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Assessment of inhaler techniques and the impact of critical errors on clinical outcomes

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***Abstract*---**Introduction: The use of inhaled medications remained as the pillar in pharmacological management of asthma and chronic obstructive pulmonary disease. Incorrect inhalation technique can impact drug delivery to the lung, compromised bronchodilation and lead to deteriorated disease control and worse disease outcomes. However, devices for inhaled medications can be difficult to learn and prone to mishandling despite presence of newer and more user-friendly inhalers. Objectives: This study aimed to assess and compare between patients' self-rated confidence with their actual technique in using inhalers This study also aimed to determine factors associated with incorrect inhalation technique and impact of inhaler critical errors on clinical outcomes. Methodology: This was a cross-sectional study among patients with chronic respiratory disease who were users of inhalers, who visited outpatient pharmacy department and respiratory clinic, Serdang Hospital from 15th July to 15th August 2019. The patients were screened using convenient sampling according to inclusion and exclusion criteria. Pertinent data and inhalation techniques were identified during interview sessions. Results and discussion: Nearly a third of the patients who were confident with their inhalation technique had incorrect inhalation techniques and performed critical errors. Patients who were still working and those who have attended medication therapy adherence clinic (MTAC) before have a significant better inhalation technique. Paradoxically, patients with a better inhalation technique seems to

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have higher frequency of exacerbation. However, these patients had exacerbation triggered by respiratory infections. Conclusion: Patients who had used inhalers for longer time were overconfident with their inhalation technique. Therefore, periodic assessment of inhalation techniques should be conducted among long-standing inhaler users for referral to pharmacist counselling services such as the respiratory MTAC for benefits on better inhaler use.

***Keywords*---**inhaler techniques, pharmacist, disease control.

Introduction

Background

There is a growing burden in morbidity, quality of life and healthcare costs from asthma. Globally, around 300 million of population are affected by asthma and it is estimated to increase to 400 million by the year of 2025 due to increase in urbanisation and atopic disorders (Capstick, 2013; Hashmi, Soomro, Memon, & Soomro, 2012). In Asia, asthma is more pronounced in the South-east Asia and the Western Pacific regions, where there is an estimated 107 million sufferers (Price et al., 2016).

Inhaled therapy remains the cornerstone therapy in respiratory diseases and is the primary treatment for both asthma and COPD (Capstick, 2013; D. et al., 2018; Parreira et al., 2014). The inhalation route has advantages over oral or parenteral route in the treatment of obstructive airway diseases, such as rapid onset and minimal side effects. The ease in medication access to the bronchoalveolar system promote high local concentrations at the targeted sites with lower total dosage needed to achieve targeted effects, thereby reducing the risk of adverse effects as compared with systemic therapy (Price et al., 2018; Darba et al., 2016; Hashmi, Soomro, Memon, & Soomro, 2012). However, among the success in the treatment of chronic airways disease, only 10% of the treatment accounts from medication, and the rest of 90% is dependent on patients' inhalation technique (Ilic et al., 2016).

The inhaler requires patients to have sufficient technical skills to allow optimal drug distribution after administration. These skills include inhalation of a suitable volume of drug, rhythm of inhalation, length of inspiratory apnea following administration of medicine and the coordination between breathing cycle and the activation of device (Hashmi et al., 2012).

'Critical errors' are which the errors are likely to significantly impair the delivery of adequate medication to the lungs, and 'non-critical' errors, which are likely to result in a reduced in amount of drug reaching the lungs, compared with that will be attained using the correct technique. There is no universal standardised definitions and steps that are classified as critical error, although most published literature defined critical errors almost similarly. Previous literatures concluded that both MDIs and DPIs users were equally likely to make critical errors, depending on the study design and the population sampled (Usmani et al., 2018).

Issue of accurate inhalation technique is of critical importance in maintaining optimal asthma and COPD control, especially when inadequate inhalation technique is found to be the leading cause of therapy failure (Chrystyn & Price, 2009; Price et al., 2018). Even with correct technique, less than one fourth of dose is deposited in lung, with most deposited in the oropharynx (Chorão, Pereira, & Fonseca, 2014; Hashmi, Soomro, Memon, & Soomro, 2012). Incorrect handling of inhalers and inappropriate inhalation technique or failure to perform one or more required steps, result in suboptimal or zero respirable fraction of the emitted dose for lung deposition of the drug and resulted in failure of allowing pharmacological effects to occur (Janežič, Locatelli, & Kos, 2019). These will then contribute to poor diseases stability and control, thereby potentially leading to symptom exacerbation and decreased health-related quality-of-life (Hashmi et al., 2012; Lee et al., 2014; Parreira et al., 2014). Furthermore, the poor inhalation technique may lead to unnecessary and repeated ED visits and hospitalisations as well as becoming an economic burden to the society (Hashmi, Soomro, Memon, & Soomro, 2012; Ilic et al., 2016).

