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Pharmacist role in optimizing asthma management for inpatients in Jordan

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ABSTRACT

Asthma remains poorly controlled for many due to poor inhaler technique. This study evaluated the effectiveness of pharmacist-led inhaler technique education for 116 asthma inpatients in Jordan. Patients were divided into three groups: active 1 received education with a checklist label attached to their inhaler, active 2 received education with initial incorrect steps highlighted on the checklist label, and a control group received standard care. Asthma symptom control (assessed via the asthma control test questionnaire (ACT)), quality of life (assessed via the mini asthma quality of life questionnaire (mini AQLQ)), and adherence (assessed via the adult asthma adherence assessment questionnaire (AAAQ)) were assessed at baseline, pre-discharge, and three months later. Significant improvements were observed in inhaler techniques, with mean follow-up scores for ACT and mini AQLQ increasing notably. After three months, the mean difference in inhaler technique score between the groups was significant (0.711, $p < 0.001$). This study demonstrates that a simple, pharmacist-led intervention is feasible and can significantly improve inhaler technique and asthma outcomes in hospitalized patients.

Keywords: inhaler technique, asthma control, asthma adherence, quality of life, hospitalized asthma patients, Jordan

INTRODUCTION

Asthma is a chronic inflammatory disease in the airway impacting all age groups according to the GINA report 2018 [1]. Its prevalence is increasing in many countries [2]. Asthma is still poorly controlled among many people [3]. Unfortunately, asthma is common and relatively high in developing countries [4, 5]. Many established management guidelines and effective medication have been found, however, asthma is still uncontrolled through a large proportion of patients [6, 7]. Poor inhaler technique can be considered one of the causes of uncontrolled asthma [8, 9].

Uncontrolled asthma has many causes, including poor adherence, poor asthma education, and poor inhaler technique [10, 11]. Incorrect inhaler technique is associated with poorer asthma control and risk of exacerbation [12, 13].

This problem appears common across the spectrum of inhaler devices, both dry powder inhaler such as Accuhaler (ACC, Diskus) and Turbuhaler (TH) and pressurized metered dose inhalers (pMDIs) [9, 14].

Proper use of the inhaler technique includes a series of steps that must be properly achieved to obtain good drug delivery [15]. Incorrect inhaler technique is associated with worse asthma results [16, 17].

Unfortunately, patients with poorer control suffer from a larger disease burden. Patients with uncontrolled asthma have a greater chance of using emergency services and hospitalization than patients with controlled asthma [18, 19]. Hospitalization is justified for patients who suffer from sustained or worsening distress during an asthma exacerbation or in patients when continuous asthma treatment is needed and cannot be relied upon after discharge [20].

Therefore this study was designed to show the effect of pharmacist education delivered to inpatients comparing education with a label attached to patient's inhaler, education with a label attached to patient's inhaler with their initial incorrect steps highlighted, and standard care. The effect of counselling on patient's inhaler technique, asthma control, adherence to medications, and quality of life was revealed at baseline and three months post education.

MATERIALS AND METHODS

This 6-month single-blind randomized groups (active group 1-active group 2-control group) study was conducted in 2019-2020. This study was conducted on hospitalized patients with asthma who were staying at a public hospital in Amman, Jordan, and using controller medication pMDI were approached by the researcher for participation. Ethics approval was obtained from hospitals at which the study was conducted, and patients gave written informed consent.

Inclusion criteria were:

(1) patients with asthma were diagnosed by a physician,

(2) patients 14 years and older,

(3) patients currently using inhaled corticosteroids with or without long-acting B2 agonist by MDI, and

(4) patients who were on the same medication and asthma dose for at least one month before study entry.

Exclusion criteria were:

(1) patients who do not speak or understand Arabic,

(2) patients who cannot return to all visits, or participate in another clinical study, and

(3) patients who do not self-administer their medication.

Baseline Assessment and Intervention

At baseline, questionnaires were used to collect data from 116 patients, developed by experts in the field and administered in Arabic questionnaire. The questionnaires included patient demographic data, an asthma control test (ACT) questionnaire [21], mini asthma quality of life questionnaire (mini AQLQ) [22], adult asthma adherence assessment questionnaire (AAAQ) [23], , and factors affecting adherence [24], and spirometry measurements recorded using the Micro Medical Spiro USB from Viasys, assessing patients' lung function FVC, FEV1 and PEF measurements.

