International Journal of Chronic Obstructive Pulmonary Disease

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ORIGINAL RESEARCH

Nurses' Reports of Inhaler Use Errors in Patients with Chronic Obstructive Pulmonary Disease in Hong Kong

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Background: Persistently high rates of inhaler errors and poor adherence among Chronic Obstructive Pulmonary Disease (COPD) patients contribute to ineffective symptomatic control, high care burdens, and increased healthcare resource utilization.

Objective: This study aimed to report (i) nurses-identified common problems and errors of inhaler use in COPD patients, (ii) nurses' attitudes, practices, training needs and required support in inhaler education.

Methods: An online questionnaire survey was conducted with nurses working in Hong Kong from May to June 2023 using an exponential, non-discriminative snowball sampling strategy.

Results: Of 156 nurses (67.3% female, 41% aged 40 or above), 37.2% and 62.8% of them had more than 10 years of experience in medical units and received respiratory-related specialist training, respectively. About 86% and 82% perceived that their patients did not have adequate basic knowledge and had incorrect use of their inhaled medications. High rates of inhaler use errors were observed by nurses across all phases: preparation (50%–92%), pre-inhalation (45%–89%), inhalation (69%–89%), and aftercare (66%–85%). Nurses with ≥10 years of working experience in medical units or specialist training showed significantly more confidence in educating on inhaler use, engaging in more discussion with patients about inhaler use, and assessing patient inhaler use techniques more frequently than those with less experience or no respiratory-related specialist training with small effect size (Cohens'd: 0.26–0.33).

Conclusion: Inhaler use errors were common issues among COPD patients in Hong Kong. Enhanced professional training and support in inhaler education could improve nurses' confidence and practices in conducting patient education on inhaler use.

Keywords: chronic obstructive pulmonary disease, nurses' experience, inhaler, errors, clinical experience

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is characterised by chronic inflammation of the small airways associated with airflow obstruction. It has been recognised as the third leading cause of death globally in 2019,[1] and leads to higher care burdens and associated healthcare resource utilisation.[2] The management of COPD heavily relies on the proper use of inhalers; if used incorrectly, it is associated with a lack of efficacy in preventing adverse outcomes, such as COPD exacerbation.[3–5] Reviews showed a significant association between inhaler errors, poor disease outcomes, and greater health-economic burden.[6,7]

The GOLD 2023 guidelines emphasise that correct inhaler technique is a cornerstone of effective COPD pharmacotherapy.[8] Despite widespread patient education on inhaler use, many patients still struggle to master correct inhaler techniques.[4,6] Inhaler misuse remains prevalent and contributes to the surge in hospital admissions and rising healthcare costs.[9] Poor adherence has been commonly identified in real-world practices.[6,10,11] A systematic review also revealed a consistent rate ranging from 27% to 36% of different inhaler misuse over the past 40 years, with no indication of decline.[12]

Received: 17 June 2024
Accepted: 14 November 2024
Published: 31 December 2024

Nurses are pivotal in effective patient inhaler education, which is crucial for managing COPD. Studies have shown that nurses effectively reduce inhaler misuse, improve overall therapeutic efficacy, and make significant contributions to patient outcomes.[13,14] Regular assessments and corrections of inhaler techniques by nursing staff can significantly reduce critical errors.[15] However, despite their importance, there is evidence to suggest that nurses and healthcare professionals, in general, may need more knowledge about proper inhaler techniques.[16] This knowledge gap could directly impact patient care, with inadequately trained staff potentially contributing to the ongoing issue of inhaler misuse among COPD patients. Therefore, there is a pressing need for enhanced educational programs and training initiatives aimed at healthcare providers to ensure they have the necessary skills and information to effectively support patients in managing their inhaler therapies.

This study aimed to (i) examine nurses-identified common problems and errors of inhaler use in COPD patients, (ii) explore nurses' attitudes and practices regarding inhaler education, and (iii) understand nurses' training needs and required support in inhaler education.

Methods

Study Design and Participants

The study received ethics approval from the Hong Kong Metropolitan University Research Ethics Committee (reference number: HE-SF2023/10). Written informed consent was obtained from all participants. This was a cross-sectional online questionnaire survey of nurses who observed problems and errors in inhaler use among COPD patients and their attitudes, practices, training needs, and support in inhaler education. The inclusion criteria were registered or enrolled nurses aged 18 years or above working in Hong Kong.

