RESPIRATORY CARE Paper in Press. Published on March 31, 2020 as DOI: 10.4187/respcare.07328

Development of a Web-Based Tool Built From Pharmacy Claims Data to Assess Adherence to Respiratory Medications in Primary Care

Alia Yousif, Sandra Peláez, Catherine Lemière, Amélie Forget, Catherine Dalal, Maria-Kim Turcotte, Marie-France Beauchesne, and Lucie Blais

BACKGROUND: Medication adherence in asthma and COPD is notoriously low. To intervene effectively, family physicians need to assess adherence accurately, which is a challenging endeavor. In collaboration family physicians and individuals with asthma or COPD, we aimed to explore the barriers and facilitators of assessing medication adherence in clinical practice (exploratory phase), and to develop a novel web-based tool (e-MEDRESP) that will allow physicians to monitor adherence using pharmacy claims data (development phase). METHODS: We used qualitative research methods and a framework inspired by user-centered design principles. Five focus groups were held: 2 with subjects ($n = 15$) and 3 with physicians ($n = 20$), and 10 individual interviews were conducted with physicians. In the exploratory phase, data were analyzed using thematic networks. In the development phase, we identified components to be included in an e-MEDRESP prototype through an iterative approach. The web-based e-MEDRESP tool was constructed by applying algorithms to pharmacy claims data that reflected end-users' recommendations through an informatics approach designed for electronic medical records. RESULTS: The main barriers to assessing medication adherence included a lack of objective information regarding medication use and short duration of medical visits. Physicians emphasized that identifying patients at risk for nonadherence requires a team effort from pharmacists, respiratory therapists, and nurses. Subjects also agreed that the use of easily interpretable pharmacy claims data could be an important facilitator and contributed to the development of the e-MEDRESP prototype, which contains graphical representations of the adherence to respiratory controller medications and dispensing of rescue medications. CONCLUSIONS: The e-MEDRESP tool has the potential to allow physicians to measure adherence objectively and to facilitate patient-physician communication concerning medication use. Future studies are needed to evaluate the feasibility of implementing e-MEDRESP in clinical practice. It would be relevant to develop strategies that could facilitate the sharing of information presented in e-MEDRESP among primary care health professionals. *Key words: treatment adherence; qualitative research; asthma; COPD; electronic medical records; medical informatics.* [Respir Care 0;0(0):1–●. © 0 Daedalus Enterprises]

Introduction

Asthma and COPD are major causes of chronic morbidity and mortality, and they pose substantial economic and social burdens worldwide.[1] Globally, asthma affects > 300 million people,[2] and approximately 65 million individuals have moderate-to-severe COPD.[3] Although adherence to long-term therapy is essential to optimize treatment effectiveness, a significant portion of these individuals do not take medications as prescribed.[4] Indeed, adherence in individuals with

Ms Yousif, Ms Forget, Ms Dalal, Ms Turcotte, and Drs Beauchesne and Blais are affiliated with the Faculty of Pharmacy, Université de Montréal, Montreal, Quebec, Canada. Ms Yousif, Ms Forget, and Drs Lemière, Beauchesne, and Blais are affiliated with the Centre Intégré Universitaire de santé et de services sociaux du Nord-de-l'île-de-Montréal, Montreal, Quebec, Canada. Dr Peláez is affiliated with the School of Kinesiology and Physical Activity Sciences, Faculty of Medicine, Université de Montréal, Montreal, Quebec, Canada. Dr Lemière is affiliated with the Faculty of Medicine, Université de Montreal, Montreal, Quebec, Canada. Dr Beauchesne is affiliated with the Centre Intégré Universitaire de santé et de services sociaux de l'Estrie-CHUS, Sherbrooke, Quebec, Canada.

RESPIRATORY CARE Paper in Press. Published on March 31, 2020 as DOI: 10.4187/respcare.07328

asthma and COPD is notoriously low, often falling below 50%.[5-7] Medication nonadherence has detrimental effects on therapeutic outcomes and leads to increases in emergency department visits, hospitalizations, and health care costs.[1,8,9]

In asthma, reasons for suboptimal medication adherence include issues pertaining to age, medication costs, adverse effects, inhaler device convenience, limited health literacy, patients' knowledge and illness beliefs, as well as limited patient involvement in the medical decision-making process.[4,10,11] Predictors of adherence in patients with COPD are similar; however, they are often faced with additional problems related to comorbidities, complex treatment regimens, and polytherapy, which can contribute to suboptimal medication use.[12] Research indicates that successful interventions to promote optimal medication use should be seamlessly integrated within clinical practice and be based on enhanced patient-physician communication and patient education.[13]

A large majority of individuals with asthma or COPD are treated in primary care.[14,15] Prior to prescribing appropriate therapy, clinical guidelines recommend that physicians assess disease control and verify for common problems such as inhaler technique, comorbidities, and medication adherence.[2,16] Yet assessing medication adherence accurately in routine clinical practice can be a challenging endeavor. In practice, physicians commonly assess adherence through patient self-report. This method is prone to inaccuracies because patients have a tendency to overestimate their adherence level due to incorrect recall or attempts to fulfill treating physicians' expectations.[17,18] Accordingly, physicians may have difficulty detecting nonadherence, and reliance upon their intuition was shown to be inaccurate.[19,20]

QUICK LOOK

Current knowledge

Medication adherence in individuals with asthma and COPD is notoriously low and is associated with suboptimal therapeutic outcomes. The majority of these patients are treated in primary care, and family physicians need to assess adherence accurately and work closely with other health care professionals to intervene effectively. In clinical practice, family physicians could benefit from tools that will better assist them in detecting nonadherence in their patients in a timely manner.

What this paper contributes to our knowledge

The timely assessment of medication adherence in clinical practice is impeded by many barriers, including short duration of medical visits, limited health care accessibility, and lack of objective and easily interpretable information on medication adherence. To alleviate some of these barriers, we developed e-MEDRESP, a web-based tool based on pharmacy claims data that will allow family physicians to assess adherence to respiratory medications. The clinical usefulness of e-MEDRESP may be enhanced if it becomes part of a multi-factorial intervention that focuses on patient education, patient-physician communication, and interprofessional collaboration between family physicians, pharmacists, respiratory therapists, and nurses.

