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Development of a Graphical Tool to Measure Medication Adherence in Asthma Patients: A Mixed-Methods Pilot Study

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KEYWORDS: Control/Management, Treatment, epidemiology

Abstract

OBJECTIVES: 1) To develop Med-Resp, a graphical tool based on prescription refills to measure adherence and use of asthma medications; 2) To test the feasibility of implementing Med-Resp in a hospital outpatient asthma clinic; 3) To explore the effectiveness of Med-Resp to improve medication adherence to asthma controller medications.

METHODS: A sequential exploratory design was used: 1) *Prototype design* in collaboration with respiratory physicians and patients via focus groups; 2) *Med-Resp creation* based on algorithms developed and applied to prescription refills data recorded in the drug

claims database reMed; 3) *Feasibility assessment of the implementation* of Med-Resp in the outpatient asthma clinic; and 4) *Exploration of the effectiveness* of Med-Resp through a pre-post design.

RESULTS: A total of 29 patients and six respiratory physicians participated in this pilot study. The tool was highly appreciated by the participants, while the majority believed that Med-Resp has the potential to enhance physician-patient communication and aid in treatment decisions. The feasibility of implementing Med-Resp in clinical practice was demonstrated. However, we did not observe an increase in medication adherence in the six months following its implementation.

CONCLUSION: In the clinical setting, the use of prescription refills data may constitute a non-invasive and objective measure of medication adherence. This study highlights the importance of providing clinicians with objective and easily interpretable measures of medication adherence and use in routine clinical practice. Med-Resp has the potential to become implemented on a larger scale if integrated in electronic medical records.

Introduction

Asthma is a leading and preventable cause of chronic morbidity, affecting over 334 million people worldwide [1]. Despite therapeutic advances in recent years, a large proportion of patients have uncontrolled asthma resulting from sub-optimal medication adherence

[2]. Indeed, medication adherence in patients with asthma is notoriously low, ranging from 20-50%, and is associated with increases in emergency department visits, hospitalizations, mortality, and healthcare-related costs [2-6].

Asthma controller medications, including inhaled corticosteroids (ICS) with or without long-acting inhaled beta2-agonists, are the cornerstone of treatment and are generally prescribed for daily use. To treat patients with persistent asthma, regular use of a controller medication is recommended, whereas rescue medications such as short-acting beta2-agonists (SABA) are prescribed on an “as needed” basis for quick relief of asthma symptoms. Given that adherence to controller medications is a key determinant of treatment success, it is crucial that physicians recognize non-adherent patients, understand the reasons contributing to their non-adherence, and actively engage in interventions which aim at enhancing patient treatment adherence. Nevertheless, assessment of medication adherence in clinical practice is challenging. Several methods of assessment are available; however, they are either impractical for routine clinical use (blood measurement of the level of drugs, metabolite, or biological markers [7]), inaccurate (patient self-report [7-10]), or too expensive and complicated (electronic medication monitoring devices [11]). On the other hand, prescription refills constitute a non-invasive, reliable, and objective surrogate measure of adherence [12].

Due to the increasing availability of drug claims databases, prescription refill records have been used in many studies to assess adherence to treatment in chronic conditions, including asthma [13-20]. In a study conducted by Gamble *et al.*, asthmatic patients who initially denied non-adherence only admitted not following their physician’s treatment recommendations when presented with

objective measurements of their medication adherence, such as prescription refills [21]. Another study found that physicians were unable to adequately identify asthma patients with sub-optimal adherence and suggested that prescription refill data may help identify such patients more easily [22]. To our knowledge, few studies have evaluated the use of tools based on prescription refills to measure adherence in clinical practice [23-27]. Williams *et al.* conducted a randomized clinical trial to assess the effect of supplying patient adherence information to primary care providers. Their findings suggested that asthmatic patients were more likely to take ICS regularly when physicians closely monitored their medication use and reviewed electronic prescription information [25]. Although these tools have great potential to improve medication adherence and use in the clinical setting, none were developed in collaboration with the end users, which might explain why their uptake was not as high as expected.

The goal of the current research was to develop and test the feasibility of implementing Med-Resp, a graphical tool based on prescription refills to measure asthma medication adherence and use in a hospital outpatient clinic, which mostly treats patients with moderate to severe chronic respiratory diseases. Our hypothesis was that Med-Resp could be feasible to implement in clinical practice and that it could also facilitate physician-patient communication regarding medication use. Our ultimate research goal following this pilot study will be to implement this tool on a larger scale. The present study was thus a crucial first step in developing a prototype of a tool based on prescription refills in collaboration with physicians and patients (i.e. the end-users) and exploring its relevance in the clinical setting from both their perspectives.

