

# Using decision support for population tracking of adherence to recommended asthma guidelines

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### **Article Summary**

## 1) Article Focus -

- The objective of this study was to evaluate the discrepancy between actual asthma treatments prescribed by primary care physicians compared to those recommended by evidence-based guidelines using a decision support tool linked to a provincial health administrative database.

2) Key Messages - up to three bullet points outlining the key messages and significance of the study.

- Decision support systems that define evidence-based guidelines, linked to an administrative database, can be used to identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment at a population level.

- When connected to the point of care, discrepancies between decision support and actual care can provide an opportunity for physicians to intervene early.

- The methods and approach from the current study can be used to evaluate adherence to evidence-based guidelines and indicators of disease management for other patient populations, at a population level if administrative databases are available or at the point of care if linked to an electronic health record.

3) Strengths and Limitations

- The availability of a provincial administrative database and decision support system allowed us to assess guideline adherence, and to identify sub-groups of individuals at risk of poor outcomes.

- The administrative database only includes individuals who are provincially insured and therefore discrepancies could not be examined for individuals with private insurance. - The proportion of individuals with poor asthma control may have been underestimated as control status was evaluated over a 3-month period.

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Using decision support for population tracking of adherence to recommended asthma guidelines

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Ahmed, Tamblyn,Winslade What is the key question? What is the discrepancy between actual asthma treatments individuals' receive as recorded in the provincial administrative database as compared to those recommended by evidence-based guidelines as defined within an asthma decision support system. What is the bottom line; and why read on? Decision support systems that define evidence-based guidelines, linked to an administrative database, can be used to identify individuals with

uncontrolled asthma or prescriptions that deviate from recommended treatment at a population

level.

Why read on? The methods and approach from the current study can provide an opportunity for physicians to intervene early and can be used to evaluate adherence to evidence-based guidelines and indicators of disease management for other patient populations.

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# Abstract

Background: Decision support systems linked to administrative databases provide a unique opportunity to monitor adherence to guidelines and target disease management strategies to patients not receiving guideline-based therapy. Objective: The objective of this study was to evaluate the discrepancy between actual asthma treatments prescribed by primary care physicians compared to those recommended by evidence-based guidelines using a decision support tool linked to a provincial health administrative database. Methods: The drug and medical services information of individuals with asthma were identified from the provincial health database and were pushed through an asthma decision support system. Recommendations aimed at optimizing asthma treatment were generated on two index dates, September 15 2007 (index date 1) and March 15 2008 (index date 2)

Results: 16, 803 individuals with asthma and provincial health insurance were identified on index date 1, and 18, 103 on index date 2. The distribution of recommendation categories were similar on both index dates. 94% were classified as well controlled and 7% as not well controlled. Among individuals well controlled, the largest proportion of individuals were in the *maintain treatment* category (50.6%), followed by *maintain/decrease treatment* (28.2%), and *decrease treatment* (2.7%). Almost all individuals not well controlled had the recommendation to *increase treatment* (88%) with a small proportion in the *refer* category (1%). Conclusions: The ADSS was able to identify sub-groups of patients from an administrative database that could benefit from a medication review and possible change. Discussion: Decision support systems linked to an administrative database can be used to identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment. When connected to the point of care, this can provide an opportunity for physicians to intervene early.

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# Introduction

Asthma poses a significant burden on healthcare resources and costs, [1] and results in reduced individual functioning and quality of life. [2, 3] Over the past 10 years there have been tremendous improvements in the scientific understanding of asthma and its treatment, and these findings have been made available to clinicians through the development of clinical practice guidelines. Despite achieving such sentinel milestones in asthma care, over 50% [4, 5] of individuals remain poorly controlled in the U.S. and Canada, with similar estimates worldwide. [6] This has translated into \$306 million per year in direct costs for providing health management for approximately 2.2 million Canadians diagnosed with asthma. With appropriate disease management over \$135 million in costs and reductions in physical and mental health can be prevented. [7]

Healthcare organizations worldwide have been charged with improving asthma outcomes over the next 2-3 years, with the aim of reducing hospitalizations and deaths related to asthma. [8] Several barriers for optimal management result in poor outcomes for asthma, [9] including clinician-related (non-adherence to guidelines), patient-related (non-adherence to treatment), and treatment- related barriers (cost, complexity of treatment). In moving towards improving clinical outcomes potentially modifiable barriers must be identified and targeted through appropriate interventions. A mechanism is needed to identify problematic asthma management so that gaps in care and barriers can be further evaluated and managed.

One potentially modifiable barrier is the gap between optimal versus actual asthma management as reflected by the lack of adoption of guidelines by clinicians or non-adherence of patients to recommended care. [10, 11] Much of the costs of asthma care are related to poor disease control

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Ahmed, Tamblyn,Winslade due to under-use of effective prophylactic therapies, and inadequate monitoring of disease control. At a population level there are few mechanisms available for tracking disease-management indicators for asthma to evaluate the current application of guidelines. Several studies have evaluated divergence from asthma guidelines, [12, 13] but have not been able to accurately estimate non-adherence to guidelines among a representative sample of individuals. Evaluations of adherence have mostly relied on chart reviews and clinician or patient reports which are difficult to complete for a large number of patients across several healthcare settings. [14-16]

Decision support systems are designed to facilitate uptake of evidence- based guidelines with the expectation that adherence to such guidelines will improve health outcomes. [17] Typically, decision support systems are used at the point of care. Such systems, however, may also have an alternate benefit of allowing population monitoring of adherence to disease management guidelines when the decision support algorithms are linked to administrative databases. By pushing through administrative health data including diagnoses, healthcare utilization and medication information, algorithms can be used to generate recommendations for optimizing treatment. In turn, patterns of under-optimization of treatment can be identified to monitor adherence to guidelines and target specific physician and patient sub-groups with disease management interventions.

The implementation of an asthma decision support system linked to provincial health insurance information represents a novel approach and facilitates the evaluation of the gap between recommended and actual treatment. We have developed a new methodology for assessing the quality of asthma management and asthma control in the population. Using evidence based decision-support systems developed to guide physicians using computerized physician order entry and electronic medical record systems, we developed a program for sequentially entering, assessing

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and extracting individual and summarized population level quality monitoring and control status indicators. Using population level administrative data for over 16,000 asthma patients, we then used this program to evaluate asthma status and quality of adherence to national guidelines in a Quebec population on two randomly selected days in the spring and fall. This information is needed for asthma management, and can be used for identifying opportunities to target interventions and improve asthma outcomes.

In this study we examined the discrepancy between actual asthma treatments as recorded in the provincial administrative database compared to those recommended by evidence-based guidelines as defined in the asthma decision support system on two index dates.

## **METHODS**

## **Study population**

The drug and medical services information of patients cared for by primary care physicians (PCP) participating in the Medical Office of the 21st Century(MOXXI) study [18] in a large metropolitan area was used to evaluate adherence to asthma treatment guidelines. PCPs were identified by professional association master lists and contacted by letter and telephone to determine their interest in participating in the MOXXI project. Patients of these physicians were identified from the Quebec provincial health data base (RAMQ) medical service claims, physician, and beneficiary files. McGill University IRB approval was obtained for this study and PCPs who accepted provided consent for the research team to receive patient anonymised administrative data.

All patients with an ICD 9 code for asthma, with no prior diagnosis for COPD, and who were  $\geq 5$  years old were identified from RAMQ based on algorithms validated in prior research. [19] For the

Ahmed, Tamblyn,Winslade purposes of this study, only patients with full drug coverage by RAMQ were included to ensure that all drugs dispensed were captured.

# The provincial drug and administrative database (RAMQ)

The RAMQ beneficiary demographic database provided data on individual age, gender, and mortality, and census data provided income and education. [20] Information on each drug dispensed was obtained from the prescription claims database and included the drug name, quantity, date, and duration for each prescription. The medical services claims database provided information on the beneficiary, date, type, provider, and location of service delivery (e.g., inpatient, emergency, clinic) for all medical services remunerated on a fee-for-service basis.

# Study Procedure: Evaluating the gap between actual and recommended asthma treatment using the Asthma Decision Support System (ADSS)

The ADSS is integrated into the MOXXI electronic prescribing drug management application with patient information retrieved by real-time integration with the beneficiary, prescription and medical services claims files of the RAMQ. Using information from the prescription drug management platform, the ADSS uses the profile of existing drugs and health problems to customize recommended changes in asthma drug therapy. For this study, recommendations aimed at optimizing asthma treatment were generated on two index dates, September 15 2007 (index date 1) and March 15 2008 (index date 2), representing peak times for asthma symptoms.

