Economic Impact of Inhaler Misuse in Australia and Jordan: Checklist Guided Patient Education can Reduce Pharmaceutical Expenditures

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ABSTRACT

Objectives: To estimate costs associated with patient inhaler misuse and potential savings that might be gained as a result of improving inhaler technique through pharmacist delivered intervention. **Methods**: This study took the form of a longitudinal, parallel group, repeated measures study design in which community pharmacists from Australia and Jordan were invited to educational workshops on inhaler technique. Pharmacists (research pharmacist in Jordan) then delivered an educational intervention to patients with asthma on inhaler technique. Patients were assessed at baseline and three months following baseline. The impact of incorrect inhaler technique on costs was determined before and after education. **Results**: Majority of pharmacists were females (Australia 56%, n=16; Jordan 57%, n=14) with no significant differences in age or years in practice. Turbuhaler and Diskus users from Australia and Jordan (n=53; n=51 respectively) showed no significant differences. Cost of inhaler misuse for Australians was estimated at US$ 6,492 per year with an average US$ 122.5 per user. Cost of inhaler misuse for Jordanians was estimated at US$ 10,990 per year with an average of US$ 215.5 per user. Substantial savings resulted due to the pharmacist delivered intervention. **Conclusions**: This study outlined the substantial costs associated with inhaler misuse and significant cost savings resulting from a pharmacist led intervention, demonstrating the necessity for pharmacist delivered education in this area.

Keywords: Cost, Turbuhaler, Diskus, Inhaler technique, Patient education, Pharmacists.

1. INTRODUCTION

The worldwide costs associated with the management of asthma in adults and children are reported substantial; primarily attributable to the costs of medications, related to both the drug and the inhaler device type[1]. When it comes to medication classes, combination medications (inhaler corticosteroids and long acting beta agonists) in the one device have become a cornerstone in the management of asthma[2]. Amongst the devices used, dry powder inhalers (DPIs) are popular as their use overcomes the co-ordination problem required with other devices such as pressurized metered dose inhalers (pMDIs), achieving higher lung deposition and minimizing side effects[3, 4].

Whilst there are theoretical and practical advantages to the delivery of respiratory medication via inhalers[5], it is recognized that a high proportion of patients (up to 90%) across all age groups do not use their inhalers correctly[6-9]. This problem appears common across the spectrum of inhaler devices[11, 12]. The implications of patient inhaler misuse are significant with suboptimal inhaler use being associated with poorer adherence[13] and asthma control[14],

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with obvious consequences on the day-to-day lives of people with asthma[15]. However, in addition to the impact on the clinical manifestations of asthma [15-20], the impact of inhaler misuse has also been suggested to be financial. In 1990, King et al., conducted a study in the UK in which a small cohort of people with asthma were evaluated in terms of the cost of misusing their pMDI inhalers. The results showed that there was a large cost associated with pMDI misuse [21]. Further, research has shown that there are differences in the primary health care costs associated with the use of different inhalers [22].

In considering the costs of using inhaler devices incorrectly, it is therefore also important to determine whether improving inhaler technique do not only impact on the use of these inhalers and subsequent clinical outcomes, but also on the costs associated with their use.

Patient education to improve inhaler technique should be a central element of patient education in asthma[1]. However, health care professionals who are expected to educate asthma patients on inhaler technique perform very little better than patients in their ability to demonstrate the correct use of asthma inhaler devices[23-25]. Pharmacists are in a pivotal position to optimize patients' inhaler and can be trained to deliver successful focused educational service to asthma patients on inhaler use[14, 26, 27].

The aim of this research was to estimate the costs associated with inhaler misuse and the potential savings that might be gained as a result of improving inhaler use through a structured, pharmacist-delivered intervention. In order to determine the multinational relevance of this question, this research included a comparison between two countries (Australia and Jordan).

Methods

Study design and settings

This interventional counselling study took the form of a pre-post study design in which people with asthma were asked to attend the community pharmacy (respiratory clinics in Jordan) and data was collected at baseline and follow-up (3 months post baseline). Similar study processes were completed in Australia and Jordan. Ethics approval for this research was obtained from the University of Sydney Human Ethics Committee (Australia), and from the Jordanian Ministry of Health and the hospitals at which the study was conducted (Jordan). Data collected in Australia was conducted during 2003/2004 and in Jordan during 2009/2010.

Pharmacist recruitment and training

A convenient sample of community pharmacists in the Sydney metropolitan area (Australia) and a random sample of community pharmacists in Amman (Jordan) were invited to participate in the study by telephone calls and formal invitation letters or visits (Jordan). Australian pharmacists were included in the study if they were practicing in a community pharmacy, with at least one pharmacist assistant present at all times, and not involved in any other clinical study. Pharmacists were excluded if they were not able to attend the study workshop or to commit to the follow-up study. Jordanian pharmacists were included in the study if they were practicing in a community pharmacy and agreed to attend the study workshop.

Once recruited, Australian pharmacists attended the workshop in the Faculty of Pharmacy, University of Sydney and Jordanian pharmacists attended the workshop at Ibn Al-haitham hospital, Amman, Jordan. The workshops were delivered in Australia and Jordan by the same researcher (IB, an expert in the area of asthma management and inhaler technique education), and were similar with regards to length (2 to 3 hours) and material covered (general information about asthma, inhaled medications, patient education on inhaler technique and clinical effect of each incorrectly performed step in the inhaler checklists with lung images to explain the consequences of incorrectly performed steps in the inhalation technique checklists)[28,29]. Similar adult learning principles were used to enhance pharmacists' knowledge and psychomotor skills on inhaler technique[23,28]. The environments in which the educational activities of both workshops took place were alike and set to satisfy all of the requirements for a good learning environment [30].