The role of healthcare professionals in educating inhaler use is critical, both in achieving initial correct inhaler technique and in maintaining this correct inhaler use over time. Inhaler technique training delivered to patients by healthcare professionals is important in terms of the nature, frequency and skill level demonstrated. Only 15-69% of healthcare professionals (across all disciplines) can demonstrate correct inhaler use (D. Price et al., 2013).

It was noticed that inhaler technique was worse in patients who did not receive education regarding inhaler technique (66.5% versus 86.4%). Only a low proportion of patients received inhaler use education and an even smaller proportion of patients have their inhaler technique reviewed over time (Price et al., 2013). Despite previous education, studies demonstrated that the number of patients making errors was still considerably high, and this was found to be decreased significantly at follow-up after instruction had been provided (Harnett et al., 2014). Approximately half of patients who initially received education on how to use their inhalers properly, do not maintain this correct technique over time (Price et al., 2013).

Thus, this study sought to evaluate the inhalation technique among patients with chronic respiratory diseases, to assess and compare patient's self-rated confidence and patient's actual technique in using inhaler and to determine factors associated with incorrect inhalation technique among patients using inhaler.

Methods

This study was conducted while patients were waiting at the respiratory clinic and outpatient pharmacy department of a Malaysian tertiary government multi-specialty hospital with 620 beds capacity. This research was conducted through a cross-sectional study with convenient sampling, from 15th July 2019 to 15th August 2019. The data was collected through interview session with patients and review of patients' medical records together with their follow-up booklets upon

receiving consent.
Potential patients for recruitment into the study were screened from the respiratory clinic register. Patients' medical records was reviewed one day prior patients' visit to clinic. Patients identified from the clinic register were approached individually for further questioning to ascertain whether they met the inclusion criteria. Patients who were having prescriptions with inhalers were also recruited from the outpatient pharmacy department.

Adult patients aged 18 years and above with chronic respiratory illnesses, attended respiratory clinic or outpatient pharmacy department during the study period and used the following inhalers: MDI and/ or Turbuhaler® and/ or Respimat® and/ or Accuhaler®, for at least 1 year were included in this study. All patients who fulfilled the criteria and those who were able to understand instructions were interviewed and requested to demonstrate their inhalation technique. Patients who were using reliever inhalers only were excluded from this study in order to allow observation of impact on disease outcomes which are mediated by controller inhalers.

Patients' medical records were screened from the electronic hospital information system and medical follow-up booklet. Demographic characteristics were collected from patients' electronic medical records and the information below were retrieved prior or during the interview session:

a) Age, gender, race, weight and height

b) Marital status

c) Diagnosis requiring inhalers and the years of disease

d) Past medical and medications history

e) Years of using preventer inhalers and the number of inhalers used

The patients were interviewed upon receiving their consent. The interview sessions and the assessments of inhalation technique was conducted by the researcher. The average time taken needed for the completion of each interview session was between 10 to 15 minutes. During the interview sessions, the following information was obtained from patients and their care takers:

a) Occupation and educational level

b) Smoking status and the amount cigarettes smoked per day

c) Side effects experienced after the use of inhalers

d) Whether patient receive previous inhalation instructions

e) Whether patient receive inhalation instructions within the past 1 year

f) History of exacerbation within the past 1 year.

g) PEFR reading

h) Adherence to the inhaler

i) Patient's self-confidence on inhalation technique

j) Patient's inhalation technique

Disease symptoms control was assessed by interviewing the patients in accordance to the COPD assessment test (CAT) (Jones et al., 2009), for patients with COPD, and Asthma Control Test (ACT) (Nathan et al., 2004) was used to assess asthma symptom control over the previous 4 weeks for patients with asthma.

Patients' disease control was categorized into 3 groups: well-controlled, not well-controlled and poorly controlled. Patients with CAT of low impact of disease on health status and ACT of well controlled asthma were categorized as having a well-controlled disease, CAT of medium impact and ACT of not well controlled asthma were categorised as not well-controlled disease, while CAT of high impact and ACT of very poorly controlled asthma were categorised as as poor controlled disease.