In the ADSS, asthma control is determined based on overuse of short acting beta agonists (SABA) and visits to the Emergency Department (ED) for a respiratory problem over a 3 month period before the index date. Based on a previously validated algorithm, a patient is considered to be not

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well controlled if the sum of the quantity of all SABA medications dispensed to the patient within the last 3 months exceeds 250 doses1, [21] and/or they visited an ED for a respiratory related problem in the last 3 months. Only asthma drugs that were 1) prescribed and dispensed within one year of the index date, and 2) active (i.e. based on prescription algorithms it is likely that the person has a supply of the medication) or expired within 30 days prior to the index date were considered when generating the recommendations.

Patient-specific recommendations related to drug therapy are translated into pre-formatted prescriptions in the drug management platform. The ADSS is structured to support the Canadian Consensus guidelines for Asthma Management. [22] Recommendations are categorised based on control status. For individuals in control, recommendations generated are one of three categories: maintain treatment, decrease treatment, or maintain or decrease treatment. Recommendations also include options for action plan prescriptions for patients who are in control. For individuals not well controlled recommendations are either to increase treatment or to refer to a specialist. Within each recommendation category, physicians are presented with specific recommendations for medications and doses to achieve the desired level of drug treatment.

#### **Data Analysis**

Results were calculated for each index date. Descriptive statistics were used to characterize the study population and to evaluate differences between individuals with and without RAMQ coverage for prescription drugs. For individuals with RAMQ coverage, the proportion of individuals under each recommendation category was evaluated among individuals classified as 'well controlled' and 'not well controlled', and descriptive statistics were used to compare the characteristics of patients across categories. Multivariable logistic regression was used to estimate the probability of being

<sup>&</sup>lt;sup>1</sup> 250 doses is based on the most commonly prescribed SABA salbutamol 100mcg, 2 inhalations at a time, or the equivalent for other fast acting bronchodilators in the last three months.

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classified in control or not well controlled as a function of sociodemographic characteristics and healthcare utilization.

## Results

# Study Population and Insured Compared to Non-Insured

47, 614 individuals with an asthma diagnosis were identified on index date 1, after removing individuals with a prior diagnosis of COPD (6018) and those  $\leq$  5 years old (Figure 1). Thirty five percent of individuals were RAMQ insured for prescription drugs at least 75% of the year prior to the index date, for both dates. On index date 2, 51 306 individuals with an asthma diagnosis were identified (Figure 2). Approximately the same proportion of individuals was classified as well controlled on index date 1 (93 %) and index date 2 (94%). As the distribution of individual characteristics, control status, and recommendation categories were similar on both index dates, we only report the results from index date 2 from this point on (Table 1).

Individuals who were RAMQ insured were on average older (mean= $38\pm22$ ) as compared to non-RAMQ insured individuals (mean= $31\pm18$ ) and had a greater percentage of individuals  $\geq 60$  years old, a larger proportion was female (61% versus 56%), and in the lower SES category (21% versus 6%). A greater proportion of RAMQ insured patients had 3 or more ED (16 versus 9%) and hospital visits ( versus 3%) one year prior to the index date, and a diagnostic code for anxiety (11compared to 7%) or depression (8 compared to 5%).

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 Table 1: Characteristics of Study Participants with and without provincial health coverage (RAMQ)

	<b>RAMQ</b> Coverage	No RAMQ Coverage
	n=18 013	n=33 293
Age mean (sd)	38,3 (21,8)	30,81 (17,5)
Age n (%)		
≤17	3 963 (22,0)	10 273 (30,9)
18-39	5 129 (28,6)	9 926 (29,8)
40-59	5 254 (29,2)	11 277 (33,9)
$\geq 60$	3 637 (20,2)	1 817 (5,5)
Sex n (% female)	11 035 (61,3)	18 665 (56,1)
Income n (%) *		
Low SES	3 490 (19,4)	2 665 (8,0)
Middle SES	13 148 (73.0)	25 947 (78,0)
High SES	1 230 (6,8 )	4 298 (13,0)
Healthcare Utilization over 1		
Medical Phycisian Visits**		
n (%)		
0 visit	1 736 (9,6)	3 855 (11,6)
1 visit	1 998 (11,1)	4 453 (13,4)
2 visits	1 895 (10,5)	4 154 (12,5)
3 or more visits	12,384 (68,8)	20 831 (62,6)
Emergency Department	, , ,	
Visits n (%)		
0 visit	10 435 (57,9)	22 738 (68,0)
1 visit	3 139 (17,4)	5 445 (16,4)
2 visits	1 698 (9,4)	2 416 (7,3)
3 or more visits	2 741 (15,2)	2 694 (8,1)
Emergency Department	1 313 (7,3)	1 644 (4,9)
Visits for asthma n (%)		
Hospitalization		
0 day	14 890 (82,7)	29 445 (88,4)
1 day	1 340 (7,4)	2 072 (6,2)
2 days	445 (2,5)	658 (2,0)
3 or more days	1 338 (7,4)	1 118 (3,4)
Co-Morbidity n (%)		
• 、 /	1 400 (7,77)	1 724 (5,2)
Depression	$1 \pm 00000000000000000000000000000000000$	

\*\* Ambulatory and specialty care

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Ahmed, Tamblyn,Winslade Control Status and Recommendation Categories

Among the 18 013 individuals who were RAMQ insured for prescription drugs, 94% were classified as well controlled and 7% as not well controlled over 3 months prior to the index date (Figure 1).

63 % of individuals who were not well controlled were in the  $\geq$  40 age group and 26% in the low SES category compared to 49% and 19%, respectively, in the well controlled group. These individuals also had a higher Charlson Co-morbidity Index of 2.11 as compared to 1.6 among those well controlled. A larger proportion of individuals among those not well controlled had a diagnostic code for depression, anxiety, mental illness, and a cardiac related condition. Among those not well controlled 69% (n=667) had at least 1 ED visit (past 3 months), and 74% a medical visit associated with a respiratory problem (in the past year). In comparison 13% (n=2,039) of those well controlled had at least one ED visit and 52% medical visit related to a respiratory problem.

53% of patients in the not well controlled group had an active prescription for an ICS, 20% a combination therapy, and 14% as compared to 36%, 10%, and 6% in the well controlled group. 63% and 42% of not well and well controlled, respectively, had an active prescription for a fast-acting beta agonist (FABA). At index date 1, all individuals not well controlled had asthma drugs as compared to 9.2 % of those well controlled who had no asthma drugs dispensed.

Table 2 presents the incremental regression coefficients for the demographic, healthcare utilization, and co-morbidity variables hypothesized to be associated with control status. Healthcare utilization including,  $\geq$  3 days of hospitalization (OR=4.58), and  $\geq$  3 visits to the ED (for reasons other than a respiratory problem) (OR=2.32), was found to be most strongly associated with control status.

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Being male (OR=.85), from a low SES (OR= 1.9), and in the 40-59 age group increased the odds of

having asthma that was not well controlled.

Table 2: Multivariable Logistic Regression Models for Identifying Individuals Controlled and
Not Well Controlled

Variable	OR (95%CI)
	<b>Control Status</b>
sge mean (sd)	
≤17	Reference
18-39	0.56 (0.44, 0.72)
40-59	2.19(1.73, 2.77)
$\geq 60$	1.19 (1, 1.42)
Sex n (% female)	
Male	Reference
Female	85 (.74, .98)
Income n (%) *	
High SES	Reference
Middle SES	1.44 (1.04, 1.98)
Low SES	1.90 (1.35, 2.68)
Healthcare Utilization over	
1 year prior to March 15,	
2008	
Medical Physician *Visits n	
(%)	
0 visit	Reference
1 visit	.73 (.47,1.2)
2 visits	.82 (.53,1.28)
$\geq$ 3 visits	1.62 (1.162.27)
Emergency Department	(
Visits (other than resp)n	
(%)	
0 visit	Reference
1 visit	1.38(1.14,1.66)
2 visits	1.46(1.16,1.84)
$\geq 3$ visits	2.32(1.94,2.8)
≥ <i>3</i> v151t5	2.32(1.77,2.0)
Hospitalisation	
0 day	Reference
1 day	2.24(1.55,3.27)
2 days	2.88(1.79,4.6)
3 or more days	4.58 (3.36,6.22)
Co-Morbidity n (%)	т.30 (3.30,0.22)
Charlson co-morbidity index	1.04 (1.01, 1.08)
Anxiety No	Reference
Alixiety No Yes	1.26 (1.05,1.52)
General practitioner and specialist	

\* General practitioner and specialist

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Ahmed, Tamblyn,Winslade *Recommendation category by control group* 

The distribution of individuals across recommendation categories is presented in Table 3.