Pharmacists' inhaler technique was scored on two DPIs

(Diskus (DIS) and Turbuhaler (TH)) using published checklists (Table 1). Both the DIS and TH checklists comprise 9 steps, of which 3 steps and 4 steps, respectively, are essential. One point was assigned for each correctly performed step, giving a maximum score of 9 for each device (Table 1). GlaxoSmithKline provided placebo DIS inhalers, and AstraZeneca provided placebo TH inhalers. Pharmacists were then shown how to teach peak flow meter technique and educate patients about DIS and TH technique.

Table 1. Inhaler technique checklists

Diskus technique checklist
1. Open Inhaler*
2. Push lever back completely*
3. Exhale to residual volume
4. Exhale away from mouthpiece
5. Place Mouthpiece between teeth and lips
6. Inhale forcefully and deeply*
7. Hold breath for 5 seconds
8. Exhale away from mouthpiece
9. Close inhaler
Turbuhaler technique checklist
1. Remove the cap from the Inhaler*
2. Keep inhaler upright*
3. Rotate grip until a click is heard*
4. Exhale to residual volume
5. Exhale away from mouthpiece
6. Place mouthpiece between teeth and lips
7. Inhale forcefully and deeply*
8. Hold breath for 5 seconds†
9. Exhale away from mouthpiece

* Essential steps based on previous published literature.[33] †Note that this step is not included in the product insert, but appears in the Turbuhaler instruction on the Global Initiative for Asthma (GINA)[2] and in the checklist published by van der Palen et al and Basheti et al.[33, 34]

The workshop concluded with re-assessment of the pharmacists' inhaler technique, with any residual problems corrected before workshop end. Pharmacists in Australia received information on how to complete data collection forms for the three month follow-up patient study they were about to deliver. The study materials they were provided with included "Inhaler Technique Labels", an evidence-based educational protocol (Figure 1). Pharmacists in Jordan did not receive the data collection forms because the patient part of the study was not delivered by them (it was delivered by a researcher clinical pharmacist). The strategies used to educate pharmacists and patients about inhaler technique were previously evaluated for their efficacy and were reported elsewhere[25, 28, 31].

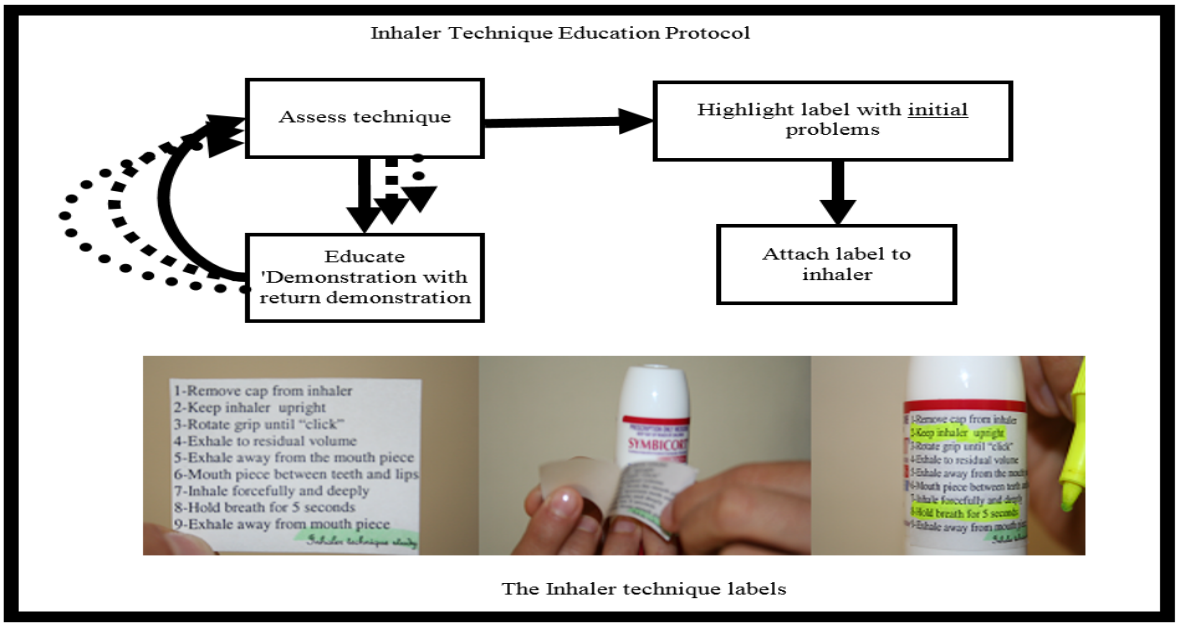
Patient Recruitment and intervention delivery

Once trained, pharmacists (researcher in the Jordanian arm of the study) were asked to approach patients with asthma presenting DIS and TH prescriptions at the pharmacy (respiratory clinics in Jordan). Individuals who agreed to participate and signed informed consent then proceeded into the study. At this time (baseline) assessment of patients' DIS or TH technique was conducted using the relevant placebo inhaler. Inhaler technique was evaluated using published checklists (as above).

Afterwards, pharmacists (researcher in Jordan) delivered inhaler technique education to the patients, which concluded with the application of the inhaler technique label, highlighting the particular steps performed incorrectly by the individual. Participants returned to the pharmacy on monthly basis in Australia (for reassessment and reeducation) [31], while in Jordan they returned only once at follow-up visit [32]. For the follow-up assessment, participants returned to the pharmacy (clinics in Jordan) after three months at which time their inhaler technique was assessed using the same inhaler technique assessment method described above.