Alternatively, pharmacy claims data, which are generated whenever a prescription at a community pharmacy is filled,[21] may offer a more objective measurement of medication adherence and have been used in many population-based studies to assess medication adherence.[5-7,13] To our knowledge, few studies have evaluated the use of tools based on pharmacy claims data to assess medication adherence in clinical practice.[22-26] As a prime example, physicians in the United States can request pharmacy claim histories through e-prescription platforms integrated in their electronic health records.[27]Additionally, since 2013, physicians in the Canadian province of Quebec may access pharmacy claims through the Quebec Health Record (QHR), which is a data repository that allows health care professionals to access health information of their patients.[28] One major drawback of the QHR, however, is that it provides raw and unprocessed pharmacy claims data (ie, one line per filled prescription), which can be hard for physicians to summarize and interpret efficiently in their workflow. Broadly speaking, these tools and platforms have the potential to enhance physicians' ability to monitor medication adherence in a timely manner; however, none were

Ms Yousif presented a version of this paper at the 46th North American Primary Care Research Group Annual Meeting, held November 9–13, 2018, in Chicago, Illinois. Ms Yousif also presented a version of this paper at the 2018 Family Medicine Forum, held November 14–17, 2018, in Toronto, Canada.

This study was funded by the Canadian Foundation for Innovation, AstraZeneca, and Omnimed. Dr Blais has disclosed relationships with AstraZeneca, GlaxoSmithKline, and Genentech. Dr Beauchesne has disclosed relationships with AstraZeneca, Boehringer-Ingelheim, and Novartis. Dr Lemière has disclosed relationships with AstraZeneca, GlaxoSmithKline, Sanofi Genzyme, and TEVA Innovation. Ms Yousif received a doctoral training award from the *Fonds de Recherche du Québec – Santé*. The other authors have disclosed no conflicts of interest.

Supplementary material related to this paper is available at http://www.rcjournal.com.

Correspondence: Lucie Blais PhD, Faculty of Pharmacy, Université de Montréal, 2940, chemin de la Polytechnique, Montréal, Québec, H3T 1J4, Canada. E-mail: lucie.blais@umontreal.ca.

DOI: 10.4187/respcare.07328

RESPIRATORY CARE Paper in Press. Published on March 31, 2020 as DOI: 10.4187/respcare.07328

developed in collaboration with end-users, which might explain why the uptake of some of these tools was not as high as expected.

The purpose of this study was to better understand the problems that revolve around the assessment of medication adherence in routine clinical practice. We believe that the use of health care technology may alleviate some of the challenges that physicians face when assessing medication adherence. Specifically, we aimed to gain greater understanding on the barriers and facilitators of assessing adherence to respiratory medications from the perspectives of family physicians and subjects with asthma or COPD through a qualitative study; we considered this the exploratory phase. Taking inspiration from user-centered design principles, we subsequently developed e-MEDRESP, a web-based tool built from pharmacy claims data that will allow family physicians to monitor adherence to respiratory medications in routine clinical practice; we deemed this the development phase, and it was conducted in 2 steps: first was design of e-MEDRESP in collaboration with family physicians and subjects with asthma or COPD; and second was the construction of the e-MEDRESP web-based tool using an integrated health informatics approach designed for electronic medical records.

Methods

Study Design

We used a qualitative research methodology and a framework inspired by user-centered design principles. For the exploratory phase, we conducted a qualitative descriptive study, which is an approach based on the general principles of naturalistic inquiry that aims to acquire greater insight into a phenomenon across disciplines of health science research using everyday factual language.[29] For the development phase, we adopted a framework inspired by user-centered design principles, which is an iterative design process in which we focus on user needs in each phase of the design and development processes.[30] Subjects included individuals with asthma or COPD treated in family medicine clinics and family physicians, recruited between January 2017 and March 2018 in the Canadian province of Quebec. This work took place at Centre Intégré Universitaire de santé et de services sociaux du Nord-de-l'île-de-Montréal, Montréal, Quebec, Canada. This study was approved by the research ethics committee of the Centre Intégré Universitaire de santé et de services sociaux du Nord-de-l'île-de-Montréal. All subjects signed an information and consent form.

Subject Recruitment

Subjects were eligible if they had a diagnosis of asthma or COPD recorded in their electronic medical records, were treated by a family physician, and were ≥ 18 y old. Eligible family physicians must have treated patients diagnosed with asthma or COPD in the last year prior to recruitment. In keeping with the research design adopted, purposive sampling[31] was used with the aim of obtaining maximum variation in key characteristics among subjects, including age, sex, region of residence, number of years since diagnosis of asthma or COPD (for individuals), and number of years of practice in family medicine (for physicians). Emails and faxes were sent to physicians to invite them to participate in the study. Subject recruitment was then performed in collaboration with the medical director of one of the participating clinics. The clinic appointed a research assistant to contact eligible subjects by telephone and invite them to participate in the study. Subjects and physicians received compensation for the time incurred due to study participation.

Data Collection

Data for the exploratory phase and the first step of the development phase were collected through 5 focus groups: 2 focus groups with subjects with asthma or COPD ($n = 15$ subjects), and 3 focus groups with family physicians ($n = 20$ subjects). To enhance the data collection strategy without compromising the project timeline, 10 individual telephone interviews were subsequently conducted with physicians unable to attend focus groups. Each focus group ran between 50 and 120 min, whereas interviews lasted 30–45 min. Focus groups were led by a moderator and two research assistants, and interviews were conducted by a research assistant. All focus groups and interviews were conducted in French using a semi-structured interview guide. The complete translated interview guides are available in the online supplement (see the supplementary materials at http://www.rcjournal.com).

In the exploratory phase of the focus groups and interviews, we identified the barriers and facilitators of assessing medication adherence in clinical practice. Topics of discussion included methods of assessing medication adherence, patient-physician communication concerning medication use, practical and ethical implications of using pharmacy claims data to measure medication adherence, and the role of other primary care health professionals, including pharmacists, respiratory therapists, and nurses. The second part of each focus group and interview was devoted to the design of e-MEDRESP (ie, the development phase). Topics of discussion included the format and content of e-MEDRESP, as well as the most appropriate metrics to assess medication adherence and use. Specifically, we identified components to be included in a prototype of e-MEDRESP. Of note, because our aim was to develop a tool that could be seamlessly integrated within physician workflow, physicians made the majority of contributions

RESPIRATORY CARE Paper in Press. Published on March 31, 2020 as DOI: 10.4187/respcare.07328

in the development phase. Data collection thus prioritized the physician perspective but was completed with subjects' accounts. An iterative approach was used to design e-MEDRESP, whereby results of the first focus group informed changes to the interview guide for subsequent focus groups and interviews. Feedback on the prototype was also gathered through informal review by 2 members of the research team: a pulmonologist and a clinical pharmacist who specializes in respiratory diseases.

Data Analysis

All discussions were audio-recorded, transcribed verbatim, and verified for accuracy.[32] Transcripts were analyzed and coded independently by 3 investigators. Data analysis began with data familiarization, in which transcripts and field notes were carefully re-read.