Data Collection

An online questionnaire was disseminated using an anonymous link, employing an exponential non-discriminative snowball sampling strategy from May to June 2023. Snowball sampling is a recognised cost-effective and efficient approach to reaching the target population. The link was initially shared through the WhatsApp instant message platform to nurses in Hong Kong, who were encouraged to forward the survey link to their colleagues. To prevent multiple submissions, the online survey platform was configured to use browser cookies to block multiple responses from the same browser. A self-reported question was included in the survey to ensure that all participants were nurses actively working in Hong Kong. In addition to obtaining informed consent before participation, we took measures to eliminate repeat entries by removing responses from duplicate IP addresses. The collected data was encrypted and stored on a password-protected computer, which was kept locked to maintain confidentiality and data integrity.

Measurements

An online questionnaire was developed by a team comprising university academia, frontline nurses, and representatives from a respiratory nursing professional body, the Hong Kong Respiratory Nursing College (HKRNC). The mission of HKRNC is to unite, support, and advance respiratory care and advocate for respiratory education to the public and community. The study focused on common problems and errors patients encounter with inhaler use. Based on clinical experiences and literature,[4,11,15] the team identified frequent general errors rather than device-specific issues. Questions were formulated and discussed internally to address the commonest issues. Thus, device-specific errors and specific issues on a specific type of inhaler were not addressed in this survey questions. Then, five nurses who were not HKRNC members participated in a pilot test to evaluate the questionnaire's clarity and length, providing feedback for revisions. The final questionnaire used in this survey comprised several sections, including demographic characteristics, common problems with inhaler use in COPD patients, observed errors regarding inhaler use, nurses' attitudes and practices regarding inhaler education, and nurses' needs and support in educating COPD patients.

Demographic Characteristics

Participants were asked to provide information on demographics, including gender, age group (18–29, 30–39, 40–49, 50–59, and 60 and over), highest education level (Associate degree/Higher diploma, Bachelor's degree, Master's degree, and Doctoral degree), number of years working in medical units (less than 1 year, 1–2 years, 3–5 years, 6–10 years, and

more than 10 years), and whether they received respiratory-related specialist training such as recognised post-registration certificate/diploma course/master degree on respiratory, geriatrics, advanced medicine, and critical care.

Common Problems with Inhaler Use Among COPD Patients

Participants were asked, based on their clinical experience, to estimate the proportions of COPD patients with inhaler use problems in the following five scenarios. The scenarios included: "Inadequate basic knowledge about inhaled medications", "Did not administer the dosage and frequency as prescribed", "Did not bring along the bronchodilator for emergency use", "Did not have confidence in using the inhaler correctly", and "Did not store the inhaler in a cool and dry place". Participants were provided with a five-point Likert scale to indicate the frequency of each issue, with the following options: 'Very low (0–20%)', 'Low (21–40%)', 'Moderate (41–60%)', 'High (61–80%)', and 'Very high (81–100%)'.

Observed Errors Regarding Inhaler Use Among COPD Patients

Participants were asked, based on their clinical experience, were asked to estimate the proportion of patients who made errors in inhaler use across 14 scenarios, organised into four distinct phases: preparation (4 items), pre-inhalation (4 items), inhalation (3 items), and aftercare (3 items). For each item, respondents were given a five-point Likert scale with the following options: "Very low (0–20%)", "Low (21–40%)", "Moderate (41–60%)", "High (61–80%)", and "Very high (81–100%)".

Nurses' Attitudes and Practices Regarding Patient Inhaler Education

Participants were asked to indicate their levels of agreement regarding their attitudes about the importance of educating COPD patients on inhaler use and their confidence in providing such education. They were presented with a five-point Likert scale consisting of the following options: "1 = Not at all important/confident", "2 = Slightly important/confident", "3 = Somewhat important/confident", "4 = Moderately important/confident", and "5 = Very important/confident".

Additionally, participants were asked to indicate the frequency with which they engaged in practices related to discussing inhaler treatment adherence and assessing patients' inhaler use techniques with feedback provided. For this, they were provided with a five-point likert scale featuring the following options: "Never", "Rarely", "Sometimes", "Often", and "Always".