For 8% (1198/15843) in control, and 21% (201/960) of those not well controlled, a recommendation could not be determined by the ADSS either because the patient 1) had dispensed prescriptions for an inappropriate combination of medications that the ADSS could not reconcile to provide an appropriate recommendation (e.g. a LABA with two prescriptions for combination therapy) or, 2) dispensed two medications that resulted in a duplication of therapy. For those not well controlled, those in the *duplicate/inappropriate* category had a larger proportion in the lower SES, a higher co-morbiditiy index and more frequent ambulatory and hospital visits.

Among individuals well controlled, the largest proportion of individuals were in the *maintain treatment* category (50.6%), followed by *maintain/decrease treatment* (28.2%), and *decrease treatment* (2.7%). Almost all individuals not well controlled had the recommendation to *increase treatment* (88%) with a small proportion in the *refer* category (1%). Reasons for the low referral to specialty care needs to be closely examined, and may be related to uncertainty of primary care physicians of when to refer patients, and/or patients may not go see specialists once referred. [23] Regardless of the recommendation category, the largest proportion of individuals was in the 40-59 age group; except for *maintain treatment* that had a larger proportion of individuals in the 18-39 age group. The middle SES was the largest for all recommendation groups and the proportion of females was the same across all categories. Individuals in the *refer* category were on average older than those in the other categories, but comparable on many of the other characteristics.

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# Table 3: Comparison of characteristics of individuals in each recommendation category (based on primary recommendation).

-8								
9		In Control N=14989					Not Well Contro N=1245	olled
<del>10</del> 11		Maintain	Maintain/Dec	Decrease	Duplicate/	Increase	Refer	Duplicate/
12			rease		Inappropriate	n=1 090	n=17	Inappropriate
13		n=9564	n=4349	n=474	n=602			n=138
<b>Å</b> ge	mean (sd)	41,8 (19,2)	38,2	44,8 (21,6)	45,9 (20,3)	40,4 (21,5)	57,1 (9,3)	46,6
<u>-15</u>	(0/)		(22,7)					(16,0)
	n (%)	010 (0 ()	1 115 (25 ()	74 (15 ()	(0,(11,2))	190 (17.2)	0	((A A))
17	$\leq 17$ 18-39	919 (9,6) 3 561 (37,2)	1 115 (25,6) 996 (22,9)	74 (15,6) 86 (18,1)	68 (11,3) 123 (20,4)	189 (17,3) 310 (28,4)	0 0	6 (4,4) 33 (23,9)
18	40-59	2 987 (31,2)	1 269 (29,2)	195 (41,1)	260 (43,2)	372 (34,1)	10 (58,8)	79 (57,2)
19	$\geq 60$	2 097 (31,2) 2 097 (21,9)	969 (22,3)	119 (25,1)	151 (25,1)	219 (20,1)	7 (41,2)	20 (14,5)
<u>-20</u> Sex	<u> </u>	6 073 (63,5)	2 659 (61,1)	303 (63,9)	381 (63,3)	709 (65,0)	12 (70,6)	101 (73,2)
	ome n (%) *	0 075 (05,5)	2 037 (01,1)	505 (05,7)	501 (05,5)	709 (05,0)	12 (70,0)	101 (75,2)
23	Low SES	1 684 (17,6)	923 (21,2)	117 (24,7)	156 (25,9)	237 (21,7)	4 (23,5)	43 (31,2)
23	Middle SES	7 028 (73,5)	3 161 (72,7)	330 (69,6)	420 (69,8)	802 (73,6)	13 (76,5)	90 (65,2)
25	High SES	763 (8,0)	228 (5,2)	25 (5,3)	22 (3,6)	47 (4,3)	0	5 (3,6)
Me	lical Visits mean							
27	All	8,78 (13,1)	9,68 (13,8)	12,62(13,3)	12,87(13,4)	16,52 (22,2)	29,29 (21,3)	24,99 (26,1)
28	Ambulatory	7,72 (9,6)	8,31 (9,2)	10,89 (9,5)	11,13 (9,5)	13,53(15,0)	19,94 (10,0)	20,01 (18,1)
29	Hospitalized	1,07 (6,8)	1,37 (7,7)	1,73 (7,4)	1,73 (7,6)	2,99 (11,6)	9,35 (16,4)	4,98 (13,3)
		(%) past year				1		
31	Phycisian	1.02((10.0))	2(5((1)))	14 (2.0)		(2(5,7))	0	7(51)
32	0 visit	1 036 (10,8) 1048 (10,96)	265 (6,1)	14(3,0)	22 (3,6)	62 (5,7) 76 (7,0)	0 0	7 (5,1)
33	1 visit 2 visits	1048 (10,98) 1000 (10,5)	451 (10,4) 486 (11,2)	31 (6,5) 41	40 (6,6) 26 (4,3)	81 (7,4)	0	5 (3,6) 2 (1,4)
34	2 115115	1000 (10,5)	460 (11,2)	(8,6)	20 (4,3)	01 (7,4)	0	2 (1,4)
35 36	3 or more visits	6 480 (67,8)	3 147 (72,4)	388 (81,9)	514 (85,4)	871 (79,9)	17 (100)	124 (89,9)
	ER	0 100 (07,0)	5 117 (72,1)	500 (01,5)	511(05,1)	0/1 (/),))	17 (100)	121(0),)
37	0 visit	5 995 (62,7)	2 501 (57,5)	240 (50,6)	289 (48,0)	200 (18,4)	1 (5,9)	25 (18,1)
38	1 visit	1 565 (16,4)	790 (18,2)	89 (18,8)	118 (19,6)	221 (20,3)	3 (17,6)	21 (15,2)
39 40	2 visits	846 (8,8)	414 (9,5)	59 (12,4)	63 (10,5)	172 (15,8)	1 (5,9)	9 (6,5)
40 41	3 or more visits	1 158 (12,1)	644 (14,8)	86 (18,1)	132 (21,9)	497 (45,6)	12 (70,6)	83 (60,2)
42 43 43	for respiratory p					1		
44		8 781 (91,8)	3 792 (87,2)	394 (83,1)	491 (81,6)	294 (27,0)	4 (23,5)	38 (27,5)
45		593 (6,2)	402 (9,2)	52 (11,0)	64 (10,6)	450 (41,3)	4 (23,5)	27 (19,6)
46	3 or more visits	142(1,5)	105 (2,4) 50 (1,2)	15(3,2)	25 (4,2)	188 (17,2)	3 (17,65) 6 (35,3)	22 (15,9) 51 (37,0)
47	5 of more visits	48 (0,3)	30 (1,2)	13 (2,7)	22 (3,7)	158 (14,5)	0 (33,3)	51 (57,0)
<b>ÉD</b> - 49								
		6 268 (65,5)	2 712 (62,4)	265 (55,9)	326 (54,2)	456	4 (23,5)	45 (32,6)
50		· _ · · (· · ; · )	_ / (-, /)			(41,8)	(,)	(,-)
51	1 visit	1 535 (16,1)	742 (17,1)	94 (19,8)	118 (19,6)	205 (18,8)	3 (17,6)	29 (21,0)
52	2 visits	746 (7,8)	370(8,5)	49 (10,3)	58 (9,6)	117 (10,7)	3 (17,6)	14 (10,1)
53	3 or more visits	1 015 (10,6)	525 (12,1)	66 (13,9)	100 (16,6)	312 (28,6)	7 (41,2)	50 (36,2)
54 55	Hospitalization							
55 56	0 day	8 046 (84,1)	3 581 (82,3)	356 (75,1)	449 (74,6)	774 (71,0)	5 (29,4)	78 (56,5)
56 57	1 day	697 (7,3)	318 (7,3)	39 (8,2)	62 (10,3)	100 (9,2)	3 (17,6)	17 (12,3)
57 58	2 days	215 (2,2)	107 (2,5)	20 (4,2)	23(3,8)	44 (4,0)	1(5,9)	3(2,2)
59	3 or more days	606 (6,3)	343 (7,9)	59 (12,4)	68 (11,3)	172 (15,8)	8 (47,1)	40 (29,0)
60								
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23		In Control N=14989			,		Not Well Contro N=1245	olled
4 5 6		Maintain	Maintain/Dec rease	Decrease	Duplicate/ Inappropriate	Increase n=1 090	Refer n=17	Duplicate/ Inappropriate
7	·····	n=9564	n=4349	n=474	n=602			n=138
•	spitalization- for r	9 370 (98,0)	4 210 (96,8)	447 (94,3)	563 (93,5)	990 (90,8)	14 (82,4)	109 (79,0)
9	1 day	100 (1,0)	4 210 (96,8) 60 (1,4)	447 (94,5) 7 (1,5)	20 (3,3)	33 (3,0)	14 (82,4) 0	
10	2 days	32 (0,3)	32 (0,74)	4 (0,8)	5 (0,8)	14 (1,3)	0	7 (5,1) 3 (2,2)
11	3 or more days	62 (0,6)		16(3,4)		53 (4,9)		
12	•		47 (1,1)	10 (3,4)	14 (2,3)	33 (4,9)	3 (17,6)	19 (13,8)
13 Aşt	thma Medications	mean (sd) range	e past year			ļ		
15		0,61 (1,7)	2,93 (3,8)	4,32 (5,2)	4,95 (5,1)	2,50 (4,4)	5,00 (5,2)	6,82 (6,8)
16	ICS	0,2 (0,7)	2,3(2,9)	1,4(2,6)	3,6(3,8)	1,4(2,4)	0,9 (1,7)	3,5(3,9)
17	Leukotrienes	0,1 (1,4)	0,4(3,0)	6,7(10,0)	1,5 (4,8)	0,8(4,4)	3,3(5,1)	3,9 (11,5)
18	Combination	0,0 (0,4)	1,2 (2,9)	5,1(4,9)	2,18 (3,9)	1,0 (2,7)	7,7 (4,5)	3,0 (4,3)
19	Therapy							
	Other	0,2(1,8)	0,8(3,4)	2,9(6,8)	2,36 (3,9)	1,8(17,0)	2,1 (2,5)	4,45 (6,6)
ξ	ntrol Status n (%)							
		0	0	0	0	1 (0,1)	0	0
22 23	visits for Asthma	0	0	0	0	1 076 (98,7)	17 (100)	135 (97,8)
	EK OF FABA	0	0	0	0	1 076 (98,7)	17 (100)	135 (97,8)
¢φ.	-Morbidity	1,6 (1,5)	1,6 (1,5)	1,8 (1,6)	1,9 (1,9)	1,8(2,0)	2,2 (1,4)	2,6 (2,5)
25	ex							
20	•	Less than 1 %	of missing val	ues for each	category			
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# Ahmed, Tamblyn, Winslade

