Cost-effectiveness of Hydrocortisone Injection, Symbicort Inhaler and Prednisolone Tablets Used in Treatment of Asthma in Alshaab Teaching Hospital Khartoum, Sudan

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ABSTRACT

Background: Asthma is a chronic disease and one of the most familiar long-term respiratory diseases affecting millions of adults worldwide. High utilisation of healthcare resources in treating asthma and limited resources allocated to the disease has imposed the use of Pharmaco-economics evaluation methods such as cost-effectiveness analysis in healthcare decision-making. Hence, the present study is planned to evaluate the cost-effectiveness of corticosteroid preparations used in treating asthmatic patients at Alshaab Teaching Hospital (ASH) Khartoum, Khartoum State, Sudan. **Materials and Methods:** A hospital-based cross-sectional design, whereby the cost and outcome of corticosteroid preparations were collected together. One hundred and thirty-nine adult asthmatic patients were systematically selected as the sample size. The data were collected using EQ-5D-3L Arabic version questionnaire and data collection forms and analysed using Statistical Package for Social Sciences (IBM) version 24.0. **Results:** In this study, out of 139 patients, the majority of them (58%) were females, fell within the 16-40 age group category (38%) and were married (82%). Our findings showed that the Symbicort inhaler was the most expensive preparation with an Average Cost-Effectiveness Ratio (ACER) of 3,283.10 SDG ($4901) per treatment. Prednisolone tablet was the least expensive, with an ACER of 643.40 SDG ($ 96) per treatment, the most reasonable alternative concerning effectiveness, and the most efficient preparation concerning effectiveness-adjusted costs. **Conclusion:** This study concluded that the prevalence of asthma and utilisation of pharmaceutical products and services among adult asthmatic patients in ASH was higher in females (58%) and those in the 16-40 age group. The Symbicort inhaler was the most expensive preparation, and the Prednisolone tablet was the least expensive and most cost-effective of the three preparations evaluated in ASH.

Keywords: Asthma, Corticosteroid preparations, Cost-effectiveness, Alshaab Teaching Hospital, Khartoum Sudan.

INTRODUCTION

Asthma is a chronic disease and one of the most familiar long-term respiratory diseases affecting millions of adults worldwide.[1-7] It remains a global public health problem affecting people of all ages.[8] The most current global prevalence of asthma is estimated to be three hundred and thirty-nine (339) million people.[9,10] The disease burden on governments, healthcare systems, families, and patients is increasing worldwide. At the same time, its morbidity and mortality have become a problem in many countries, especially developing ones,[11] where access to healthcare facilities and essential medicines remains a problem.[12]

Dramatic increases in the global prevalence of asthma over the last decades were reported, where 1 out of 7 people worldwide is affected by the disease.[2] The overall global prevalence of asthma was reported as 4.3%,[13] and the prevalence of asthma symptoms among adults (aged 18-45 years) was 8.6%.[9]

In previous decades asthma was claimed as a disease in high-income countries. Today, this claim is no longer valid; the prevalence of asthma rises in middle and low-income countries more than in high-income countries.[12] The prevalence of asthma in these countries is expected to reach its peak in the nearest future, probably due to the emergence of economic and epidemiologic transitions.[3,14] Moreover, in Africa, only a few studies have been conducted on asthma and related topics because of a lack of data which caused as a result of poor documentation habits among health practitioners and health facilities. Data related to the prevalence of asthma is available

only on country-based, where few countries have it while the majority do not have.[15,16]

However, in Sudan, no unified figures indicate the overall prevalence of asthma because asthma is not considered a public health priority in the country. The overall prevalence of asthma in Sudan has yet to be indicated.[17] Some studies highlighted that the prevalence of asthma among adult Sudanese in some regions of the country is around 10% of the region's population.[18,19] However, a survey by Thomson R, *et al.* in 2020 in Khartoum reported asthma as the "third most common cause of hospitalisation after pneumonia and malaria".[13]

This study is the first of its kind to be conducted in Sudan, which evaluates the costs and outcomes of three corticosteroid preparations (hydrocortisone injection 100mg, prednisolone tablet 30mg and Symbicort (budesonide/formoterol) inhaler 160/4.5 ug/dose.) use for treating asthmatic patients at Alshaab Teaching Hospital. We used the provider perspective to evaluate the cost and outcomes of these preparations.

MATERIALS AND METHODS

Ethical Approval

The study was conducted after the approvals of the research committee of the faculty of pharmacy and deanship of the post-graduate studies-International University of Africa, Ministry of Health Khartoum state and Alshaab Teaching Hospital. EQ-5D-3L Arabic version questionnaire was used in data collection in this study. Permission to use the instrument from 2015-2016 was obtained from EuroQol Group, United Kingdom.