To identify the barriers and facilitators of assessing medication adherence, we used the thematic network technique,[33] a theoretically flexible analytical tool used to explore the understanding of an issue by identifying the main themes from a piece of text. Transcripts were first dissected using a coding framework that was devised using ideas from the literature review, topics in the interview guides, and concepts identified during the discussions. This coding framework was developed through an iterative process whereby codes were continuously refined as clearer insight was gained on the collected data. Once consensus on the coding framework was reached, overarching themes were identified by grouping codes that unified a common idea.[34,35] Themes were subsequently clustered into basic themes (ie, lowest order premises of evidence), then into organizing themes (ie, middle-order themes), and finally into global themes (ie, macro super-ordinate themes). Web-like illustrations (ie, networks) were developed to depict the salient themes and the relationships between them. Interviews were conducted until data saturation was reached, which is the point in which no new codes emerged from the data and themes were considered to be adequately specified.[36,37] We used Dedoose 8.0.42 (SocioCultural Research Consultants, Manhattan Beach, California) to assist in data analysis.

For the development phase, opinions and user preferences regarding tool content and format were identified. Once the paper-based prototype was finalized and no additional suggestions were given by the subjects, an interactive web-based module was built in Visual Studio 15.9 (Microsoft, Redmond, Washington). e-MEDRESP was constructed by developing algorithms of medication adherence that reflect the end-user recommendations identified during the discussions. These algorithms were subsequently applied to pharmacy claims data recorded in the reMed database, which is a computerized claims database that collects information on prescribed medications dispensed in community pharmacies for a sample of Quebec residents.[38] reMed is based on data purchased from community pharmacies' computer services providers, which transfer medication data required for reimbursement. The link between the providers and reMed is established by way of a dynamic, computerized, and confidential list that contains the identity of enrolled participants.

Table 1. Subject Characteristics

Characteristics	*n* (%)
Age, y (mean ± SD)	63.3 ± 12.8
Men	9 (60.0)
Diagnosis, as reported by subject	
Asthma	6 (40.0)
COPD	6 (40.0)
Concomitant diagnosis of asthma and COPD	3 (20.0)
Time since diagnosis, y	
< 5	6 (40.0)
5–10	5 (33.3)
≥ 10	4 (27.7)
Mean ± SD	10.5 ± 10.0
Nonsmoker	9 (60.0)
Level of physical activity	
None	5 (33.3)
Low	5 (33.3)
Moderate	4 (26.7)
High	1 (6.7)

Data are presented as *n* (%) unless otherwise noted. *n* = 15 subjects.

Results

Subject Characteristics

The characteristics of individuals with asthma or COPD (*n* = 15 subjects) and family physicians (*n* = 30 subjects) are presented in Table 1 and Table 2, respectively. Subjects with asthma or COPD were on average 63 y old, were mostly male (60%), and had been diagnosed with their respiratory disease for an average of nearly 11 y. Although the focus groups were conducted separately with subjects with asthma (*n* = 6) and COPD (*n* = 6), some subjects reported having both respiratory diseases (*n* = 3). Physicians were on average 41 y old, 59% were women, and they had been practicing family medicine for an average of 12 y. T1-2

Exploratory Phase: Barriers and Facilitators of Assessing Medication Adherence

Consistent with our research purpose, we grouped subjects' discussions into 2 global themes, namely the barriers and the facilitators of assessing medication adherence in

RESPIRATORY CARE Paper in Press. Published on March 31, 2020 as DOI: 10.4187/respcare.07328

Table 2. Family Physician Characteristics

Characteristics	*n* (%)
Age, y (mean ± SD)	41.0 ± 3.9
Women	17 (58.6)
Length of practice in family medicine, y	
< 10	17 (56.7)
10–19	4 (13.3)
20–29	3 (10.0)
≥ 30	6 (20.0)
Mean ± SD	12 ± 1.5
Practice region	
Urban	17 (56.7)
Rural	13 (43.3)
Patients with chronic respiratory diseases seen per month	
< 20	9 (30.0)
20–39	13 (43.3)
≥ 40	8 (26.7)
Patients with respiratory diseases most commonly seen in clinical practice	
COPD	21 (70)
Asthma	4 (13.3)
Equal number of patients with asthma or COPD	5 (16.7)

Data are presented as *n* (%) unless otherwise noted. *n* = 30 physicians.

primary care. Figure 1 presents the thematic network illustrating the global, organizing, and basic themes. Excerpts from the transcripts are presented to support the identified themes. Additional excerpts are available in the online supplement (see the supplementary materials at http://www.rcjournal.com).

Barriers to Assessing Medication Adherence. The first barrier discussed is patient beliefs related to medication use and disease. Physicians explained that, prior to properly assessing medication adherence, they must establish a treatment regimen that their patient is willing and able to follow. However, they raised the issue that some patients showed reluctance to take medications on a regular basis. According to these physicians, discussing medication adherence was especially challenging with patients with COPD, who appear to have adapted, over the years, to a limited quality of life and suboptimal respiratory function due to the insidious nature of the disease. As explained by a physician with 40 years of experience in family medicine, patients with COPD often "trivialize their symptoms." Because patients with asthma seen in their practice tend to be younger and more adaptive to change, physicians reported having fewer difficulties initiating discussions regarding medication adherence with these patients.

In contrast, most subjects with asthma or COPD mentioned that they usually follow their physician's treatment recommendations; however, a small proportion reported either adjusting the doses of their prescribed therapeutic regimen or not taking their prescribed medications altogether. Some subjects with COPD also confused natural disease progression with treatment effects, claiming that respiratory controller medications can lead to lung collapse. In this respect, subjects' perceptions of their illness and treatment corroborate to some extent the discussions that were held with physicians and may add a layer of complexity to the discussion on medication adherence with their physician.

The second barrier discussed is the lack of objective and easily interpretable information on medication use. The most salient discussions among family physicians revolved around their desire to have access to such information. Physicians also acknowledged that patient self-report measures of adherence were often inaccurate: "We directly ask patients knowing full well that patient reliability is mediocre. We know that adherence in patients with COPD is about 40%, and relying on patients' accounts can be misleading" (26-y-old physician, recent medical graduate).

To obtain more objective information on medication adherence, most physicians reported accessing the QHR data repository to review pharmacy claims data. Although the QHR provides valuable information that allows health care providers to optimize patient care, physicians voiced concerns about the prescription module of the QHR. Physicians emphasized the need to make the data in the QHR more easily interpretable, especially for diseases with complex therapeutic regimens, such as asthma and COPD. Indeed, the prescription module is neither clinically intuitive nor user-friendly, as was explained by a 57-y-old physician with more than 27 years of experience: "When it comes to the QHR, there is no organization! It's a jumble of information. [...] Sometimes I have to go through 2 or 3 pages to find the drug I am looking for."