Adherence to inhaler devices was assessed by using 'test of the adherence to inhalers' (TAI) questionnaire (Gutiérrez-Pereyra et al., 2015)The questionnaire included 12 items with two main domains, the patient (items 1 to 10) and the health professional (items 11 and 12) domain. The scores for items 1 to 10 were answered directly from the patients' response. However, the scores for items 11 and 12 were given after assessment of inhaler techniques by the researcher. TAI was designed to identify non-adherent patients to their inhaler medications. For items 1 to 10, each item scored from 1 to 5 (where 1 was the worst possible score and 5 was the best possible score), with a range from 10 to 50. For items 11 and 12 of the health care professionals, it scored as 1 or 2 (where 1 was bad and 2 was good), with a range from 2 to 4. An erratic and deliberate non-adherent behavioural pattern was defined in the presence of scores ≤24 for items 1 to 5 and items 6 to 10, respectively. The forgetful pattern was defined in the presence of a score 1 in at least one of the number 11 or 12 items of the questionnaire.

Inhalation technique was assessed according to the presence of critical error. Critical error, was defined as errors that if performed by the patients, will cause a significantly impairment in delivery of adequate medication to the lungs on all occasions (Price et al., 2013; Usmani et al., 2018). When there was a presence of one or more critical errors, it was considered as performing an incorrect inhalation technique (Rootmensen, van Keimpema, Jansen, & de Haan, 2010). The correct steps and critical errors for MDIs, Accuhaler® and Turbuhaler® were defined as according to previous published literature (Press et al., 2011; Rootmensen et al., 2010).

The collected data was analysed by using Statistical Package for the Social Sciences (SPSS) software, version 24.0. For descriptive analysis, the results were

presented by frequency, percentage, mean and standard deviation, or median and interquartile range. Charts were also used to present the relevant results from analysis. Association between patient demographics factors or disease outcomes on inhalation techniques analysed by using Pearson's Chi-square test or non-parametric Fisher Exact test where appropriate. Results with a 95% confidence interval and a p-value of <0.05 were considered as a significant data.

All patients were fully informed about the details of research, including objectives of this research, methods, risk and benefits from the research stated in the patient's information sheets. Patients' consents were obtained prior collection of data. This research did not involve any kind of blood or tissue sampling and posed minimal potential health risk to the patients.

The participation of patients was on voluntarily basis. Patients were free to withdraw anytime, without affecting their subsequent treatment. All particulars of the patients remained private and confidential, reviewed only by related researchers. Research findings did not interfere with patient's clinical management. Relevant data will be anonymous during publication. No personal information was and will be disclosed, and subjects will not be identified when the findings of this study are published. Patients' data will be kept for 3 years and be confiscated in an appropriate manner afterward. This research has received ethical approval from the Malaysian Research Ethics Committee (NMRR-19-501-46230).

Results

The demographic data of all 53 patients have been studied, which include age, gender, race, BMI, marital status, smoking status, educational level, their working status and the number of comorbidities, diagnosis requiring the use of inhalers, duration of disease, duration of using inhalers, number of inhaler types, received usage instruction when the inhaler was started and within the 1 year, attendance to respiratory MTAC and patients' adherence to inhaler use were also recorded. Patients' demographic characteristics are outlined in table 1.

Table 1: Demographic data of patients using inhalers.

Characteristics	Number (%)			
	Total N (%) (n = 53)	Asthma (*n* = 29)	COPD (n = 18)	ACOS (n = 6)
Age				
Mean ± SD (years)	57.0 ± 15.9			
<50 years old	14 (26.4)	13 (92.9)	1 (7.1)	0 (0)
≥50 years old	39 (73.6)	16 (41.0)	17 (43.6)	6 (15.4)
Gender				
Male	27 (50.9)	6 (22.2)	15 (55.6)	6 (22.2)
Female	26 (49.1)	23 (88.5)	3 (11.5)	0 (0)