Study design

A hospital-based cross-sectional whereby the cost and outcome of corticosteroid preparations are collected together. This study was conducted at a government hospital specialising in chest and heart diseases, Alshaab Teaching Hospital (ASH), between May and December 2016.

Target population and subgroups

Male and female patients aged 16 to 80 visited Alshaab Teaching Hospital from May to December 2016 were included in the study. A systematic sampling method was used, which allowed the selection of study participants at the regular interval after selecting the first one randomly and devoid of bias. The sample size of this study was calculated to be 139 adult asthmatic patients. Patients with severe or acute exacerbated asthma, patients with age ≥16 to ≤80 years old, admitted to emergency or visited the outpatient clinic of Alshaab Teaching Hospital between May and December of 2016, using hydrocortisone injection 100mg, prednisolone tablet ≥30mg or Symbicort (budesonide/

formoterol) inhaler 160/4.5 ug/dose were included in the study. Severe and acute exacerbated hospitalised asthmatic patients, patients with asthma and other respiratory diseases such as Chronic Obstructive Pulmonary Disease (COPD) and patients with age <16 or >80 years were excluded from the study.

Study perspective

Cost-Effectiveness Analysis (CEA) of corticosteroid preparations were conducted in this study. The costs and outcomes of corticosteroid preparations were determined from a provider's perspective. Therefore, only direct medical (health service) costs: expenses and services provided are evaluated, while direct non-medical such as costs of transportation costs expenses of non-medical or informal care, and indirect costs, such as costs of patient's productivity and other non-health service costs were excluded.

Discount rate

Discounting on the costs and effectiveness is optional as the study time horizon was less than one year.

Choice of health outcomes

To obtain the Quality Adjusted Life Years (QALYs) related to each Preparation, the Health-Related Life (HRQoL) should be multip by the quantity of life (i.e. time spent by patients in a particular health state obtained from medication or while using a specific drug). In this study, estimating the quantity of life was difficult due to the time factor and the inability of the patients to recall when they start using corticosteroids. Also, there are no documented patient records from which such information can be extracted in the hospital. Therefore, Health-Related Quality of Life (HRQoL) was used instead of the QALY because of its ability to reflect the effectiveness of the medication and one of the parameters used in computing QALYs.[20]

Estimating resources and costs

A bottom-up costing approach was used as a costing approach, in which the costs of medication (corticosteroid preparations), laboratory investigations, and medical personnel services were collected separately and then summed to give a direct medical cost prospectively. This approach was used to compute the following cost categories.

Medication cost (corticosteroid preparations cost)

The cost of each corticosteroid preparation was obtained from the pharmacy department of the hospital. To calculate the cost of medication (corticosteroid preparations), the Prescribed Daily Dose (PDD), frequency and duration of treatment were considered. The cost was computed by multiplying the total quantity of medication prescribed by the unit cost of the drug:

Medication cost = Total quantity of prescribed medication x Unit cost of the medication.

Medical personnel service cost

The medical personnel service cost was calculated by multiplying the number of units per service per 8 months by the price per unit service, then the costs of medical personnel services (doctor, pharmacist, laboratory scientists, nurse) were added together to give medical personnel service cost. Price per unit service was calculated from the salaries of medical personnel, which were obtained from the accounts department of ASH, and the average time taken by medical personnel to deliver a service to the patient:

Cost per unit service = Average salary per month ÷ 22 working days ÷ eight working hours per day ÷ 60 min x Average time taken per service or visit.

Medical personnel service cost = the number of units per service per 8 months x cost per unit service.

Laboratory investigations cost

The cost of laboratory investigations was obtained from the hospital's laboratory department. The costs of laboratory investigations are calculated by multiplying the number of each laboratory investigation by its unit cost:

Laboratory investigation cost = Number of the lab. Investigation x laboratory investigation unit cost.

Furthermore, the costs of medication, medical personnel service and laboratory investigation were added to calculate each corticosteroid preparation's direct medical cost. The cost categories related to each preparation were summed and multiplied by the number of patients prescribed the preparation, then multiplied by eight months to calculate the total direct medical cost for each preparation. The average direct medical cost per patient per 8 months was then calculated.

However, the instruments used in this study's data collection were: Data collection forms which collected data related to the costs of corticosteroid preparations and the EQ-5D-3L questionnaire.

Measurement of the effectiveness of corticosteroid preparations

Due to the time factor and limited resources at the time of data collection, in addition to the dimension (strategy) of measurement of the instrument used, only positive outcomes of the corticosteroid preparations were identified, measured and evaluated, while, the negative outcomes were not evaluated. The EQ-5D-3L questionnaire Arabic version[21] measured the positive outcome. The questionnaire has two parts: a descriptive system which measures a patient's health state, and a visual analogue scale. Value sets (UK TTO) were used to value the health states, and the health states were later presented in the form of utilities or health-related quality of life (HRQoL) (refer to Technical Appendix).

