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Research Article

Assessment of Inhaler Technique among Asthmatic Children at Pediatric Asthma Clinics, Khartoum State, 2018

Amna Muawia Eltayeb Ahmed*, Einas Ahmed Abdelraheem Hassan and Rawya Ismail Mohamed Elbakri

Community Medicine Department, Faculty of Medicine, University of Khartoum, Omdurman, Khartoum State, Sudan

***Corresponding Author:** Amna Muawia Eltayeb Ahmed, Community Medicine Department, Faculty of Medicine, University of Khartoum, Omdurman, Khartoum State, Sudan.

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Abstract

Introduction: Asthma is a heterogeneous disease, usually characterized by chronic airway inflammation. it's a public health problem for both high income countries and developing countries as in Sudan where the study has been conducted its ranked as the fifth cause of hospital admissions. The concerning in asthma was mainly in managing its symptoms and inhalers take a critical role in that but inadequate inhaler technique is the leading cause of therapy failure and thus in this study we assess inhaler technique in Sudanese asthmatics children and their caregiver.

Objective: The aim of this study was to assess inhaler technique among asthmatic children and their caregiver at pediatric asthma clinics in Khartoum state.

Methods: This was descriptive cross-sectional hospital-based study conducted in pediatric asthma clinics in Khartoum state from November 2018 to October 2019. The inhaler technique was assessed using validated checklist inhaler devise assessment tool and the characteristics of their inhaler, usage of it and the parameters that affecting the technique was collected using a self-designed questionnaire. The data was collected from 165 participants and their data with high confidentiality was analyzed by using SPSS version 22.

Results: The children mean age was (mean = 8.63 SD = 4.074) years (mean ± SD). The percentage of participants with correct inhaler technique was only 38.2% and all participants were using meter dose inhaler 77% were using it with spacer and mask. the incorrect technique regarding each device was 63.1% for meter dose inhaler and 61.1% for meter dose inhaler plus spacer and mask and the most frequent step with error was exhalation before inhalation 45.5%. associations were found between inhaler technique of children and their caregiver educational level (p-value = 0.030) also there was correlation between their caregiver knowledge about asthma and their technique (p-value = 0.042) and between their years of usage and inhaler technique (p-value = 0.023).

Conclusion: Inhaler technique was found poor among high proportion of children despite instructions was provided to them this contribute largely to poor asthma control. The technique was affected by caregivers' educational level and knowledge about the disease.

Keywords: *Asthma; Inhalers; Children; Inhalers Misuse*

Abbreviations

DALYs: Disability Adjusted Life Years; GINA: Global Initiative for Asthma; IDAT: Inhaler Device Assessment Tool; ICS: Inhaled Corticosteroid; LABA: Long-Acting Beta Agonist; MDIs: Metered Dose Inhalers; pMDIs: Pressurized Metered Dose Inhalers; DPIs: Dry Powder Inhal-

ers; BD: Positive Bronchodilator; FEV1: Forced Expiratory Volume; PEF: Peak Expiratory Flow; SABA: Short-Acting Beta2-Agonist; VHCs: Valve Holding Chambers; ACT: Asthma Control Test

Introduction

Asthma is a heterogeneous disease, usually characterized by chronic airway inflammation. It is defined by the history of respiratory symptoms such as wheeze, shortness of breath, chest tightness and cough that vary over time and in intensity, together with variable expiratory airflow limitation [1]. Asthma triggers by many stimuli it includes: Allergens including molds, animal dander and feathers. Environment and air pollution, occupational factors it could be wood and vegetable dust, pharmacological agent, industrial chemical, biological enzymes, Infections of the respiratory tract and Exercise. Those stimuli increase airway responsiveness and incite acute episode of asthma [2].

According to the trigger that induce asthma it lies in one of the following types: Atopic Asthma; asthmatic attack is preceded by allergic rhinitis, urticaria or eczema.

It usually begins in childhood, Non-Atopic Asthma; respiratory infection due to viruses and inhaled air pollution are common trigger a positive family history of asthma is less common, Drug-Induced Asthma; several pharmacological agents provoke asthma including aspirin and Occupational Asthma [3].

Childhood asthma (pediatric asthma) is the most common serious chronic disease in infants and children; yet is often difficult to diagnose in infants and children, asthma may appear as: Wheezing, Coughing, rapid breathing, labored breathing, chest tightness [4].

It is estimated that 4.3% of the population globally are affected by asthma by annual estimate rate and 9.5% among children [5], according to WHO estimates, 235 million people suffer from asthma, and it's the most common chronic disease among children [6]. It ranked 16th among the leading causes of years lived with disability and 28th among the leading causes of burden of disease [7] and this burden is growing over time as its prevalence is increasing up to 9.5% from 2005 to 2015 for both sexes and all ages [5], in 2014 asthma affected more than 300 million of the population [8] it contributes to 250,000 annual deaths [9] and in 2016, asthma, across all ages, contributed to 23.7 million DALYs (disability adjusted life years) globally [7] it's not just a public health problem for high income countries it occurs in all countries regardless of level of development. Over 80% of asthma deaths occurs in low and lower-middle income countries [6].

Regarding asthma burden in children it is estimated that Asthma is the most common chronic illness of childhood and a leading cause of pediatric hospitalization and disability in US [10] while in Sudan, Khartoum state 12.2% of children are affected by asthma [11].

The long-term goals of asthma management are to achieve good symptom control and to minimize future risk of exacerbations, fixed airflow limitation and side effects accordingly, asthma medications can be grouped into three categories: Controller medications: these are used for regular maintenance treatment. They reduce airway inflammation, control symptoms, and reduce future risks such as exacerbations and decline in lung function. Reliever (rescue) medications: these are provided to all patients for as-needed relief of breakthrough symptoms, including during worsening asthma or exacerbations. They are also recommended for short-term prevention of exercise-induced bronchoconstriction. Reducing and, ideally, eliminating the need for reliever treatment is both an important goal in asthma management and a measure of the success of asthma treatment. Add-on therapies for patients with severe asthma: these may be considered when patients have persistent symptoms and/or exacerbations despite optimized treatment with high dose controller medications (usually a high dose ICS (inhaled corticosteroid) and a LABA (long acting beta agonist) and treatment of modifiable risk factors [1].

Use of inhaler therapy allows drugs to rapidly reach high concentrations in the airways, with therapeutic effects even with low drug bioavailability and few adverse effects [12] making them the most popular management ways for asthma and they can be divided into four gropes: Pressurized metered dose inhalers (MDIs), Dry powder inhalers (DPIs), Inhalers with spacer devices and Nebulizers.