The third barrier is that some physician practices might directly hinder the assessment of adherence. For example, some physicians admitted to not prioritizing adherence to respiratory medications in their approach to disease management. Moreover, some physicians reported difficulties in keeping up with the evolving therapeutic landscape of asthma and COPD, as various respiratory therapeutic agents have entered the market in the last few years,[39] many of which have comparative safety/effectiveness profiles that the physicians do not understand clearly. Accordingly, some physicians acknowledged that it was difficult to establish an optimal therapeutic regimen that is adapted to their patients' needs.

Yet another barrier involves issues related to the organization of health care services, such as the short duration of medical visits and limited health care accessibility. Physicians consistently reported not having enough time to comprehensively assess adherence. Furthermore, physicians struggle to obtain accurate information on medications dispensed in hospital pharmacies or to know the medication

RESPIRATORY CARE Paper in Press. Published on March 31, 2020 as DOI: 10.4187/respcare.07328

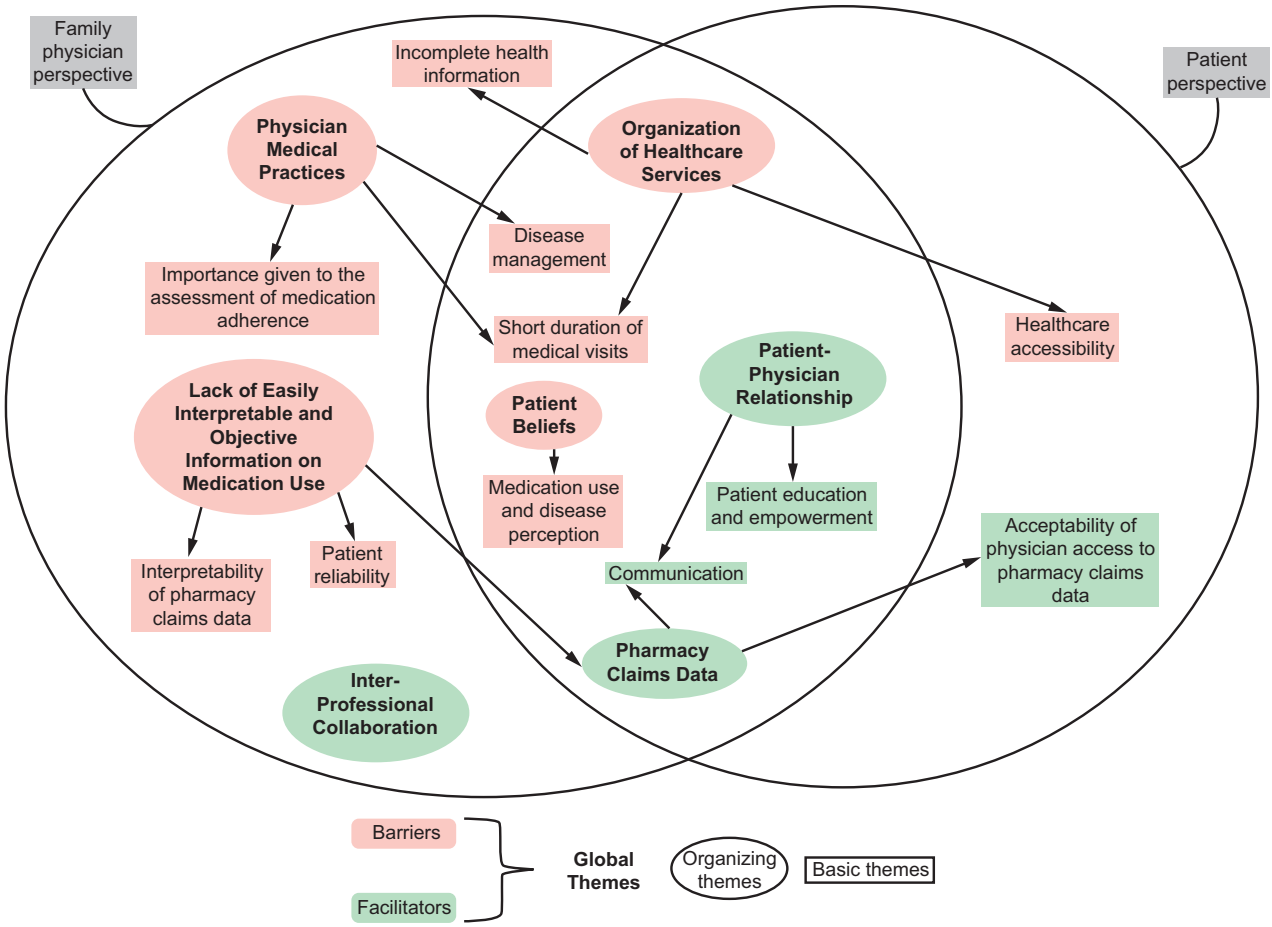

Fig. 1. Thematic network depicting the barriers and facilitators of assessing and monitoring medication adherence in primary care from the perspectives of family physicians and of patients.

history of patients who have been followed by other physicians. In fact, access to complete health information on patients is often spread over many medical records kept by different health structures or health care professionals in many health care settings.[40] Moreover, subjects with asthma or COPD complained about how the difficult transition of care between their pulmonologist and family physician affected their access to vital health care: "When my pulmonologist retired, I was told that I was going to be followed by a family doctor. I waited 3.5 years for a family doctor. I recently met her, so she obviously doesn't know me very well" (81-y-old asthma subject, diagnosed for 35 y).

Thus, some subjects reported having few opportunities to discuss their medication adherence with the same provider. This lack of continuity of care with the same provider may thus be problematic, especially because not all physicians integrate the assessment of medication adherence into their approach to disease management.

Facilitators of Assessing Medication Adherence. When discussing medication adherence, subjects agreed on the importance of having a trusting relationship between the patient and physician, built over time. Moreover, to foster patient empowerment, physicians stressed the need to work collaboratively with their patients, adapt to their knowledge level, ask open-ended questions, and use language that is not patronizing. In a similar vein, a 58-y-old asthma subject said, "I think it's important that our doctor respects us. My doctor told me to stop smoking, but he knows I am not at this stage yet. He respects me and gives suggestions, without forcing me. He communicates with me."

Physicians have reported that collaboration with other health care professionals greatly facilitated the assessment of medication adherence. They highlighted the role of respiratory therapists, who conduct spirometry tests, verify inhaler device techniques, and patient adherence to treatment recommendations. Physicians also mentioned directly calling pharmacists to obtain information on prescription refills, and some reported that pharmacists send them faxes to notify them when a patient has not filled a prescription. Indeed, physicians explained that medication adhere nce monitoring is a team effort with other health care

RESPIRATORY CARE Paper in Press. Published on March 31, 2020 as DOI: 10.4187/respcare.07328

professionals because such collaboration allows them to determine whether suboptimal disease control is due to inadequate therapeutic regimen, low medication adherence, or incorrect use of an inhaler device.