# DISCUSSION

The purpose of this study was to evaluate the discrepancy between current asthma management and recommended guidelines using the provincial administrative databases and an ADSS. The present study represents an example of how decision support systems can be used to monitor guideline adherence, and to identify individuals at risk of poor outcomes to provide targeted interventions. To our knowledge this is the first time that a decision support system has been used to evaluate disease management at a population level.

As expected, individuals who were provincially insured were on average older, from a lower SES, and a higher proportion used healthcare services. A larger proportion compared to those non-provincially insured also had a diagnosis code for anxiety and depression.

The algorithms used to identify individuals with asthma and evaluate control status were validated in previous work. [24, 25] The majority of individuals well controlled were on an appropriate quantity of asthma treatment. We found, however, that ~ 31% of those well controlled could benefit from a medication review and potentially lower doses of asthma medications.

The majority of individuals not well controlled had the recommendation to increase treatment and for these individuals there was an opportunity to change therapy according to the existing guidelines. [26] The SMART inhaler helps address needs for increase in therapy, as it allows patients to use their as-needed medication because of declining asthma control—as is very often the case—evolving exacerbations will possibly be treated at an early stage and a further worsening of asthma may possibly be prevented. The SMART inhaler is not a recommended yet part of

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Canadian guidelines, however, with emerging evidence of its benefits for marinating control compared to other alternatives, [27, 28] it will be included in the next version of guidelines and become more commonly prescribed for Canadian patients. Individuals who were not well controlled were in the 40-59 age range, and had a more complex health profile with greater co-morbidity, including a higher proportion with a diagnosis of anxiety or depression as compared to those well-controlled. The logistic regression analysis in our study also supported these conclusions. These individuals represent a more vulnerable sub-group of the asthma population, and place a greater burden on the healthcare system given the higher proportion that had an ED visit or hospitalization. As such, they require closer monitoring and review of medication to reach doses sufficient to maintain asthma control, or to review reasons for failed treatment.

In this study we were not able to generate a recommendation for a larger proportion of individuals not well controlled compared to controlled either because they were dispensed prescriptions for an inappropriate combination of medications that the ADSS could not reconcile to provide an appropriate recommendation, or they were dispensed two medications that resulted in a duplication of therapy. These cases in themselves represent a segment of the asthma population that requires closer review of their prescribed medication.

The generation of asthma recommendations at a population level using an administrative database allows individuals not receiving treatment based on guidelines to be identified. We found that many individuals with non-controlled asthma visit a physician 3 or more times per year, and potentially represent missed opportunities to optimize treatment. Possible reasons for our findings may include the lack of knowledge of PCPs of guidelines in general, especially for more complicated cases. It may also be, however, that patients are not going to see the same physician, or are switching

Ahmed, Tamblyn,Winslade physicians to ensure access to SABAs. In such situations, physicians may be reluctant to conduct a complete medication review if they do not perceive themselves as the primary provider for the patient.

Other physician concerns may be the reluctance to prescribe ICS and/or concern regarding polypharmacy with multiple inhalers. [29] This is where the role of pharmacists is important as they can see individuals' entire medication dispensing history and have been shown to be effective in managing asthma patients in particular if supported by an ADSS. [30]

Previous studies have also found that physicians do not adopt guidelines in their practice because of perceived appropriateness of the guidelines. [13, 31] Surveys have shown that they believe that guidelines do not take into account the heterogeneity of asthma and do not account for individual patient variations in response to treatment, [32] and other factors that impact response to asthma therapy such as age and co-morbidities.

Further, patient non-adherence to prescribed therapy and not having prescribed medications filled may also explain the findings from our study. Patient beliefs about the negative impact and benefits of their medications, [33] their confidence to manage their asthma, and not seeking care early enough to prevent exacerbations have all been identified as contributors to poor outcomes for asthma.

Mechanisms to identify patients who need closer follow-up and evaluation have been identified as an important need for primary healthcare. [3, 34, 35] Future initiatives can include linking administrative databases to decision support systems that can help identify individuals who need

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closer monitoring and follow-up and allow for targeted services such as visit reminders sent to patients or to their care provider. The ongoing implementation of electronic health records and patient health portals will facilitate this approach. Information can be fed back to physicians and pharmacists to improve patient management, and initiate care early on, before individuals experience deteriorations in health.

# Limitations

Our approach for identifying individuals with asthma and assessing asthma status may have underestimated the percentage out of control in our study. We examined asthma control on two index dates, and went back 3 months prior to the index date to assess control status. A more sensitive algorithm that treats control as a time varying covariate would likely provide a more accurate evaluation of control status. In addition, at the time that the ADSS was being developed, the SMART treatments, that allow for the same inhaler to be used as a preventative and rescue inhaler were not commonly used or part of the guidelines. Therefore, they were not programmed as part of the ADSS and not included in the recommendations.

Further, use of decision support during clinical encounters allow for a patient-reported assessment of symptoms at the time when recommendations are generated, and allow for a more accurate assessment of asthma control. We were also limited to generating recommendations for those provincially insured that represent a more vulnerable segment of the population.

#### Conclusions

This study demonstrated how a decision support system linked to an administrative database could be used to identify individuals in the population that require a review of asthma treatment. Such an approach can help identify individuals with uncontrolled asthma or prescriptions that deviate from

Ahmed, Tamblyn,Winslade recommended treatment to intervene early. This study provides a model for monitoring adherence

to guidelines for other chronic conditions such as hypertension and diabetes.

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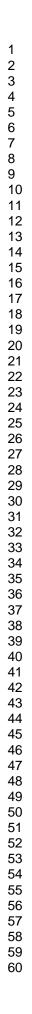
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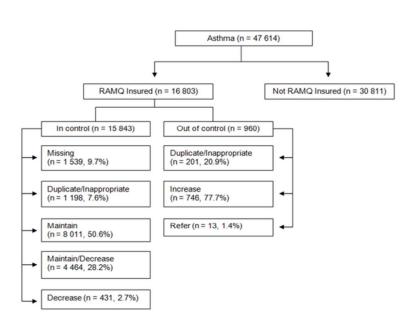
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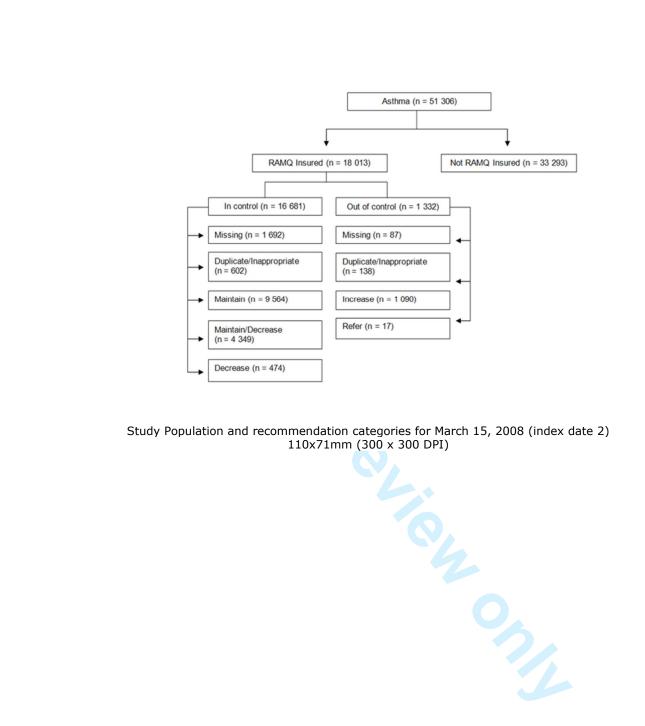