Methods

Subjects, setting, and study design

This pilot study was conducted in the outpatient asthma clinic of the *Hôpital du Sacré-Coeur de Montréal* (HSCM) and was approved by the ethics and research committee of the same hospital. We conducted a sequential multi-phase exploratory design [28] with a mixed-methods approach (Figure 1). In Phase I, a Med-Resp prototype was developed with respiratory physicians and patients via focus groups. In Phase II, the feasibility of implementing Med-Resp in the hospital outpatient asthma clinic was assessed. In Phase III, we explored the effectiveness of Med-Resp to improve medication adherence through a pre-post design. Asthma patients were recruited from the *Registre de données en santé pulmonaire* (RESP), a registry that collects clinical information and lifestyle habits of patients with asthma or chronic obstructive pulmonary disease (COPD) from the outpatient asthma clinic of HSCM and the *Centre hospitalier de l'Université de Sherbrooke*. RESP is a continually updated research database for which patients' consent to be contacted for future research projects is obtained at registration. Patients registered in RESP also consented to their information being used for research purposes.

Phase I: Med-Resp Prototype Design and Development

In the first phase of the pilot study, two focus groups were conducted, one with patients and one with respiratory physicians. Patients were selected from the RESP database and recruited by telephone. Eligible patients were required to fulfill the following criteria: 1) to be registered in RESP; 2) to have asthma diagnosed by a respiratory physician; 3) to be aged 18-64 years old; and 4) to neither take part in a medication special access program, nor be currently enrolled in another clinical study. Demographic information was obtained from the RESP database and confirmed during the telephone interview. In addition, physicians from the HSCM were sent an email invitation to participate in the focus group.

The objective of the focus groups was to design and develop a Med-Resp prototype in collaboration with respiratory physicians and patients, as well as gain further insight on how to efficiently implement it in clinical practice. We adopted a user-centered design to develop the prototype. User-centered design is a framework of processes that is characterized by a focus on the user, while integrating the user's perceptions in all stages of the design and implementation process [29]. All focus group questions are presented in the online supplementary file.

For the focus group with physicians, we investigated the challenges they face when assessing their patients' adherence. Specifically, we aimed to: 1) identify the most appropriate metric that can be used to measure and describe medication adherence and use; and 2)

explore practical issues regarding the implementation of a tool based on prescription refills to measure adherence in the clinical setting. Since our project is a single-center pilot study, it was only possible to conduct one focus group with physicians, who were the primary users of Med-Resp. All the respiratory physicians who worked in the outpatient clinic were thus invited to participate in the focus group discussion, since their opinion was crucial for the elaboration of the Med-Resp prototype. Along similar lines, the focus group with patients was also conducted to complement the physicians' perspective. Questions on the following dimensions were addressed: 1) physician-patient communication; and 2) the extent to which patients feel comfortable with their physician having access to continuously updated information on their adherence and use of prescribed medications.

Once the most appropriate means to report adherence and medication use was identified via the focus group with respiratory physicians, Med-Resp was created based on algorithms developed and applied to prescription refills data recorded in reMed [30]. reMed is a computerized drug claims database which collects information on prescribed medications dispensed in community pharmacies for a sample of Quebecers covered with private drug insurance. reMed is developed based upon the data that are purchased from the community pharmacies' computer services providers, which transfer medication data required for reimbursement; therefore, pharmacies are not required to report the refills. The link between the providers and reMed is established by way of a dynamic, computerized, and confidential list which contains the identity of the enrolled participants.

Phase II: Feasibility of Implementation

In the second phase of the study, the feasibility of implementing Med-Resp in the HSCM outpatient asthma clinic was assessed. Patients were selected from RESP and had to fulfill the same eligibility criteria as the ones presented in Phase I, in addition to receiving coverage through private drug insurance and being registered in reMed. Eligible patients were invited by phone to participate in Phase II of the study. Patients consented to having their respiratory physicians access their drug claims data via Med-Resp. Respiratory physicians did not have access to Med-Resp for patients who refused to participate.

Respiratory physicians had access to Med-Resp in the outpatient asthma clinic between May 12, 2013 and August 24, 2016 for patients who consented to participate in the study. They were given a presentation on Med-Resp during their staff meeting, in addition to receiving an email containing information on the study. For each asthma patient who consented to participate, a research assistant inserted a paper-version of Med-Resp in the medical record before the patient's medical visit at the outpatient asthma clinic, since HSCM currently only operates with paper-based medical records.

For the feasibility assessment, physicians were requested to fill out a questionnaire following the medical visit of their first patient who participated in the study in order to evaluate their satisfaction with Med-Resp. To evaluate patient satisfaction with Med-Resp, a

research assistant invited all participants to take part in a short telephone interview that occurred on the same day as their medical visit. Post-visit questionnaires are presented in the online supplementary file.

Phase III: Effectiveness of Med-Resp

In order to explore the effectiveness of Med-Resp to improve medication adherence, a pre-post design with a historical control group was used, whereby participants served as their own control during the last visit prior to the availability of Med-Resp in the clinic. For each patient, adherence was assessed in the: 1) six-month period following a medical visit prior to the availability of Med-Resp in the clinic; and 2) six-month period following the first medical visit at the clinic in which the treating physician had access to Med-Resp. Adherence was measured using the PDC (Proportion of days covered) [31] from the prescription refills data recorded in reMed.