Nurses' Training Needs and Required Support in Patient Inhaler Education

Participants were asked how they could be provided with assisting inhaler education. Seven options were provided, including "In-hospital service training", "Respiratory-related specialist training", "Inhaler technique education competency assessment for nurses", "Online training package for nurses", "Patient education videos about inhaler use", and "Others".

Statistical Analysis

The data were analysed using SPSS (version 23). Demographics, inhaler use problems and errors observed in COPD patients were presented as percentages. Figures 1 and 2 present the percentages of nurses who encountered moderate or above proportions of COPD patients with inhaler use problems in five common scenarios and observed errors in COPD patients who made errors in inhaler use in four distinct phases. The moderate proportions and above included those nurses who encountered "Moderate (41–60%)", "High (61–80%)", or "Very High (81–100%)" proportion of COPD patients with problems or errors in inhaler use.

Nurses' attitudes and practices related to inhaler use education were described using mean scores and standard deviations. Linear regression was utilised to examine the differences in nurses' attitudes (importance and confidence) regarding conducting inhaler education, as well as their practices of discussing and assessing patient inhaler use and technique, between nurses with different levels of working experience in medical units (≤10 years vs >10 years) and between those who received respiratory-related specialist training (Yes vs No). The respiratory-related specialist training included advanced medicine, respiratory, geriatric, and critical care.

To control for potential confounders, the analyses were adjusted for age group (≤40 years vs>40 years), sex (male vs female), education level (Bachelor's degree or lower vs Master's degree or higher), post-graduate working experience in