Figure 1: Inhaler Technique Education Protocol using the novel inhaler technique labels

1. Assess patient's inhaler technique
2. Highlight any incorrect steps on the "Inhaler Technique Label"
3. Educate patient on correct inhaler technique by verbal counselling and physical demonstration with a placebo inhaler, addressing all steps in the inhaler technique checklist
4. Repeat steps 1 and 3 up to three times if necessary, until the patient has correct technique.
5. Attach the highlighted 'Inhaler Technique Label' to the patient's own inhaler
6. Repeat the inhaler technique assessment and education at each subsequent visit, and place a new 'Inhaler Technique Label' on the patient's replacement inhaler (or on the old one if still in use), highlighting the label with the initial problems.



Economic impact of incorrect inhaler use

In order to determine the impact of incorrect inhaler use on costs, inhaler technique errors were divided into those rated as 'essential' and 'non-essential' steps (Table 1)[33,34]. Participants with incorrect essential technique are those who demonstrate the technique with at least one incorrect essential step. Errors related to essential steps are considered to have substantial cost impact, as patients with incorrect essential technique are assumed to receive minimal drug delivered to their lungs [15, 19, 34], and therefore the acquisition costs to purchase the controller inhalers can be considered wasted [20].

The proportion of participants with at least one error with 'essential' steps (incorrect essential technique) was estimated at two points in the study: Baseline and follow-up visit after 3 months. This was done for Australian and Jordanian participants.

"Total annual expenditure" is the estimated annual spending on inhaler therapy use by the study participants. This was estimated by calculating inhalers' total price over the study period (three months) multiplied by four. Inhalers' total price over the study period were estimated assuming that TH users required one inhaler every two month (120 doses per inhaler, twice daily); whilst DIS users use one inhaler monthly (60 doses per inhaler, twice daily) [22].

Public acquisition unit prices for the year 2016 were utilized in the costs estimation of the inhalers used in each country was obtained from the Australian department of health - the Pharmaceutical Benefits Scheme [35]; and the Jordan Drug and food administration (JFDA) [37] (Table 2).

"Cost of inhaler misuse" at baseline was estimated by multiplying "Total annual expenditure" by the proportion of patients with incorrect essential technique (at least one incorrect essential step exists). "Cost of inhaler misuse" at follow up was estimated the same way using the proportion of patients with incorrect essential technique at follow up.

"Cost savings" was estimated as the difference in 'cost of inhaler misuse' between baseline and follow up.

The "net benefit" was estimated as the "cost savings" minus the cost of training the pharmacists in each country.

Table 2. Unit prices of the registered controller medications in each type of inhaler (Diskus and Turbuhaler) used by the participants in the study arms conducted in Australia and Jordan

Type of registered controller medications in each type of inhaler	Australia Australian Dollar (AUS)*	Australia American Dollar (US$)	Jordan Jordanian Dinar (JD)†	Jordan American Dollar (US$)
Diskus				
Seretide® 250/50	AUS$ 38.3	US$ 27.2	JD 34.9	US$ 49.1
Seretide® 500/50	AUS$ 38.3	US$ 27.2	JD 47.5	US$ 66.9
Flixotide® 250	AUS$ 36.1	US$ 25.6	JD 20.6	US$ 29.0
Turbuhaler				
Pulmicort® 200	AUS$ 36.4	US$ 25.8	JD 15.1	US$ 21.3
Pulmicort® 400	AUS$ 38.3	US$ 27.2	NA	NA
Symbicort® 160/4.5#	NA	NA	JD 42.37	US$ 59.7
Symbicort® 400/12#	AUS$ 38.3	US$ 27.2	NA	NA

Seretide 250/50 (fluticasone plus salmeterol (250mcg/50mcg)); Seretide 500/50 (fluticasone plus salmeterol (500mcg/50mcg)); Flixotide 250 (fluticasone 250mcg); Pulmicort 200 (budesonide 200mcg); Pulmicort 400 (budesonide 400mcg); (Symbicort 160/4.5) (budesonide plus eformoterol (160mcg/4.5mcg)); (Symbicort 400/12) (budesonide plus eformoterol (400mcg/12mcg)). *Australian Government, Department of Health [35] (Note: current prices for inhalers in Australia are slightly higher than that at the time of the study (AU$36.1)). †Public prices in Jordan as approved by Jordan Food and Drug Association [37]. #Calculations were done using prices for Symbicort 120 doses. One American dollar equals 0.71 Jordanian Dinar. One Australian dollar equals to 0.71 American dollar. NA= not applicable. Prices presented here are the maximum prices to consumers in Australia and the public prices (plus taxes) in Jordan.

Statistical analysis

Data were analyzed with statistics software (SPSS 20, SPSS, Chicago, Illinois). Proportional data were analyzed using Pearson's Chi-Square test to compare between the groups. For continuous variables, Independent sample T test (normally distributed data) or Mann–Whitney U-test was used. For all statistical analysis, p-values of 0.05 or less were considered statistically significant.

Results

Sixteen pharmacists and 14 pharmacists in Australia and Jordan respectively participated in this study. Majority of pharmacists were females (Australia 56%, Jordan 57%) with similar age (Australia: 40.4 ± 10.7; Jordan: 36.0 ± 10.4 (mean ± SD)) and years in practice (Australia: 16.1 ± 11.4; Jordan: 15.9 ± 9.8; (mean ± SD)). Results of pharmacists' inhaler technique and effect of workshops are reported elsewhere [28, 29]. Average training costs was US$ 650 in Australia whilst the average cost in Jordan was US$ 320 per one educational workshop. Details of training costs are presented in (Table 5).