After randomization, patients' technique with their MDI was assessed by a trained researcher, and validated inhaler technique checklists [14, 25], translated into Arabic. Patients in active group 1 ("education + inhaler label") after education had a checklist label attached to their preventer inhaler without highlighting their initial incorrect steps, but in active group 2 ("education + inhaler label + highlight incorrect steps") after education had a checklist label attached to their preventer inhaler highlighting their initial incorrect steps. Patients in the control group (were educated after the study was completed) only recieved the usual standard care provided at the hospital. The checklist for the MDI device consisted of 9 steps (potential score 0-9). MDI steps contain three steps that were classified as "essential" (steps without which little or no medication would reach the airway) [25].

Post-discharge intervention and assessment

After one month, the researcher sent a mobile message to all participants to remind them about correct inhaler use, control groups only received a message to check their health in general. Three months after the baseline visit, the researcher made a telephone call to all participants to assess their inhaler technique and asked them to complete their asthma control, quality of life, and medication adherence questionnaires. After the final assessment, all patients in all groups including the control group were re-trained on correct inhaler technique.

Sample Size Calculations

The determination of the sample size was based on the primary results variable of the inhaler technique scores improvement before and after education based on previous work in this area [8, 25], for three treatment groups: active group 1 ("education + inhaler label"), active group 2 ("education + inhaler label + highlighting incorrect steps"), and for the control group (received standard care).

To detect a significantly different change in inhaler technique score of 1 point, with a level of significance of 5%, power of 80%, with a standard deviation (SD) of change of 1.4 points based on a previously published data [26], a sample size of 32 patients in each group was needed in this parallel study, with a dropout rate calculation of 20%, sample size of 116 patients was needed to be recruited (around 40 patients was in each group).

Statistical Analysis

For continuous variables, we employed the mean (M) ± SD, while categorical variables were represented using frequencies (percentages %). To examine the correlation between demographic, clinical, and genetic variables with study groups,

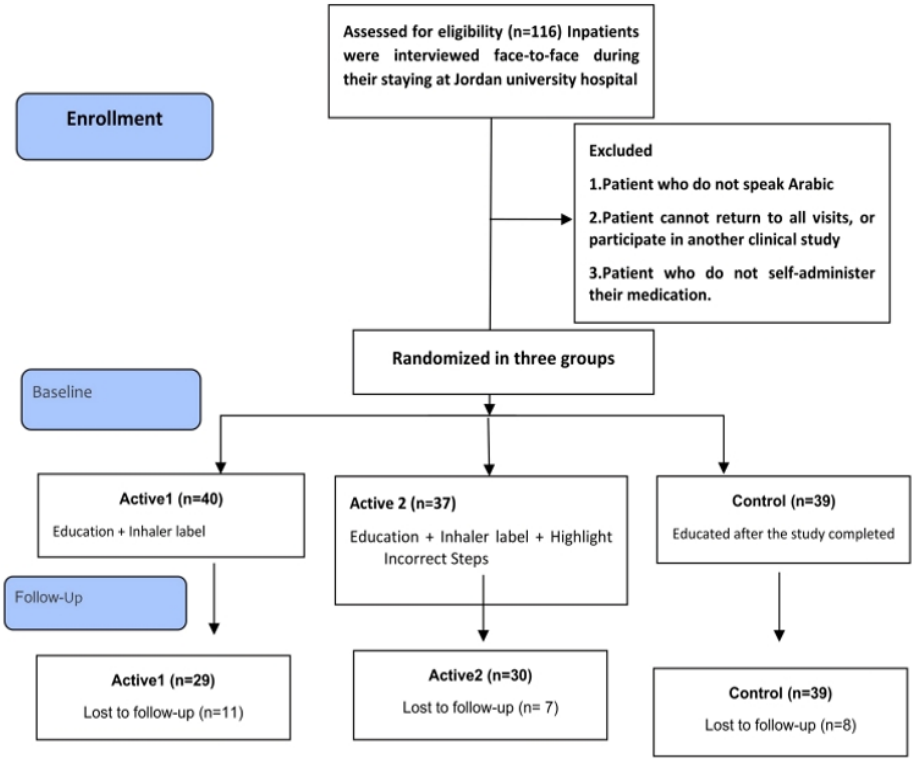

Figure 1. Patient groups and selection criteria (Source: Authors' own elaboration)