Study Population and recommendation categories for September 15, 2007 (index date 1) 100x58mm (300 x 300 DPI)





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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies* 

	Item No	Recommendation
Title and abstract	1	( <i>a</i> ) Indicate the study's design with a commonly used term in the title or the abstract (page 1)
		(b) Provide in the abstract an informative and balanced summary of what was done
		and what was found (page 3)
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Buekground/futionale	2	(page 4)
Objectives	3	State specific objectives, including any prespecified hypotheses (page 5 and 6)
Methods		$\mathbf{r} = \mathbf{r} + $
Study design	4	Present key elements of study design early in the paper (page 7)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment,
5		exposure, follow-up, and data collection (page 6-7)
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of
F		participants (page 7)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect
		modifiers. Give diagnostic criteria, if applicable (page 8)
Data sources/	8*	For each variable of interest, give sources of data and details of methods of
measurement		assessment (measurement). Describe comparability of assessment methods if there is
		more than one group (page 8-9)
Bias	9	Describe any efforts to address potential sources of bias (page 8)
Study size	10	Explain how the study size was arrived at (page 7)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable,
		describe which groupings were chosen and why (page 8)
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding
		(page 8)
		(b) Describe any methods used to examine subgroups and interactions (page 8)
		(c) Explain how missing data were addressed (n/a)
		(d) If applicable, describe analytical methods taking account of sampling strategy
		(n/a)
		( <u>e</u> ) Describe any sensitivity analyses (n/a)
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially
		eligible, examined for eligibility, confirmed eligible, included in the study,
		completing follow-up, and analysed (page 9)
		(b) Give reasons for non-participation at each stage (n/a)
		(c) Consider use of a flow diagram (refer to figures 1 and 2)
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and
		information on exposures and potential confounders (table on page 10)
		(b) Indicate number of participants with missing data for each variable of interest (in
		figures 1 and 2)
Outcome data	15*	Report numbers of outcome events or summary measures (page 13)
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and
		their precision (eg, 95% confidence interval). Make clear which confounders were
		adjusted for and why they were included (page 9)

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	-	<ul> <li>(b) Report category boundaries when continuous variables were categorized (n/a)</li> <li>(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period (n/a)</li> </ul>
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses $(n/a)$
Discussion		
Key results	18	Summarise key results with reference to study objectives (page 16-17)
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or
		imprecision. Discuss both direction and magnitude of any potential bias (page 19)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations,
		multiplicity of analyses, results from similar studies, and other relevant evidence
		(page 17-18)
Generalisability	21	Discuss the generalisability (external validity) of the study results (end of page 17-
		18)
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if
		applicable, for the original study on which the present article is based (page 21)

\*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.



# Using decision support for population tracking of adherence to recommended asthma guidelines

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<b>Primary Subject Heading</b> :	Health informatics
Secondary Subject Heading:	Health informatics, Medical management
Keywords:	Asthma < THORACIC MEDICINE, Health informatics < BIOTECHNOLOGY & BIOINFORMATICS, EPIDEMIOLOGY



Ahmed, Tamblyn, Winslade

Using decision support for population tracking of adherence to recommended asthma guidelines

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Word Count: 3092

Figures: 2

Tables: 3

#### Ahmed, Tamblyn, Winslade

# Keywords: Asthma, clinical practice guidelines, disease management, decision support, administrative

database

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What is the key question? What is the discrepancy between actual asthma treatments individuals' receive as recorded in the provincial administrative database as compared to those recommended by evidence-based guidelines as defined within an asthma decision support system.

What is the bottom line; and why read on? Decision support systems that define evidence-based guidelines, linked to an administrative database, can be used to identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment at a population level.

**Why read on?** The methods and approach from the current study can provide an opportunity for physicians to intervene early and can be used to evaluate adherence to evidence-based guidelines and indicators of disease management for other patient populations.

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# Abstract

Objective: Decision support systems linked to administrative databases provide a unique opportunity to monitor adherence to guidelines and target disease management strategies to patients not receiving guideline-based therapy. The objective of this study was to evaluate the discrepancy between actual asthma treatments prescribed by primary care physicians compared to those recommended by evidencebased guidelines using a decision support tool linked to a provincial health administrative database. Design: The drug and medical services information of individuals with asthma were identified from the provincial health database and were pushed through an asthma decision support system (ADSS). Recommendations aimed at optimizing asthma treatment were generated on two index dates, September 15 2007 (index date 1) and March 15 2008 (index date 2). Setting: Primary care settings in a large Canadian metropolitan area. Participants: Individuals with asthma and provincial health insurance Primary and secondary outcome measures: well controlled asthma Results: 16, 803 eligible individuals were identified on index date 1, and 18, 103 on index date 2. The distribution of recommendation categories were similar on both index dates. 94% were classified as well controlled and 7% as not well controlled. Among individuals well controlled, the largest proportion of individuals were in the maintain treatment category (50.6%), followed by maintain/decrease treatment (28.2%), and decrease treatment (2.7%). Almost all individuals not well controlled had the recommendation to increase treatment (88%) with a small proportion in the refer category (1%). Conclusions: The ADSS was able to identify sub-groups of patients from an administrative database that

could benefit from a medication review and possible change. Decision support systems linked to an administrative database can be used to identify individuals with uncontrolled asthma or prescriptions that

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deviate from recommended treatment. When connected to the point of care, this can provide an

opportunity for physicians to intervene early.

# **Article Summary**

1) Article Focus –

- The objective of this study was to evaluate the discrepancy between actual asthma treatments prescribed by primary care physicians compared to those recommended by evidence-based guidelines using a decision support tool linked to a provincial health administrative database.

2) Key Messages - up to three bullet points outlining the key messages and significance of the study.

- Decision support systems that define evidence-based guidelines, linked to an administrative database, can be used to identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment at a population level.

- When connected to the point of care, discrepancies between decision support and actual care can provide an opportunity for physicians to intervene early.

- The methods and approach from the current study can be used to evaluate adherence to evidence-based guidelines and indicators of disease management for other patient populations, at a population level if administrative databases are available or at the point of care if linked to an electronic health record.

3) Strengths and Limitations

- The availability of a provincial administrative database and decision support system allowed us to assess guideline adherence, and to identify sub-groups of individuals at risk of poor outcomes.

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The administrative database only includes individuals who are provincially insured and therefore discrepancies could not be examined for individuals with private insurance.
The proportion of individuals with poor asthma control may have been underestimated

as control status was evaluated over a 3-month period.

#### Ahmed, Tamblyn, Winslade

# Introduction

Asthma poses a significant burden on healthcare resources and costs, [1] and results in reduced individual functioning and quality of life. [2, 3] Over the past 10 years there have been tremendous improvements in the scientific understanding of asthma and its treatment, and these findings have been made available to clinicians through the development of clinical practice guidelines. Despite achieving such sentinel milestones in asthma care, over 50% [4, 5] of individuals remain poorly controlled in the U.S. and Canada, with similar estimates worldwide. [6] This has translated into \$306 million per year in direct costs for providing health management for approximately 2.2 million Canadians diagnosed with asthma. With appropriate disease management over \$135 million in costs and reductions in physical and mental health can be prevented. [7]

Healthcare organizations worldwide have been charged with improving asthma outcomes over the next 2-3 years, with the aim of reducing hospitalizations and deaths related to asthma. [8] Several barriers for optimal management result in poor outcomes for asthma, [9] including clinician-related (non-adherence to guidelines), patient-related (non-adherence to treatment), and treatment- related barriers (cost, complexity of treatment). In moving towards improving clinical outcomes potentially modifiable barriers must be identified and targeted through appropriate interventions. A mechanism is needed to identify problematic asthma management so that gaps in care and barriers can be further evaluated and managed.