From Australia, 30 DIS users and 23 TH users participated in the study. From Jordan, similar number of patients participated (28 DIS users and 23 TH users). Majority of participants from both countries were females (Australia 68%; Jordan 61%). Most of the participants were aged in their fourth decade (Australia: 48.85 ± 19.0; Jordan: 43.25 ± 14.5). No significant differences were found between the inhaler groups in each study arm, $p > 0.05$ One way ANOVA.

Correct essential technique

At baseline, in both Australia and Jordan, a significantly greater proportion of participants were able to demonstrate correct essential technique with the DIS compared to the TH. Three months following education, all patients in Australia and majority of the patients from Jordan were able to demonstrate correct essential technique for both inhaler devices (Table 3).

Economic impact of incorrect inhaler use

Table 4 presents the type of controller medications that DIS and TH users were taking from the start of the study. This information was used to estimate the 'Total annual expenditure' of DIS and TH inhalers use in both Australia and Jordan.

Table 3. Proportion of patients with correct essential techniques in Australia and Jordan at baseline and after 3 months of education

	Australia		**Jordan**	
Correct essential technique at baseline	**Diskus n=30**	**Turbuhaler n=23**	**Diskus n=28**	**Turbuhaler n=23**
	18 (60%)	7 (30%)	19 (68%)	1 (4%)
Correct essential technique at three months	**Diskus n=29**	**Turbuhaler n=20**	**Diskus n=26**	**Turbuhaler n=23**
	29 (100%)	20 (100%)	23 (88%)	19 (83%)
*P value	NA	NA	P=0.109	P<0.001

*Comparing proportion of patients with correct essential technique at baseline to three months follow-up (McNemar's test).
NA= not applicable.

Table 4. Proportion of patients using registered controller medications in each type of inhaler (Diskus and Turbuhaler) used by the participants in the study arms conducted in Australia and Jordan

Type of registered controller medications in each type of inhaler	Australia	Jordan
Diskus	**#n=30**	**n=28**
Seretide® 250/50	16 (50.0%)	14 (50%)
Seretide® 500/50	13 (40.6%)	6 (21.4%)
Flixotide® Diskus (250)	1 (3.1%)	6 (28.6%)
Flixotide® Diskus (250) (plus Oxis)	1 (3.1%)	0 (0.0%)
Flixotide® Diskus (250) (plus Foradil)	1 (3.1%)	2 (7.1%)
Turbuhaler	**n=23**	**n=23**
Pulmicort® 200	4 (17.4%)	8 (34.8%)
Pulmicort® 400	8 (34.8%)	0 (0.0%)
Pulmicort® 200 (plus Oxis)	1 (4.3%)	1 (4.3%)
Pulmicort® 400 (plus Oxis)	4 (17.4%)	0 (0%)
Symbicort® 160/4.5	0 (0.0%)	14 (60.9%)
Symbicort® 400/12	6 (26.1%)	0 (0.0%)

* The inhaler strengths are in micrograms. #In the Australian study arm, two patients withdrew consent before inhaler technique assessment and education (Seretide users), hence inhaler costs were calculated for n=30. Seretide 250/50 (fluticasone plus salmeterol (250mcg/50mcg)); Seretide 500/50 (fluticasone plus salmeterol (500mcg/50mcg)); Flixotide 250 (fluticasone 250mcg); Oxis (formoterol 12mcg); Foradile (formoterol 12mcg); Pulmicort 200 (budesonide 200mcg); Pulmicort 400 (budesonide 400mcg); (Symbicort 160/4.5) (budesonide plus eformoterol (160mcg/4.5mcg)); (Symbicort 400/12) (budesonide plus eformoterol (400mcg/12mcg)).

Australia

"Total annual expenditure" of DIS used by the Australian participants was calculated as US$ 9,734.4. As for TH users, it was calculated as US$ 3,711.6. Total annual expenditure for both inhalers equaled to US$ 13,446.0.

"Cost of inhaler misuse" at baseline for the DIS was calculated as US$ 3,893.8, equaling to US$ 129.8 per patient. As for TH Australian participants, it was estimated at US$ 2,598.1, equaling to US$ 113.0 per patient. 'Cost of inhaler misuse' at follow up for both DIS and TH was zero as all of the patients were able to demonstrate correct essential technique at this stage of the study.

The annual 'cost savings' for both inhalers equaled to US$ 6,491.9, corresponding to US$ 132.5 per patient. Considering the cost of the workshop (US$ 650), the 'net benefit' here was US$ 5,841.9, corresponding to US$ 119.2 per patient.

Jordan

"Total annual expenditure" for the DIS used by the Jordanian participants during the study period was US$ 15,849.6. As for the TH users, it was US$ 6,165.0. 'Total annual expenditure' for both inhalers was US$ 22,014.6.

'Cost of inhaler misuse' at baseline was calculated at US$ 5,071.9 for the DIS users, equaling to US$ 181.1 per

patient. Cost of inhaler misuse was US$ 5,918.4 for TH users, equaling to US$ 257.3 per user.

At follow up, the 'cost of inhaler misuse' was US$ 1902.0 for DIS users, equaling to US$ 73.2 per patient. Cost of inhaler misuse was US$ 1048.1 for TH users, equaling to US$ 45.6 per patient.

Table 5. Cost of pharmacist education delivery in Australia and Jordan

Resource used	Australia	Jordan
Venue* plus catering (Dinner / coffee break)	US$ 290	US$ 160
#Trainers (n=3)	US$ 70 each (total $210)	US$ 50 each (total $150)
administrative costs	US$ 50	US$ 50
Advertising	US$ 50	US$ 50
Printing	US$ 50	US$ 50
Placebo inhalers[#]	Provided by the company	Provided by the company
Total cost of one workshop	US$ 650	US$ 320

* Place of workshop: Australia- University of Sydney, Common room. Jordan- Meeting room at Ibn Al-haitham Hospital (Private hospital in Amman, Jordan). Cost shown in American Dollars (US$). #This cost is an estimate; trainers in this study were the researchers and were not paid. [#]GlaxoSmithKline provided placebo DIS inhalers; AstraZeneca provided placebo TH inhalers.