Randomized trials and a systematic review comparing metered dose inhaler to nebulizer have found similar efficacy when albuterol is administered via either route [13] in the other hand they found that (ICS) is the most efficacious agent for the control of airway inflammation and airway remodeling and the prevention of asthma death [14].

However even with effective inhaled therapy asthma remain poorly controlled worldwide one of the reasons for that is the improper inhaler use [15].

Accordingly, there is a lot of guidelines on inhaler use herby a summarized for the basic steps for every inhaler device: Removes cap. Correctly primes device. Exhales. Inhales appropriately for device. Holds breath [16].

Although asthma is a major cause of death worldwide according to the statistics (250,000 annual deaths) [9] most of this death and 75% of hospital admission for asthma is avoidable [17] many factors contribute to preventions of asthma complications includes effective asthma therapy, alongside appropriate drug usage which is achieve by prober inhalers use and adherence [15,18,19].

In Sudan asthma affects 12.2% of the children in Khartoum state [11] according to the federal ministry of health asthma ranks as the fifth cause of hospital admission following essential hypertension, moreover the frequency of children of age group [5,14] years in outpatient clinic is estimated 143342 cases in 2016 and in Khartoum state is 88953 cases in 2016 [20]. This statistics suggest that asthma burden is expanding even in the present of the effective therapy modalities.

Most patients (up to 70 - 80%) are unable to use their inhaler correctly [19,21] 14% to 90% of them do not use their pressurized metered dose inhaler correctly, whereas 50% to 60% misuse a dry powder inhaler [22].

Poor inhaler technique leads to poor asthma control, increased risk of exacerbations and increased adverse effects [23] there are plenty of factors that lead to this misuse including insufficient education [23,24] older age, and lack of instruction on inhaler technique by caregivers [19]. Inhaler devices are an important part of the armamentarium of clinicians who treat asthma. The efficacy of inhaled treatment depends on a proper inhaler technique and treatment adherence by the patients but most people with incorrect technique are unaware that they have a problem fortunately over 90% of studies reported a significant improvement in inhaler technique after intervention [25].

Aims and Objectives

In this study we aim to contribute of improvement of pediatrics asthma in Sudan by reveling their technique status. So, the objective of this study is to assess inhaler technique among asthmatics children and their caregivers at pediatrics asthma clinics in Khartoum state.

Materials and Methods

Study design

Descriptive, cross-section, hospital base study.

Study area

Pediatrics asthma clinics at Khartoum state: Mohamed Alamin Hamid pediatric Hospital in Omdurman (eastern Omdurman), the largest pediatrics hospital in Sudan, was established in 1986 with total area of 7200 square meters with length 120 meter and width 60 meter. The clinic was established in January 2013, consisted of two rooms, reception and waiting room for the patients and their caregiver, there is a screen used to display educational videos for the patients and their caregiver while waiting. The staff is composing of one pediatric

consultant, pediatric medical officer, 4 - 5 pediatric registrars and two nurses. The clinic receives patients referred from the hospital and from other pediatrics private and public hospitals in Khartoum and from outside Khartoum state. It is held in Wednesdays and received about 10 - 15 new patients per week and about 25 - 30 patients coming for their regular follow up. The clinic had a contact number and social media account through which the staff can communicate with the patients and their caregiver, send them educational material and reply for any queries about asthma and it is management once weekly and Ahmed Gasim pediatric Hospital in Bahri, the clinic consists of one room, reception, and waiting room for the patients and their caregiver. The staff is composing of one pediatric consultant and one registrar. The clinic receives patients referred from the hospital and from other pediatrics private and public hospitals in Khartoum and from outside Khartoum state. It is held in Wednesdays and received about 5 - 10 new patients per week and about 5 patients coming for their regular follow up.

Study population

All children males and females with maximum age of eighteen years attending referral asthma clinics at Mohamed Alamin Hamad and Ahmed Gasim pediatric hospitals.

Inclusion criteria

They should be diagnosed clinically by a physician with bronchial asthma according to diagnosis criteria in Sudan (GINA 2018) (global initiative for asthma) [1] and on prescription of asthma inhaler treatment for at least one month.

Exclusion criteria

To exclude infants because the diagnosis is difficult and wheezing is common in this age group, children with neurodisabilities because they have chronic lung diseases, patients who are in their first visit for the clinic to avoid bias because those patients receive the instruction of inhaler use on the first visit and Patients who use nebulizer as the main asthma inhaler.

Sample frame

Asthmatic children at pediatric asthma clinics in Khartoum state.

Sample method

Study areas were selected on the basis of their large catchment areas and the presence of asthma clinics serving only asthmatic patients (other hospitals in Khartoum have general chest clinics were the odds of catching a large number of asthma patients in time allocated for the study are low).

Based on the frequency of patients attending both clinics in a period of 4 weeks, a ratio of 2:1 was obtained and sample size was divided according to this ratio. 110 sample were collected from Mohamed Alamin Hamad hospital and 55 sample were collected from Ahmed Gasim hospital. Randomization was not applicable due to clinic setting and time constraint, therefore purposive sampling was conducted to all participants who met the inclusion criteria during the study period.

Sample size

Calculated using the following formula:

$$n = \frac{Z^2\ pq}{E^2}$$

Where:

n= Sample size.

Z= Level of confidence 95%.

p= Prevalence (estimated as 12.2).

q= 1-p.

E= Correction factor or maximum acceptable random sampling error (0.05).

The sample size was calculated is 165.

Data collection

Tool

1. IDAT (inhaler device assessment tool) checklists of the different inhaler devices to assess the practice of inhaler, the checklist assesses 5 critical steps to insure proper use of the devices.

2. Inhaler Device Assessment Tool (IDAT) it is Purpose was to assess proper techniques for the following inhaler devices: MDI, MDI plus spacer, MDI plus spacer with mask, Diskus, Turbuhaler. To teach nurses and healthcare providers, and children and their families about proper inhalation techniques for various inhaler devices. The IDAT assesses how well 5 critical steps are demonstrated when using an inhaler device, correctly prime the device, exhalation, inhalation and breath holding. It has form for each type of inhaler device; Form A1 is for all types of MDIs. Form A2 is for MDIs plus spacer with mask. Form A3 is for MDIs plus spacer. Form B is for Diskus and Turbuhaler.