Data analysis

A descriptive analysis was conducted on the focus group transcripts in order to develop Med-Resp and explore the acceptability of the tool among physicians and patients. In addition, descriptive statistics were used to: 1) compare the sociodemographic characteristics and patterns of medication use between patients who accepted to participate and those who refused to participate in Phase II and III;

and 2) evaluate the users' satisfaction with Med-Resp from the post-visit telephone interviews. For the pre-post analysis, the mean adherence level was compared using paired t-tests between the two following periods: 1) six-month period following a medical visit prior to the availability of Med-Resp in the clinic; and 2) six-month period following the first visit at the clinic in which the treating respiratory physician had access to Med-Resp. In addition, data on prescriptions were retrieved from the patients' medical charts in order to obtain the complete list of prescribed medications. All statistical analyses were performed with SAS 9.4[®] (SAS Institute, Cary NC).

Results

Phase I: Med-Resp Prototype Development

A total of six asthma patients and six respiratory physicians participated in each of the two focus groups. The focus group with the respiratory physicians lasted 80 minutes, whereas the one with the patients lasted two hours. All patients were open to the idea of their physicians having access to data on their medication use and believed that Med-Resp had the potential to enhance physician-patient communication. Moreover, respiratory physicians unanimously agreed that measuring and assessing adherence in clinical practice can be challenging and expressed their eagerness to have access to an objective measure of their patients' medication adherence. It was

also agreed that Med-Resp should be presented in a graphical format and illustrate the patterns of asthma medications dispensed in community pharmacies during the last year preceding each medical visit, overall and on a quarterly basis. Physicians wished to develop a prototype that would enable them to rapidly identify, over a 1-year period, important refill gaps, as well as seasonal fluctuations of medication doses. The Med-Resp prototype is presented in Figure 2. Specifically, Med-Resp includes two components. The first component presents the monthly dispensing of asthma controller and SABA medications, as well as oral corticosteroids. The second component presents bar charts illustrating the daily dose of ICS, number of oral corticosteroids prescriptions, and weekly doses of SABA on a quarterly and annual basis. The estimate of the mean daily ICS dose was calculated by using an algorithm which we developed for previous studies that takes into account the following parameters: potency of different ICS; medication form; quantity dispensed; and medication dispensing date [32, 33]. By using the equivalency table published in the Canadian asthma consensus report [34], the mean daily ICS dose was converted to a fluticasone equivalent. To estimate weekly SABA doses, we used an algorithm which we developed in a previous study [35] that is based on equivalencies between the different SABAs and data on dispensed prescriptions including the medication's dose, formulation, quantity dispensed, date of claims, and number of days between claims.

Phase II: Feasibility of Implementation

A total of 127 patients from RESP were eligible to participate, 56 of whom accepted to take part in the study (recruitment rate: 44%). They were mostly female (60.7%), were on average 59.4 years old, and had been diagnosed with asthma for nearly 20 years on average, upon recruitment in RESP. Thirty-three participants were subsequently excluded during follow-up, because they either switched to public drug insurance (n=13; 39.4%); did not have a medical visit at the outpatient asthma clinic (n=17; 51.5%); or participated in another study (n=3; 9.1%). A total of 23 patients were included in the final analysis (Figure 3). Compared to patients who consented to participate in the study, patients who refused to participate were on average younger, had a lower level of disease control (Asthma Control Questionnaire score: 1.5 ± 1.2 vs. 1.2 ± 1.0) and had a lower adherence level to controller medications upon recruitment in RESP (Table 1).

Feasibility assessment: Capturing user experience

Of these 23 patients, we were able to reach 20 by telephone following their first medical visit in which Med-Resp was available to their treating physician. All contacted patients reported discussing their medication use with their physician. For the majority of patients (n=14; 70%), the treating physician shared the information presented in Med-Resp. Nearly half the patients (n=9; 45%) believed that Med-Resp enhanced physician-patient communication concerning their medication use. In addition, nearly three quarters

of the patients (n=14; 70%) believed that Med-Resp could be a useful tool to guide asthma treatment decision. The tool was also generally highly appreciated by the physicians. Nearly all physicians (n=5; 83.3%) consulted Med-Resp during the medical visit of their patients. In addition, the majority of physicians (n=4; 66.7%) agreed that Med-Resp can help enhance physician-patient communication concerning asthma medication use. Physicians reported that Med-Resp was a useful tool to adjust the dose of the medications for 13 of the patients who were seen during the feasibility assessment.