Table 1. Demographic and clinical characteristics of included patients

Parameter	Active 1 (n = 40)	Active 2 (n = 37)	Control (n = 39)	Total (n = 116)	p-value
Age (year), M ± SD	51.510 ± 17.376	49.920 ± 16.238	48.280 ± 18.947	49.790 ± 17.464	0.768**
Gender, n (%)					0.302*
Male	8 (20.0)	11 (29.7)	6 (15.4)	25 (21.6)	
Female	32 (80.0)	26 (70.3)	33 (84.6)	91 (78.4)	
BMI, n (%)					0.429*
Underweight	0 (0.0)	0 (0.0)	2 (5.1)	2 (1.7)	
Normal weight	8 (20.0)	8 (21.6)	9 (23.1)	25 (21.6)	
Overweight	16 (40.0)	15 (40.5)	10 (25.6)	41 (35.3)	
Obese	16 (40.0)	14 (73.8)	18 (46.2)	48 (41.4)	
Acute and chronic medical problems, n (%)					0.138*
Positive	25 (62.5)	25 (67.6)	18 (46.2)	68 (85.6)	
Negative	15 (37.5)	12 (32.4)	21 (53.8)	46 (41.4)	
Family and social history, n (%)					0.355*
Yes	24 (60.0)	23 (62.2)	29 (74.4)	76 (65.5)	
No	16 (40.0)	14 (37.8)	10 (25.6)	40 (34.5)	
Marital status, n (%)					0.779*
Married	28 (70.0)	26 (70.3)	21 (53.8)	75 (64.7)	
Single	7 (17.5)	7 (18.9)	10 (25.6)	24 (20.7)	
Widow	4 (10.0)	3 (8.1)	6 (15.4)	13 (11.2)	
Divorce	1 (2.5)	1 (2.7)	2 (5.1)	4 (3.4)	
Past medical/surgical history, n (%)					0.570*
Positive	26 (65.0)	25 (67.6)	22 (56.4)	73 (62.4)	
Negative	14 (35.0)	12 (32.4)	17 (43.6)	43 (37.1)	
Smoking status n (%)					0.176*
Smoke	5 (12.5)	3 (8.1)	2 (5.1)	10 (8.6)	
Never smoked	26 (65.0)	32 (86.5)	31 (79.5)	89 (76.7)	
Quit smoking	9 (22.5)	2 (5.4)	6 (15.4)	17 (14.7)	

Table 2. ACT means score and mini AQLQ mean score at baseline (N = 116)

Parameter	Active 1 (n = 40)	Active 2 (n = 37)	Control (n = 39)	Total (n = 116)	p-value
Very poor controlled asthma (5-15)	39 (97.5)	36 (97.3)	38 (97.4)	113 (97.4)	0.998*
Not-well controlled asthma (15-20)	1 (2.5)	1 (2.7)	1 (2.6)	3 (2.6)	
Well-controlled asthma (≥ 20)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.9)	
M ± SD	8.330 ± 2.664	8.190 ± 2.952	8.080 ± 2.517	8.200 ± 2.690	0.920**
Symptoms domain, M ± SD	1.680 ± 0.854	1.529 ± 0.710	1.640 ± 0.939	1.619 ± 0.837	0.722
Activity limitation domain, M ± SD	2.400 ± 0.868	2.220 ± 0.950	2.170 ± 1.036	2.270 ± 0.951	0.531
Emotional function, M ± SD	5.730 ± 1.678	6.045 ± 1.394	5.598 ± 1.890	5.787 ± 1.667	0.494
Environmental stimuli, M ± SD	1.200 ± 0.592	1.315 ± 0.702	1.461 ± 1.248	1.328 ± 0.894	0.455
Total domain, M ± SD	2.750 ± 0.571	2.722 ± 0.562	2.682 ± 0.791	2.717 ± 0.646	0.901

Note. *One-way ANOVA

the Wilcoxon (Mann-Whitney U) and one-way ANOVA tests were employed for continuous variables, while the Chi-squared (X^2) and Fisher-exact tests were used for categorical variables with a category count of less than 5. The significance level was set at a p-value of < 0.05. All analyses were carried out using the R software package (version 4.3.1) with the glm and gtsummary packages.