3. In structural interview the information has been collected through questionnaire, the information included: demographic data, Knowledge about asthma. And sources of this knowledge, the usage of inhaler (reliver, controller, both), frequencies of usage according to prescription instruction adherence to instruction of usage and factor of not adhering, inhaler usage instructions sources and methods of demonstrations, factors that may associate with poor inhaler technique.

4. Some information was obtained from follow up file provided for the patients in the clinics, the information includes: Initial asthma diagnosis according to GINA [1] guidelines and Asthma control status according to GINA [1] guidelines.

Data collection technique

The data was collected in the period between October 2018 to April 2019 by two medical students headed by the author and the other student was trained appropriately. Convenient Patients and their caregivers were met at the clinics and were interviewed in a structural interview using a questionnaire, the questions were close and open ended, then the patients had to demonstrate to researchers how they use that devices by themselves or by the aid of their caregiver.

The inhaler technique was assessed at baseline by the author. Each patient demonstrated the inhaler technique with placebo devices of each type of inhaler they were using. Patients were asked to use their inhalers as they normally did at home. A validated checklist of steps specific for each device was used to score technique [16]. Patients were classified as "incorrect users" of a device if greater than or equal to one error was made. There is no uniformity in the literature as to what classifies a patient as incorrect user of a device, as previous studies have shown that each error can have significant effect on asthma control, we chose to classify patients as "incorrect users" if greater than or equal to 1 step was performed incorrectly. Incorrect users were given correct instructions verbally after assessment.

Variables

Knowledge about asthma, source of this knowledge, inhaler usage and frequencies of usage, adherence to the treatment instructions, sources of instruction of usage and way of demonstration.

Data analysis

After being collected, the data was analyzed using SPSS version 22. Descriptive statistics were used to compute means and standard deviations for numerical variables, as well as frequencies for numerical and ordinal variables. Associations and correlations with chi-square cross-tabulations with significance value of 0.05. Scoring system was applied in asthma knowledge for caregivers, caregiver who scored less than 50% were considered as poor knowledge 74% to 50% as moderate knowledge and 75% and above as high knowledge.

Ethical issues

The author reports no conflicts of interest in this work:

1. An approval from community department, faculty of medicine, university of Khartoum was obtained.
2. Permission from federal ministry of health.
3. Permission from Mohamed Alamin Hamid and Ahmed Gasim pediatric Hospital.
4. E mail permission from IDAT checklist [16] authors was obtain.

Study limitations

A major limitation of the methodology used to assess the technique of inhaler use, direct observation, is that it involves a subjective visual assessment of the individual's technique during inhaler use, which means that it is not easy to assess the inspiratory flow rate also only one type of inhaler devices was found to be used by participants of this study so we didn't assess all the devices for technique of use.

Results

Sociodemographic and patient's characteristic results

A hospital based descriptive cross-sectional study was conducted in Khartoum state pediatric asthma clinics, with a (n = 165) participants to assess inhaler technique among asthmatics children and their caregivers, the response rate was 100%, caregivers were 16% males and 84% females with maximum age 79, minimum 18 and mean of 38.79, their educational level was mainly university followed by primary school level (Figure 3) while children were 52% males and 48% females with maximum age of 17, minimum 2 and age mean was 8.63, their education was mainly primary school and kinder garden level (Figure 6) 56.3% of patients have frequent intermittent asthma when diagnosed initially (Table 1).

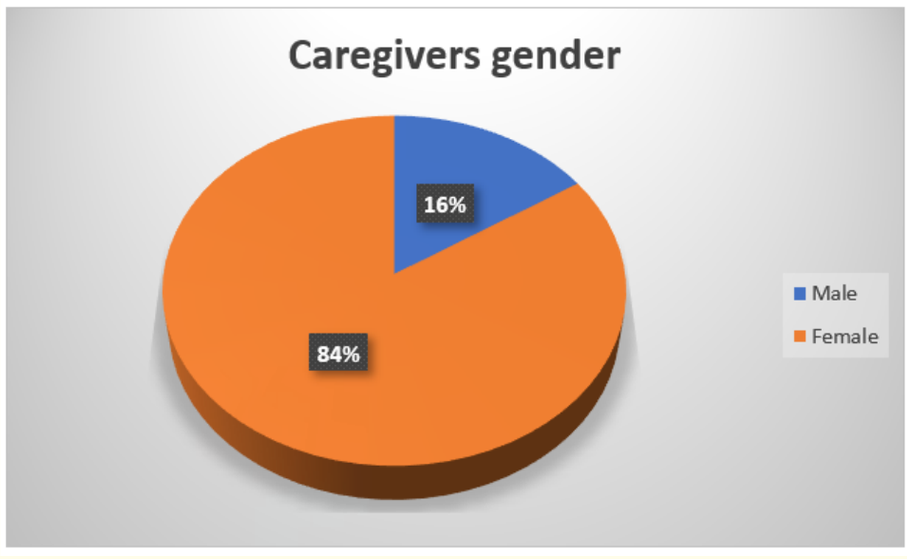

Figure 1: *Gender distribution of caregivers of asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

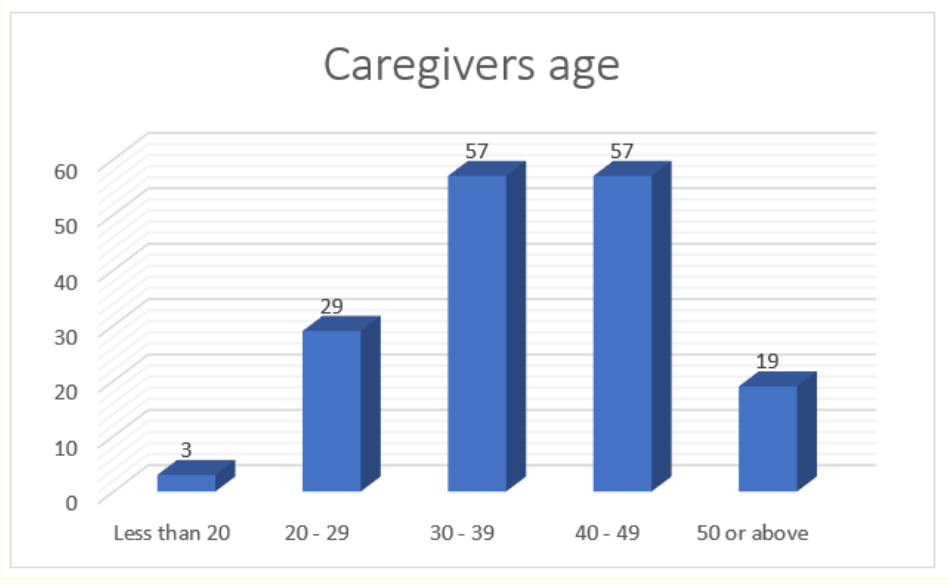

Figure 2: *Age frequencies of caregivers of asthmatic children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