Annual 'cost savings' for both inhalers (DIS: 3,169.9; TH: 4,870.3) was calculated at US$ 8,040.2, equaling to US$ 164.1 per patient. Cost of the workshop in Jordan was estimated at US$ 320, hence the 'Net benefit' was calculated at US$ 7,720.2, equaled to US$ 157.6 per patient.

Discussion

This study is among the few studies that assesse costs associated with poor inhaler techniques in Australia[38, 39], and to the best of our knowledge, this is the first study in Jordan. Thus, it provides valuable insight to decision makers on the potential cost savings and cost implications of patient-pharmacist led education. This study sheds light on the importance of pharmacists' tailored education program delivered to asthmatic patients on the proper use of inhalers, as it can lead to a sustained increase in correct inhaler technique and therefore substantial cost savings. This has been demonstrated in two countries with different healthcare systems; Australia and Jordan. Our results are consistent with other studies highlighting the significant role pharmacists can play in patient inhaler technique education[40, 42, 43].

Clinical guidelines for asthma treatment recommend that inhaler technique training should be delivered and repeated on regular basis, and that all health-care professionals should participate [2]. Pharmacists are the last health-care providers with patient contact before patients start using their asthma medications. Patients must see their pharmacist before they are dispensed their controller medications, giving the pharmacist the ideal chance to assess their technique and to deliver the needed education. Also, patients need to come back to the pharmacy to obtain their refill prescriptions, providing the pharmacist the chance to reassess their technique on regular basis. Add to that, in Jordan many patients self-medicate themselves, and may buy their inhalers from the pharmacy without a prescription [44], resulting in the possibility of the pharmacist being the only health care professional they see for their asthma management and treatment. Inhaler technique education by pharmacists requires few minutes only[31]. Considering these factors and the feasibility of pharmacists providing patient education about asthma and inhaler technique, preparing the pharmacists for this task is anticipated to be highly rewarding.

Australia and Jordan represent different healthcare systems and health education, yet the issues associated with incorrect inhaler use were found consistent with certain parts of the Dis and TH technique in both countries[25]. There were similar rates of error amongst the

pharmacists and patients in Jordan and Australia [25]. This would suggest that these problematic steps are device-specific and not a result of cultural or health education backgrounds. Most patients were unable to perform correctly the essential technique steps at baseline. Three months following education by pharmacists, all patients from Australia and majority from Jordan (86%) demonstrated correct use of their inhalers. The better results obtained in the Australian study arm could be due to the fact that patients were seen (reassessed and reeducated on correct inhaler technique) on monthly basis before the third month assessment was completed. Patients from Jordan were only seen once following baseline (at the follow-up visit). A nationwide pharmacist – patient guided educational program focusing on the importance of regular inhaler technique assessment and education can provide a potential effective strategy to improve patients' use of their inhalers and subsequently achieve substantial cost savings.

Studies suggested that asthma costs increase significantly with uncontrolled patients with asthma[15, 19, 38, 39, 45]. A study in the USA reported that medical expenditures attributable to asthma were up to $4423 greater for those with markers of uncontrolled asthma compared with those who did not have asthma [46]. Suboptimal use of the inhaler devices leads to lower amounts of the medication reaching the targeted areas in the patient's lungs [47, 48]. This eventually results in worse asthma control, leading to stepping up in corticosteroid therapy to higher doses, or to adding additional therapies (such as the long acting beta agonists) for patients who could be managed well with inhaled corticosteroid therapy alone [49, 50]. In Australia, the Australian institute for health and welfare reported total health expenditure due to asthma as $606 million [51]. This accounts to 1% of the total health expenditure in Australia, with almost 60% spent on prescriptions, accounting to 363 million [51].

This study sheds light on the direct costs of inhaler misuse, which was found to be similar across both inhaler devices, but generally higher in Jordan than Australia. Cost of inhaler misuse for Australians was estimated at an average of US$ 122.5 per user, with close estimates for DIS users (US$ 129.8) and TH users (US$ 113.0). As for Jordan, the cost of inhaler misuse was estimated at an average of US$ 215.5 per user, somewhat lower for DIS users (US$ 181.1) compared to TH users (US$ 257.3). This dissimilarity was mainly due to the differences in inhaler unit prices used in the calculations. In Australia, the maximum prices to consumers as provided by the Pharmaceutical Benefits Scheme Health [35] were used and were somewhat lower than the public prices provided by the JFDA in Jordan[37]. In Australia, health insurance is provided to all eligible Australian residents through Medicare, allowing access to a range of medical services, lower cost prescriptions and free care as a public patient in a public hospital [52]. In Jordan, the government provides health insurance for the majority of the population. In 2010, it was estimated that 69.6% of the population are insured, with the Ministry of Health being the most prominent, (30.7% of the population), followed by the Royal Medical Services (17.8%), both the Ministry and Royal Medical Services (7.0%), Ministry and the private sector (2.6%), or Ministry and UNRWA (1.7%) [53]. This leaves about 30% of the population in Jordan uninsured, drawing attention to the importance of correcting patient's inhaler technique in order to save the inhaler treatment wastage cost on the government and the uninsured patient.

Limitations

This study provides a meaningful insight about the effect and structure of a pharmacy led asthma service, however, there are a number of limitations that warrants discussion; this study does not capture the impact of educating and improving inhaler techniques on asthma control or quality of life. Recent studies have highlighted though that correct inhaler techniques are associated with better asthma control and lower frequent emergency department visits due to exacerbation[49].