As yet another facilitator in assessing medication adherence, physicians and subjects reported that the use of pharmacy claims data may help discussions on adherence. Such information could provide an objective measure of medication use, even though filling a prescription does not necessarily guarantee its consumption. Generally, subjects believed that physicians' access to pharmacy claims could help initiate discussion concerning their medication use and agreed that physicians should have access to this information: "If doctors prescribe us medications, they assume that we take them. I agree that physicians should have access [to our prescription refill data]. I would even be okay with physicians knowing exactly if I took all the doses..., that I didn't just hide my inhalers in a cupboard at home" (38-y-old asthma subject, diagnosed for 22 y).

However, some subjects described concern about physicians' access to such information as a "double-edged sword"; on the one hand, physicians may be able to rapidly detect nonadherent patients, but, on the other hand, if they know that patients do not follow treatment recommendations, the patient-physician relationship may be strained. Some physicians shared a similar opinion: "I think this is a delicate issue.... The patient can ask himself: "What? You have access to all this information? You even know when I [purchased my medicine]? It's unpleasant to feel like you are [being monitored]" (39-y-old physician, 6 y of clinical experience).

Development Phase: Creation of the e-MEDRESP Web-Based Module

Despite the limitations of pharmacy claims data, physicians pointed out that such data may help them detect nonadherent patients more easily if information on medication use is seamlessly integrated in electronic medical records and is presented in a user-friendly manner. Thus, physicians expressed their eagerness to contribute to the development of e-MEDRESP. The final version of the e-MEDRESP web-based module is presented in Figure 2 and includes 3 distinctive sections.

One-Year Medication Adherence. Physicians agreed that presenting medication adherence as a percentage and applying color codes would allow them to easily flag nonadherent patients. Therefore, the first section of e-MEDRESP that was developed displays the level of adherence to controller medications filled in the prior year, presented as a percentage in a donut chart. For patients filling several controller medications in the 1-y period, the global adherence to controller medications is shown, which represents the average percentage adherence to all controller medications dispensed in the prior year. A collapsible section underneath the global adherence donut chart was created to show detailed information on the percentage adherence to controller medications dispensed in the prior year, according to medication class. The proportion of days covered was the metric chosen to assess adherence over a 1-y period.[41] The proportion of days covered is defined as the total days' supply divided by the number of days of study period.[41] For medications initiated in the prior 6 months, it was decided that adherence would be calculated starting from the date of the first dispensing. The following color code scheme was selected to designate adherence levels: green for optimal adherence ($\geq$ 80%); yellow for medium-level adherence (50–79%), and red for suboptimal adherence ($<$ 50%).

For patients filling medications containing inhaled corticosteroids (ICS) in the prior year, physicians deemed it was appropriate to illustrate the mean daily ICS dose, on a quarterly and annual basis, using a bar chart. In e-MEDRESP, the mean daily ICS dose is thus calculated via an algorithm that we developed in previous studies[42,43] and takes into account the following parameters: potency of different ICS; medication form; quantity dispensed (taking into account the number of doses per device); and medication dispensing date. By using the equivalency table published in the Canadian asthma consensus report,[44] the mean daily ICS dose is converted to the equivalent of the fluticasone propionate hydrofluoroalkane medication.

List of Respiratory Medications Dispensed in the Prior Year. Physicians wished to include in e-MEDRESP a component that could help them to rapidly identify, over a 1-y period, important refill gaps. To satisfy this requirement, we built a comprehensive table of all controller and rescue medications, as well as oral corticosteroids and antibiotics, dispensed in the prior year. Generic names and type of device, along with prescription durations, are provided in the table.

Rescue Medications, Oral Corticosteroids, and Antibiotics Dispensed per Trimester. Physicians felt that it was pertinent to include in the tool a section that could allow them to assess disease control based on their patients' use of rescue medications, and to identify potential markers of disease exacerbation. To this end, the third section included in e-MEDRESP presents several bar charts illustrating the days' supply of oral corticosteroids and antibiotics, as well as the weekly doses of rescue medications, per trimester. For short-acting β_2 agonists, the average weekly number of doses is estimated using an algorithm that we developed in a previous study[45] incorporating the following parameters: dose per inhalation, pharmaceutical form, quantity

RESPIRATORY CARE Paper in Press. Published on March 31, 2020 as DOI: 10.4187/respcare.07328