RESULTS

Demographic and Clinical Characteristics

The study included 116 patients, divided into three groups: active 1 (n = 40), active 2 (n = 37), and control (n = 39) (**Figure 1**). The mean participants' age was 49.79 (17.64) years. Gender distribution across the groups showed 25 (21.6%) males and 91 (78.4%) females. Body mass index (BMI) classifications indicated 2 (1.7%) underweight, 25 (21.6%) normal weight, 41 (35.3%) overweight, and 48 (41.4%) obese participants. No significant differences were found in demographic and clinical characteristics across the groups (p > 0.05) (**Table 1**).

Asthma Control

Baseline ACT scores revealed that 113 (97.4%) participants had very poorly controlled asthma. The mean ACT score across all participants was 8.20 (2.69), indicating poor asthma control among the cohort at the study's commencement. The distribution of ACT scores showed no significant differences between groups (**Table 2**).

Quality of Life

The mini AQLQ scores at baseline were similar across groups, with total domain scores averaging 2.72 (0.65). The domains of symptoms, activity limitations, emotional function, and environmental stimuli showed no significant differences in baseline scores among the groups (p > 0.05) (**Table 2**).

Medication Adherence

Assessment of medication adherence through the AAAQ indicated that 32 (27.6%) participants scored 1 (suggesting possible adherence issues), while 84 (72.4%) scored less than 1. The mean adherence score was 1.72 (0.45), with no significant difference observed between the groups (**Table 3**).

Table 3. Adult asthma adherence questionnaire barrier score at baseline (n = 116)

Questions	Active 1 (n = 40)	Active 2 (n = 37)	Control (n = 39)	Total (N = 116)	p-value
I follow my asthma medication plan					0.852***
Score = 1	12 (30.0)	9 (24.3)	11 (28.2)	32 (27.6)	
Score < 1*	28 (70.0)	28 (75.7)	28 (71.8)	84 (72.4)	
M ± SD	1.700 ± 0.435	1.760 ± 0.435	1.720 ± 0.456	1.720 ± 0.449	
I forget to take at least one dose of my inhaled steroids each day					0.987***
Score ≤ 3**	7 (17.3)	Score ≤ 3**	7 (17.3)	Score ≤ 3**	7 (17.3)
Score > 3	33 (82.5)	Score > 3	33 (82.5)	Score > 3	33 (82.5)
M ± SD	1.830 ± 0.385	M ± SD	1.830 ± 0.385	M ± SD	1.830 ± 0.385
My asthma is mild and does not require regular preventive treatment					0.941***
Score ≤ 4**	4 (10.0)	Score ≤ 4**	4 (10.0)	Score ≤ 4**	4 (10.0)
Score > 4	36 (90.0)	Score > 4	36 (90.0)	Score > 4	36 (90.0)
M ± SD	1.900 ± 0.304	M ± SD	1.900 ± 0.304	M ± SD	1.900 ± 0.304
My inhaled steroid causes side effect					
Score ≤ 3**	8 (20.0)	6 (16.2)	10 (25.6)	24 (20.7)	0.593***
Score > 3	32 (80.0)	31 (83.8)	29 (74.4)	92 (79.3)	
M ± SD	1.800 ± 0.405	1.840 ± 0.374	1.740 ± 0.442	1.740 ± 0.407	
I can't afford my inhaled steroid medication					
Score ≤ 3**	0 (0.0)	1 (2.7)	0 (0.0)	1 (0.9)	0.341***
Score > 3	40 (100)	36 (97.3)	39 (100)	115 (99.1)	
M ± SD	2.000 ± 0.000			1.990 ± 0.093	

Note. *Suggest possible adherence problem; **Indicated probable specific barrier; & ***X^2 test

Table 4. Inhaler technique score out of 9 at baseline (n = 116)