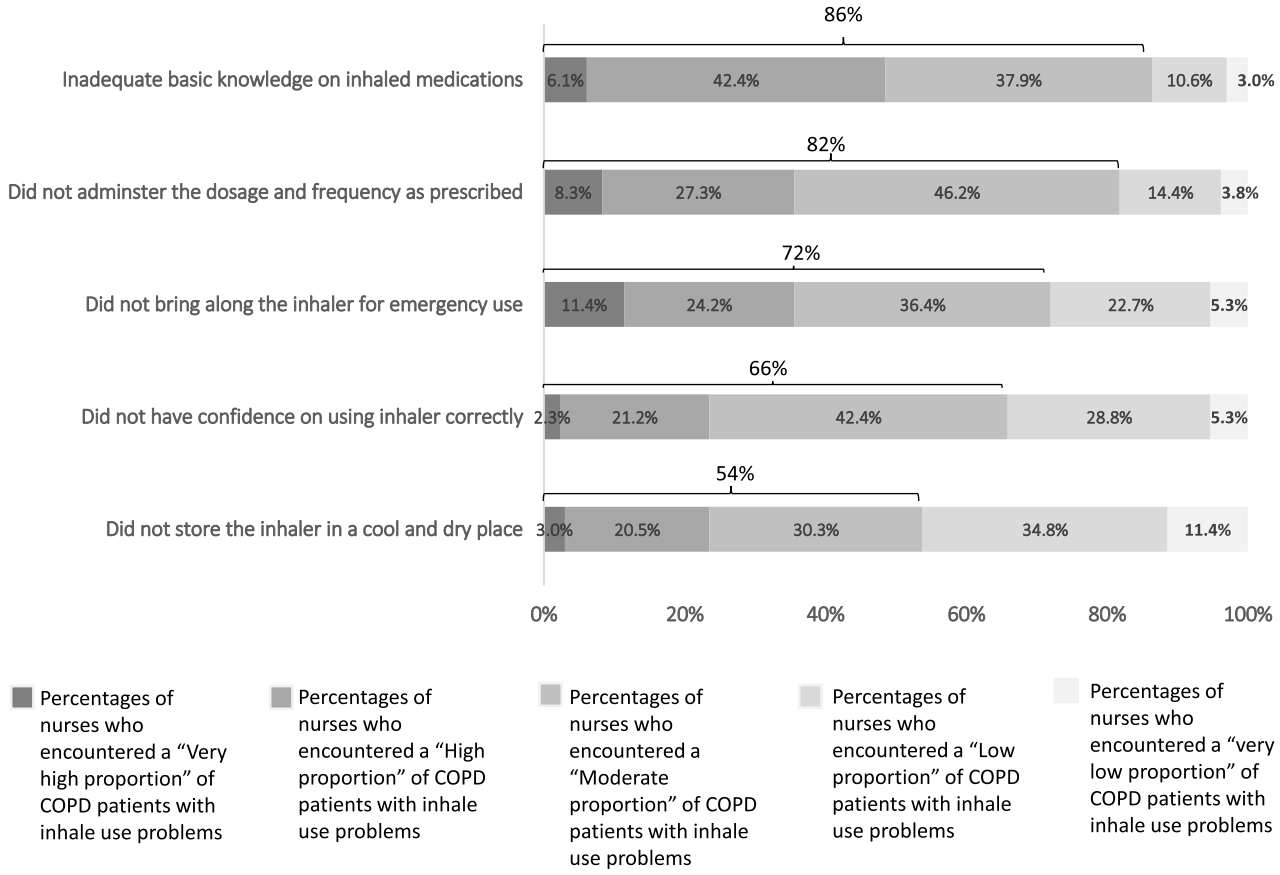

Figure 1 Percentages of nurses who encountered various proportions of COPD patients with inhaler use problems.

medical units, and respiratory-related specialist training. All tests were two-sided. A P-value of <0.05 indicated statistical significance, while a P-value ranging from <0.1 to ≥0.05 indicated marginal statistical significance.

Results

Demographic Characteristics

Table 1 shows 67.3% of the nurses were female, 41% were aged 40 years or above, 54.5% completed a Master's degree or higher, 50% had more than 10 years of post-registration working experience, 37.2% had more than 10 years of working experience in medical units, and 62.8% received respiratory-related specialist training.

Common Problems with Inhaler Use Among COPD Patients

Figure 1 shows the percentage of nurses who encountered COPD patients with inhaler use problems in each proportion category. The top three most common inhaler use problems that nurses encountered in moderate or above proportions of COPD patients with inhaler use problems were: inadequate basic knowledge of their inhaled medications (86%), not administering the dosage and frequency as prescribed (82%), and not bringing along the rescue bronchodilator for emergency use (72%).

Observed Errors Regarding Inhaler Use Among COPD Patients

Figure 2 illustrates the percentages of nurses who encountered moderate or above proportions of COPD patients who made errors in inhaler use in the four operational phases. During the preparation phase (Figure 2a), errors were observed between 50% and 92%, with the most frequent issues including not checking the inhaler's expiry date (92%), failing to prime a new or infrequently used inhaler (83%), and not verifying the remaining medication or dose counter (80%). In