Analytical methods

The empiric approach, in which all relevant costs and effects were collected in one study, was selected and used in this study. Two types of data related to the use of corticosteroid preparations by the patients were collected.

The direct medical cost of corticosteroid preparations includes medication, laboratory investigations and medical personnel services data, which were collected using data collection forms. The monetary values were attached to each data mentioned earlier to calculate the direct medical cost of each corticosteroid preparation. Moreover, the cost of the preparations was recorded in the Sudanese Currency (SDG) and then converted to the American dollar (US) based on the current average bank exchange rate of 6.7 SDG per 1 $ (Central Bank of Sudan, 2016) at the time of the study.

Outcomes of corticosteroid preparations

Data related to the outcome of corticosteroid preparations were collected using the EQ-5D-3L questionnaire Arabic version.[21] The questionnaire has five dimensions which collectively give health states. Weights were attached to these health states to provide a single patient health index (known as utilities or HRQoL) which was then used to define the outcome of each preparation.

However, the data were assembled and entered into Microsoft excel 2013 and then transferred to SPSS version 24 for analysis. Data analysis was performed for corticosteroid preparations used in treating asthmatic patients. The data on costs and outcomes were collected within eight months. Therefore, the cost and outcomes were not discounted. Statistical significance was defined at *p*-value ≤0.05.

Analysing the Costs and outcomes

An Average Cost-Effectiveness Ratio Analysis (ACER) was conducted to determine the most cost-effective corticosteroid.

Sensitivity Analyses

A deterministic two-way sensitivity analysis was performed to test the uncertainty of the results of the research, where two parameters were varied relative to their base case value. These parameters include an average direct medical cost per patient (SDG) and outcomes (HRQoL). High and low estimates of costs (+20% and -20%) and outcomes (+10% and -10%) were inserted, and ACER were re-calculated. The impact (i.e., change in the ACER from the base case) was interpreted.

RESULTS

Demographic characteristics

The number of asthmatic patients that participated in this study was 139 patients. Of these, 53 patients were prescribed hydrocortisone injection, 51 were prescribed prednisolone tablets, and 35 took Symbicort inhaler (Table 1).

Summary of the cost-effectiveness analysis Results

To explore and find the most cost-effective Average Cost-Effectiveness Ratio Analysis (ACER) was conducted. From the Table 2, after considering both the direct medical costs and defined effectiveness (HRQoL) parameters, the direct medical costs per successfully treated patient for each preparation were determined, and prednisolone preparation was marked as the most efficient preparation concerning effectiveness-adjusted expenses with:

An approximate average cost-effectiveness ratio of 643.40 SDG ($96)/HRQoL proved more favourable than Hydrocortisone injection with 2600.00 SDG ($388) /HRQoL after the two preparations were compared.

An approximate average cost-effectiveness ratio of 643.40 SDG ($96)/HRQoL proved more favourable than the Symbicort inhaler with =3283.10 SDG ($490) /HRQoL after the two preparations were compared.

Cost-Effectiveness Plane

Prednisolone tablet versus Hydrocortisone injection: prednisolone tablet was more effective at a lower price, i.e. prednisolone tablet is dominant.

Prednisolone tablet versus Symbicort inhaler: prednisolone tablet was as effective as Symbicort inhaler at a Lower price, i.e. prednisolone tablet is dominant.

Sensitivity Analyses

Table 3 illustrates the impact on the ACER for two values of the cost and two values of the outcomes of the corticosteroid preparations. Again, we see how sensitive the ACER is to each parameter and the extensive range of estimates, from SDG 585 to SDG 3641.67.

DISCUSSION

Health-related quality of life HRQoL is a measure that is commonly used; its uses are not certainly limited to the monitoring of population health state but also extended to measure and compare the effectiveness of different types of medications and their related health care services for a given disease at hospitals level and in clinical trials. Among the generic

instruments used for measuring the HRQoL is EQ-5D-3L, the most familiar and straightforward instrument used in almost all kinds of diseases, including asthma.[22-28]

Evaluating the cost and effectiveness of asthma medications, particularly the most expensive ones, such as corticosteroid preparations, is essential to ensure the rational and cost-effective use of the preparations in managing severe or acute exacerbated asthma.[29]

In Sudan and other African countries, little or no studies are conducted in the field of Pharmaco-economics of asthma. The studies published on the economic evaluation of asthma in Africa are more of partial economics evaluation studies.[30] There is a need to encourage researchers to conduct researches on economic evaluations of asthma, considering the recent rise in the prevalence of asthma in Sudan and Africa.[31]