Phase III: Effectiveness of Med-Resp

During the pre-post assessment, the majority of patients were prescribed a combination of ICS and LABA or a combination of ICS, LABA and leukotriene receptor antagonists (Table 2). The mean PDC of patients ranged between 60.2 to 77.3% and 56.5 to 73.0%, respectively, in the six-month period before and after Med-Resp was available to the treating physician, depending on the type of asthma controller medication. In addition, the mean difference in PDC between the six-month period when Med-Resp became available to the treating physician versus when it was not available ranged from -3.7% to 0.4%, depending on the type of asthma controller medication, although these results were not statistically significant (Table 3).

Discussion

The results of the present study suggest that the implementation of Med-Resp in clinical practice is feasible, with the potential to improve adherence to asthma medications and physician-patient communication. Our user-centered approach provided participants with the opportunity to be involved throughout the design and development of Med-Resp. In addition, the focus groups allowed us to generate data that were essential to develop a prototype that was tailored to the needs of physicians and patients, whereas the feasibility study provided an assessment of the practicality of our proposed tool. Furthermore, the pre-post analysis in the feasibility study allowed for a better control of potential confounding, given that each participant served as his/her own control. This study also allowed us to explore patient and physician behaviour in a clinical context in which physicians had access to detailed information regarding medications dispensed in community pharmacies.

During the focus group, all patients were open to the idea of their physicians having access to data on their medication use. Nevertheless, recruitment rate in Phase II of the pilot study was low (44.0%) and patients who refused to participate in the study had significantly lower levels of adherence and disease control than those who accepted to participate in the study. This low recruitment rate is an interesting finding in itself, as it contrasts with that of the RESP database (95%) as well as the results of the focus group with

patients, which highlights the complex issues surrounding medication adherence and the physician-patient relationship. It was previously suggested that patients are more likely to admit that they are not following their physicians' treatment recommendations when they feel they will not be criticized and "in the context of true partnership with their physicians" [36]. Accordingly, the low recruitment rate could suggest that patients do not wish to feel like they are under constant surveillance or are criticized for their behaviours. On the other hand, the results of the focus group with physicians reflected their eagerness to have access to tools that would provide objective information on their patients' medication use, since physicians recognized that they may have difficulties detecting the non-adherence of their patients. The majority of physicians agreed that Med-Resp can help enhance physician-patient communication concerning asthma medication use, which could suggest that Med-Resp has the potential to improve the interpersonal dynamics of the physician-patient relationship in the clinical practice, and ultimately, foster higher levels of medication adherence. It would have been interesting and informative to audio-record medical visits to explore the influence of Med-Resp on the physician-patient relationship; however, this was beyond the scope of this study.

A few other studies published worldwide have evaluated the use of tools based on prescription refills to measure adherence in clinical practice. Williams *et al.* conducted a cluster randomised controlled trial to assess the effect of providing clinicians with numeric ICS adherence information of their asthma patients via an electronic prescription software [25]. The study did not find a significant difference in ICS adherence among patients in the intervention arm compared with those in the control arm, although adherence was

significantly higher in a small proportion of the patients (2.6%) for which physicians elected to view the detailed adherence information. In the United States and in Denmark, researchers have integrated graphical displays of patients' medication refill patterns within existing electronic medical records (EMR) [23, 24]; however, to our knowledge, they have not evaluated the efficacy of their tools to improve adherence and prescribing. Despite their great potential, the uptake of most of these tools was not as high as expected. Accordingly, our study suggests that adopting a user-centered approach can help develop interventions that are adapted to the needs of the primary end-users (i.e. physicians and patients), and ultimately, enhance their use and integration in the routine clinical setting. In the future, larger qualitative and mixed-methods studies should be conducted with patients and physicians to identify barriers and facilitators of the acceptability of such tools.

Although Med-Resp was highly appreciated by the physicians, we were unable to evaluate its effectiveness to improve prescribing and medication adherence. However, this study was neither designed nor powered to assess these outcomes. Furthermore, several reasons may explain why we did not find a difference in the adherence in the pre-post analysis. First, participating patients had higher levels of adherence than those observed in the general population. Indeed, previous epidemiologic studies have shown that less than 50% of asthma patients take their medications as prescribed [37-39]. In contrast, patients included in this study had mean adherence levels ranging from 60% to 77%. Thus, there may have been a smaller window of opportunity for optimizing use of asthma controller

medications in these patients. Second, many patients were not included in the pre-post analysis because they either did not have a medical visit or were no longer covered with private drug insurance during the six-month follow-up period, thus reducing the power of the analysis. Along the same lines, this short observation period may not have been sufficient to evaluate the effects of Med-Resp on patients' adherence. Finally, Med-Resp was evaluated as a stand-alone intervention and was not incorporated with other components beyond usual care that could promote medication adherence, such as patient education on medicine use and physician training in monitoring adherence. Since adherence is a complex issue woven into a myriad of factors related to patients, physicians, and healthcare systems [40], we believe that the effectiveness of Med-Resp may be enhanced if it becomes an integral part of a multi-focal intervention aiming to improve medication adherence. In this context, Med-Resp could enable physicians to assess their patients' medication use in a more accurate and timely manner, which will in turn allow them to readily suggest interventions to improve adherence and provide personalized treatments based on their patients' adherence. Similarly, the clinical value of Med-Resp could also be enhanced if it contains information regarding the level of disease control, which would allow physicians to directly correlate the level of adherence with the clinical symptoms of the patients.