Incorrect essential technique means little or no medication has reached the patient's lung. Zero effectiveness due to incorrect inhaler technique was assumed. This has been assumed previously by expert researchers in this field[15, 19, 34]. Noteworthy, this might lead to underestimation of the effectiveness and control of patients with certain incorrect essential steps. Thus, future

research needs to reveal the impact of correcting each essential step in the inhaler technique checklist on patient outcomes. Identify the significance of correcting each essential step with regards to clinical outcomes would be useful.

The inhaler technique check lists used are validated and reliable in assessing patient's inhaler techniques[33], yet the criteria to inhale "forcefully and deeply" might be associated with variability. For examples, DIS manufacturer's instruction sheet recommends patients to inhale "steadily and deeply" for optimum delivery. Thus, our finding might have device-specific pitfalls, and there are areas for improvements in this regard.

Cost estimation was based on assuming total waste of drug in case of incorrect essential inhaler technique, studies of similar scope assumed zero delivery too[15, 19]. However, a proportion of drug might still be delivered [54] and thus cost savings shown in this paper might be overestimated. Sensitivity analysis was not performed to assess study conclusions on a range of drug delivery to the lungs. Nevertheless, the cost savings shown here would be substantial even if only 50% was taken into consideration.

Other limitations to this study include that it was not conducted in both countries at the same time and patients were not randomly selected. In Australia, the participating pharmacists recruited patients to whom they might have previously provided education in the pharmacy, whereas in Jordan the patients were recruited from established asthma clinics by one pharmacist researcher, so there was no professional relationship between the patients and the participating pharmacists. Nevertheless, it is not expected that the different settings between the two countries would significantly affect the generalizability of the results.

Conclusions

This study outlines an estimate of the substantial cost associated with inhaler misuse in both Australia and Jordan, and demonstrates considerable potential cost savings when patient educational-focused intervention is applied by the pharmacist. However, pragmatic trials, reflecting variations between randomly recruited patients with larger sample size are needed to confirm the true economic value of improving inhalation techniques. Future studies also need to explore the impact of improving inhaler technique compared to increasing the dose of existing therapies, when asthma control is not established.

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REFERENCES

(1) Braman S.S. The global burden of asthma. *Chest* 2006; 130(1 Suppl): 4S-12S.

(2) Global Initiative for Asthma (GINA) - Global strategy for asthma management and prevention report 2016 Available online at: http://www.ginasthma.org. Accessed April 2016.

(3) Roche N., Huchon G.J. Rationale for the choice of an aerosol delivery system. *J Aerosol Med.* 2000; 13(4): 393-404.

(4) Borgstrom L., Asking L., Thorsson L. Idealhalers or realhalers? A comparison of Diskus and Turbuhaler. *Int J Clin Pract* 2005; 59 (12): 1488-1495.

(5) Elvin-Lewis M. Should we be concerned about herbal remedies. *Journal of Ethnopharmacology* 2001; 75 (2-3): 141-164.

(6) Melani A.S., Zanchetta D., Barbato N., Sestini P., Cinti C., Canessa P.A., Aiolfi S., Neri M. Inhalation technique and variables associated with misuse of conventional

metered-dose inhalers and newer dry powder inhalers in experienced adults. *Ann Allergy Asthma Immunol* 2004; 93 (5): 439-446.

(7) Cayo-Quine A., Martinez-Vargas V., Bustamante-Voysest R., Piscoya A. Alberca Y. Incorrect use of metered-dose inhalers in adult patients at a hospital in Callao, Peru, 2014: cross-sectional study. *Medwave* 2015; 15(5): e6163.

(8) Basheti I.A., Reddel H.K., Armour C.L., Bosnic-Anticevich S.Z. Counseling about turbuhaler technique: needs assessment and effective strategies for community pharmacists. *Respir Care* 2005; 50(5): 617-623.

(9) Capanoglu M., Dibek Misirlioglu E., Toyran M., Civelek E., Kocabas C.N. Evaluation of inhaler technique, adherence to therapy and their effect on disease control among children with asthma using metered dose or dry powder inhalers. *J Asthma* 2015; 52 (8): 838-845.

(10) Adams R.J., Wilson D.H., Taylor A.W., Daly A., Tursan d'Espaignet E., Dal Grande E. Ruffin R.E. Coexistent chronic conditions and asthma quality of life: a population-based study. *Chest* 2006; 129 (2): 285-291.

(11) Basheti I.A. The effect of using simulation for training pharmacy students on correct device technique. *Am J Pharm Educ* 2014; 78 (10): 177.

(12) Melani A.S., Bonavia M., Cilenti V., Cinti C., Lodi M., Martucci P., Serra M., Scichilone N., Sestini P., Aliani M. Neri M. Inhaler mishandling remains common in real life and is associated with reduced disease control. *Respir Med* 2011; 105 (6): 930-938.

(13) Darba J., Ramirez G., Sicras A., Garcia-Bujalance L., Torvinen S. Sanchez-de la Rosa R. Identification of factors involved in medication compliance: incorrect inhaler technique of asthma treatment leads to poor compliance. *Patient Prefer Adherence* 2016; 10: 135-145.

(14) Basheti I.A., Reddel H.K., Armour C.L. Bosnic-Anticevich S.Z. Improved asthma outcomes with a simple inhaler technique intervention by community pharmacists. *J Allergy Clin Immunol* 2007; 119 (6): 1537-1538.

(15) Giraud V., Roche N. Misuse of corticosteroid metered-dose inhaler is associated with decreased asthma stability. *Eur Respir J* 2002; 19(2): 246-251.