These findings clearly show that asthma in ASH is more common in the age group (16-40 years), which is known as the most economically active group, followed by the age group 60-80 (elderly patients). The increase in the prevalence of asthma among the elderly group may be due to the overall decrease in their quality of life seen with ageing.[23] However, out of 139 patients that participated in this study, 58% were females, and 42% were males. Similar results were reported in studies conducted in Ankara, Turkey, by Çelik *et al*. 2004 [32] and Accordini *et al*. 2006.[33]

In this study, systemic corticosteroids (hydrocortisone injection and prednisolone tablet) were found to be the most prescribed corticosteroid preparations in an emergency department, which are either prescribed alone or in combination with inhaled corticosteroids. This finding was found to be similar to a finding in studies conducted by Raissy *et al*. 2013[34] and Donohue *et al*. 2004,[35] in which they reported the advantage of systemic corticosteroids over inhaled corticosteroids. Also, Rowe *et al*. 2004[36] highlighted in their study that systemic corticosteroids have a high preference in the emergency department than inhaled corticosteroids. However, among the laboratory investigations done by the patients in ASH, chest X-ray was the most systematic.

In this study, the medication cost category was the predominant cost category, accounting for 72% of the total direct medical costs of three preparations. Followed by medical personnel services cost, which accounted for 18% of the total direct medical costs of three preparations, and laboratory investigations, with 10% of the total direct medical costs of three preparations. These findings are found to be similar to the findings of studies conducted in Turkey, Sweden, the Netherlands, the USA, and France, which reported the cost of medication as a critical cost driver among different cost categories of the direct medical cost.[32,37-41] In contrast, this was found to be dissimilar to a finding from a study conducted by Bahadori *et al*. 2010.[29] Also, the fact that the laboratory investigation cost was the lowest cost category in this study was found to be similar to a finding in a study conducted

Table 1: Distribution of Demographic characteristics of patients.

Patients (*n*=139)		
Age (in years)	Per cent (%)	Mean ± S.D
16-40	38	29.50±7.7
41-60	30	51.53±5.5
61-80	32	69.75±5.6
Total	100	
Sex	Percent (%)	
Male	42	
Female	58	
Total	100	
Marital status	Percent (%)	
Married	82	
Unmarried	18	
Total	100	

in Turkey by Bavbek *et al.* (2011).[41] The reason behind which among the cost categories have higher contribution and which have a low contribution to the direct medical cost may be due to but certainly not limited to differences in unit cost, study period, exchange rates and annual inflation rate[32] which varies from one study to another or one from country to another. Furthermore, in this study, the most expensive prescribed corticosteroid preparation for treating adult asthmatic patients in ASH was inhaled corticosteroids (Symbicort inhaler). This finding was supported by a study by Rowe *et al.* 2004.[36]

Health states reflect the health benefit obtained by a patient as a result of using a particular medication. Adult asthmatic patients in ASH described their health states as a result of using a specific type of corticosteroid preparation using the descriptive system of EQ-5D-3L questionnaire Arabic version, from which we estimated the health benefit (in the form of HRQoL) gained by the patients from a particular corticosteroid preparation using the TTO-UK value sets.[20,42]

Table 2: Summary of CEA of corticosteroid preparations.

	Prednisolone tablets (A)	Hydrocortisone injection (B)	Symbicort inhaler (C)
Cost-Consequence Analysis (CCA)			
Total direct medical cost (SDG)	21,328.80	34,450.00	64,349.00
Average direct medical cost per patient (SDG)	418.21	650.00	1835.40
Total outcomes (HRQoL)	0.65	0.25	0.56
Average Cost-Effectiveness Ratios (ACER)			
	418.21/0.65 = 643.40 ($96) Per treatment	650.00/0.25 =2,600.00 ($388) Per treatment	1835.40/ 0.56 =3,283.10 ($490) Per treatment
Incremental Cost-Effectiveness Ratios (ICER)			
A compared with B = Dominant			
A compared with C = Dominant			
C compared with B = (3,283.10-2,600.00)/(0.56-0.25) = SDG 2,203.54 per extra treatment			

Table 3: Two-way sensitivity analysis.