Race				
Malay	33 (62.3)	22 (66.7)	9 (27.3)	2 (6.1)
Chinese	14 (26.4)	4 (28.6)	8 (57.1)	2 (14.3)
Indian	6 (11.3)	3 (50.0)	1 (16.7)	2 (33.3)
BMI				
Mean ± SD (kg/m²)	27.1 ± 6.9			
Normal (<18.5: Underweight 18.5 – 24.9: Normal)	25 (47.2)	12 (48.0)	10 (40.0)	3 (12.0)
25.0 – 29.9 Overweight	12 (22.6)	8 (66.7)	3 (25.0)	1 (8.3)
≥30 Obese	16 (30.2)	9 (56.3)	5 (31.3)	2 (12.5)
Smoking status				
Never smoke	26 (49.1)	25 (96.2)	1 (3.8)	0 (0)
Ex smoker	20 (37.3)	2 (10.0)	13 (65.0)	5 (25.0)
Current smoker	7 (13.2)	2 (28.6)	4 (57.1)	1 (14.3)
Working status				
Working	14 (26.4)	11 (78.6)	2 (14.3)	1 (7.1)
Retired/ Not working	35 (66.0)	14 (40.0)	16 (45.7)	5 (14.3)
Student	4 (7.5)	4 (100)	0 (0)	0 (0)
Educational level				
Postgraduate/ Professional/ University degree	16 (30.2)	8 (50.0)	6 (37.5)	2 (12.5)
Secondary	29 (54.7)	19 (65.5)	7 (24.1)	3 (10.3)
Primary/ None	8 (15.1)	2 (25.0)	5 (62.5)	1 (12.5)
Duration of disease				
Median ± IQR (years)	10.0 ± 25.0			
<20	36 (67.9)	17 (47.2)	15 (41.7)	4 (11.1)
≥20	17 (32.1)	12 (70.6)	3 (17.6)	2 (11.8)
Duration using inhalers				
Median ± IQR (years)	7.0 ± 10.0			
<20	37 (69.8)	18 (48.6)	15 (40.5)	4 (10.8)
≥20	16 (30.2)	11 (68.8)	3 (18.8)	2 (12.5)
Number of comorbidities				
0	17 (32.1)	13 (76.5)	3 (17.6)	1 (5.9)
1	16 (30.2)	9 (56.3)	6 (37.5)	1 (6.3)
≥2	20 (37.7)	7 (35.0)	9 (45.0)	4 (20.0)

	Total N (%) (n = 27)
Years of smoking (n = 26)	
Mean ± SD (years)	35.9 ± 20.0
Cigarette/ day	
Median ± IQR (stick)	20.0 ± 36.0

There was a total of 64 preventer inhalers prescribed to 53 patients requiring inhalers for their diseases. Table 2 outlined patient's exposure to inhaler instructions and patient's adherence to their inhaler regimen. The test of inhaler adherence (TAI) consisted of 2 sections: the first section assessed on patient's self-reported adherence to their inhaler regimens and the second section is the healthcare personnel's report on patient's adherence to their inhaler regimen.

Table 2: Patients' exposure to education on inhalation technique and adherence to inhalers.

Characteristics	Number (%)				
	Total N = 64	MDI (n = 26)	Turbuhaler (n = 10)	Accuhaler (n = 16)	Respimat (n = 12)
Diagnosis required inhalers					
Asthma	31 (48.4)	14 (45.2)	8 (25.8)	8 (25.8)	1 (3.2)
COPD	24 (37.5)	8 (33.3)	1 (4.2)	7 (29.2)	8 (33.3)
ACOS	9 (14.1)	4 (44.4)	1 (11.1)	1 (11.1)	3 (33.3)
Number of inhalers					
1	43 (67.2)	20 (46.5)	8 (18.6)	9 (20.9)	6 (14.0)
>1	21 (32.8)	6 (28.6)	2 (9.5)	7 (33.3)	6 (28.6)
Previous inhaler technique education					
Yes	61 (95.3)	25 (41.0)	8 (13.1)	16 (26.2)	12 (19.7)
No	3 (4.7)	1 (33.3)	2 (66.7)	0 (0)	0 (0)
Inhaler technique education within 1 year					
Yes	39 (60.9)	16 (41.0)	5 (12.8)	10 (25.6)	8 (20.5)
No	25 (39.1)	10 (40.0)	5 (20.0)	6 (24.0)	4 (16.0)
Attended MTAC respiratory					
Yes	23 (35.9)	11 (47.8)	2 (8.7)	6 (26.1)	4 (17.4)

No	41 (64.1)	15 (36.6)	8 (19.5)	10 (24.4)	8 (19.5)
Self-reported adherence level					
≤24: Non-adherent	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
>24: Adherent	64 (100)	26 (40.6)	10 (15.6)	16 (25.0)	12 (18.8)
Healthcare personnel reported patient adherence level					
Presence of one score of 1: Non-adherent	44 (68.8)	19 (43.2)	8 (18.2)	11 (25.0)	6 (13.6)
Absence of one score of 1: Adherent	20 (31.3)	7 (35.0)	2 (10.0)	5 (25.0)	6 (30.0)

Majority of the patients (81.1%) were prescribed with 1 type of inhaler whereas only 1.9% of patients received 3 different types of inhalers that needed different inhalation. Four different types of inhalers use were assessed in this study: pressurised MDI, Turbuhaler® and Accuhaler® dry powder inhalers and Respimat®, a soft mist inhaler. The frequency distribution of types of inhalers prescribed are detailed in Figure 1.