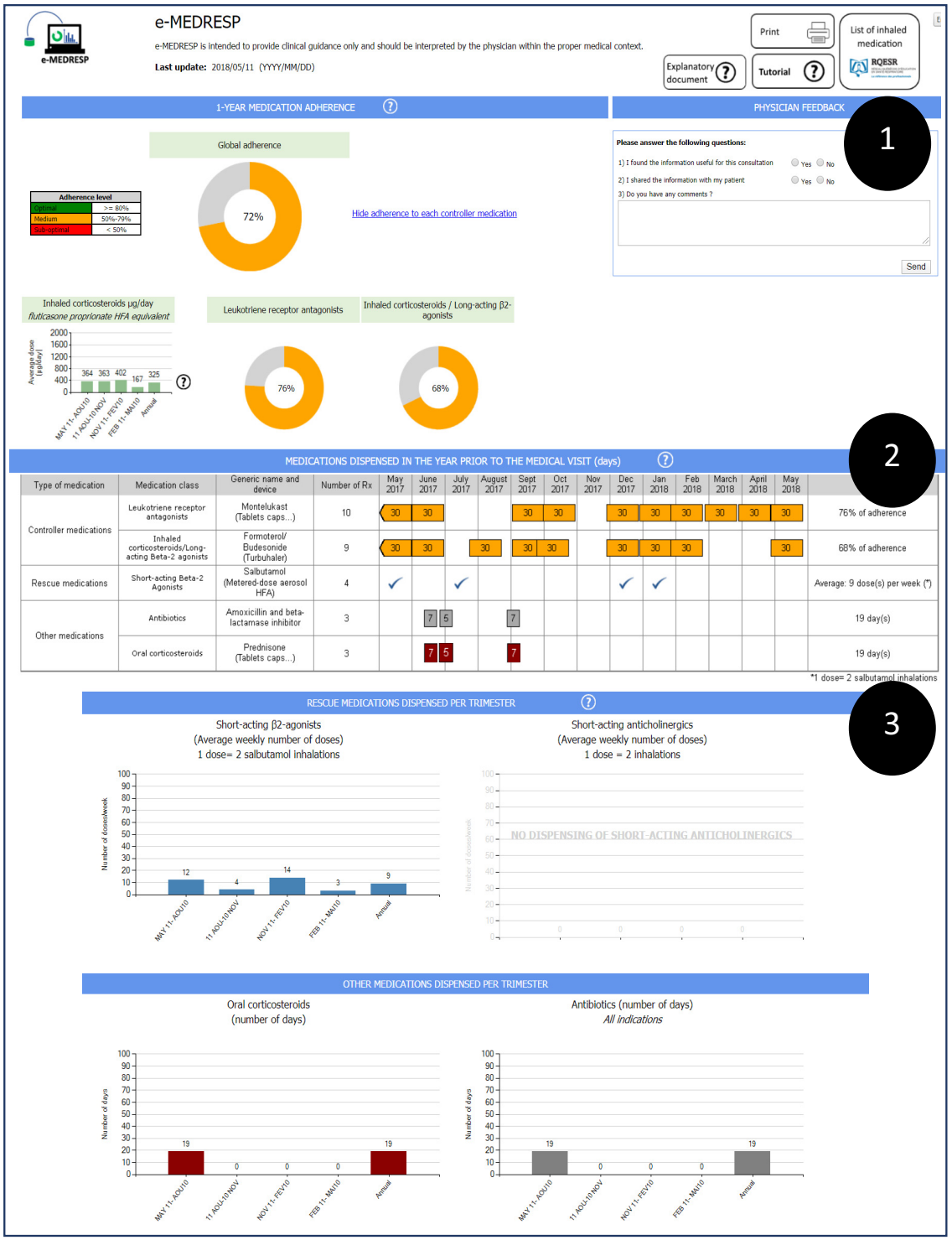

Fig. 2. Prototype of an e-MEDRESP report of an asthma patient. The web-based format of e-MEDRESP is compatible with electronic medical records, thus ensuring its seamless integration within physicians' workflow. All information on medication adherence is calculated from pharmacy claims data. Section 1 displays the adherence to all controller medications dispensed in community pharmacies in the year prior to the medical visit, presented as a percentage. Information on adherence to controller medications, according to medication class is also available. Color codes are used to designate different adherence levels. Section 2 shows an overview of all respiratory medications dispensed in community pharmacies in the prior year. Dates and duration of refills, as well as generic names of medications, are provided. Section 3 presents the use of rescue medications, oral corticosteroids, and antibiotics dispensed in the prior year, per trimester. Of note, e-MEDRESP is available in English and French.

RESPIRATORY CARE Paper in Press. Published on March 31, 2020 as DOI: 10.4187/respcare.07328

dispensed (taking into account number of doses per device), and dates of prescription dispensing. If a short-acting β_2 agonist other than salbutamol is dispensed, the mean number of doses is converted to a salbutamol equivalent. For short-acting anticholinergics, the mean weekly number of doses is estimated using an algorithm that incorporates the following parameters: dose per inhalation, pharmaceutical form, quantity dispensed (taking into account number of doses per device), and dates of prescription dispensing.

Other Salient Features of e-MEDRESP. Upon the request of several physicians, an explanatory document presenting the list of inhaled respiratory medications, along with photos of inhaler devices, was integrated in e-MEDRESP. Physicians mentioned that having access to this document could be useful if they wanted to further discuss medication use with their patients or adjust their treatment. Additionally, a video tutorial and an explanatory document were created to introduce physicians to e-MEDRESP. An automated data extraction procedure was established to update the information presented in e-MEDRESP every 2 weeks. Ultimately, physicians felt that e-MEDRESP could help them provide more personalized treatments based on their patients' medication adherence. After each focus group and interview, most physicians expressed their eagerness to have access to such a tool in their electronic medical records. As one physician with 15 years of clinical experience exclaimed: "Now that we know that such a tool could exist, we expect it will be available to us very soon!"

Discussion

Our study has highlighted important barriers of assessing and monitoring adherence to respiratory medications from the perspectives of family physicians and of patients with asthma or COPD. These included short duration of medical visits, limited health care accessibility, and patient understanding of treatment recommendations. Importantly, the lack of objective, rapidly accessible, and easily interpretable information on medication use constitutes an important barrier to monitoring adherence. To overcome this barrier, physicians contributed to the development of e-MEDRESP, a novel, web-based tool constructed from pharmacy claims data for assessing adherence to respiratory medications. Furthermore, a good patient-physician relationship and a strong interprofessional collaboration are crucial in helping physicians to identify nonadherent patients.

There is no question that medication adherence monitoring should be an integral component of disease management and patient care. With increasingly evolving health care models in recent years, primary care professionals now have a proactive, continuous, and multidisciplinary approach to disease management, which is also leveraged by the innovation of electronic medical records.[15] In the last decade, treatment guidelines, including the Global Initiative for Asthma (GINA) and the Global Initiative for Chronic Obstructive Lung Disease (GOLD), have encouraged physicians to address medication adherence with their patients on a regular basis.[2,16,46,47] Yet our findings suggest that physicians may not always have time to comprehensively assess this aspect of care. Consistent with previous findings in the literature,[48-50] study subjects explained that a strong patient-physician relationship enables physicians to detect nonadherent patients more easily because it fosters more open and honest communication and promotes patient-centered care. Furthermore, having information from past health care events (eg, prescriptions dispensed in hospitals, exacerbation occurrences), otherwise called "informational continuity,"[51] and having a long-term patient-provider relationship, might also be important facilitators to the timely monitoring of adherence. Working closely with other health care professionals, such as pharmacists and respiratory therapists, may also help mitigate some of these time-related constraints and promote informational continuity.

We believe that e-MEDRESP may help alleviate some of the barriers that physicians face when discussing medication use with their patients because it provides objective information on medication adherence. Our results support the idea that pharmacy claims data, when processed into a user-friendly format, can enhance communication regarding medication use and promote adherence, but only when used in a context in which the patient feels empowered and is involved in the decision-making process. Importantly, patients must provide consent to their physicians having access to their detailed pharmacy refill histories, which may not always be easy to obtain. In a study we conducted in an out-patient asthma clinic,[52] only 40% of eligible subjects with moderate-to-severe asthma provided such consent. This low acceptance rate could be partly explained by some patients' reluctance to share detailed information on their medication use with their pulmonologist. Although subjects and physicians in the present study acknowledged these ethical implications, they remained optimistic and emphasized the need to develop tools based on pharmacy claims that can empower patients and facilitate communication on medication use.

Our findings should be interpreted in the light of some limitations. Because participation was on a voluntary basis, physicians and subjects with asthma or COPD who participated in our study may not be fully representative of the primary care setting. For example, subjects may have been more adherent to their medications compared to the general population of patients with chronic respiratory diseases and therefore be more at ease when discussing their medication use in a group setting. Some of our findings, such as those

RESPIRATORY CARE Paper in Press. Published on March 31, 2020 as DOI: 10.4187/respcare.07328

pertaining to the QHR, are applicable to the Quebec primary care setting and may not be generalizable to other clinical settings. Limitations of the e-MEDRESP tool include those that are inherent to pharmacy claims data. Namely, pharmacy claims data in reMed only include prescriptions dispensed in community pharmacies. Thus, prescriptions filled in hospital pharmacies or prescriptions that were written by the treating physician but not filled by the patient are not captured by the tool. Moreover, filling prescriptions does not guarantee that the medication will be taken by the patient. Nevertheless, e-MEDRESP can serve as a communication aid and help physicians identify nonadherent patients more easily, which will ultimately allow them to counsel and support their patients in a timely manner.