Parameter	Variation range	Average Cost-Effectiveness Ratios (ACER)		
		Prednisolone tablets	Hydrocortisone injection	Symbicort inhaler
Base case		643.40	2,600.00	3,283.10
	+20%	+20%	3120	3933
Change in average direct medical cost per patient (SDG)	-20%	-20%	2080	2622
Change in outcomes (HRQoL)	+10%	585	2363.64	2731.25
	2731.25	714.89	2889	3641.67

Corticosteroids are the most effective and widely used medications among the available anti-inflammatory medications for treating severe and acute exacerbated asthma.[34] There are many corticosteroids with different efficacy, effectiveness and potency available in various dosage forms. Regarding this, corticosteroids are categorised into systemic and inhaled corticosteroids. These two categories of corticosteroids are shown to have differences in efficacy/effectiveness, potency, safety and cost of their acquisition. Some studies showed that inhaled corticosteroids (such as Symbicort inhaler) have an advantage over systemic corticosteroids due to their high topical potency and low systemic absorption and actions.[43] Some argued that systemic corticosteroids (such as hydrocortisone injections and prednisolone tablets) have an advantage over inhaled corticosteroids, especially in the emergency department.[35] However, many systemic corticosteroids are available in the market with different efficacy, potency and duration of action.[44] The difference in efficacy/effectiveness of systemic corticosteroids may be explained by their differences in the glucose-mineralocorticoid property ratio. Corticosteroids with more glucocorticoid properties were shown to have more anti-inflammatory activity in the treatment of asthma, and oral corticosteroids such as prednisolone tablets are shown to have more glucocorticoid properties than parenteral corticosteroids such as hydrocortisone injection and are also preferred over parenteral corticosteroids.[44,45] These claims shed more light on the reason why prednisolone tablet was more effective than hydrocortisone injection in our study.

Moreover, our findings show that the use of a Symbicort inhaler offers additional benefits only when compared with hydrocortisone injection while offering no additional benefits when compared with a prednisolone tablet. Some studies reported the patients' incorrect use of inhaler devices, poor adherence and steroid phobia as a reason behind the low or no additional benefits shown by Symbicort compared with prednisolone tablets.[38,45] In support of our finding, a study by Rowena *et al.* 2004 reported that oral corticosteroids, such as prednisolone tablets showed better effectiveness than inhaled corticosteroids.[36] However, Kemp *et al.* 2010 argued that inhaled corticosteroids are a cornerstone of asthma therapy, considering the route it administers.[46]

The Average Cost-Effectiveness Ratio (ACER) is the most suitable and straightforward analysis to use when comparing medications used to treat the same disease but differs only in their route of administration. The cost-effectiveness ratio of corticosteroid preparations identifies how much it will cost ASH to provide a corticosteroid preparation and its related services to the patient to achieve a unit of gain of HRQoL. ACER was performed to find the most cost-effective corticosteroid preparations for treating asthmatic patients at ASH. Prednisolone preparation was found to be the least expensive preparation, also marked as the most reasonable alternative concerning effectiveness (HRQoL) and once again as the most efficient preparation concerning effectiveness-adjusted costs among the available options (preparations) in ASH. This fact was confirmed by the cost-effectiveness plane, which indicated prednisolone tablet as the most efficient (dominated) preparation on effectiveness-adjusted costs compared with hydrocortisone injection and Symbicort inhaler. This result makes prednisolone preparation a non-competitive preparation with no competitor that can necessitate us to do incremental cost-effectiveness ratio (ICER) analysis; hence prednisolone preparation was proved to be the most cost-effective preparation among the available preparations used among the asthmatic patients at ASH.

Limitation of the study

In this study, there are a few limitations that we want to acknowledge

The absence of the EQ-5D-3L Sudan Arabic version and lack of country value sets let us use the EQ-5D-3L Saudi Arabian Arabic version and UK value sets (TTO-UK). There is a need to reassess the patients' health states using the Sudan EQ-5D-3L Arabic version and value sets obtained from the Sudanese population.

Health-Related Quality of Life (HRQoL) was used instead of QALY due to time factors and limited resources. Future studies should focus on measuring the patients' Quality and Quantity of Life to assess QALY gained due to using particular corticosteroid preparation.

Only positive outcomes were evaluated. Asthmatic patients' comorbidities are not considered when evaluating costs and outcomes.

CONCLUSION

In conclusion, this study found that the prevalence of asthma and the utilisation of pharmaceutical products and services by asthmatic patients in ASH was more in females than males, also more in the age group 16-40 years. Hydrocortisone injection was the most prescribed preparation, followed by prednisolone tablet, and the least was Symbicort inhaler. Medication cost was seen as the significant cost category of the direct medical cost of preparations, and chest X-rays as the most frequently done laboratory investigation in ASH. The Symbicort inhaler was concluded to be the most expensive preparation, and the prednisolone tablet was the least expensive preparation. Prednisolone was found to be the most reasonable alternative concerning effectiveness (HRQoL) and most cost-effective (efficient preparation concerning effectiveness-adjusted costs) among the available corticosteroid alternatives (preparations) in ASH.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

Authors' contributions

Mansir. A and Mousnad. M conceived of the presented idea. Mansir. A developed the theory and performed the computations. Mousnad.M and AE verified the analytical methods. Mousnad.M, AE and Asma.N supervised the findings of this work. Mansir. A and Mousnad.M draft ed the manuscript. All authors discussed the results and contributed to the final manuscript. Mousnad.M guarantor of the paper.