Baseline	Number	Mean	Standard deviation	Minimum	Maximum	p-value*
Active 1	40	7.380	1.234	5	9	0.710
Active 2	37	7.510	0.870	5	9	
Control	39	7.590	1.332	4	9	
Total	116	7.490	1.161	4	9	

Note. *One-way ANOVA

Table 5. Comparing AQLQ mean score between baseline and follow up

Variables	Pre-mean ± standard deviation	Post-mean ± standard deviation	p-value*
Symptoms domain	1.670 ± 0.887	2.930 ± 0.811	≤ 0.001
Activity limitation domain	2.290 ± 0.970	2.970 ± 1.205	≤ 0.001
Emotional domain	5.837 ± 1.687	6.425 ± 0.886	≤ 0.001
Environmental domain	1.363 ± 0.980	1.490 ± 0.738	≤ 0.001
Total	2.763 ± 0.674	3.350 ± 0.554	≤ 0.001

Inhaler Technique

The evaluation of the inhaler technique scored out of 9, showed a mean score of 7.49 (1.16) across all participants. Scores ranged from 4 to 9, with no significant differences between groups (**Table 4**).

Post-Intervention Improvements

Significant improvements were noted in the AQLQ scores from baseline to follow-up. The symptoms domain improved from 1.67 to 2.93, the activity limitation domain from 2.29 to 2.97, the emotional domain from 5.837 to 6.425, and the environmental domain from 1.363 to 1.49 (**Table 5**).

Medication adherence (AAAQ) also showed significant improvements, with a reduction in barriers to following medication plans (from 27.6% to 18.9%, p = 0.021) and forgetting to take medication (from 18.1% to 10.0%, p = 0.008) (**Table 6**).

Table 6. Comparing AAAQ barrier at baseline and follow up

Question	Baseline (n = 119)	Follow-up (n = 90)	p-value **
Follow medication plan			0.021
Barrier present, n (%)	32 (27.6)	17 (18.9)	
Barrier absent, n (%)	84 (72.4)	73 (81.1)	
p-value*	0.852	0.744	
Forget			0.008
Barrier present, n (%)	21 (18.1)	9 (10.0)	
Barrier absent, n (%)	95 (81.9)	81 (90.0)	
p-value*	0.987	0.710	
Need			1.000
Barrier present, n (%)	11 (9.5)	8 (8.9)	
Barrier absent, n (%)	105 (90.5)	82 (91.1)	
p-value*	0.941	0.399	

Note. *X^2 test & **McNemar test

Table 6 (Continued). Comparing AAAQ barrier at baseline and follow up

Question	Baseline (n = 119)	Follow-up (n = 90)	p-value **
Side effect			1.000
Barrier present, n (%)	24 (20.7)	18 (20.0)	
Barrier absent, n (%)	92 (79.3)	72 (80.0)	
p-value*	0.593	0.288	
Cost			
Barrier present, n (%)	1 (0.9)	1 (1.1)	1.000
Barrier absent, n (%)	115 (99.1)	89 (98.9)	
p-value*	0.341	0.364	

Note. *X^2 test & **McNemar test

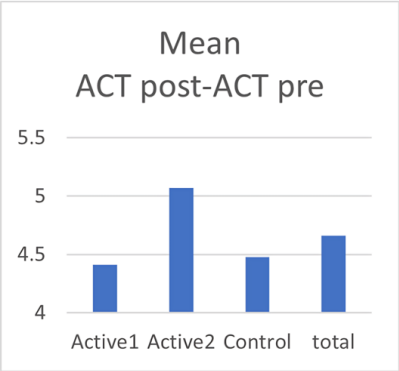

Figure 2. Mean difference between follow up and baseline of ACT score (Source: Authors' own elaboration)

The mean differences in ACT scores from baseline to follow-up showed a significant enhancement in asthma control post-intervention (**Figure 2**).

Inhaler Technique Mean Score Analysis

Both active groups demonstrated significant improvements in their inhaler technique mean scores from baseline to follow-up, with active 1 showing a mean change of 0.897 (SD = 1.012, p ≤ 0.001) and active 2 showing a mean change of 1.067 (SD = 0.961, p ≤ 0.001) (**Table 7**). The control group exhibited a smaller yet significant change of 0.194 (SD = 0.402, p = 0.012). Overall, the total cohort saw a mean change of 0.711 (SD = 0.824, p ≤ 0.001), indicating a significant improvement in inhaler technique post-intervention.