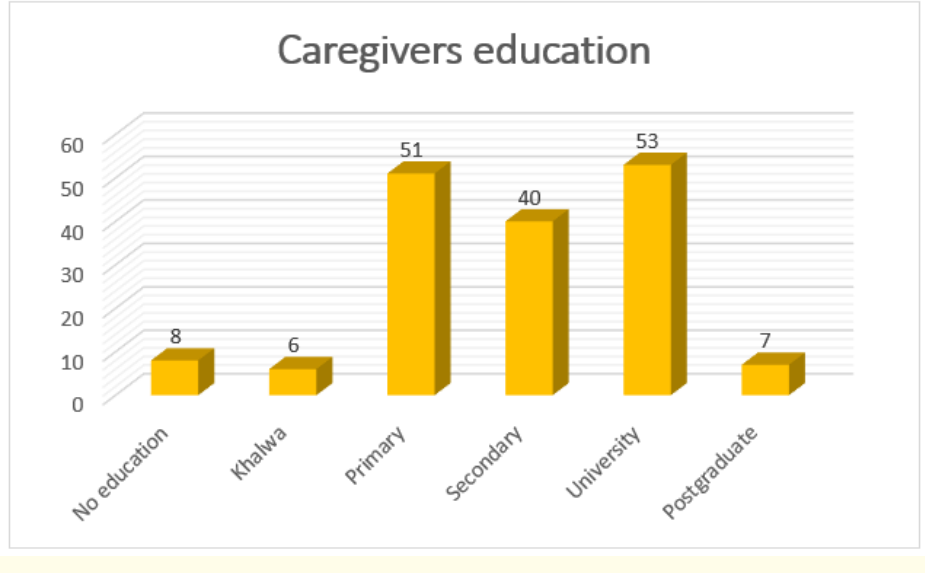

Figure 3: *Educational level of caregivers of asthmatic children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

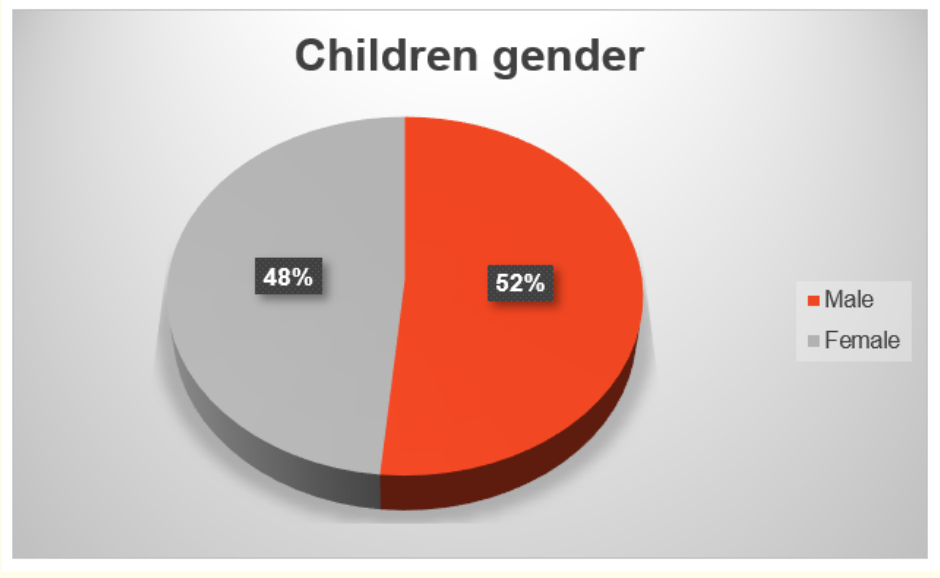

Figure 4: *Gender distribution of asthmatic children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

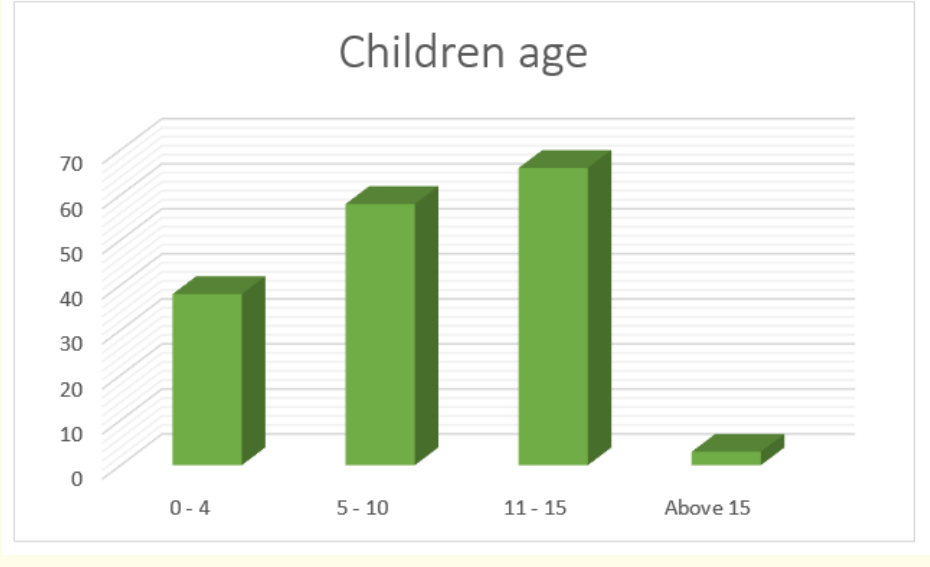

Figure 5: *Age frequencies of asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