Overall, our study has many strengths and extends the literature on the practical and logistical issues regarding the assessment of adherence to respiratory medications in clinical practice. Of note, combining focus group and interview data resulted in a more nuanced and richer analysis and provided an opportunity to achieve data saturation more rapidly, although this methodological approach was initially adopted to ensure the timeliness of data collection. The analysis of the transcripts by 3 independent investigators, coupled with our iterative approach to qualitative inquiry, ensured congruence between the research purpose, literature review, data collection strategies, subject sampling, and analysis, which ultimately conferred validity and reliability to our findings.[53] Although physicians play an important role in assessing and promoting medication adherence, integrating the patient perspective into our analysis allowed us to gain further insight on illness beliefs and treatment perceptions among patients, as well as barriers to patient-physician communication. Finally, developing e-MEDRESP in collaboration with physicians allowed us to better understand the unmet needs of the primary end-users and ensured that the tool can be easily integrated within physician workflow.

Clinical Implications and Future Work

We are currently integrating e-MEDRESP in the electronic medical records of several clinics in the Canadian province of Quebec. A feasibility study will be conducted to evaluate physicians' use of e-MEDRESP, physician and patient satisfaction with the tool, and its capacity to enhance patient medication adherence and physician prescribing practices. A cluster randomized clinical trial will be important to evaluate the effectiveness of e-MEDRESP to improve medication adherence and disease control. The clinical usefulness of e-MEDRESP may be enhanced if it becomes part of a multifactorial intervention that focus on patient education and patient–physician communication. Given the emerging trend for interdisciplinary teams to provide primary health care, it would be relevant to develop strategies that could facilitate the sharing of information presented in e-MEDRESP among primary care professionals, including pharmacists, respiratory therapists, and nurses. Ultimately, the integration of easily interpretable pharmacy claims data in electronic medical records may serve as the basis for monitoring adherence and improving prescribing practices.

Conclusions

In routine clinical practice, the accurate assessment of medication adherence in patients with asthma or COPD may be hindered by several barriers, including time-related constraints and a lack of objective and easily interpretable information on medication use. e-MEDRESP has the potential to allow physicians to measure adherence objectively and to facilitate patient-physician communication concerning medication use. Future studies are required to evaluate the feasibility of implementation as well as patient and physician satisfaction of e-MEDRESP in clinical practice.

ACKNOWLEDGMENTS

The authors thank OMNIMED for facilitating subject recruitment. We also thank Benoit Archambault for his programing services. We are grateful to the *Réseau québécois d'éducation en santé respiratoire*, who granted us permission to integrate their inhaled respiratory medications explanatory document in e-MEDRESP.

REFERENCES

1. GBD 2015 Chronic Respiratory Disease Collaborators. Global, regional, and national deaths, prevalence, disability-adjusted life years, and years lived with disability for chronic obstructive pulmonary disease and asthma. 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet Respir Med 2015;5(9):691-706.
2. Global Initiative for Asthma. Pocket Guide for Asthma Management and Prevention. Available at: https://ginasthma.org/pocket-guide-for-asthma-management-and-prevention. *Accessed February 27, 2020.*
3. World Health Organization. Burden of COPD. Available at: https://www.who.int/respiratory/copd/burden/en. *Accessed February 27, 2020.*
4. George M. Adherence in asthma and COPD: new strategies for an old problem. Respir Care 2018;63(6):818-831.
5. Blais L, Kettani FZ, Forget A, Beauchesne MF, Lemière C, Ducharme FM. Assessing adherence to inhaled corticosteroids in asthma patients using an integrated measure based on primary and secondary adherence. Eur J Clin Pharmacol 2017;73(1):91-97.
6. Humenberger M, Horner A, Labek A, Kaiser B, Frechinger R, Brock C, et al. Adherence to inhaled therapy and its impact on chronic obstructive pulmonary disease (COPD). BMC Pulm Med 2018;18(1):163.
7. Savaria F, Beauchesne MF, Forget A, Blais L. Adherence and persistence to long-acting anticholinergics treatment episodes in patients with chronic obstructive pulmonary disease. Ann Pharmacother 2017;51(12):1063-1068.
8. Ismaila AS, Sayani AP, Marin M, Su Z. Clinical, economic, and humanistic burden of asthma in Canada: a systematic review. BMC Pulm Med 2013;13:70-70.
9. Dang-Tan T, Ismaila A, Zhang S, Zarotsky V, Bernauer M. Clinical, humanistic, and economic burden of chronic obstructive pulmonary

RESPIRATORY CARE Paper in Press. Published on March 31, 2020 as DOI: 10.4187/respcare.07328