(16) Lahdensuo A., Muittari A., Lahdensuo A., Jukkara A. Bronchodilator effects of a fenoterol metered dose inhaler and fenoterol powder in asthmatics with poor inhaler technique- Theophylline plus hydroxyzine versus theophylline monohydrate in the treatment of asthma. *Eur J Respir Dis* 1986; 68(5): 332-335.

(17) Lindgren S., Bake B., Larsson S. Clinical consequences of inadequate inhalation technique in asthma therapy. *Eur J Respir Dis* 1987; 70 (2): 93-98.

(18) McFadden E.R., Jr. Improper patient techniques with metered dose inhalers: clinical consequences and solutions to misuse. *J Allergy Clin Immunol* 1995; 96 (2): 278-283.

(19) Brennan T.A., Leape L.L., Laird N.M., Hebert L., Localio A.R., Lawthers A.G., Newhouse J.P., Weiler P.C. Hiatt H.H. Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *N Engl J Med* 1991; 324 (6): 370-376.

(20) Fink J.B. Inhalers in asthma management: is demonstration the key to compliance? *Respir Care.* 2005; 50(5): 598-600.

(21) King D., Earnshaw S.M. Delaney J.C. Pressurised aerosol inhalers: the cost of misuse. *Br J Clin Pract* 1991; 45 (1): 48-49.

(22) Scott W.J., Shepherd J., Gambhir S.S. Cost-effectiveness of FDG-PET for staging non-small cell lung cancer: a decision analysis. *Ann Thorac Surg* 1998; 66 (6): 1876-1883; Discussion, 1883-1875.

(23) Basheti I.A., Hamadi S.A., Reddel H.K. Inter-professional education unveiling significant association between asthma knowledge and inhaler technique. *Pharm Pract (Granada)* 2016; 14 (1): 713.

(24) Casset A., Meunier-Spitz M., Rebotier P., Lefevre H., Barth C., Heitz C. de Blay F. Asthma management and inhalation techniques among community pharmacists in 2009: a comparison with the 1999 survey. *J Asthma* 2014; 51 (9): 964-973.

(25) Basheti I.A., Qunaibi E., Bosnic-Anticevich S.Z., Armour C.L., Khater S., Omar M. Reddel H.K. User error with Diskus and Turbuhaler by asthma patients and

pharmacists in Jordan and Australia. *Respir Care* 2011; 56 (12): 1916-1923.

(26) Bouwmeester C., Kraft J., Bungay K.M. Optimizing inhaler use by pharmacist-provided education to community-dwelling elderly. *Respir Med* 2015; 109 (10): 1363-1368.

(27) Basheti I.A., Hamadi S.H., Al-Saraj N., Reddel H.K. Learning and teaching inhaler technique by Health Care Professionals: an interprofessional approach revealing needs and barriers. *Jord J of App Sci* 2016; [Accepted for publication].

(28) Basheti I.A., Armour C.L., Reddel H.K. Bosnic-Anticevich S.Z. Long-term maintenance of pharmacists' inhaler technique demonstration skills. *Am J Pharm Educ* 2009; 73 (2): 32.

(29) Basheti I.A., Qunaibi E.A., Hamadi S.A. Reddel H.K. Inhaler technique training and health-care professionals: effective long-term solution for a current problem. *Respir Care* 2014; 59 (11): 1716-1725.

(30) Caffarella R.S., Planning programs for adult learners. A practical guide for educators, trainers and staff developers. 2002; Second edition, Jossey-Bass publications, San Francisco: 176-351.

(31) Basheti I.A., Armour C.L., Bosnic-Anticevich S.Z., Reddel H.K. Evaluation of a novel educational strategy, including inhaler-based reminder labels, to improve asthma inhaler technique. *Patient Educ Couns* 2008; 72 (1): 26-33.

(32) Basheti I.A., Obeidat N.M., Reddel H.K. Effect of novel inhaler reminder labels on the retention of inhaler technique skills in asthma: a single-blind randomized controlled trial *NPJ Prim Care Respir Med* 2017; [Accepted for publication].

(33) Basheti I.A., Bosnic-Anticevich S.Z., Armour C.L. Reddel H.K. Checklists for Powder Inhaler Technique: A Review and Recommendations. *Respir Care* 2014; 59(7): 1140-1154.

(34) van der Palen J., Klein J.J. Schildkamp A.M. Comparison of a new multidose powder inhaler (Diskus/Accuhaler) and the Turbuhaler regarding preference and ease of use. *J Asthma* 1998; 35 (2): 147-152.

(35) Australian Government Department of Health, the Pharmaceutical Benefits Scheme. *available at http://www.pbs.gov.au/medicine/item.* Accessed September 2016.

(36) Anderson H.R., Bailey P.A., Cooper J.S., Palmer J.C., West S. Morbidity and school absence caused by asthma and wheezing illness. *Arch Dis Child* 1983; 58 (10): 777-784.

(37) Jordan Food and Drug Association. Drugs Prices and Information *available at http://www.jfda.jo/Default.aspx*. Accessed September 2016.

(38) National Asthma Campaign Report on the cost of asthma in Australia. *National Asthma Campaign Ltd, Melbourne, Australia* 1992.

(39) Poulos L.M., Toelle B.G., Marks G.B. The burden of asthma in children: an Australian perspective. *Paediatr Respir Rev* 2005; 6 (1): 20-27.

(40) Giraud V., Allaert F.A., Roche N. Inhaler technique and asthma: feasibility and acceptability of training by pharmacists. *Respir Med* 2011; 105 (12): 1815-1822.