One potentially modifiable barrier is the gap between optimal versus actual asthma management as reflected by the lack of adoption of guidelines by clinicians or non-adherence of patients to recommended

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care. [10, 11] Much of the costs of asthma care are related to poor disease control due to under-use of effective prophylactic therapies, and inadequate monitoring of disease control. At a population level there are few mechanisms available for tracking disease-management indicators for asthma to evaluate the current application of guidelines. Several studies have evaluated divergence from asthma guidelines, [12, 13] but have not been able to accurately estimate non-adherence to guidelines among a representative sample of individuals. Evaluations of adherence have mostly relied on chart reviews and clinician or patient reports which are difficult to complete for a large number of patients across several healthcare settings. [14-16]

Decision support systems are designed to facilitate uptake of evidence- based guidelines with the expectation that adherence to such guidelines will improve health outcomes. [17] Typically, decision support systems are used at the point of care. Such systems, however, may also have an alternate benefit of allowing population monitoring of adherence to disease management guidelines when the decision support algorithms are linked to administrative databases. By pushing through administrative health data including diagnoses, healthcare utilization and medication information, algorithms can be used to generate recommendations for optimizing treatment. In turn, patterns of under-optimization of treatment can be identified to monitor adherence to guidelines and target specific physician and patient sub-groups with disease management interventions.

The implementation of an asthma decision support system linked to provincial health insurance information represents a novel approach and facilitates the evaluation of the gap between recommended and actual treatment. We have developed a new methodology for assessing the quality of asthma

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management and asthma control in the population. Using evidence based decision-support systems developed to guide physicians using computerized physician order entry and electronic medical record systems, we developed a program for sequentially entering, assessing and extracting individual and summarized population level quality monitoring and control status indicators. Using population level administrative data for over 16,000 asthma patients, we then used this program to evaluate asthma status and quality of adherence to national guidelines in a Quebec population on two randomly selected days in the spring and fall. This information is needed for asthma management, and can be used for identifying opportunities to target interventions and improve asthma outcomes.

In this study we examined the discrepancy between actual asthma treatments as recorded in the provincial administrative database compared to those recommended by evidence-based guidelines as defined in the asthma decision support system on two index dates.

# METHODS

# **Study population**

The drug and medical services information of patients cared for by primary care physicians (PCP) participating in the Medical Office of the 21st Century(MOXXI) study [18] in a large metropolitan area was used to evaluate adherence to asthma treatment guidelines. PCPs were identified by professional association master lists and contacted by letter and telephone to determine their interest in participating in the MOXXI project. Patients of these physicians were identified from the Quebec provincial health data base (RAMQ) medical service claims, physician, and beneficiary files. McGill University IRB approval was

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obtained for this study and PCPs who accepted provided consent for the research team to receive patient anonymised administrative data.

All patients with an ICD 9 code for asthma, with no prior diagnosis for COPD, and who were  $\geq$  5 years old were identified from RAMQ based on algorithms validated in prior research. [19] For the purposes of this study, only patients with full drug coverage by RAMQ were included to ensure that all drugs dispensed were captured.

# The provincial drug and administrative database (RAMQ)

The RAMQ beneficiary demographic database provided data on individual age, gender, and mortality, and census data provided income and education. [20] Information on each drug dispensed was obtained from the prescription claims database and included the drug name, quantity, date, and duration for each prescription. The medical services claims database provided information on the beneficiary, date, type, provider, and location of service delivery (e.g., inpatient, emergency, clinic) for all medical services remunerated on a fee-for-service basis.

Study Procedure: Evaluating the gap between actual and recommended asthma treatment using the Asthma Decision Support System (ADSS)

The ADSS is integrated into the MOXXI electronic prescribing drug management application with patient information retrieved by real-time integration with the beneficiary, prescription and medical services

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claims files of the RAMQ. Using information from the prescription drug management platform, the ADSS uses the profile of existing drugs and health problems to customize recommended changes in asthma drug therapy. For this study, recommendations aimed at optimizing asthma treatment were generated on two index dates, September 15 2007 (index date 1) and March 15 2008 (index date 2), representing peak times for asthma symptoms.

In the ADSS, asthma control is determined based on overuse of short acting beta agonists (SABA) and visits to the Emergency Department (ED) for a respiratory problem over a 3 month period before the index date. Based on a previously validated algorithm, a patient is considered to be not well controlled if the sum of the quantity of all SABA medications dispensed to the patient within the last 3 months exceeds 250 doses1, [21] and/or they visited an ED for a respiratory related problem in the last 3 months. Only asthma drugs that were 1) prescribed and dispensed within one year of the index date, and 2) active (i.e. based on prescription algorithms it is likely that the person has a supply of the medication) or expired within 30 days prior to the index date were considered when generating the recommendations.

Patient-specific recommendations related to drug therapy are translated into pre-formatted prescriptions in the drug management platform. The ADSS is structured to support the Canadian Consensus guidelines for Asthma Management. [22] Recommendations are categorised based on control status. For individuals in control, recommendations generated are one of three categories: maintain treatment, decrease treatment, or maintain or decrease treatment. Recommendations also include options for action plan

<sup>&</sup>lt;sup>1</sup> 250 doses is based on the most commonly prescribed SABA salbutamol 100mcg, 2 inhalations at a time, or the equivalent for other fast acting bronchodilators in the last three months.

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prescriptions for patients who are in control. For individuals not well controlled recommendations are either to increase treatment or to refer to a specialist. Within each recommendation category, physicians are presented with specific recommendations for medications and doses to achieve the desired level of drug treatment.

# Data Analysis

Results were calculated for each index date. Descriptive statistics were used to characterize the study population and to evaluate differences between individuals with and without RAMQ coverage for prescription drugs. For individuals with RAMQ coverage, the proportion of individuals under each recommendation category was evaluated among individuals classified as 'well controlled' and 'not well controlled', and descriptive statistics were used to compare the characteristics of patients across categories. Multivariable logistic regression was used to estimate the probability of being classified in control or not well controlled as a function of sociodemographic characteristics and healthcare utilization.

# Results

# Study Population and Insured Compared to Non-Insured

47, 614 individuals with an asthma diagnosis were identified on index date 1, after removing individuals with a prior diagnosis of COPD (6018) and those  $\leq$  5 years old (Figure 1). Thirty five percent of individuals were RAMQ insured for prescription drugs at least 75% of the year prior to the index date, for both dates. On index date 2, 51 306 individuals with an asthma diagnosis were identified (Figure 2). Approximately the same proportion of individuals was classified as well controlled on index date 1 (93 %) and index date 2

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(94%). As the distribution of individual characteristics, control status, and recommendation categories were similar on both index dates, we only report the results from index date 2 from this point on (Table 1).

Individuals who were RAMQ insured were on average older (mean= $38\pm22$ ) as compared to non-RAMQ insured individuals (mean= $31\pm18$ ) and had a greater percentage of individuals  $\geq$  60 years old, a larger proportion was female (61% versus 56%), and in the lower SES category (21% versus 6%). A greater proportion of RAMQ insured patients had 3 or more ED (16 versus 9%) and hospital visits (8 versus 3%) one year prior to the index date, and a diagnostic code for anxiety (11 compared to 7%) or depression (8 compared to 5%).

Table 1: Characteristics of Study Participants with and without provincial health coverage (RAMQ)

	RAMQ Coverage	No RAMQ Coverage
	n=18 013	n=33 293
Age mean (sd)	38,3 (21,8)	30,81 (17,5)

Age n (%)

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≤ 17	3 963 (22,0 )	10 273
18-39	5 129 (28,6 )	9 926 (
40-59	5 254 (29,2)	11 277
≥ 60	3 637 (20,2)	1 817
Sex n (% female)	11 035 (61,3)	18 665 (
Income n (%) *		
Low SES	3 490 (19,4)	2 665 (
Middle SES	13 148 (73.0)	25 947
High SES	1 230 (6,8 )	4 298 (
Healthcare Utilization over 1 year prior	to March 15, 2008	
Medical <i>Phycisian</i> Visits**  n (%)		
0 visit	1 736 (9,6 )	3 855 (
1 visit	1 998 (11,1)	4 453 (
2 visits	1 895 (10,5)	4 154 (
3 or more visits	12,384 (68,8)	20 831
Emergency Department Visits n (%)		
0 visit	10 435 (57,9)	22 738 (
1 visit	3 139 (17,4)	5 445 (
2 visits	1 698 (9,4)	2 416
3 or more visits	2 741 (15,2)	2 694
Emergency Department Visits for asthma n (%)	1 313 (7,3)	1 644

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0 day	14 890 (82,7)	29 445 (88,4)
1 day	1 340 (7,4)	2 072 (6,2)
2 days	445 (2,5)	658 (2,0)
3 or more days	1 338 (7,4)	1 118 (3,4)
Co-Morbidity n (%)		
Depression	1 400 (7,77)	1 724 (5,2)
Anxiety	1 913 (10,62)	2 361 (7,1)

\* Around 1 % of missing values for each category

\*\* Ambulatory and specialty care

Control Status and Recommendation Categories

Among the 18 013 individuals who were RAMQ insured for prescription drugs, 94% were classified as well controlled and 7% as not well controlled over 3 months prior to the index date (Figure 1).