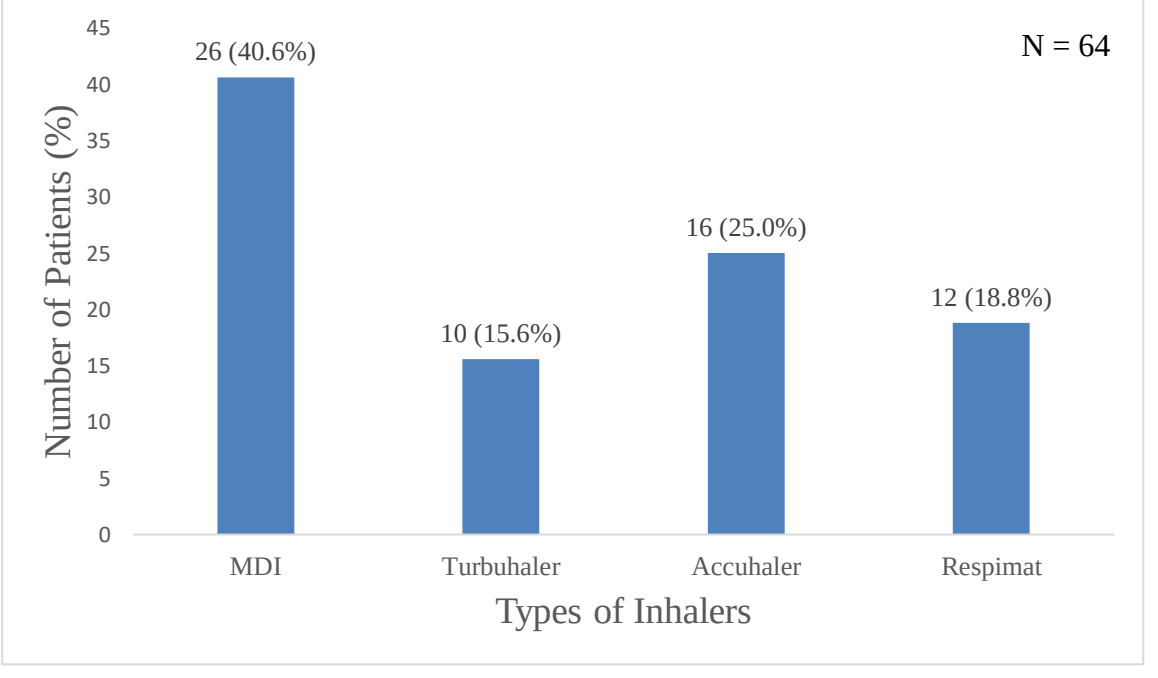

Figure 1: Frequency of types of inhalers prescribed to patients.

Majority of the patients (67.2%) demonstrated correct steps of inhalation technique based on having demonstrated at least 75% of correct steps but worryingly, 45.3% demonstrated critical errors (Table 3).

Table 3: Inhalation technique for inhaler types.

Technique	Total N = 64	MDI (n = 26)	Turbuhaler (n = 10)	Accuhaler (n = 16)	Respimat (n = 12)
Correct steps					
≥75%	43 (67.2)	14 (53.8)	8 (80.0)	13 (81.3)	8 (66.7)
<75%	21 (32.8)	12 (46.2)	2 (20.0)	3 (18.8)	4 (33.3)
Median ± IQR (%)	80 ± 28				
≥1 critical error (s)					
Yes	29 (45.3)	14 (53.8)	4 (40.0)	4 (25.0)	7 (58.3)
No	35 (54.7)	12 (46.2)	6 (60.0)	12 (75.0)	5 (41.7)

Majority of the patients using MDIs, Turbuhaler®, Accuhaler® and Respimat® strongly agreed with the statement "I am confident that I know how to use this inhaler correctly" (Table 4).

Table 4: Patients' self-rated score of confidence on inhalation technique

Self rated score "I am confident that I know how to use this inhaler correctly"	Total N = 64	MDI (n = 26)	Turbuhaler (n = 10)	Accuhaler (n = 16)	Respimat (n = 12)
1 Strongly disagree	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2 Disagree	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3 Neutral	7 (10.9)	5 (19.2)	1 (10.0)	1 (6.3)	0 (0)
4 Agree	20 (31.3)	8 (30.8)	3 (30.0)	6 (37.5)	3 (25.0)
5 Strongly agree	37 (57.8)	13 (50.0)	6 (60.0)	9 (56.3)	9 (75.0)

37 patients who answered strongly agree to have the confident that they knew

how to use the inhalers correctly, 32.4% patients had poor inhalation technique with total correct steps of <75%. There existed a clear discrepancy between patient's confidence with actual performance of correct steps in using inhalers.