Comparing essential inhaler technique mean score at baseline and follow-up, active group 1 improved from 2.52 (SD = 0.688) to 2.76 (SD = 0.435), with a change mean of 0.241 (SD = 0.511, p = 0.017). The active 2 group's scores rose from 2.50 (SD = 0.682) to 2.83 (SD = 0.379), reflecting a change mean of 0.333 (SD = 0.661, p = 0.010). The control group showed no change, maintaining scores at 2.52 (SD = 0.724). The total group's scores significantly increased to 5.70 (SD = 0.550) from 2.51 (SD = 0.691), with a change mean of 0.189 (SD = 0.495, p ≤ 0.001), highlighting a substantial improvement in essential inhaler technique skills (**Table 8**).

DISCUSSION

Main Findings

To the best of our knowledge, the present single-blind randomized controlled study is the first to evaluate the role of pharmacists in educating inpatients with asthma to correctly use their inhaler devices. This study is different from any previous study as for the first time it compares the effect of an intervention on inhaler technique education using inhaler labels highlighting patient's incorrect technique steps before education versus labels not highliting patient's incorrect techique steps before education versus a control group where patients only recieved the standard hospital care (no inhaler technique education). Our results showed that asthma inpatients' inhaler technique improved significantly after 3 months for all patients regardless of the type of intervention.

However, the study showed that participants who had novel personalized inhaler technique labels highlighting the error they initially performed on the technique labels placed on their inhalers after training had significantly better inhaler techniques after 3 months than those who had only inhaler technique labels without highlighting their error and those who didn't receive any educational intervention. With personalized labels highlighting patient's baseline errors, 70% were able to demonstrate the correct technique at follow-up, compared with 44.8% of those who received inhaler labels without highlighting their error and only 38.7% of patients who did not receive educational intervention. In addition to these

Table 7. Comparing inhaler technique mean score at baseline and follow-up

Groups	M (SD) at baseline	M (SD) at follow up	Change M (SD)	p-value within the same group*
Active 1	7.380 ± 1.208	8.280 ± 0.751	0.897 ± 1.012	≤ 0.001
Active 2	7.600 ± 0.814	8.670 ± 0.547	1.067 ± 0.961	≤ 0.001
Control	7.650 ± 1.380	7.840 ± 1.319	0.194 ± 0.402	0.012
Total	7.540 ± 1.153	8.260 ± 0.983	0.711 ± 0.824	≤ 0.001

Note. *Paired t-test

Table 8. Comparing essential inhaler technique mean score at baseline and follow-up

Groups	M (SD) at baseline	M (SD) at follow up	Change M (SD)	p-value within the same group*
Active 1	2.520 ± 0.688	2.760 ± 0.435	0.241 ± 0.511	0.017
Active 2	2.500 ± 0.682	2.830 ± 0.379	0.333 ± 0.661	0.010
Control	2.520 ± 0.724	2.520 ± 0.724		-
Total	2.510 ± 0.691	2.700 ± 0.550	0.189 ± 0.495	≤ 0.001

Note. *Paired t-test

vital outcomes, this study revealed improvements in asthma symptom control, quality of life, and adherence for patients in all study groups at follow-up compared with baseline. Such results indicate the vital role pharmacists can play in improving asthma control and quality of life regardless of the detailed intervention delivered. With that said the active group who received the intervention with highlighted labels showed a trend of higher improvements when compared to the other two study groups.

Interpretation of Findings With Previously Published Work

Poor inhaler technique is a major problem that contributes to the risk of asthma exacerbation and hospitalization, and maintaining the correct technique over long term requires time and resources for repeated education. This study demonstrates that maintaining the correct inhaler technique with metered-dose inhalers can be enhanced by attaching a personalized inhaler technique label, highlighting each patient's wrong steps performed before education. The inhaler technique label represents an inexpensive, feasible, and expandable intervention that increases the clinical efficacy of inhaler training and has the potential to extend the resulting improvement in asthma outcomes.