(41) Centre for epidemiology and research - New South Wales Department of Health New South Wales public health Bulletine (New South Wales Child Health Survey 2001). 2002; 13(Suppl 3): 34-36.

(42) Bosnic-Anticevich S.Z., So S., Armour C.L., Reddel H.K. MDI Technique: Effect of education interventions delivered in community pharmacy over time. *Am J Respir Crit Care Med* 2003; 167(7): Suppl: A 896.

(43) Armour C.L., Bosnic-Anticevich S., Brillant M., Burton D., Emmerton L., Krass I., Saini B., Smith L. Stewart K. Pharmacy Asthma Care Program (PACP) improves outcomes for patients in the community. *Thorax* 2007; 62(6): 496-502.

(44) Yousef A.M., Al-Bakri A.G., Bustanji Y. Wazaify M. Self-medication patterns in Amman, Jordan. *Pharm World Sci* 2008; 30(1): 24-30.

(45) Thompson S. On the social cost of asthma. *Eur J Respir Dis Suppl* 1984; 136: 185-191.

(46) Sullivan P.W., Slejko J.F., Ghushchyan V.H., Sucher B., Globe D.R., Lin S.L., Globe G. The relationship between asthma, asthma control and economic outcomes in the

United States. *J Asthma.* 2014; 51 (7): 769-778.

(47) Delvadia R.R., Longest P.W., Hindle M., Byron P.R. In vitro tests for aerosol deposition. III: effect of inhaler insertion angle on aerosol deposition. *J Aerosol Med Pulm Drug Deliv.* 2013; 26 (3): 145-156.

(48) Newman S.P., Newhouse M.T. Effect of add-on devices for aerosol drug delivery: deposition studies and clinical aspects. *J Aerosol Med.* 1996; 9(1): 55-70.

(49) Baddar S., Jayakrishnan B., Al-Rawas O.A. Asthma control: importance of compliance and inhaler technique assessments. *J Asthma* 2014; 51 (4): 429-434.

(50) Al-Jahdali H., Ahmed A., Al-Harbi A., Khan M., Baharoon S., Bin Salih S., Halwani R., Al-Muhsen S. Improper inhaler technique is associated with poor asthma control and frequent emergency department visits. *Allergy Asthma Clin Immunol* 2013; 9 (1): 8.

(51) Australian Bureau of Statistics The Health and Welfare of Australian Aboriginal and Torres Strait Islander People. *ABS Cat No. 4704.0. Canberra : ABS* 2003.

(52) Australian Government Department of Human Services Medicare servceis. *Available at https://www.humanservices.gov.au/customer/subjects/medicare-services.* Accessed September 2016.

(53) The Jordanian Health Sector Report (2012) *Available at https://usaidjordankmportal.com/system/resources/attachments/000/000/359/original/pdf?1456219357.* Accessed September 2016.

(54) Cochrane M.G., Bala M.V., Downs K.E., Mauskopf J., Ben-Joseph R.H. Inhaled corticosteroids for asthma therapy: patient compliance, devices, and inhalation technique. *Chest* 2000; 117 (2): 542-550.

الأثر الاقتصادي للاستخدام الخاطئ لأدوية البخاخ في استراليا والأردن: التعليم الصيدلاني للمرضى والتقليل من كلفة العلاج

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ملخص

الأهداف: تقدير التكاليف المرتبطة بسوء استخدام البخاخات من قبل مرضى الربو والتوفير الذي يمكن تحقيقه من خلال تحسين استخدام المريض للبخاخات عن طريق تقديم التعليم والتوجيه الممنهج من قبل الصيدلاني في صيدليات المجتمع.

المنهج البحثي: تضمنت هذه الدراسة مجموعتين متوازيتين من الصيادلة والمرضى من استراليا والأردن. تم دعوة الصيادلة المشاركين في البحث إلى حضور ورشات تعليمية عن طرق استخدام البخاخات. ومن ثم قام الصيادلة بدورهم بتعليم المرضى على الطريقة الأمثل لاستخدام البخاخ. جرى تقييم استخدام المرضى للبخاخات عند بداية الدراسة، أي قبل تلقي التعليم الصيدلاني وبعد ثلاثة شهور من تلقيهم التعليم. كلفة البخاخات المهدورة نتيجة سوء استخدام البخاخ تم احتسابها عند بداية الدراسة وبعد ثلاثة شهور.

النتائج: معظم المشاركين الصيادلة من استراليا والأردن كانوا أناثا (استراليا: 56%، ن=16، الأردن: 57%، ن=14). لم يكن هناك فرق إحصائي بين المشاركين من البلدين من ناحية العمر وسنوات الخبرة. كما لم يظهر فرق إحصائي بين مستخدمي بخاخ التيربوهيلر والاكيوهيلر من استراليا والأردن (استراليا: ن=53، الأردن: ن=51). كلفة الدواء المهدور نتيجة سوء استخدام البخاخ من قبل المرضى في استراليا كانت حوالي 6,492 آلاف دولار سنويا مع متوسط 122.5 دولاراً سنويا لكل مريض. أما في الأردن فالكلفة قدرت ب 10,990 آلاف دولار سنويا مع متوسط 215.5 دولار سنويا لكل مريض. نتج توفير مادي هائل بسبب التعليم الصيدلاني الممنهج الذي قدم لمرضى الربو.

الاستنتاج: هذه الدراسة وجدت أن الكلفة الناتجة عن سوء استخدام البخاخات هائلة وهناك حاجة ماسة لتقديم التعليم الصيدلاني الممنهج لمرضى الربو.

الكلمات الدالة: الكلفة، بخاخ التيربوهيلر، بخاخ الديسكاس، طريقة استخدام البخاخات، تعليم المرضى، الصيادلة.

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