The implementation of Med-Resp in the clinical practice was further compromised due to the fact that our study population was restricted to patients who were covered with private drug insurance, which caused several patients to be lost during the follow-up period. Moreover, physicians did not have access to an EMR, as only paper-based medical records were available in the hospital in

which this study was conducted. Consequently, the graphical tool had to be dragged in the paper medical record by a research assistant before the patient's medical visit, which is evidently not an efficient procedure that can be implemented on a large scale. In addition, although the Hawthorn effect cannot be ruled out from this study, we believe it was minimal given that the mean time between recruitment and the medical visit exceeded 1 year ($422.9 \text{ days} \pm 208.4$; results not presented), after which some patients may have forgotten that they consented to their physicians having access to their prescription refill information. However, given that patients consented to be followed for 6 months only, it was not possible to assess the long-term effects of Med-Resp on medication adherence. In the future, we intend to conduct studies with a longer follow-up time to assess the true effect of Med-Resp.

This study does, however, serve as a proof-of-concept to highlight the importance of developing a tool to measure medication adherence in collaboration with the end-users. Our findings allowed us to confirm the need for such tools and the eagerness of physicians to have access to an objective measure of patient adherence to prescribed medications. However, given the limitations of the available infrastructure at the outpatient asthma clinic, our next step will be to implement Med-Resp in a setting in which it can be seamlessly integrated in EMR and include all patients, regardless of their drug insurance type, in order to be effectively used in clinical practice. Moreover, as a large proportion of asthma patients are treated by general practitioners [41], evaluating the feasibility of implementing such a tool in the primary care setting would be a worthwhile endeavour.

Conclusion

This pilot study has demonstrated the feasibility of implementing a tool based on prescription refills in the clinical practice of respiratory physicians to measure medication adherence. Further studies are required to explore the acceptability of patients regarding such interventions and the possibility of integrating Med-Resp in an EMR to enhance its uptake and integration in the clinical practice. Finally, it would be relevant to evaluate the effectiveness of Med-Resp as an integral part of a multi-factorial intervention aiming to improve prescribing and medication adherence.

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Author contributions

LB, AY, CL, AC designed the study and wrote the manuscript. LB and CL acquired the funding. LB, AY, AF contributed to data analyses. AY, CL, AC, AF, and LB interpreted the data, revised the manuscript, had access to complete study data, and had authority over manuscript preparation as well as approval of the final version and the decision to submit for publication.

Declaration of interest

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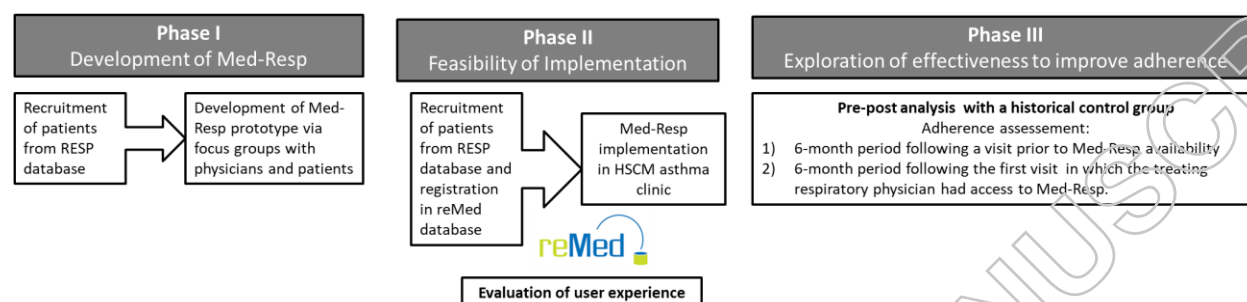
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Figure 1. Overview of study design



RESP: Registre de données en santé pulmonaire

Figure 2. Med-Resp Prototype

Figure 2a. Number and duration of prescriptions dispensed in the year preceding the medical visit