Ethical approval

The procedures performed in this study involving human participation were in accordance with the standard ethical standards of the institutional research committee (International University of Africa, Faculty of Pharmacy and Alshaab Teaching Hospital research committees) and with the Helsinki Declaration and its later amendment or comparable ethical standards.

Consent to participate

A verbal consent to participate in this study was received from the asthmatic patients before questionnaire administration.

Content for publication

The participants were briefed about this study and we sought their consent verbally to publish their data in a journal.

ABBREVIATIONS

ACER: Average cost effectiveness ratio; **ASH:** Alshaab teaching hospital; **EQ-5D-3L:** Questionnaire European quality of life-5 dimension-3 level questionnaire; **ESR:** Erythrocytes Sedimentation Rate; **Euroqol group:** European quality of life group; **HRQoL:** Health related quality of life; **ICER:** Incremental cost effectiveness ratio; **PDD:** Prescribed daily dose; **QALY:** Quality adjusted life years; **SDG:** Sudanese pound; **TTO:** Time trade-off.

SUMMARY

- Asthma is a chronic disease and one of the commonest long term respiratory diseases that affects millions of adults around the world. Asthma is ranked in 2020 as the "third most common cause of hospitalization following pneumonia and malaria".

- There is inadequate and lack of documented data that indicates the overall prevalence and cost of asthma in Sudan. This study is the first of its kind to be conducted in the field of Pharmaco-economics regarding Asthma medication (corticosteroids) in and Sudan at large and it is going to open door to upcoming researchers that have the interest to conduct researches in the field.

- This study is a cost-effectiveness analysis of corticosteroid preparations used in treating asthmatic patients at Alshaab Teaching Hospital (ASH) Khartoum, Khartoum state, Sudan. Symbicort inhaler was concluded to be the most expensive preparation and Prednisolone tablet the least expensive and most cost-effective preparation among the three preparations that were evaluated in ASH.

REFERENCES

1. Barnett SB, Nurmagambetov TA. Costs of asthma in the United States: 2002-2007. J Allergy Clin Immunol. 2011;127(1):145-52. doi: 10.1016/j.jaci.2010.10.020, PMID 21211649.

2. Zar HJ, Lalloo UG. Acute asthma treatment guidelines: reducing morbidity and mortality in South Africa. S Afr Med J. 2013;103(3):159-60. doi: 10.7196/samj.6791 , PMID 23472699.

3. Franco R, Santos AC, do Nascimento HF, Souza-Machado C, Ponte E, Souza-Machado A, *et al*. Cost-effectiveness analysis of a state funded programme for control of severe asthma. BMC Public Health. 2007;7(1):82. doi: 10.1186/1471-2458-7-82, PMID 17509137.

4. An asthma follow-up system using rapid SMS. Asthma SMS Sudan; 2013. Friendship hall in Khartoum, Sudan.

5. Bateman ED, Hurd SS, Barnes PJ, Bousquet J, Drazen JM, FitzGerald JM, *et al*. Global strategy for asthma management and prevention: GINA executive summary. Eur Respir J. 2008;31(1):143-78. doi: 10.1183/09031936.00138707, PMID 18166595.

6. Hahn-Pedersen J, Worm M, Green W, Andreasen JN, Taylor M. Cost utility analysis of the SQ® HDM SLIT-tablet in house dust mite allergic asthma patients in a German setting. Clin Transl Allergy. 2016;6(1):1-8.

7. Arun JJ, Lodha R, Kabra SK. Bronchodilatory effect of inhaled budesonide/formoterol and budesonide/salbutamol in acute asthma: a double-blind, randomized controlled trial. BMC Pediatr. 2012;12(1):21. doi: 10.1186/1471-2431-12-21, PMID 22394648.

8. Tan WC, Aït-Khaled N. Dissemination and implementation of guidelines for the treatment of asthma [State of the Art Series. Asthma in high-and low-income countries, Edited by M. Chan-Yeung. Number 6 in the series]. Int J Tuberc Lung Dis. 2006;10(7):710-6. PMID 16848330.

9. Network GA. The global asthma report 2018. Auckland, New Zealand: Global Asthma Network; 2018.

10. Roche N, Colice G, Israel E, Martin RJ, Dorinsky PM, Postma DS, *et al*. Cost-effectiveness of asthma step-up therapy as an increased dose of extrafine-particle inhaled corticosteroid or add-on long-acting beta 2-agonist. Pulm Ther. 2016;2(1):73-89. doi: 10.1007/s41030-016-0014-2.