Patients who received instruction on inhalation technique during initiation of inhalers and those who received instruction within the past 1 year showed had more absence of critical error than those who did not receive the instructions (Table 5).

Table 5: Association between patients' characteristics to presence of critical error in inhalation technique.

Characteristics	Presence of critical error		X^2 stat (df)	p-value
	Yes (n = 29)	No (n = 35)		
Age				
<50 years, *n* (%)	6 (40.0)	9 (60.0)		
≥50 years, *n* (%)	23 (46.9)	26 (53.1)	0.223 (1)	0.770[a]
Educational level				
Postgraduate/ Professional/ University degree	7 (36.8)	12 (63.2)		
Secondary	17 (54.8)	14 (45.2)		
Primary/ None	5 (35.7)	9 (64.3)	2.206 (2)	0.353[a]
Diagnosis requiring inhalers				
Asthma	14 (45.2)	17 (54.8)		
COPD	11 (45.8)	13 (54.2)		
ACOS	4 (44.4)	5 (55.6)	0.006 (2)	1.000[a]
Number of comorbidities				
0	11 (57.9)	8 (42.1)		
1	5 (26.3)	14 (73.7)		
≥2	13 (50.0)	13 (50.0)	4.211 (2)	0.125[a]
Duration using inhalers				
<20	20 (43.5)	26 (56.6)		
≥20	9 (50.0)	9 (50.0)	0.222 (1)	0.781[a]
Number of inhalers				
1	19 (44.2)	24 (55.8)		
>1	10 (47.6)	11 (52.4)	0.067 (1)	1.000[a]
Type of inhalers				

MDI	21 (55.3)	17 (44.7)		
DPI	8 (30.8)	18 (69.2)	3.738 (1)	0.074[a]
Previous inhaler technique education				
Yes	27 (44.3)	34 (55.7)		
No	2 (66.7)	1 (33.3)	0.582 (1)	0.586[b]
Inhaler technique education within 1 year				
Yes	16 (41.0)	23 (59.0)		
No	13 (52.0)	12 (48.0)	0.740 (1)	0.447[a]
Attended MTAC respiratory				
Yes	10 (43.5)	13 (56.5)		
No	19 (46.3)	22 (53.7)	0.049 (1)	1.000[a]
Self-reported adherence level				
≤24: Non-adherent	0 (0)	0 (0)		
>24: Adherent	29 (45.3)	35 (54.7)		**

a: Pearson Chi-square

b: Fisher Exact

*: Significant, $p<0.05$

**: All patients were adherent according to self-reported adherence level. No statistics were computed as self-reported adherence is a constant.

Interestingly, those who performed less critical errors had more respiratory exacerbations, hospital admissions and ED visits than those who performed more critical errors (Table 6), although findings were statistically insignificant.

Table 6: Association between presence of critical errors in inhalation technique and clinical outcomes over the past 1 year.

Clinical Outcomes	Presence of critical error			
	Yes (n = 29)	No (n = 35)	X^2 stat (df)	p-value
Exacerbation				
Never	12 (41.4)	12 (34.3)		
1	3 (10.3)	6 (17.1)		
2-3	3 (10.3)	2 (5.7)		
>3	11 (37.9)	15 (42.9)	1.330 (3)	0.785[b]

Hospital admission				
Never	19 (65.5)	22 (62.9)		
1	6 (20.7)	5 (14.3)		
2-3	4 (13.8)	5 (14.3)		
>3	0 (0)	3 (8.6)	2.583 (3)	0.515[b]
ED visits				
Never	17 (58.6)	18 (51.4)		
1	5 (17.2)	5 (14.3)		
2-3	2 (6.9)	6 (17.1)		
>3	5 (17.2)	6 (17.1)	1.580 (3)	0.686[b]
Near fatal respiratory event				
-Intubation				
-ICU admission				
Never	28 (96.6)	30 (85.7)		
1	1 (3.4)	3 (8.6)		
2-3	0 (0)	2 (5.7)		
>3	0 (0)	0 (0)	2.094 (2)	0.443[b]
PEFR from expected (%)				
Green (80-100)	5 (17.2)	6 (17.1)		
Yellow (50-79.99)	13 (44.8)	14 (40.0)		
Red (<50)	11 (37.9)	15 (42.9)	0.182 (2)	0.944[a]
Disease control	N = 55			
Well controlled	8 (32.0)	8 (26.7)		
Not well controlled	12 (48.0)	15 (50.0)		
Poor controlled	5 (20.0)	7 (23.3)	0.214 (2)	0.882[a]