This pre/post-intervention study found that among patients who were hospitalized for asthma, few had the correct inhaler technique. Although many patients reported that they received some training on the inhaler technique while entering the respiratory ward, the inhaler technique was still not correct. However, the inhaler technique was significantly improved by the "show-and-tell" educational intervention provided by the pharmacist at baseline, and significant improvements in inhaler technique were maintained at 3 months after post-discharge compared to the baseline.

In this study, the pharmacist participated in an educational intervention on inhaler technique at a public hospital in Jordan. The study revealed the effectiveness of a simple educational intervention led by a pharmacist on inhaler technique and clinical outcomes for asthma patients, including asthma control, quality of life, and medication adherence.

Participants in this study were evaluated shortly after admission to the hospital due to asthma, baseline inhaler technique scores were relatively the same (mean score 7.54 out of 9), compared with baseline scores of 7.76 in a previous study conducted on inpatients with asthma in Jordan using the same checklists [7, 27]. Such outcomes are considered high scores. This indicates that the incorrect inhaler technique may not be the primary reason for the current hospitalization [27].

In this study, results show that pharmacists in hospitals can play a vital role for patients with asthma. Moreover, previous research has suggested that the main source of patients' inhaler technique education was their specialists and pharmacists [28, 29]. The role of pharmacists is highlighted further by the findings that showed that education was mostly provided to asthma patients when they started using their inhalers [29, 30]. And in general, the inhaler technique was not checked regularly [27]. Hence, pharmacists can provide education regularly and assess patients' techniques when the patient picks up their inhaler refill prescription.

Many studies have shown that the inhaler technique can be corrected through a variety of educational methods like "show and tell", which drops off after education in the short term [31]. Applying personalized technique labels on the inhaler after education results in better maintenance of the correct inhaler technique over 3 months, compared to education alone. This hypothesis was proven for the first time in this study. Thus, inhaler technique labels can increase the efficiency of inhaler education in both the short term and the long term [26].

The novel inhaler labels investigated in this study are important tools for personalizing inhaler education, by highlighting incorrect technique step/s for each inpatient. The labels offer a simple visual cue that can provide daily personalized instruction to patients, and act as a constant reminder of correct technique [8]. At a 3-month follow-up, patients in active group 2 (initial incorrect technique steps highlighted) had better inhaler technique scores than patients in the control group and active group 1. Personalizing treatment has shown effectiveness when it comes to maintaining the correct inhaler technique three months after patient education.

The most common errors in the use of pMDI in our study were step 7 (continue slow and deep inhalation), step 6 (inhale slowly and press canister), and step 5 (put mouthpiece between teeth and lips). Other previous studies also identified the same steps (steps 7, 6, and 5) as the most common errors made by pMDI users [16, 32-34]. With significant improvements in these steps, the inhaler technique was maintained after 3 months when compared to the baseline.

The ACT was validated in the Arabic language and used to assess the intervention conducted in this study [21]. ACT is a reliable and valid questionnaire often used to assess asthma control in clinical care settings [35], which reflects the patient's condition over the past 4 weeks. A cutoff score of 19 or less identifies patients with poorly controlled asthma [36].

The three-month follow-up results confirm that poor asthma control is common among recent hospitalized asthma patients, regardless of socioeconomic background and place of living [11].

Improving patients' inhaler technique skills has been shown previously to improve asthma outcomes, including lung function [8, 12, 37]. In the present study, asthma symptom control over the previous 4 weeks, assessed by ACT, improved markedly in all patients, with a mean improvement of more than twice the minimal important difference of 3.0 [38], and with no difference between randomization groups. Contributory factors may include that the study was conducted in a medium-resource country in which few patients have access to asthma education [9], and most patients had very poorly controlled asthma at baseline, giving substantial room for improvement following any educational intervention; improved symptom control may also have led to improved adherence. Given the higher inhaler technique scores and lower reliever use based on patient's anecdotal comments and researcher notes in the active group at 3 months, longer follow-up may have revealed a difference between groups in symptom control or exacerbations [26].

This study showed both face-to-face surveys and and personalized education effectiveness with assessment happening after three months using the mobile phone call survey (which was decided to be done due to the coronavirus pandemic).