63 % of individuals who were not well controlled were in the  $\geq$  40 age group and 26% in the low SES category compared to 49% and 19%, respectively, in the well controlled group. These individuals also had a higher Charlson Co-morbidity Index of 2.11 as compared to 1.6 among those well controlled. A larger proportion of individuals among those not well controlled had a diagnostic code for depression, anxiety, mental illness, and a cardiac related condition. Among those not well controlled 69% (n=667) had at least 1 ED visit (past 3 months), and 74% a medical visit associated with a respiratory problem (in the past year). In comparison 13% (n=2,039) of those well controlled had at least one ED visit and 52% medical visit related to a respiratory problem.

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53% of patients in the not well controlled group had an active prescription for an ICS, 20% a combination therapy, and 14% as compared to 36%, 10%, and 6% in the well controlled group. 63% and 42% of not well and well controlled, respectively, had an active prescription for a fast-acting beta agonist (FABA). At index date 1, all individuals not well controlled had asthma drugs as compared to 9.2 % of those well controlled who had no asthma drugs dispensed.

Table 2 presents the incremental regression coefficients for the demographic, healthcare utilization, and co-morbidity variables hypothesized to be associated with control status. Healthcare utilization including,  $\geq$ 3 days of hospitalization (OR=4.58), and  $\geq$  3 visits to the ED (for reasons other than a respiratory problem) (OR=2.32), was found to be most strongly associated with control status. Being male (OR=.85), from a low SES (OR= 1.9), and in the 40-59 age group increased the odds of having asthma that was not well controlled.

# Table 2: Multivariable Logistic Regression Models for Identifying Individuals Controlled and Not Well Controlled

Variable		OR (95%CI)			
		Control Status			
Age mean (sd)			_		
	≤ 17	Reference			
	18-39	0.56 (0.44, 0.72)			
	40-59	2.19(1.73, 2.77)			
	≥ 60	1.19 (1, 1.42)			
Sex n (% female)		·			

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2 3		Ahmed, Tamblyn, Winslade
4 5 6 7	Male	Reference
6 7	Female	85 (.74, .98)
8 9	Income n (%) *	
10 11	High SES	Reference
12 13	Middle SES	1.44 (1.04, 1.98)
14 15	Low SES	1.90 (1.35, 2.68)
16 17	Healthcare Utilization over 1	1.50 (1.55, 2.66)
18 19	year prior to March 15, 2008	
20 21	Medical Physician *Visits n (%)	
22 23	0 visit	Reference
24 25	1 visit	.73 (.47,1.2)
26 27		
28 29	2 visits	.82 (.53,1.28)
30 31	$\geq$ 3 visits	1.62 (1.162.27)
32 33	Emergency Department Visits (other than resp)n (%)	
34 35	0 visit	Reference
36 37		
38 39	1 visit	1.38(1.14,1.66)
40 41	2 visits	1.46(1.16,1.84)
42 43	≥3 visits	2.32(1.94,2.8)
44 45		
46 47	Hospitalisation	
48 49	0 day	Reference
50 51	1 day	2.24(1.55,3.27)
52 53	2 days	2.88(1.79,4.6)
54 55	3 or more days	4.58 (3.36,6.22)
56 57		
58 59		
60	For peer review on	ly - http://bmjopen.bmj.com/site/about/guidelines.xhtml
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Co-Morbidity n (%)	
Charlson co-morbidity index	1.04 (1.01, 1.08)
Anxiety No	Reference
Yes	1.26 (1.05,1.52 )
* General practitioner and specialist	
Recommendation category by control	l group

The distribution of individuals across recommendation categories is presented in Table 3.

For 8% (1198/15843) in control, and 21% (201/960) of those not well controlled, a recommendation could not be determined by the ADSS either because the patient 1) had dispensed prescriptions for an inappropriate combination of medications that the ADSS could not reconcile to provide an appropriate recommendation (e.g. a LABA with two prescriptions for combination therapy) or, 2) dispensed two medications that resulted in a duplication of therapy. For those not well controlled, those in the *duplicate/inappropriate* category had a larger proportion in the lower SES, a higher co-morbiditiy index and more frequent ambulatory and hospital visits.

Among individuals well controlled, the largest proportion of individuals were in the *maintain treatment* category (50.6%), followed by *maintain/decrease treatment* (28.2%), and *decrease treatment* (2.7%). Almost all individuals not well controlled had the recommendation to *increase treatment* (88%) with a small proportion in the *refer* category (1%). Reasons for the low referral to specialty care needs to be closely examined, and may be related to uncertainty of primary care physicians of when to refer patients, and/or patients may not go see specialists once referred. [23] Regardless of the recommendation category, the

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largest proportion of individuals was in the 40-59 age group; except for maintain treatment that had a larger proportion of individuals in the 18-39 age group. The middle SES was the largest for all recommendation groups and the proportion of females was the same across all categories. Individuals in the *refer* category were on average older than those in the other categories, but comparable on many of the other characteristics.

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 Table 3: Comparison of characteristics of individuals in each recommendation category (based on primary recommendation).

13 14								
15		In Control					Not Well Contro	lled
16								
17		N=14989					N=1245	
18					<b>D P F F F</b>	•	<b>D</b> (	
19		Maintain	Maintain/Dec	Decrease	Duplicate/	Increase	Refer	Duplicate/
20 21			rease		Inappropriate	n=1 090	n=17	Inappropriate
22			n=4349		n=602	1-1050		n=138
23		n=9564	11-4349	n=474	11-002			11-130
24								
26	nean (sd)	41,8 (19,2)	38,2	44,8 (21,6)	45,9 (20,3)	40,4 (21,5)	57,1 (9,3)	46,6
27			(22,7)					(16,0)
28								
Age r 30	n (%)							
<del>31</del> 32	≤ 17	919 (9,6)	1 115 (25,6)	74 (15,6)	68 (11,3)	189 (17,3)	0	6 (4,4)
33	10.20	2 F(4/27.2)	000 (22.0)	06 (40.4)	122 (20 4)	240 (20.4)	0	22 (22 0)
34	18-39	3 561 (37,2)	996 (22,9)	86 (18,1)	123 (20,4)	310 (28,4)	0	33 (23,9)
35	40-59	2 987 (31,2)	1 269 (29,2)	195 (41,1)	260 (43,2)	372 (34,1)	10 (58,8)	79 (57,2)
36	10 33	2 307 (31)27	1 200 (20)2)	100 (11)1)	200 (10,2)	372 (31)27	10 (00)0)	, , , , , , , , , , , , , , , , , , , ,
37 38	≥ 60	2 097 (21,9)	969 (22,3)	119 (25,1)	151 (25,1)	219 (20,1)	7 (41,2)	20 (14,5)
_39								
-	i (% F)	6 073 (63,5)	2 659 (61,1)	303 (63,9)	381 (63,3)	709 (65,0)	12 (70,6)	101 (73,2)
41								
	ne n (%) *							
<u>43</u> 44	Low SES	1 684 (17,6)	923 (21,2)	117 (24,7)	156 (25,9)	237 (21,7)	4 (23,5)	43 (31,2)
45	2010 323	1004(17,0)	525 (21,2)	117 (24,7)	130 (23,3)	237 (21,7)	4 (23,3)	43 (31,2)
46	Middle SES	7 028 (73,5)	3 161 (72,7)	330 (69,6)	420 (69,8)	802 (73,6)	13 (76,5)	90 (65,2)
47								
48	High SES	763 (8,0)	228 (5,2)	25 (5,3)	22 (3,6)	47 (4,3)	0	5 (3,6)
49 50 -		(1)						
51	cal Visits mean	(sa) past year						
52	All	8,78 (13,1)	9,68 (13,8)	12,62(13,3)	12,87(13,4)	16,52 (22,2)	29,29 (21,3)	24,99 (26,1)
53	740	0,70 (10,1)	3,00 (13,0)	12,02(10,0)	12,07 (10,77)		23,23 (21,3)	- ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
54	Ambulatory	7,72 (9,6)	8,31 (9,2)	10,89 (9,5)	11,13 (9,5)	13,53(15,0)	19,94 (10,0)	20,01 (18,1)
55	,	•••	,	,	• • •		,	
56 57	Hospitalized	1,07 (6,8)	1,37 (7,7)	1,73 (7,4)	1,73 (7,6)	2,99 (11,6)	9,35 (16,4)	4,98 (13,3)
58								
59								