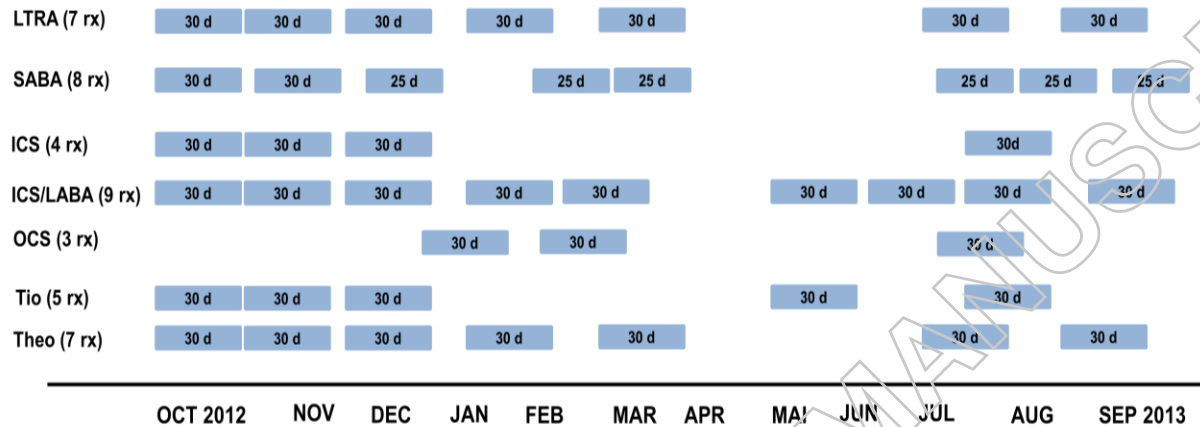


Figure 2b. Medication use during the last 4 trimesters prior to the medical visit

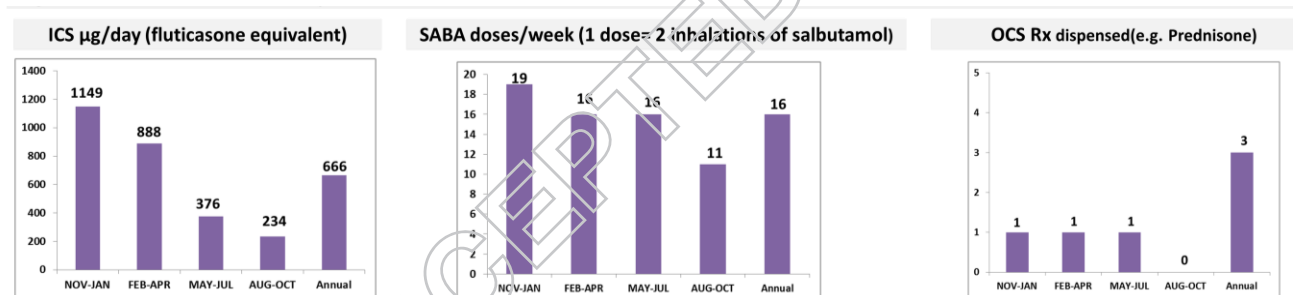


Figure 2a. Monthly dispensing of asthma controller, SABA medications, and oral corticosteroids in the year preceding the medical visit. Each rectangle represents a dispensing and the length of the rectangle is proportional to the prescription duration.

Figure 2b. Bar charts illustrating the daily dose of ICS, number of oral corticosteroids prescriptions, and weekly doses of SABA on a quarterly and annual basis.

ICS: Inhaled corticosteroids; LABA: Long-Acting Beta2-agonists; OCS: Oral corticosteroids; LTRA: Leukotriene receptor antagonists; Tio: Tiotropium; SABA: Short-acting beta2-agonists; Theo: Theophylline

Figure 3. Recruitment of participants for the feasibility assessment and exploration of effectiveness of Med-Resp to improve adherence