Quality of life was measured using a "mini AQLQ" [39]. The AQLQ contains questions divided into four domains with a two-week recall period, which included an assessment of activity limitation, symptoms of asthma, exacerbations due to

environmental stimuli, and emotional disturbances due to illness. Higher scores indicate a better quality of life [39,40]. The mini AQLQ (all domains and total scores) distinguishes between patients who suffer an exacerbation of their asthma which requires the use of hospitalization compared to other patients [41]. In this study the mini AQLQ mean scores at baseline for hospitalized patients were significantly low in all groups with no statistical difference between groups. This showed that asthma exacerbation and hospitalization are strongly associated with patients' quality of life. So, the baseline AQLQ reflected the exacerbation that resulted in the patient's hospitalization.

Improving inhaler techniques have been shown in previous research to improve asthma symptoms and quality of life [8, 12, 37]. In this study, all patients improved concerning the quality of life but a significant difference between the interventional groups was not found indicating a lack of association between inhaler technique improvements and quality of life improvements.

Patient adherence to medication may be improved by reminder-based interventions, such as the labels used in this study. Strategies aimed at improving medication adherence behavior should target the underlying barriers to adherence [42]. The AAAQ is used as an adherence screening test for asthma drug-related barriers with five questions that reflect general and specific barriers. The presence of any barrier, especially more than one, indicates the necessity to initiate a discussion between the physician and the patient about adherence in general and the specific barriers identified [23]. More studies will be necessary to provide additional validation data in more diverse population groups and to show that interventions in response to adherence problems identified by these questions improve asthma outcomes. The intervention delivered in this study led to improvements in all patients' adherence, hence the personalized inhaler technique intervention, although led to a minimal improvement in the adherence score, it did not lead to a significant improvement when compared to the control group. Further research studies are needed to investigate the reasons behind this finding.

Strengths and Limitations of This Study

Strengths of the present study include rigorous checking of inhaler technique using published checklists [25]; the use of a brief 'show-and-tell' inhaler technique intervention that is feasible and effective [8, 14, 43]; use of a validated measure of asthma symptom control, quality of life, adherence and factors affecting adherence; and the assessment of inhaler technique shortly after admission, and follow-up after 3 months, by a researcher blinded to the participants in three randomized groups.

Limitations include the unusually high baseline inhaler scores, improvements seen at follow-up might be due to factors other than the inhaler intervention, including recovery from the index exacerbation. Data was collected from Amman (the capital city of Jordan) only; hence the results of the study are not generalizable to the rest of Jordan. The pandemic coronavirus episode delayed face-to-face follow-up assessment which might have changed or decreased the outputs expected otherwise.

CONCLUSION

Poor inhaler technique is a major problem for patients hospitalized with asthma in Jordan. In this study, we showed that attaching personalized labels to the inhaler devices and highlighting the patient's technique error was a successful technique in significantly improving and maintaining improved inhaler technique three months after hospital discharge. All patients who participated in the study, whether in the control group, inhaler label group, or inhaler label with a highlight of errors group, improved significantly concerning their ACT scores, adherence, and quality of life. The significant difference in improved inhaler technique that resulted from using the highlighted labels did not show a significant association with patients' ACT, adherence, and quality of life, which could be due to the setting of the study.

Quality of life assessment indicated improvements in the mean of mini AQLQ activity limitation, symptom, emotional, and environmental domains for all patients in all the groups. In the analysis of the AQLQ domains comparing the three groups, it was observed that there was no statistically significant change observed between the three groups at baseline, nor at follow-up.

Assessment of adherence showed a similar pattern, revealing a significant improvement in the 'follow medication plan question' for all patients, while the other items in the adherence questionnaire showed no significant improvements; comparing the three groups together, although all patients improved with regards to their adherence to treatment, no significant difference was found for any of the adherence items at follow up.

Finally, knowing the importance of having correct inhaler technique for patients with asthma, this study concludes that using inhaler technique labels attached to the patient's inhaler and highlighted with the patient's own performed incorrect steps is vital. Hence, the intervention conducted in this study was successful in answering the main aim of the research, which is to improve patient's inhaler technique skills at baseline and follow up using personalized inhaler technique labels attached to the patient's controller inhaler.

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