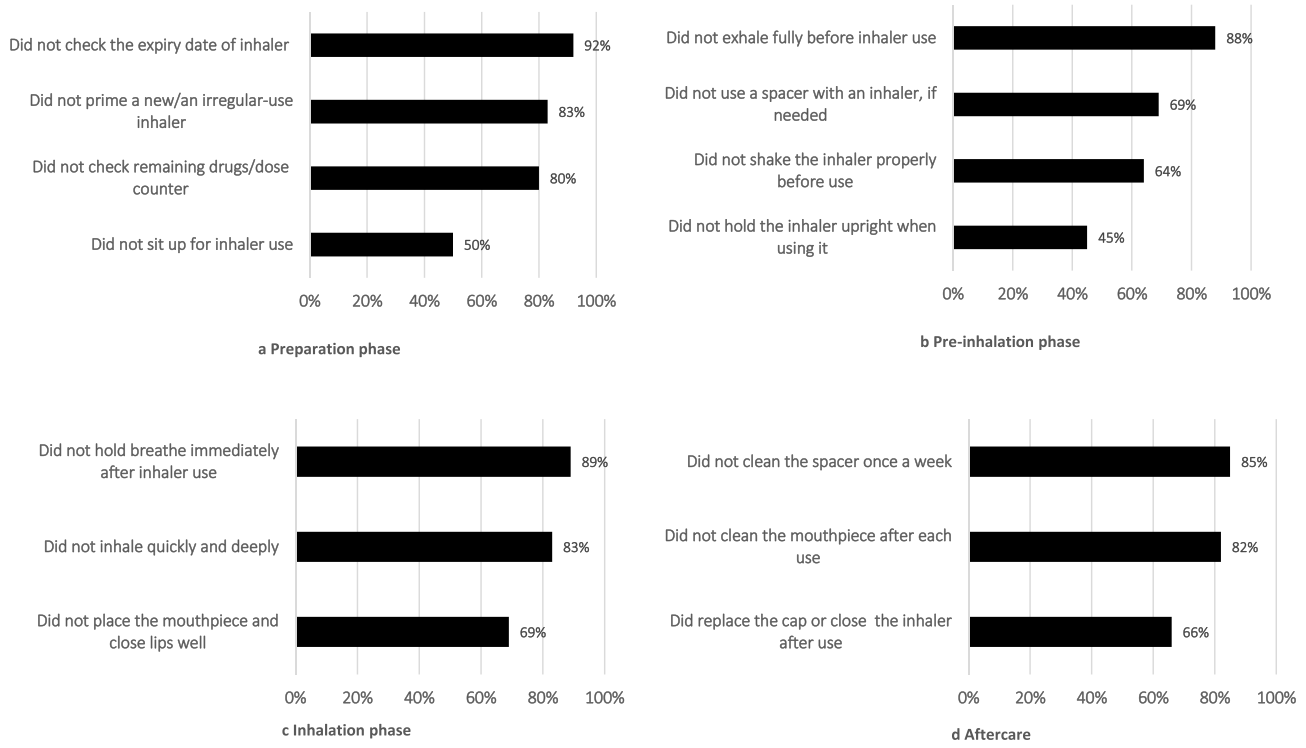

Figure 2 Percentages of nurses who encountered moderate to higher proportions of patients with errors in inhaler use in the four operational phases: (**a**). Preparation phase; (**b**). Pre-inhalation phase; (**c**). Inhalation phase; and (**d**). Aftercare.

the pre-inhalation phase (Figure 2b), which showed error rates of 45% to 88%, the primary errors were not exhaling fully and away from the mouthpiece (88%), not using a spacer with the inhaler (69%), and not shaking the inhaler thoroughly (64%). In the inhalation phase (Figure 2c), errors were observed ranging from 69% to 89%, with the most common being not holding one's breath after inhalation (89%), not inhaling quickly and deeply enough (83%), and incorrect placement and sealing of the mouthpiece (69%). Lastly, the aftercare phase (Figure 2d), with errors from 66% to 85%, saw frequent mistakes such as not cleaning the spacer (85%), not cleaning the mouthpiece (82%), and failing to replace the cap or close the inhaler properly after use (66%).

Nurses' Attitudes and Practices Regarding Patient Inhaler Education

Table 2 shows nurses with high scores on the importance of inhaler use education, with a mean score of 4.7 out of 5. However, their confidence in educating patients about inhaler use, discussing inhaler adherence with patients, and assessing patients' inhaler use techniques were rated as moderate, with mean scores of 3.9, 3.9, and 3.7, respectively.

After considering the potential confounding effects, nurses with >10 years of working experience in medical units showed significantly greater awareness of the importance of educating patients on inhaler use [mean difference (β), 95% confidence interval (CI): 0.39 (0.12 to 0.66), $p < 0.01$, Cohen's d = 0.29]. They also had more confidence in their educational methods [β (95% CI): 0.54 (0.15, 0.92), $p < 0.01$, Cohen's d: 0.28], engaged more frequently in discussions with patients about inhaler use [β (95% CI): 0.64 (0.30, 0.98), $p < 0.001$, Cohen's d: 0.33] and were more likely to assess patients' inhaler use and techniques with feedback provided [β (95% CI): 0.56 (0.15, 0.96), $p < 0.01$, Cohen's d: 0.26], with a small effect size, compared to those with less working experience in medical units.

Similarly, nurses who received respiratory-related specialist training had significantly more confidence in educating patients about inhaler use [β, 95% (CI): 0.51 (0.14, 0.87), $p < 0.01$, Cohen's d: 0.25], engaged more frequently in discussions with patients about inhaler use [β (95% CI): 0.51 (0.14, 0.87), $p < 0.01$, Cohen's d: 0.27] and were more likely to assess patients' inhaler use and techniques with feedback provided [β (95% CI): 0.59 (0.21, 0.98), $p < 0.01$, Cohen's d: 0.28], with a small effect size, than those who did not receive respiratory-related specialist training.