11. Masoli M, Fabian D, Holt S, Beasley R, Global Initiative for Asthma (GINA) Program. The global burden of asthma: executive summary of the GINA Dissemination Committee report. Allergy. 2004;59(5):469-78. doi: 10.1111/j.1398-9995.2004.00526 .x, PMID 15080825.

12. Ait-Khaled N, Enarson DA, Bissell K, Billo NE. Access to inhaled corticosteroids is key to improving quality of care for asthma in developing countries. Allergy. 2007;62(3):230-6. doi: 10.1111/j.1398-9995.2007.01326.x, PMID 17298339.

13. Bousquet J, Bousquet PJ, Godard P, Daures JP. The public health implications of asthma. Bull World Health Organ. 2005;83(7):548-54. PMID 16175830.

14. Network GA. The global asthma report 2014. Auckland, New Zealand; 2014.

15. Nafti S, Taright S, El Ftouh M, Yassine N, Benkheder A, Bouacha H, *et al*. Prevalence of asthma in North Africa: the Asthma Insights and Reality in the Maghreb (AIRMAG) study. Respir Med. 2009;103(S2):S2-11. doi: 10.1016/S0954-6111(09)70022-8, PMID 20122625.

16. Adeloye D, Chan KY, Rudan I, Campbell H. An estimate of asthma prevalence in Africa: a systematic analysis. Croat Med J. 2013;54(6):519-31. doi: 10.3325/cmj.2013.54.519, PMID 24382846.

17. Ahmed YiS, Eltayeb EM. Management of bronchial asthma in Khartoum state hospitals. IJIPSR. 2014;2(11):2647-56.

18. Elamin SA, Merghani TH, Alawad AO. Adequacy of asthma management among patients attending referred clinics in Khartoum. Khartoum. Med J. 2012;4(1).

19. Kodouda SF, Zachariah R, Khogali M, van Griensven J, Saeed M, Ibrahim EH, *et al*. How well are asthma treatment cards filled out in public health centres in Gazeera State, Sudan? Public Health Action. 2014;4(2):116-21. doi: 10.5588/pha.14.0004, PMID 26399211.

20. McEwan PJ. Cost-effectiveness analysis of education and health interventions in developing countries. J Dev Eff. 2012;4(2):189-213. doi: 10.1080/19439342.2011.649044.

21. EuroQol Group. EuroQol-a new facility for the measurement of health-related quality of life. Health Policy. 1990;16(3):199-208. doi: 10.1016/0168-8510(90)90421-9, PMID 10109801.

22. Jelsma J, Maart S. Should additional domains be added to the EQ-5D health-related quality of life instrument for community-based studies? An analytical descriptive study. Popul Health Metr. 2015;13(1):13. doi: 10.1186/s12963-015-0046-0, PMID 26045697.

23. Shafie AA, Hassali MA, Mohamad Yahaya AH. Health-related quality of life among nonprescription medicine customers in Malaysia. Value Health Reg Issues. 2013;2(1):107-17. doi: 10.1016/j.vhri.2013.02.005, PMID 29702838.

24. Chen J, Wong CK, McGhee SM, Pang PK, Yu WC. A comparison between the EQ-5D and the SF-6D in patients with Chronic Obstructive Pulmonary Disease (COPD). PLOS ONE. 2014;9(11):e112389. doi: 10.1371/journal.pone.0112389, PMID 25379673.

25. Freeman III AM, Hammitt JK, De Civita P, Branch CS. On quality adjusted life years (QALYs) and environmental/consumer safety valuation. Aere Newsl. 2002;22(1):7-11.

26. Lindkvist M, Feldman I. Assessing outcomes for cost-utility analysis in mental health interventions: mapping mental health specific outcome measure GHQ-12 onto EQ-5D-3L. Health Qual Life Outcomes. 2016;14(1):134. doi: 10.1186/s12955-016-0535-2, PMID 27644119.

27. Kontodimopoulos N, Pappa E, Niakas D, Yfantopoulos J, Dimitrakaki C, Tountas Y. Validity of the EuroQoL (EQ-5D) instrument in a Greek general population. Value Health. 2008;11(7):1162-9. doi: 10.1111/j.1524-4733.2008.00356.x, PMID 18489492.

28. Ferreira LN, Ferreira PL, Pereira LN. Comparing the performance of the SF-6D and the EQ-5D in different patient groups. Acta Med Port. 2014;27(2):236-45. doi: 10.20344/amp.4057, PMID 24813493.

29. Bahadori K, Quon BS, Doyle-Waters MM, Marra C, Fitz Gerald JM. A systematic review of economic evaluations of therapy in asthma. J Asthma Allergy. 2010;3:33-42. doi: 10.2147/jaa.s11038, PMID 21437038.