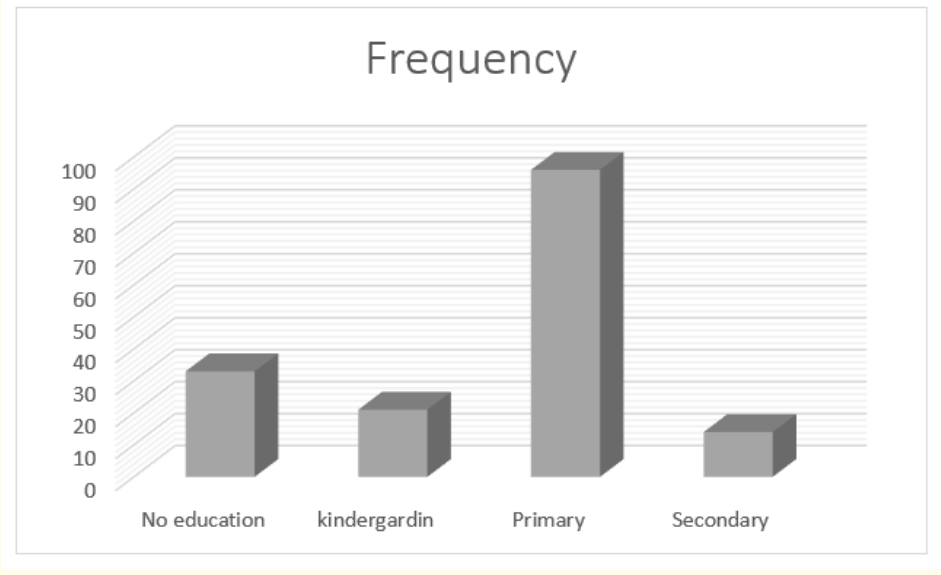

Figure 6: *Educational level of asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

	Frequency	Percent
Persistence mild	23	14.1
Persistence moderate	28	17.2
Persistence severe	16	9.8
Frequent intermittent	93	56.3
Intermittent sever	5	3.1
Total	165	100.0

Table 1: *Demonstrate the percentages and frequencies of the initial asthma diagnosis among asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Technique assessment results

All participants of this study were using MDI inhalers 23% uses only MDI and 77% use it with spacer and mask (Figure 7) 54% were using their inhaler alone and 46% use it with the aid of their caregivers (Figure 8). A Very interesting result was found when assessment of inhaler technique among asthmatics children was performed where only 38.2% performed all correct steps when using inhaler (Table 2) in regard to our classification in this step only those who performed all steps correctly were termed correct users while those who performed one or more incorrect step were termed incorrect users and the most frequent incorrect step was exhalation before inhalation through the devices 45.5% followed by holding breath 36.4% (Table 3), 63.1% of MDI user has incorrect technique while 61.1% of MDI plus spacer and mask (Table 4) shows no associations between inhaler type and participants technique.

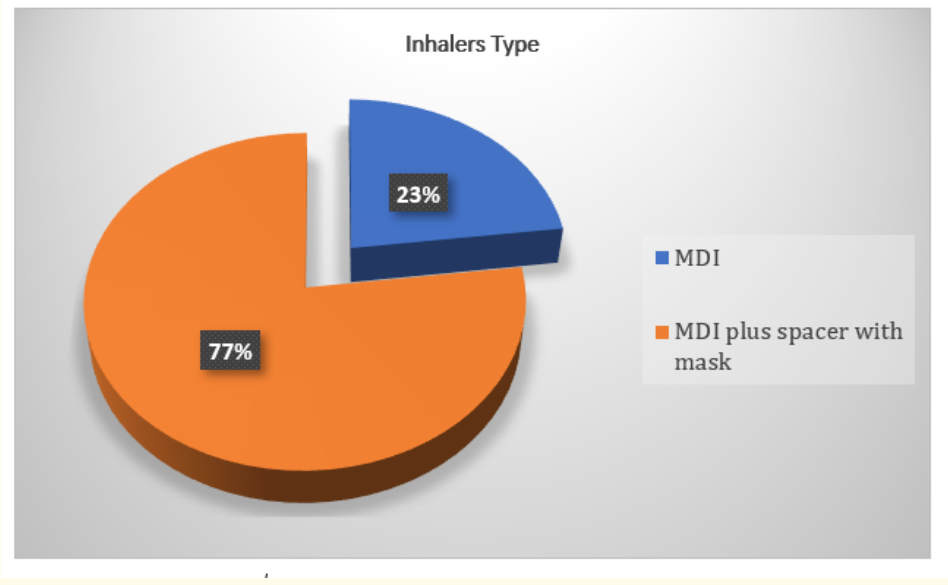

Figure 7: *Demonstrate inhalers types used by asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

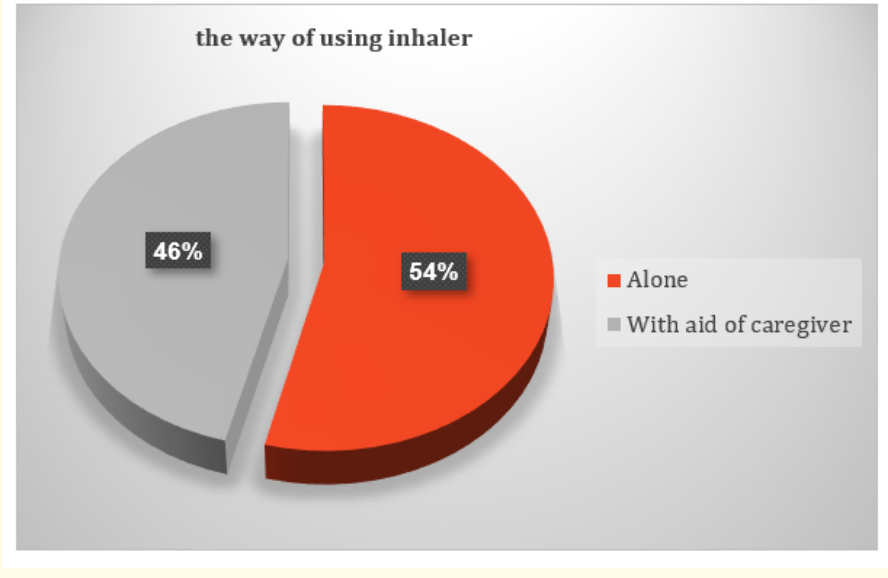

Figure 8: *Demonstrate the way of using inhaler by asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Correct steps	Frequency	Percent
1 correct step	5	3.0
2 correct steps	21	12.7
3 correct steps	32	19.4
4 correct steps	44	26.7
5 correct steps	63	38.2
Total	165	100.0

Table 2: *Demonstrate the percentages and frequencies of total score in inhaler technique assessment among asthmatic children using IDAT checklist in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Steps	Performed it correctly		Performed it incorrectly	
	Frequency	Percent	Frequency	Percent
Remove the cap	164	99.4	1	.6
Correctly prime the device	143	86.7	22	13.3
Exhale before inhalation through the devise	90	54.5	75	45.5
Inhalation probably through the device	139	84.2	26	15.8
Hold breath	105	63.6	60	36.4

Table 3: *Demonstrate the percentages and frequencies of each step-in inhaler technique assessment using IDAT checklist if it corrects or not among asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Type of inhaler vs participants inhaler technique Incorrect users		Participants inhaler technique		Total
		Correct users		
Types of inhaler devices	MDI	24	14	38
	MDI plus spacer with mask	78	49	127
Total		102	63	165

Table 4: *Crosstabulation between type of inhaler used by participants and inhaler technique of asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n=165).*

(p-value = 0.846).