a: Pearson Chi-square

b: Fisher Exact

*: Significant, $p<0.05$

Discussions

More than half (54.7%) of the patients using inhaler were diagnosed with asthma, followed by 34% patients with COPD and the rest of 11.3% with ACOS. Majority of the inhaler users are male patients. More males aged ≥ 50 years had a diagnosis of COPD. Asthma was the most prevalent chronic respiratory disease, affecting an estimated 358 million people in 2015. COPD was half as common, with 174 million people affected in 2015 although it is associated with higher disease burden (Soriano et al., 2017). Majority of the patients with asthma were having the disease for 20 years or more, while most COPD patients were having the disease for less than 20 years. They have been using their preventer inhalers for a

median year of 7.0 ± 10.0, with majority of them (69.8%) used it for less than 20 years.

49.1% of the patients reported to have never smoked before. However, 37.3% of the patients were ex-smokers and 13.2% were currently smoking. Among ever smokers (n = 26), mean smoking years was 35.9 ± 20.0 years with median of 20.0 ± 36.0 cigarettes a day. The frequency of COPD being diagnosed was higher among patients with history of smoking and current smoking. Active and current smoking has been confirmed as one of the known risk factors for COPD (Afonso, Verhamme, Sturkenboom, & Brusselle, 2011; de Marco et al., 2013; Musafiri et al., 2011). Majority of the patients received their education up to secondary level (54.7%) whereas 15.1% of the patients had their education up to primary level or some had never received any formal academic education before. The link between having chronic respiratory diseases with education or employment is mediated by income level, living conditions and urbanization and its associated pollution (Musafiri et al., 2011).

Most of the patients were suffered from other comorbidities besides the chronic respiratory diseases. 37.7% patients were having 2 or more comorbidities, while 30.2% patients were having one other comorbidity. The 3 most common comorbidities among patients were hypertension, dyslipidaemia and diabetes mellitus, in line with 3 most common non-communicable diseases and their risk factors in Malaysia among ages 50 years and above are hypertension (32.7% and 51.1%), dyslipidaemia (29.1% and 41.8%) and diabetes (18.8% and 27.7%) (National Health and Morbidity Survey 2018: Elderly Health, Ministry of Health Malaysia).

Majority of patients (96.2%) had received education from the pharmacists regarding the inhalation technique upon initiation of an inhaler. More than half of the patients received education on inhalation technique within the past 1 year. Most of the patients did not attend to the respiratory MTAC before, with only 39.6% of the patients having follow-up under respiratory MTAC.

MDI was the most common type of inhaler being prescribed to the patients as preventer inhaler in the maintenance therapy, which occupied a 40.6% of the total inhalers prescribed. Among a variety of inhalers available in the market, pMDI is found to be widely prescribed globally. The reason of it might explained by its low cost and widespread availability of medications delivered by such inhaler (Lavorini et al., 2011). Patients' characteristics can be used as guidance for the selection on types of inhaler devices. Among population of COPD patients with poor lung function parameters and elderly who usually have reduced ability to inhale efficiently, the choice on an inhaler device without the need of breath actuation is preferred (Ding, Small, Scheffel, & Holmgren, 2018).

The type of inhaler devices being prescribed was dependent on the type of patients encountered in the clinical practice. Patients being referred to pulmonologist tending to be more severely affected by their diseases and the pulmonologists might needed to prescribe more combination medication products, which are more readily available in DPIs (Ding et al., 2018). Most of the patients were using only 1 preventer inhaler (67.2%). Up to 95.3% of the patients

went through education on inhalation technique during initiation of inhaler use. In the Malaysian government hospitals, patients are taught with the correct technique of using their respective inhaler when patients were newly prescribed with an inhaler. 60.9% of the patients had received counselling on inhalation technique within the past one year. Re-education was given within the one-year period due to prescription with an additional inhaler as part of maintenance therapy or change in types of inhalers for the therapy. Additionally, some patients received extra counselling session if the pharmacists detected there was error in inhalation technique during dispensing of inhalers.