disease (COPD) in Canada: a systematic review. BMC Res Notes 2015;8:464-464.
10. Dima AL, Hernandez G, Cunillera O, Ferrer M, de Bruin M, ASTRO-LAB Group. Asthma inhaler adherence determinants in adults: systematic review of observational data. Eur Respir J 2015;45(4):994-1018
11. Pollard S, Bansback N, FitzGerld JM, Bryan S. The burden of nonadherence among adults with asthma: a role for shared decision-making. Allergy 2017;72(5):705-712.
12. Bourbeau J, Bartlett SJ. Patient adherence in COPD. Thorax 2008;63 (9):831-838.
13. Kini V, Ho PM. Interventions to improve medication adherence: a review. JAMA 2018;320(23):2461-2473.
14. Wechsler ME. Managing asthma in primary care: putting new guideline recommendations into context. Mayo Clin Proc 2009;84(8):707-717.
15. Broekhuizen BD, Sachs AP, Verheij TJ. COPD in primary care: from episodic to continual management. Br J Gen Pract 2012;62(595): 60-61.
16. Global Initiative for Chronic Obstructive Lung Disease. Global Strategy for the Diagnosis, Management, and Prevention of COPD. Available at: https://goldcopd.org. *Accessed February 27, 2020.*
17. Jimmy B, Jose J. Patient medication adherence: measures in daily practice. Oman Med J 2011;26(3):155-159.
18. Lim KG, Rank MA, Li JT, Patel A, Volcheck GW, Branda ME, et al. How well does patient self-report predict asthma medication possession? Implications for medication reconciliation and adherence assessment. J Asthma 2010;47(8):878-882.
19. Martin LR, Williams SL, Haskard KB, DiMatteo MR. The challenge of patient adherence. Ther Clin Risk Manag 2005;1(3):189-199.
20. Sherman J, Hutson A, Baumstein S, Hendeles L. Telephoning the patient's pharmacy to assess adherence with asthma medications by measuring refill rate for prescriptions. J Pediatr 2000;136(4):532-536.
21. Cadarette SM, Wong L. An introduction to health care administrative data. Can J Hosp Pharm 2015;68(3):232-237.
22. Harbig P, Barat I, Lund Nielsen P, Damsgaard EM. Instantaneous detection of nonadherence: quality, strength, and weakness of an electronic prescription database. Pharmacoepidemiol Drug Saf 2012;21 (3):323-328.
23. Heisler M, Hogan MM, Hofer TP, Schmittdiel JA, Pladevall M, Kerr EA. When more is not better: treatment intensification among hypertensive patients with poor medication adherence. Circulation 2008;117 (22):2884-2892.
24. Williams LK, Peterson EL, Wells K, Campbell J, Wang M, Chowdhry VK, et al. A cluster-randomized trial to provide clinicians inhaled corticosteroid adherence information for their patients with asthma. J Allergy Clin Immunol 2010;126(2):225-231.231.
25. Vollmer WM, Feldstein A, Smith DH, Dubanoski JP, Waterbury A, Schneider JL, et al. Use of health information technology to improve medication adherence. Am J Manag Care 2011;17(12 Spec No):SP79-SP87.
26. Dixon BE, Alzeer AH, Phillips EO, Marrero DG. Integration of provider, pharmacy, and patient-reported data to improve medication adherence for type 2 diabetes: a controlled before-after pilot study. JMIR Med Inform 2016;4(1):e4.
27. Comer D, Couto J, Aguiar R, Wu P, Elliott D. Using aggregated pharmacy claims to identify primary nonadherence. Am J Manag Care 2015;21(12):e655-660.
28. Government of Canada. Dossier Santé Québec. Available at: https://www.quebec.ca/sante/vos-informations-de-sante/dossier-sante-quebec. *Accessed February 27, 2020.*
29. Colorafi KJ, Evans B. Qualitative descriptive methods in health science research. HERD 2016;9(4):16-25.
30. Garrett JJ. The elements of user experience: user-centered design for the web and beyond. London: Pearson Education; 2010.
31. Green J, Thorogood N. Qualitative methods for health research. Thousand Oaks, CA: Sage; 2014.
32. Poland BD. Transcription quality. In: Gubrium JF, Holstein JA, editors. Handbook of interview research. Thousand Oaks, CA: Sage; 2002:629-650.
33. Attride-Stirling J. Thematic networks: an analytic tool for qualitative research. Qual Res 2001;1(3):385-405.
34. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol 2006;3(2):77-101.
35. Vaismoradi M, Jones J, Turunen H, Snelgrove S. Theme development in qualitative content analysis and thematic analysis. J Nurs Educ Pract 2016;6(5):100-110.
36. Saunders B, Sim J, Kingstone T, Baker S, Waterfield J, Bartlam B, et al. Saturation in qualitative research: exploring its conceptualization and operationalization. Qual Quant 2018;52(4):1893-1907.
37. Guest G, Bunce A, Johnson L. How many interviews are enough? An experiment with data saturation and variability. Field Meth 2006;18 (1):59-82.
38. RQRM. reMed: Data Registry for Prescribed Medications/Banque de données sur les médicaments d'ordonnance. Available at: http://www.rqrm.ca/plateformes/optimisation-de-l-usage/64-4-remed-data-registry-for-prescribed-medications-banque-de-donnees-sur-les-medicaments-d-ordonnance.html. *Accessed February 27, 2020.*
39. Gross NJ, Barnes PJ. New therapies for asthma and chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2017;195(2):159-166.
40. Quantin C, Coatrieux G, Fassa M, Breton V, Jaquet-Chiffelle DO, de Vlieger P, et al. Centralised versus decentralised management of patients' medical records. Stud Health Technol Inform 2009;150:700-704.
41. Nau DP. Proportion of days covered (PDC) as a preferred method of measuring medication adherence. Springfield, VA: Pharmacy Quality Alliance; 2012.
42. Blais L, Beauchesne MF, Rey E, Malo JL, Forget A. Use of inhaled corticosteroids during the first trimester of pregnancy and the risk of congenital malformations among women with asthma. Thorax 2007; 62(4):320-328.
43. Martel M-J, Rey É, Beauchesne M-F, Perreault S, Lefebvre G, Forget A, et al. Use of inhaled corticosteroids during pregnancy and risk of pregnancy induced hypertension: nested case-control study. BMJ 2005;330(7485):230.
44. Boulet L-P, Becker A, Bérubé D, Beveridge R, Ernst P. Summary of recommendations from the Canadian asthma consensus report. CMAJ 1999;161(11 Suppl):S1-S12.
45. Blais L, Beauchesne M-F, Lévesque S. Socioeconomic status and medication prescription patterns in pediatric asthma in Canada. J Adolesc Health 2006;38(5):607.e609-.e616.
46. Reddel HK, Bateman ED, Becker A, Boulet L-P, Cruz AA, Drazen JM, et al. A summary of the new GINA strategy: a roadmap to asthma control. Eur Respir J 2015;46(3):622-639.
47. Lareau SC, Yawn BP. Improving adherence with inhaler therapy in COPD. Int J Chron Obstruct Pulmon Dis 2010;5:401-406.
48. Kerse N, Buetow S, Mainous AG3rd, Young G, Coster G, Arroll B. Physician-patient relationship and medication compliance: a primary care investigation. Ann Fam Med 2004;2(5):455-461.
49. Stavropoulou C. Non-adherence to medication and doctor-patient relationship: evidence from a European survey. Patient Educ Couns 2011; 83(1):7-13.
50. Tarn DM, Mattimore TJ, Bell DS, Kravitz RL, Wenger NS. Provider views about responsibility for medication adherence and content of physician-older patient discussions. J Am Geriatr Soc 2012;60(6): 1019-1026.

RESPIRATORY CARE Paper in Press. Published on March 31, 2020 as DOI: 10.4187/respcare.07328

51. McKendry R, Haggerty J. Defusing the confusion: concepts and measures of continuity of health care. Ottawa, Canada: Canadian Foundation for Healthcare Improvement; 2002.
52. Yousif A, Lemière C, Cartier A, Forget A, Blais L. Development of a graphical tool to measure medication adherence in asthma patients: a mixed-methods pilot study. J Asthma 2019;56(5):543-552.
53. Morse JM, Barrett M, Mayan M, Olson K, Spiers J. Verification strategies for establishing reliability and validity in qualitative research. Int J Qual Methods 2002;1(2):13-22.