There are no associations has been found between inhaler type and participants technique.

Asthma knowledge among caregiver's results

Knowledge was assessed through 8 questions, (Table 5 (1-9)) demonstrate the knowledge questions, the total score for the knowledge was 23, accordingly participants who score 75% and above were high knowledge, from 74% - 50% were moderate and less than 50% poor knowledge, the majority in this study were moderate knowledge 50.3% followed by poor 32.1% and least of them possess high knowledge 17.6 (Table 6). A significant linear correlation was found (p-value = 0.042) between increasing the knowledge score of caregivers and their children inhaler technique (Table 23), (Table 7) show the major source of their asthma knowledge was doctors.

Table 5 1 to 9: Demonstrate the percentage and frequencies for each question of knowledge questions for asthmatic children caregivers in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).

Score	Frequency	Percent	Valid Percent	Cumulative Percent
0	35	21.2	21.2	21.2
1	130	78.8	78.8	100.0
Total	165	100.0	100.0	

Table 5.1: *Do you think asthma is contiguous?*

1. Yes 2. No 3. Don't know.

Score	Frequency	Percent	Valid Percent	Cumulative Percent
0	19	11.5	11.5	11.5
1	86	52.1	52.1	63.6
2	33	20.0	20.0	83.6
3	27	16.4	16.4	100.0
Total	165	100.0	100.0	

Table 5.2: *What information do you know about asthma? (Can mention more than one answer).*

1. Hereditary 2. Lifelong 3. Due to air pollution.

Score	Frequency	Percent	Valid Percent	Cumulative Percent
0	6	3.6	3.6	3.6
1	28	17.0	17.0	20.6
2	56	33.9	33.9	54.5
3	28	17.0	17.0	71.5
4	2	1.2	1.2	72.7
5	45	27.3	27.3	100.0
Total	165	100.0	100.0	

Table 5.3: *What are symptoms of asthma do you know? (Can mention more than one answer).*

1. Cough 2. Sputum 3. Difficulty in breathing 4. chest pain 5. Wheezing sound on breathing 6. All of the above.

Score	Frequency	Percent	Valid Percent	Cumulative Percent
0	3	1.8	1.8	1.8
1	162	98.2	98.2	100.0
Total	165	100.0	100.0	

Table 5.4: *Which part of the body affected by asthma?*

Score	Frequency	Percent	Valid Percent	Cumulative Percent
1	27	16.4	16.4	16.4
2	68	41.2	41.2	57.6
3	36	21.8	21.8	79.4
4	3	1.8	1.8	81.2
5	2	1.2	1.2	82.4
6	29	17.6	17.6	100.0
Total	165	100.0	100.0	

Table 5.5: *What are the factors that increase asthma? (Can mention more than one answer).*

1. Flu 2. Chest infections 3. Smoke 4. Dust 5. Decrease in temperature 6. Increase in temperature 7. All of the above.

Score	Frequency	Percent	Valid Percent	Cumulative Percent
0	29	17.6	17.6	17.6
1	136	82.4	82.4	100.0
Total	165	100.0	100.0	

Table 5.6: *Can we control this disease.*
1. Yes 2. No 3. Don't know.

Score	Frequency	Percent	Valid Percent	Cumulative Percent
0	28	17.0	17.0	17.0
1	76	46.1	46.1	63.0
2	61	37.0	37.0	100.0
Total	165	100.0	100.0	

Table 5.7: *If the answer was yes on the pervious question: how? (Can mention more than one answer).*
1. Medications only 2. Avoid the triggers 3. Others 4. Don't know.

Score	Frequency	Percent	Valid Percent	Cumulative Percent
0	20	12.1	12.1	12.1
1	145	87.9	87.9	100.0
Total	165	100.0	100.0	

Table 5.8: *Do you think asthma can lead to death if not managed?*
1. Yes 2. No 3. Don't know.

Score	Frequency	Percent	Valid Percent	Cumulative Percent
0	17	10.3	10.3	10.3
1	110	66.7	66.7	77.0
2	38	23.0	23.0	100.0
Total	165	100.0	100.0	

Table 5.9: *What are the uses of asthma inhalers? (Can mention more than one answer).*
1. To manage asthma symptoms 2. To prevent against triggers 3. Don't know.

Knowledge score of caregivers	Frequency	Percent
Poor	53	32.1
Moderate	83	50.3
High	29	17.6
Total	165	100.0

Table 6: *Asthma knowledge score in caregivers of asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Sources of knowledge	Frequency	Percent
Doctors	155	73%
Relatives and friend	30	14%
Media	9	4%
Internet	12	6%
Others	5	2%
Sum	211	100%

Table 7: *Demonstrate the sources of asthma knowledge in caregivers of asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Participants gets their asthma knowledge from more than one source but majority of them gets their knowledge from doctors.

Usage of inhaler and adherence results

Most of participants 88.5% of this study were using inhalers for both reliving symptoms and daily inhaler for controlling it (Table 8), they frequency of using inhaler according to doctor instructions of the majority of the patients 89.1% were twice daily (Table 9), fortunately high proportion of participants 91.5% follow doctors order in the usage of inhaler (Table 10) not adhering reasons were claimed by the participants as The inhaler was finished 29%, Forgetting to take the inhaler 50%, they think no need to take inhaler due to improvement21% (Table 11), 95.7% of participants receives instructions of inhaler use from doctor or pharmacist (Table 12) the most frequent way for demonstration was verbal demonstration 60.9% (Table 13).