Despite all patients self-reporting to be adherent with their inhalers use as much as 68.8% of the patients were considered as non-adherent to the inhalers by the healthcare professional, when patients presented with critical errors in inhalation technique or having remembered the frequency and dose of the inhaler's administration wrongly. This demonstrated discrepancies between patient's perceived adherence and healthcare perceived patient adherence. When judging according to patients-reported adherence only, healthcare professionals might mistakenly think that patients' disease were controlled and stepped down the treatment when patients actually did not utilize the medications fully. Hence, both patients' self-reported and healthcare personnel reported adherence in TAI score should be recorded to allow better and more accurate decision on disease management using inhalers Majority of non-adherent cause were due to improper inhalation technique and performance with critical error during inhaler usage, rather than remembering to take inhalers during prescribed time.

The result was in line with the previous study that demonstrated an association between adherence and inhalation technique where poor adherence was linked with poor inhalation technique instead of forgetfulness (Kocks et al., 2018). Asthma patients had a higher rate of inhaler adherence when compared to COPD patients. "Unconsciously non-adherent behaviour" was more common among patients with COPD. Unconsciously non-adherent behaviour is related to misunderstanding of the therapeutic regimen or incorrect inhalation technique, which are the circumstances that may be more frequently presented in older and less educated patients. Older adults consistently manifested poorer recall of prescription information than young adults (Plaza et al., 2016).

In several wide-scale studies involving respiratory outpatients who have been using an inhaler device for at least one month found that, the largest number of inhalation technique errors were made in MDIs, with the majority of patients (65.7%) having poor technique (Aydemir, 2015; Melzer et al., 2017). A similar finding was found in this present study. Patients using MDIs shown to have a higher rate of inhalation technique errors than those who are using DPIs. MDIs are claimed to be more difficult to be used than DPIs, as it required a greater motor coordination while inhaling slowly and deeply together with great cognitive function, leading to a higher proportion of inhalation technique errors (Aydemir, 2015; Parreira et al., 2014). Patients who had been using their inhalers for longer duration were overconfident on their own technique and caused an elevated number of errors in inhalation technique (Arora et al., 2014). Patients have the tendency to have difficulty in recall the informed instruction after a period of time. Hence, inhalation technique education is necessary to be repeated regularly as it

was found to have decreased error frequency among patients and have positive impacts on disease and clinical outcomes (Hashmi et al., 2012; Usmani et al., 2018). Lack of repeated patient education and the often rushed and poor quality follow-up education with almost always less than 10 minutes duration, might be the reason that there was still large amount of patients presented with poor inhalation technique despite initial intensive patient education (Hashmi et al., 2012; Yildiz, 2014).

An explanation can be the lack of relationship between inhaler techniques and efficacy of medication delivery through inhalers but rather exacerbation that led to hospital admission or ED visit triggered by respiratory infections instead of worsening in disease stage, as recorded in the medical record system in hospital. Moreover, a previous study had found that patients with history of exacerbation demonstrated a significant increase in adherence and attention to their inhalers use (Duangrithi, Saiprom, SaeTew, & Sa-u, 2017). Intensive and repeated training during hospitalisation might cause the improvement in inhalation technique (Duangrithi et al., 2017). No association was found between performance of critical errors during inhaler use with disease control in this study. However, poor inhalation technique was associated with suboptimal disease control, disease instability and increased hospital visits in previous published literature (Bosnic-Anticevich et al., 2018). The dissimilarity of findings in this present study may be due to the limited sample size.

Limitations

Certain information was obtained through interview session with the patients. Information like years of disease, years of using preventer inhalers and whether patients received previous inhalation instruction were not recorded in the medical record system. Furthermore, past medical and medication history, patients' utilization of healthcare facilities was not known when the patients were not having follow-up visit or admitted to Serdang Hospital. Hence information was vulnerable to recall bias from the relevant patients.

This study was conducted only in a single health facility and had presented a limited sample size. Parameter such as changes in patients' symptoms over certain observation period and disease were not recorded. This issue had made the decision difficult on whether the patients experienced a worsening of disease condition or due to the severe disease stage itself. Additionally, as data was collected at one point of time, better or poorer inhaler techniques may have presented at different period over time.

Other inhaler devices that were not included in this current study can be further investigated in the future. The errors and difficulties found during usage of the inhalers by the elderly such as limited dexterity also deserve more research attention.

Conclusions

This small study found that the majority of patients at a tertiary government hospital were currently prescribed with 1 type of inhaler device with MDI as the

most common inhaler type being prescribed. Patients had received education on inhalation technique during initiation of inhaler use and had received repeated education within the past 1 year. Despite this, almost a third of the patients were found to be overconfident with their inhalation technique when being assessed. Periodic assessment of inhalation techniques should be conducted among long-standing inhaler users for benefit of better inhalation technique.

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