https://doi.org/10.2147/COPD.S482243

Table 1 Nurses' Demographic Characteristics

n=156	n (%)
Sex	
Male	51 (32.7)
Female	105 (67.3)
Age, years	
Less than 30	40 (25.6)
30–39	52 (33.3)
40–49	34 (21.8)
50–59	25 (16.0)
60 or more	5 (3.2)
Education level	
Associate degree/higher diploma	7 (4.5)
Bachelor's degree	64 (41.0)
Master's degree	78 (50.0)
Doctoral degree	7 (4.5)
Working experiences in medical units, years	
Less than 1	20 (12.8)
1–2	19 (12.2)
3–5	26 (16.7)
6–10	33 (21.2)
More than 10	58 (37.2)
Respiratory-related specialist training[#]	
No	58 (37.2)
Yes	98 (62.8)

Note: [#]Respiratory-related specialist training refers to a recognised post-registration certificate/diploma course/master degree in respiratory-related specialist training, including respiratory, advanced medicine, geriatric, and critical care.

Figure 3 shows nurses' training needs and required support to enhance their ability to provide inhaler education. The relatively high rating included respiratory specialist training (56%), in-hospital service training (47%), and providing resources about inhaler use and education (40%).

Discussion

This study reported that, from nurses' clinical experience and perspectives, high proportions of COPD patients, ranging from 42% to 92%, had errors in inhaler use among different phases. Nurses reported a high score on the importance of inhaler education to COPD patients but relatively lower scores on the confidence and practice of educating COPD patients. In addition, nurses with >10 years of experience working in medical units and receiving respiratory-related specialist training had more confidence, engaged more frequently in discussions with patients and were more likely to assess patients' inhaler use and techniques than those with less experience.

Our study found that over four-fifths of nurses believed their COPD patients had inadequate basic knowledge about their inhaled medications and did not use their inhalers as prescribed. This rate was substantially higher than that reported in other studies, which showed that 50–54% of COPD patients had moderate to poor self-reported inhaler use technique and adherence.[12,13] This discrepancy may be attributed to the optimistic bias in patients' self-perceptions, leading to a significant difference between patients' self-assessed and professional-observed errors in inhaler use. This might relate to Hong Kong's nurse-to-patient ratio of 1:11 during the daytime, particularly in public hospitals, indicating a higher patient load per nurse,[17] compared to many Western countries adopting the common international standard of one nurse to four patients.[18] This discrepancy can impact the quality of patient care, nurse job satisfaction, and overall healthcare outcomes.[19]

Table 2 Nurses' Attitudes and Practices Regarding Inhaler Use Education in All Participants and Subgroups

		Working experience in medical units				Received respiratory-related specialist training[c]			
	All	10 years or less (n=98)	More than 10 years (n=58)	Mean difference	Effect size	No (n=58)	Yes (n=98)	Mean difference	Effect size
	Mean ± SD	Mean ± SD	Mean ± SD	B (95% CI)	Cohen's d	Mean ± SD	Mean ± SD	B (95% CI)	Cohen's d
Attitudes[a]									
Importance of inhaler use education	4.7±0.7	4.6±0.7	4.9±0.5	0.39 (0.12, 0.66)	0.29**	4.6±0.7	4.8 ± 0.6	0.08 (−0.18, 0.34)	0.06
Confidence in educating on inhaler use	3.9±1.0	3.6±1.0	4.3±0.8	0.54 (0.15, 0.92)	0.28**	3.4±1.0	4.2±0.9	0.51 (0.14, 0.87)	0.27**
Practices[b]									
Discussing with patients to improve inhaler use	3.9±0.9	3.6±0.9	4.3±0.8	0.64 (0.30, 0.98)	0.33***	3.4±0.8	4.1±0.9	0.53 (0.20, 0.86)	0.28**
Assessing patients' technique of inhaler use	3.7±1.0	3.4±1.0	4.2±0.9	0.56 (0.15, 0.96)	0.26**	3.2±0.9	4.0±1.0	0.59 (0.21, 0.98)	0.28**

Note: [a]Scores ranged from 1 to 5, " 1 = Not at all important/confident", "2 = Slightly important/confident", "3 = Somewhat important/confident", "4 = Moderately important/confident", and "5 = Very important/confident". [b]Scores ranged from 1 to 5, "1 =Not at all important/confident", "2 = Slightly important/confident", "3 = Somewhat important/confident", "4 = Moderately important/confident", and "5 = Very important/confident". Linear regression was conducted with adjustment of potential confounders of sex, age, education, years of working in medical units, received respiratory-related specialist training [c]Respiratory-related specialist training refers to a recognised post-registration certificate/diploma course/master's degree in respiratory-related specialist training, including respiratory, emergency, geriatric, and critical care Difference between two subgroups: *p<0.05, **p<0.01, ***p<0.001 Effect size (Cohen's d): small = 0.20, moderate = 0.50.

