technique is widespread among healthcare professionals. BMJ. 2014;348(jun05 11):g3452–g3452. Available from: https://doi.org/10.1136/bmj.g3452

79. Plaza V, Sanchis J, Roura P, Molina J, Calle M, Quirce S, et al. Physicians' knowledge of inhaler devices and inhalation techniques remains poor in Spain. J Aerosol Med Pulm Drug Deliv. 2012;25(1):16–22. Available from: https://doi.org/10.1089/jamp.2011.0895

80. Rootmensen GN, van Keimpema ARJ, Jansen HM, de Haan RJ. Predictors of incorrect inhalation technique in patients with asthma or COPD: a study using a validated videotaped scoring method. J Aerosol Med Pulm Drug Deliv. 2010;23(5):323–328. Available from: https://doi.org/10.1089/jamp.2009.0785

81. Global Strategy for Asthma Management and Prevention Updated. 2010. Available from: https://ginasthma.org/wp-content/uploads/2019/01/2010-GINA.pdf