Usage of inhaler	Frequency	Percent
Reliver inhaler	8	4.8
Controller inhaler	11	6.7
Both types	146	88.5
Total	165	100.0

Table 8: *Demonstrate the inhaler usage of asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165). Most of the children were using 2 types of inhalers.*

Usage frequencies	Frequency	Percent
Once	8	4.8
Twice	147	89.1
When symptoms appear	7	4.2
Others	3	1.8
Total	165	100.0

Table 9: *Demonstrate the frequencies of using the inhaler in asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at asthma clinics in Khartoum state 2018 (n = 165).*

Adherence to instructions	Frequency	Percent
No	14	8.5
Yes	151	91.5
Total	165	100.0

Table 10: *Demonstrate the percentage and frequencies of asthmatics children who adhere to inhaler treatment or not according to doctor instructions in the study of inhaler technique assessment among asthmatics children and their caregivers at asthma clinics in Khartoum state 2018 (n = 165).*

Reasons for non-adherence	Frequency	Percent
The inhaler was finished	4	29.0
Forgetting to take the inhaler	7	50.0
They think no need to take inhaler due to improvement	3	21.0
Total	14	100

Table 11: *Demonstrate the percentage and frequencies of the reasons why of those who don't adhere to inhaler treatment among asthmatic children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Sources of inhaler us instructions	Frequency	Percent
Doctor or pharmacist	158	95.7
Relatives or friends	6	3.6
Internet	1	.6
Total	165	100.0

Table 12: *Demonstrate the percentages and frequencies of the sources of inhalers instructions asthmatics children get it from in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Ways of demonstrating inhaler use instructions	Frequency	Percent
Verbal demonstration	14	6
acting the instructions in front of you	142	60.9
Explain by acting and ask to perform it	13	5.5
Demonstration using pictures	2	0.8
Demonstration using videos	62	26.6
Sum	233	100.0

Table 13: *Demonstrate the percentages and frequencies of how inhaler use instructions demonstrated to the asthmatic's children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165). Patients were receiving more than one demonstration way but the majority received verbal instructions.*

Factors related to inhaler technique results

Majority of participants 92.1% claimed to using inhaler easily when they were asked (Table 14).

Easily using the inhaler	Frequency	Percent
No	152	92.1
Yes	13	7.9
Total	165	100.0

Table 14: *Demonstrate the percentages and frequencies of asthmatics children who admit to use the devices easily or not when asking them in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Those who were not using it easily was due to "its complicated"38% and "the children don't like it" 62% (Table 15). Also, when they were asked if they are comfortable while using it 89.1% answer yes (Table 16) and those who were not comfortable with it mainly due to "its expensive" 28% and "no improvement" (Table 17). There was a significant association (p-value = 0.03) between caregiver's education level and their children inhaler technique (Table 18). but there was no association was found (p-value = 0.365) between having other family member who using the inhaler and participants inhaler technique (Table 19). also there was no association (p-value = 0.3) if they were using it alone or with the aid of caregiver (Table 20) while very significant association was found between asthma control status and participant inhaler technique (p-value = 0.0004) (Table 21). Majority of participants 66.1% were using the inhaler between (1 - 4) years followed by those who were using it less than years 17% (Table 22) accordingly a significant linear correlation was found between increasing the duration of usage and inhaler technique of the participants (p-value = 0.023) (Table 23). while no correlation was found between age of participants and their inhaler technique (p-value = 0.992) (Table 23).

Reasons for not easily using the inhaler	Frequency	Percent
Complicated	5	38.0
The children don't like it	8	62.0
Total	13	100.0

Table 15: *Demonstrate the percentages and frequencies of the reasons they mentioned it of not using the devices easily among asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Comfortably using the inhaler	Frequency	Percent
No	147	89.1
Yes	18	10.9
Total	165	100.0

Table 16: *Demonstrate the percentages and frequencies of asthmatics children who are comfortable or not with their inhaler treatment when they were asked in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Reasons for not using the inhaler comfortably	Frequency	Percent
can cause death in excessive use	1	6.00
cannot use it correctly	1	6.00
do not accept it	3	17.0
Its expansive	5	28.0
no improvement	5	28.0
slow effect	3	17.0
Total	18	100

Table 17: *Demonstrate the percentages and frequencies of the reasons they mentioned it of not feeling comfortable with their inhaler treatment among asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Caregivers educational level vs inhaler technique Incorrect user		Participant inhaler technique		Total
		Correct users		
Caregiver Education	No education	8	0	8
	Khalwa	6	0	6
	Primary	32	19	51
	Secondary	24	16	40
	University	27	26	53
	Postgraduate	5	2	7
Total		102	63	165

Table 18: *Demonstrate association between educational levels of caregivers and the inhaler technique of asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric clinics in Khartoum 2018 (n = 165). (P-value = 0.030).*

There was association between caregiver's educational level and their children inhaler technique.

Others family members with asthma using inhalers vs inhaler technique Correct use		Inhaler technique		Total
		Incorrect use		
Other family member using inhaler	No	26	15	41
	Yes	27	23	50
Total		53	38	91

Table 19: *Demonstrate associations between inhaler technique of asthmatics children and other family member with asthma whether they using inhaler or not in the study of inhaler technique assessment among asthmatics children and their caregivers of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165). (p-value = 0.365).*

Other family members using inhaler treatment was not associated with asthmatic children inhaler technique.

Inhaler technique vs how they using it	Inhaler technique		Total
	Correct users	Incorrect users	
Using it alone	58	31	89
With aid of caregiver	44	32	76
Total	102	63	165

Table 20: *Demonstrate associations between inhaler technique of asthmatics children and how they using their inhaler not in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165). (p-value = 0.338). There were no associations was found between inhaler technique of asthmatics children and whether they were using the inhaler alone or with aid of caregivers.*

Asthma control vs inhaler technique of participants	Participants inhaler technique		Total
	Incorrect users	Correct users	
Poor control	24	7	31
Controlled	35	11	46
Well controlled	39	45	84
Total	98	63	161

Table 21: *Associations between asthma control status and inhaler technique of asthmatics children in the study of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165). (p-value = 0.0004). There is a strong association was found between inhaler technique and asthma control status.*

Durations of using asthma inhaler	Frequency	Percent
Less than year	28	17.0
1 - 4 Years	109	66.1
5 - 10 Years	28	17
Total	165	100.0

Table 22: *Demonstrate the percentages and frequencies of the duration of using asthma inhaler among asthmatic children in the study of inhaler technique assessment among asthmatics children and their caregivers of inhaler technique assessment among asthmatics children and their caregivers at pediatric asthma clinics in Khartoum state 2018 (n = 165).*

Age of asthmatics children vs their inhaler technique	Asthma knowledge score of caregiver's vs inhaler technique of their asthmatic children	Duration of using asthma inhaler vs inhaler technique
0.992	0.042	0.023
no correlation	Correlated	Correlated

Table 23: *Pearson correlation (crosstabulation_ p-value).*

Discussion

This was a hospital based descriptive cross-sectional study done in pediatrics asthma clinics in Khartoum state about inhaler technique assessment among asthmatics children and their caregivers which use questionnaire and checklist to assess inhaler technique, the

majority of caregivers were females, most of them above 30 years old. Regarding their educational level university graduate and primary school were the highest frequencies among the caregivers, while in children the gender distribution was almost equal with maximum age of 17, minimum of 2 years old and the mean was 8.63, regarding their educational level they were mainly at primary school followed by kindergarten.