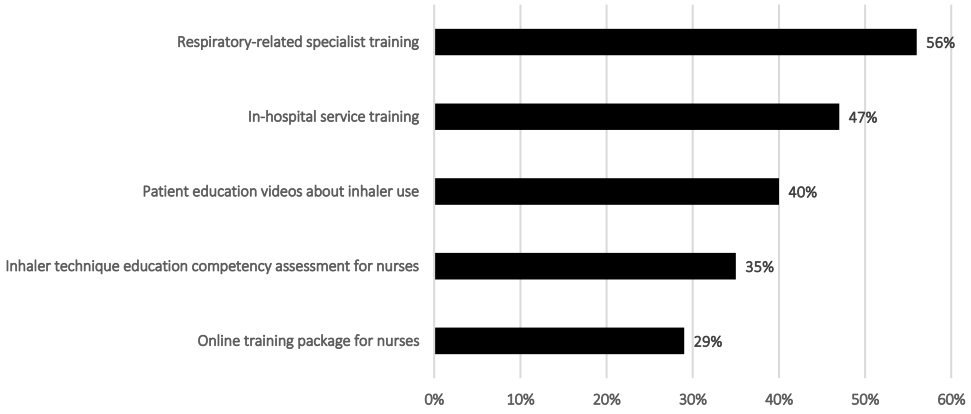

Figure 3 Nurses' training needs and required supports for patient inhaler education.

Our study also documented common errors across different phases of inhaler use. In the preparatory phase, the most frequent mistake, identified in 92% of cases, was failing to check the expiry date. While this error rate is high, few other studies have explored this aspect of inhaler preparation. During the pre-inhalation phase, our findings indicate that the most prevalent error, occurring in 88% of instances, was not exhaling fully and away from the mouthpiece before inhaling. This finding aligns with two systematic reviews, which reported that 75% and 79% of COPD patients did not fully exhale before using pressurised metered-dose inhalers (pMDIs)[10] and dry powder inhalers (DPIs),[16] respectively. In the inhalation phase, we observed that 89% of COPD patients did not hold their breath after inhaling, a mistake also noted in other studies with error rates ranging from 37% to 63%.[3,8,13,15] Consistently, a review reported no full exhalation before dosing and poor inhalation technique were the common errors in using different inhalers.[14] For the aftercare phase, failing to clean the spacer once a week was noted in 85% of cases. However, while most studies have concentrated on inhalation techniques and related errors, there has been less focus on the errors in the preparation and aftercare phases. Previous research has documented that limited health literacy is associated with lower medication adherence and poorer self-management outcomes,[20,21] which showed the importance of patient education and the quality of education conducted by professionals.

Our study also revealed that although nurses recognised the importance of inhaler education for COPD patients, they felt less confident, less practised in discussing inhaler use with patients and less assessed patients' inhalation techniques. This is particularly true for nurses with less experience in medical units or those without respiratory-related specialist training. Researchers suggest that nurses need to be more self-aware of their practices and take responsibility for maintaining competence in assessing patients' inhaler techniques through regular training. This would allow them to retain and refresh their knowledge and skills.[22] Hsiao et al highlighted the importance of shared decision-making when selecting an inhaler device; discussions with patients could lead to fewer inhaler errors, improved adherence, greater patient satisfaction, and a stronger willingness to continue with the initially prescribed inhaler for newly diagnosed COPD patients.[23] Scullion J. suggested that inhaler competency is crucial for effective self-management of asthma and COPD.[14] As primary contacts for these patients, nurses play a pivotal role in educating both patients and caregivers to optimise disease control and must be well trained to take their responsibilities.[14]