30. El Sony AI AI, Chiang CY, Malik E, Hassanain SA, Hussien H, Khamis AH, *et al*. Standard case management of asthma in Sudan: a pilot project. Public Health Action. 2013 Sep 21;3(3):247-52. doi: 10.5588/pha.13.0019, PMID 26393039.

31. Mori AT, Robberstad B. Pharmacoeconomics and its implication on priority-setting for essential medicines in Tanzania: a systematic review. BMC Med Inform Decis Mak. 2012;12:110. doi: 10.1186/1472-6947-12-110, PMID 23016739.

32. Çelik GE, Bavbek S, Paşaoğlu G, Mungan D, Abadoğlu O, Harmancı E, *et al*. Direct medical cost of asthma in Ankara, Turkey. Respiration. 2004;71(6):587-93. doi: 10.1159/000081759, PMID 15627869.

33. Accordini S, Bugiani M, Arossa W, Gerzeli S, Marinoni A, Olivieri M, *et al*. Poor control increases the economic cost of asthma. A multicentre population-based study. Int Arch Allergy Immunol. 2006;141(2):189-98. doi: 10.1159/000094898, PMID 16899987.

34. Raissy HH, Kelly HW, Harkins M, Szefler SJ. Inhaled corticosteroids in lung diseases. Am J Respir Crit Care Med. 2013;187(8):798-803. doi: 10.1164/rccm.201210-1853PP, PMID 23370915.

35. Donohue JF, Ohar JA. Effects of corticosteroids on lung function in asthma and chronic obstructive pulmonary disease. Proc Am Thorac Soc. 2004 Nov;1(3):152-60. doi: 10.1513/pats.200402-003MS, PMID 16113428.

36. Rowe BH, Edmonds ML, Spooner CH, Diner B, Camargo CA. Corticosteroid therapy for acute asthma. Respir Med. 2004;98(4):275-84. doi: 10.1016/j.rmed.2003.11.016, PMID 15072167.

37. Stock S, Redaelli M, Luengen M, Wendland G, Civello D, Lauterbach KW. Asthma: prevalence and cost of illness. Eur Respir J. 2005;25(1):47-53. doi: 10.1183/09031936.04.00116203, PMID 15640322.

38. Rutten van-Mölken MP, Feenstra TL. The burden of asthma and chronic obstructive pulmonary disease: data from the Netherlands. Pharmacoeconomics. 2001;19(S2):1-6. doi: 10.2165/00019053-200119002-00001, PMID 11700783.

39. Cisternas MG, Blanc PD, Yen IH, Katz PP, Earnest G, Eisner MD, *et al*. A comprehensive study of the direct and indirect costs of adult asthma. J Allergy Clin Immunol. 2003;111(6):1212-8. doi: 10.1067/mai.2003.1449, PMID 12789219.

40. Weiss KB, Sullivan SD. The health economics of asthma and rhinitis. I. Assessing the economic impact. J Allergy Clin Immunol. 2001;107(1):3-8. doi: 10.1067/mai.2001.112262, PMID 11149982.

41. Bavbek S, Mungan D, Türktaş H, Mısırlıgil Z, Gemicioğlu B, ADVISE Study Group. A cost-of-illness study estimating the direct cost per asthma exacerbation in Turkey. Respir Med. 2011;105(4):541-8. doi: 10.1016/j.rmed.2010.10.011, PMID 21035319.

42. van der Meer V, van den Hout WB, Bakker MJ, Rabe KF, Sterk PJ, Assendelft WJ, *et al*. Study Group. Cost-effectiveness of Internet-based self-management compared with usual care in asthma. PLoS One. Self-Management Asthma Supported Hosp ICT Nurs Gen Pract. 2011;6(11):e27108.

43. Stoloff SW, Kelly HW. Updates on the use of inhaled corticosteroids in asthma. Curr Opin Allergy Clin Immunol. 2011;11(4):337-44. doi: 10.1097/ACI.0b013e328348a813, PMID 21720220.

44. Liu D, Ahmet A, Ward L, Krishnamoorthy P, Mandelcorn ED, Leigh R, *et al*. A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. Allergy Asthma Clin Immunol. 2013;9(1):30. doi: 10.1186/1710-1492-9-30, PMID 23947590.

45. Rowe BH, Spooner CH, Ducharme FM, Bretzlaff JA, Bota GW. Corticosteroids for preventing relapse following acute exacerbations of asthma. Cochrane Database Syst Rev. 2001(1). doi: 10.1002/14651858.CD000195.pub2.

46. Kemp L, Haughney J, Barnes N, Sims E, von Ziegenweidt J, Hillyer EV, *et al*. Cost-effectiveness analysis of corticosteroid inhaler devices in primary care asthma management: a real world observational study. Clinicoecon Outcomes Res. 2010;2:75-85. doi: 10.2147/ceor.s10835, PMID 21935316.