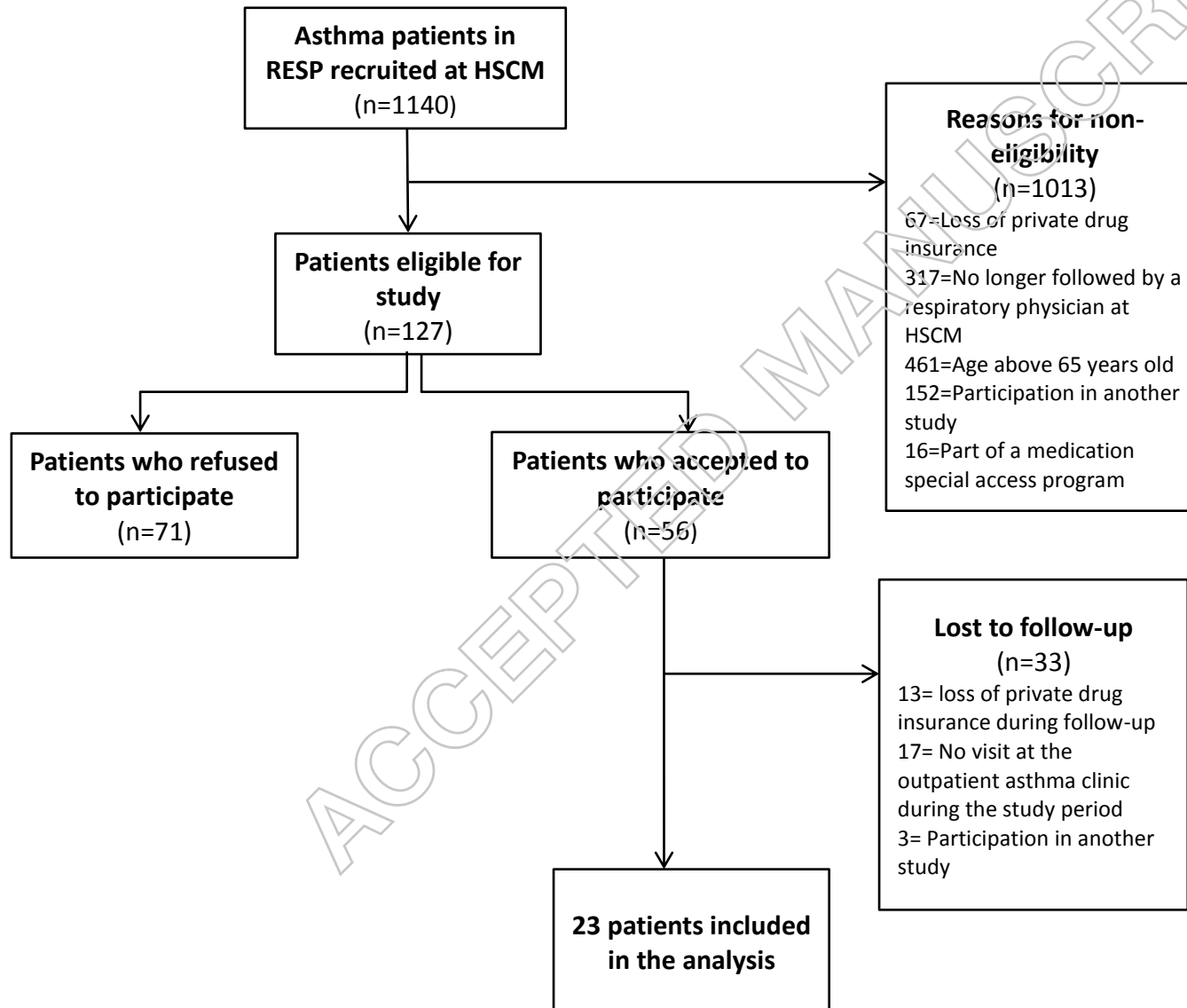


Table 1. Characteristics of patients eligible for the study

Patient characteristics, upon recruitment in RESP	Patients who accepted to participate (n=56)	Patients included in the analysis* (n=23)	Patients who refused to participate (n=71)
Age , mean $\pm$ SD	59.4 $\pm$ 10.8	48.7 $\pm$ 9.6	44.7 $\pm$ 13.2
Female , n (%)	34 (60.7)	12 (52.2)	39 (54.9)
Atopy			
Yes	25(44.6)	12 (52.2)	38 (53.5)
No	24 (42.6)	8 (34.8)	19 (26.8)
Missing	7(12.5)	3 (13.0)	14 (19.7)
Years since asthma diagnosis , mean $\pm$ SD	19.3 $\pm$ 15.5 (n=54)	22.1 $\pm$ 16.0 (n=21)	19.5 $\pm$ 14.3 (n=64)
ACQ score , mean $\pm$ SD	1.2 $\pm$ 1.0 (n=51)	1.0 $\pm$ 0.8 (n=20)	1.5 $\pm$ 1.2 (n=65)
% FEV₁ predicted , mean $\pm$ SD	82.3 $\pm$ 27.2 (n=50)	75.4 $\pm$ 23.8 (n=20)	80.0 $\pm$ 25.9 (n=65)
Adherence to most commonly prescribed controller medications, PDC , mean $\pm$ SD			
Inhaled corticosteroids	54.6 $\pm$ 29.2 (n=52)	60.7 $\pm$ 28.6 (n=21)	43.0 $\pm$ 31.0 (n=62)
Inhaled corticosteroids and long-acting beta2-agonists	52.5 $\pm$ 28.5 (n=39)	57.2 $\pm$ 25.0 (n=18)	40.3 $\pm$ 28.4 (n=43)

ACQ: Asthma control questionnaire; FEV₁: Forced expiratory volume in one second; PDC: Proportion of Days Covered

* These 23 patients are included among the 56 patients who initially accepted to participate in the study

Table 2. Patterns of medication use when Med-Resp was made available to the respiratory physicians

Patterns of asthma medications prescribed	N (%)
Inhaled corticosteroids only	1 (4.4)
Inhaled corticosteroids and long-acting beta2-agonists	10 (43.5)
Inhaled corticosteroids, long-acting beta2-agonists, and long-acting anticholinergics	2 (8.7)
Inhaled corticosteroids, long-acting beta2-agonists, and leukotriene receptor antagonists	6 (26.1)
Inhaled corticosteroids, long-acting beta2-agonists, leukotriene receptor antagonists, and long-acting anticholinergics	3 (13.0)
Long-acting anticholinergics only	1 (4.4)
Patterns of asthma medications dispensed, as recorded in reMed	mean $\pm$ SD
Daily dose of inhaled corticosteroid (μ g/day in fluticasone equivalent) used in the previous year, mean $\pm$ SD	114.9 $\pm$ 106.2
Weekly doses of short-acting beta2-agonists used in the previous year	2.9 $\pm$ 3.7
Number of oral corticosteroids prescriptions dispensed in the previous year, mean $\pm$ SD	1.3 $\pm$ 3