All participants in this study were using MDIs, with the majority 77% of them using MDI plus spacer with mask, In the literature, there is a lack of agreement on the checklists used for inhaler technique for different inhalers and type of critical errors. in this study, we use IDAT checklist which comprised 5 critical steps for correct inhaler use, 61.8% of the participants made errors when using inhaler so as mentioned before in this study will termed as incorrect users which in consistent with the finding of C. M. Harnett., *et al.* [19] study which found it 63% of MDI user have errors in the technique, a much lower percentage than our study was found in Murat Capanoglu., *et al.* [18] study who found 31.9% of children using MDI were using it incorrectly our studies participants were similar except for that they included patients who were using inhaler for at least 6 month unlike our study only 1 month which may contribute to our high percentage of incorrect users, a study conducted by Yusuf Aydemir [26] reported high percentage of incorrect user 68.9% of participants with age mean of 58.26, also a high percentage of incorrect users was found in Maha Al Ammari., *et al.* [27] study which was found 73% of MDI users were incorrect it was assessed in only 47 patients with mean age of 58.4, Muhammad Zain Farooq., *et al.* [28] study found 79.8% of MDI user were incorrect their participants were older than in our study with age range of (30 - 65) years old, another high percentage was found in Adam J. Vanderman., *et al.* [29] study which included 24 participants with average age of 82 years old the incorrect users were 79%, the previous 4 studies with very high percentage of incorrect users suggest that elderly have poorer inhaler technique than children.

To ensure proper drug delivery while using inhalers, all steps for inhaler use must be correct. In this study, the most common mistake while using MDI was found to be not exhaling before inhaling throughout the device which is very important as experts recommend it as that clears the lungs allowing the patient to breathe deeply while drug is being inhaled, followed by failure to hold breath after inhaling it's important to hold the breath for 10 seconds as rapid triggers can decrease the dose delivery many studies has reported the same finding, in study was conducted by C. M. Harnett., *et al.* [19] in 47 participants with age mean of 44 they found not exhaling prior to inhalation followed by failure to breath-hold following inhalation were the most common errors in MDI use, the same finding also was found in Muhammad Zain Farooq., *et al.* [28] study among 202 participants with ag mean of 53 ± 16 years, while Murat Capanoglu., *et al.* [18] they found The most common incorrect step for MDI devices was not breathing in from the spacer 5 - 6 times or 10 s and the second frequent incorrect step was not shaking the inhaler for 5s (5 - 6 times) in 171 participants with age mean of 8.29 ± 4.65 years using 7 steps for assessment of inhaler technique.

In Sudan the inhaler device is prescribed to the patient by the physician according to the available and I regards to their ages, in this study we found all the patients were using MDI and the majority 77% using it with spacer and mask and the rest using it alone 23%, the percentage of incorrect user between the 2 devises were almost similar, unlike study of Maha Al Ammari., *et al.* [27] who found the majority 41 patients were using MDI while only 3 patients were using MDI with spacer and there is a big variation in the percentage of incorrect user among the 2 devices with 100% incorrect user of MDI with spacer in comparison to 70% of MDI user this may be due to difference of age of participants between our studies in which their age mean was 58.4 assuming that elderly can't coordinate spacer use more than children may be due to aging factors like arthritis.

In this study, we found the majority of caregivers of asthmatic children knowledge about asthma was moderate 50.3% and there is a positive correlation between asthma knowledge score of caregivers and inhaler technique of their asthmatic children. Sreeram Venugopal., *et al.* [30] found a correlation between parents knowledge score and asthma control of their children, those finding highlighted the importance of caregivers knowledge about their children conditions because it reflected directly on their conditions.

Regarding adherence to inhaler therapy, in this study we found only a very small percentage of patients not adhering 8.5% to inhaler and the reasons for not adhering as claimed by the patients was the inhaler was finished, forgetting to take it and feeling improved and

there is no need for using it, a study with similar participants of our Murat Capanoglu., *et al.* [18] study found poor adherence 22.8% in which "forgetting to take the drug", "the technique of use is complicated" and "feeling well, doesn't need the drug" was the most frequent reasons for poor adherence they classified patients "good adherence" if they were taking most of their daily requirements (missing the dose twice a week or less). Missing the dose more than twice a week was labeled as "partial adherence" and patients using their drug as needed only were labeled as "poor adherence" bot our study Murat Capanoglu., *et al.* study was estimating adherence by only asking the participants which sometimes may not reflect the truth only follow up will estimate the real percentage and accordingly physicians must be aware to fully in lights the patients about the importance of adhering to the treatment.

Many factors were found to affect inhaler technique in this study a significant association (p-value = 0.030) between educational level of caregivers and their children inhaler technique in which all children of illiteracies and khalwa education caregivers have incorrect technique despite the educational level of their children. This finding is very important as those caregivers play a vital role in the management of their children, Yusuf Aydemir [26] noticed the same finding but regarding educational level of the patients themselves not their caregivers. Another correlation was found in asthma control and inhaler technique (p-value = 0.0004) so asthma control was related directly to inhaler technique directly to inhaler which is in consistence with Fusun Yildiz., *et al.* [31] study who was found asthma control status was better in patients with no errors while using inhaler. A linear correlation between Cumulative usage experiences and inhaler technique (p-value = 0.023) was found in patients in this study as the duration of therapy increased they will have better inhaler technique Elif Şen., *et al.* [32] noticed the same finding in their study. This finding gives a bit of hope that in future those incorrect users may have correct technique, but this will not be achieved unless they adhere to the doctors' instructions. We didn't find in the literature a study to assess inhaler technique in children at Sudan**.**

Conclusion

A high proportion of children in this study was using inhalers incorrectly and they were not aware about it. Hence, this was reflected negatively in their asthma control status due to failure of proper delivery of the medication to the lung. Caregivers play a huge role on their children conditions as it was found that their educational level and knowledge about the disease was largely affects the children inhaler technique also the duration of using inhaler was positively reflected in their inhaler technique.

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Conflict of Interest

There was no conflict of interest.

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