Training and clinical experience are pivotal in providing effective inhaler education. Luley et al suggested that training with a video demonstration of inhalation techniques and video-based teach-to-goal intervention could improve patients' inhaler use and technique and lead to better symptomatic control.[24,25] Professional bodies should be responsible for enhancing training and supporting clinical practice. Thus, Hong Kong Respiratory Nursing College, a professional body of respiratory nursing, has prepared a series of videos demonstrating how to use different types of inhalation devices, which helps healthcare professionals teach inhaler use and assist COPD patients in revising the correct steps and identifying common errors. These resources can be accessed via the HKRNC website.[26] Supplementary Figure 1 shows the leaflet with QR codes to access the demonstration videos of different inhalers. These videos have been widely promoted locally and globally to healthcare professionals and COPD patients in hospitals and communities.

Swami et al suggested that nurses with adequate training can improve their competency in assessing and teaching correct inhaler techniques to their patients and provide personalised education. This could help reduce the incidence of inhaler use errors and effectively manage COPD.[22] The information highlights the critical need for structured respiratory-related specialist training programs to improve nurses' competency in assessing and educating patients on proper inhaler techniques. Such specialised training has been limited to more experienced nurses within the Hospital Authority, leaving junior nurses and those outside the Hospital Authority without access to this important education. To address this gap, a local university is now offering a Master's degree program in the specialisation of Advanced Respiratory Nursing to provide a valuable opportunity for nurses to enhance their knowledge and skills in respiratory nursing care through a comprehensive curriculum.[24] By equipping nurses with advanced respiratory assessment and patient education capabilities, this program might help reduce the incidence of inhaler use errors and lead to more effective management of conditions like COPD. Ultimately, the master's program might advance clinical respiratory services and improve the overall quality of patient care.

The major strength of this study is its comprehensive survey of different phases of inhaler use, including preparation, pre-inhalation, inhalation, and aftercare. Additionally, the study explored nurses' perceptions of COPD patients' inhaler use based on their clinical experience rather than relying on patients' self-reported practices. This approach helps to eliminate the optimistic bias inherent in self-assessments. These findings have significant clinical implications. Healthcare providers can tailor subsequent patient education efforts more effectively by identifying COPD patients' common errors. This targeted approach allows for addressing specific issues directly, thus potentially improving inhaler technique, enhancing medication adherence, and ultimately leading to better disease management and outcomes, such as reducing the frequency of hospital visits and healthcare costs associated with poorly managed COPD.

There are several limitations to our study. Firstly, the online survey included a limited number of questions, offering a simplified overview of observed errors. This approach may not capture all potential issues, such as coordination between inhalation and actuation with metered-dose inhalers. Secondly, the common errors in inhaler use among COPD patients were surveyed based on nurses' perceptions rather than directly assessing patients' inhaler techniques. Indeed, conducting a comprehensive assessment of patients' inhaler use is the most effective and appropriate method to identify patient errors in inhaler use. Although this process is time-consuming and resource-intensive, it is crucial because it provides targeted, patient-centred education to improve the accuracy of inhaler use, enhance treatment efficacy and patient outcomes, and ultimately reduce the frequency of hospital visits and healthcare costs associated with poorly managed COPD. Thirdly, various factors contribute to the high error rate among patients, such as age, manual dexterity, cognitive impairment, personal preference, ease of use, and the specific medication required.[23]

Conclusion

High rates of inhaler use errors in COPD patients have been observed by nurses, highlighting the importance of enhanced monitoring and targeted interventions to improve inhaler techniques. The confidence and practice of nurses in educating patients about inhaler use strongly correlate with their work experience in medical units and respiratory-related specialist training. These findings suggest a pressing need for focused training programs to enhance nurse competency in patient education, ultimately aiming to improve patient outcomes.

Data Sharing Statement

The data used in this study are available from the corresponding author upon reasonable request.

Acknowledgments

The authors would like to thank the nurses who participated in our study and the support from Hong Kong Respiratory Nursing College for questionnaire distribution, the support from Hong Kong Respiratory Nursing College and Hong Kong Thoracic Society for the use of the leaflet with QR codes to show the correct use of inhalers, and Hong Kong Metropolitan University for the support of the manuscript publications.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

No funding support.

Disclosure

The authors report no conflicts of interest relevant to this work.

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