Table 3. Adherence assessment over a six-month period with and without access to Med-Resp

Asthma medications	Adherence assessment*		
	No access to Med-Resp Mean PDC (%) $\pm$ SD	Access to Med-Resp Mean PDC (%) $\pm$ SD	Mean Difference PDC (%) (95% CI)
Inhaled corticosteroids + Long-Acting Beta2-agonists combination therapy (n=19)	64.1 $\pm$ 24.5	64.4 $\pm$ 24.5	0.4 (-12.6 ; 13.4)
Inhaled corticosteroids (alone or in combination) (n=22)	66.6 $\pm$ 28.8	67.7 $\pm$ 28.4	1.1 (-10.02 ; 12.2)
Long-Acting Beta2-agonists (n=20)	63.7 $\pm$ 30.9	64.8 $\pm$ 23.9	1.1 (-11.3 ; 13.5)
Leukotriene Receptor Antagonists (n=7)	77.3 $\pm$ 34.2	73.0 $\pm$ 34.7	-4.3 (-7.6 ; -1.0)
Tiotropium (n=6)	60.2 $\pm$ 32.4	56.5 $\pm$ 31.9	-3.7 (-13.2 ; 5.8)

*Adherence was assessed for medications that were prescribed both before and after the visit with access to Med-Resp

**Development of a Graphical Tool to Measure Medication Adherence in Asthma Patients:
A Mixed-Methods Pilot Study**

ONLINE SUPPLEMENTARY FILE

Interview Guide – Focus Group with Respiratory Physicians

A. Therapeutic relations and physician-patient communication

1. Can you describe a typical medical visit with your asthma patients (duration, patient/physician dynamics)?
2. Do you discuss medication adherence with your asthma patients? How do you assess it?
3. What strategies do you use to assess medication adherence? How often do you assess it?

B. Development of a tool based on prescription refills

1. What additional information would you require to monitor your patients' medication adherence and use in a more adequate manner?
2. Would a tool based on prescription refills be relevant in clinical practice? Would it help you assess medication adherence and use?
3. In the clinical practice, what would be the most appropriate metric to measure medication adherence based on prescription refills (number of refills, percentage of adherence, graphical format, etc.)?
4. What impact would such a tool have on the physician-patient relationship?
5. What impact would such a tool have on your patients' medication adherence?

Interview Guide – Focus group with Patients

A. Disease management & physician-patient communication

1. Since when have you been diagnosed with asthma?
2. Can you describe your medical visits and your relationship with your respiratory physician? Do you discuss your medication use with your physician?
3. Do you sometimes modify the dose of asthma medication that was prescribed by your physician?
4. What strategies do you use to remember to take your medication on a day-to-day basis? Do you sometimes forget to take your medication?

B. Development of a tool based on prescription refills: ethical considerations and patient acceptability

1. We would like to develop a tool that would allow your respiratory physician to have access to detailed information concerning your asthma medication use, based on your prescription refills at the pharmacy. This tool will allow your physician to have access to a more objective measure of your medication use and adherence.

To what extent would you feel comfortable with your physician having access to this kind of information?

2. Would you like to have access to detailed information regarding your prescription refills for your asthma medication or would you prefer that your physician directly shares with you this information?
3. What impact would such a tool have on your relationship with your physician? Do you think that it will facilitate the communication concerning your medication use?

**Development of a Graphical Tool to Measure Medication Adherence in Asthma Patients:
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Post-visit follow-up questionnaire with physicians

1. Did you consult the **Med-Resp** during your patient's medical visit?
Yes
No, please justify_____
2. Were the data presented in the **Med-Resp** easily interpretable?
Yes
No, please justify_____
3. Did the **Med-Resp** report help you better evaluate the medication use of your patient?
Yes
No, please justify_____
4. Did the **Med-Resp** report help you adjust the medication doses of your patient?
Yes
No, please justify_____
5. Did the **Med-Resp** report facilitate the communication with your patient concerning his/her asthma medication use?
Yes
No, please justify_____

**Development of a Graphical Tool to Measure Medication Adherence in Asthma Patients:
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Follow-up questionnaire with patients (phone interview)

1. During your last medical appointment, did you discuss your medication use with your respiratory physician?

Yes

No

2. Did your respiratory physician mention that he consulted the information presented in the **Med-Resp** report?

Yes

No

3. Did your respiratory physician share with you the information presented in the **Med-Resp** report?

Yes

No

4. Did your respiratory physician discuss the number of times you refilled the medications prescribed to treat your asthma during the year preceding your medical visit?

Yes

No

5. Do you think that the **Med-Resp** report has facilitated the discussion with your respiratory physician concerning your medication use?

Yes

No