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1								21
2 3			Ahm	ned, Tamblyn,	Winslade			
_4		In Control					Not Well Contr	olled
5 6 7		N=14989					N=1245	
8								
9 10		Maintain	Maintain/Dec rease	Decrease	Duplicate/ Inappropriate	Increase	Refer	Duplicate/ Inappropriate
11 12			n=4349		n=602	n=1 090	n=17	n=138
13 14		n=9564	11-4345	n=474	11-002			11-130
Me	dical Visits n (	%) past year						
16 17	Phycisian							
18 19	0 visit	1 036 (10,8)	265 (6,1)	14 (3,0)	22 (3,6)	62 (5,7)	0	7 (5,1)
20 21								
22 23	1 visit	1048 (10,96)	451 (10,4)	31 (6,5)	40 (6,6)	76 (7,0)	0	5 (3,6)
24	2 visits	1000 (10,5)	486 (11,2)	41	26 (4,3)	81 (7,4)	0	2 (1,4)
25 26				(8,6)				
27 28	3 or more visits	6 480 (67,8)	3 147 (72,4)	388 (81,9)	514 (85,4)	871 (79,9)	17 (100)	124 (89,9)
29 30	ER							
31 32	0 visit	5 995 (62,7)	2 501 (57,5)	240 (50,6)	289 (48,0)	200 (18,4)	1 (5,9)	25 (18,1)
33 34	1 visit	1 565 (16,4)	790 (18,2)	89 (18,8)	118 (19,6)	221 (20,3)	3 (17,6)	21 (15,2)
35 36	2 visits	846 (8,8)	414 (9,5)	59 (12,4)	63 (10,5)	172 (15,8)	1 (5,9)	9 (6,5)
37	3 or more visits	1 158 (12,1)	644 (14,8)	86 (18,1)	132 (21,9)	497 (45,6)	12 (70,6)	83 (60,2)
38 39		1 130 (12,1)	044 (14,0)	00 (10,1)	132 (21,3)	437 (43,0)	12 (70,0)	03 (00,2)
40 41						0		
<b>412-</b> 43	for respiratory pr	oblems						
44 45	0 visit	8 781 (91,8)	3 792 (87,2)	394 (83,1)	491 (81,6)	294 (27,0)	4 (23,5)	38 (27,5)
46 47	1 visit	593 (6,2)	402 (9,2)	52 (11,0)	64 (10,6)	450 (41,3)	4 (23,5)	27 (19,6)
48	2 visits	142 (1,5)	105 (2,4)	15 (3,2)	25 (4,2)	188 (17,2)	3 (17,65)	22 (15,9)
49 50	3 or more visits	48 (0,5)	50 (1,2)	13 (2,7)	22 (3,7)	158 (14,5)	6 (35,3)	51 (37,0)
51 52								
53 6 <b>1</b> -	NOT for respirato	ry problems						
56		6 268 (65,5)	2 712 (62,4)	265 (55,9)	326 (54,2)	456	4 (23,5)	45 (32,6)
57 58	e visit	(00,0)	<u> </u>				. (_0,0)	
59 60								

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1								22
2 3			Ahm	ned, Tamblyn, V	Vinslade			
_4		In Control		•			Not Wall Control	llad
5 6		In Control					Not Well Contro	lied
7		N=14989					N=1245	
9		Maintain	Maintain/Dec	Decrease	Duplicate/	Increase	Refer	Duplicate/
10 11			rease		Inappropriate	n=1 090	n=17	Inappropriate
12 13		n=9564	n=4349	n=474	n=602			n=138
14 15						(41,8)		
16								
17 18	1 visit	1 535 (16,1)	742 (17,1)	94 (19,8)	118 (19,6)	205 (18,8)	3 (17,6)	29 (21,0)
19 20	2 visits	746 (7,8)	370(8,5)	49 (10,3)	58 (9,6)	117 (10,7)	3 (17,6)	14 (10,1)
21 22	3 or more visits	1 015 (10,6)	525 (12,1)	66 (13,9)	100 (16,6)	312 (28,6)	7 (41,2)	50 (36,2)
23 24	Hospitalization							
25 26	0 day	8 046 (84,1)	3 581 (82,3)	356 (75,1)	449 (74,6)	774 (71,0)	5 (29,4)	78 (56,5)
27 28	1 day	697 (7,3)	318 (7,3)	39 (8,2)	62 (10,3)	100 (9,2)	3 (17,6)	17 (12,3)
29 30	2 days	215 (2,2)	107 (2,5)	20 (4,2)	23 (3,8)	44 (4,0)	1 (5,9)	3 (2,2)
31 32	3 or more days		343 (7,9)	59 (12,4)	68 (11,3)	172 (15,8)	8 (47,1)	40 (29,0)
	pitalization- for re	spiratory problem	ns			•		
35 36	0 day	9 370 (98,0)	4 210 (96,8)	447 (94,3)	563 (93,5)	990 (90,8)	14 (82,4)	109 (79,0)
37 38 20	1 day	100 (1,0)	60 (1,4)	7 (1,5)	20 (3,3)	33 (3,0)	0	7 (5,1)
39 40 41	2 days	32 (0,3)	32 (0,74)	4 (0,8)	5 (0,8)	14 (1,3)	0	3 (2,2)
41 42 43	3 or more days	62 (0,6)	47 (1,1)	16 (3,4)	14 (2,3)	53 (4,9)	3 (17,6)	19 (13,8)
44 45								
Asth	ma Medications	mean (sd) range	oast year					
47 48	FABA	0,61 (1,7)	2,93 (3,8)	4,32 (5,2)	4,95 (5,1)	2,50 (4,4)	5,00 (5,2)	6,82 (6,8)
49 50 51	ICS	0,2 (0,7)	2,3(2,9)	1,4(2,6)	3,6(3,8)	1,4(2,4)	0,9 (1,7)	3,5(3,9)
52 53	Leukotrienes	0,1 (1,4)	0,4(3,0)	6,7(10,0)	1,5 (4,8)	0,8(4,4)	3,3(5,1)	3,9 (11,5)
54 55 56 57 58	Combination Therapy	0,0 (0,4)	1,2 (2,9)	5,1(4,9)	2,18 (3,9)	1,0 (2,7)	7,7 (4,5)	3,0 (4,3)

1							23
2 3		Ahm	ned, Tamblyn,	Winslade			
5	In Control					Not Well Con	trolled
5 6 7 8	N=14989					N=1245	5
8 9 10 11	Maintain	Maintain/Dec rease	Decrease	Duplicate/ Inappropriate	Increase n=1 090	Refer n=17	Duplicate/ Inappropriate
12 13 14	n=9564	n=4349	n=474	n=602	11-1 050	11-17	n=138
15 Other 16	0,2(1,8)	0,8(3,4)	2,9(6,8)	2,36 (3,9)	1,8(17,0)	2,1 (2,5)	4,45 (6,6)
<b>Čontrol Status n (%)</b> 18					I		
19 Overuse FABA 20	0	0	0	0	1 (0,1)	0	0
24 visits for Asthma 22 23 ER or FABA	0	0	0	0	1 076 (98,7)	17 (100)	135 (97,8)
23 24 ER or FABA	0	0	0	0	1 076 (98,7)	17 (100)	135 (97,8)
25-Morbidity Index	1,6 (1,5)	1,6 (1,5)	1,8 (1,6)	1,9 (1,9)	1,8(2,0)	2,2 (1,4)	2,6 (2,5)
27 28	Less than 1 % c	of missing values	for each cate	gory			
29         30         31         32         33         34         35         36         37         38         39         40         41         42         43         44         45         46         47         48         49         50         51         52         53         54         55         56         57         58         59         60	ED=emergency	department					

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# DISCUSSION

The purpose of this study was to evaluate the discrepancy between current asthma management and recommended guidelines using the provincial administrative databases and an ADSS. The present study represents an example of how decision support systems can be used to monitor guideline adherence, and to identify individuals at risk of poor outcomes to provide targeted interventions. To our knowledge this is the first time that a decision support system has been used to evaluate disease management at a population level.

As expected, individuals who were provincially insured were on average older, from a lower SES, and a higher proportion used healthcare services. A larger proportion compared to those non-provincially insured also had a diagnosis code for anxiety and depression.

The algorithms used to identify individuals with asthma and evaluate control status were validated in previous work. [24, 25] The majority of individuals well controlled were on an appropriate quantity of asthma treatment. We found, however, that ~ 31% of those well controlled could benefit from a medication review and potentially lower doses of asthma medications.

The majority of individuals not well controlled had the recommendation to increase treatment and for these individuals there was an opportunity to change therapy according to the existing guidelines. [26] The SMART inhaler helps address needs for increase in therapy, as it allows patients to use their as-needed

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medication because of declining asthma control—as is very often the case—evolving exacerbations will possibly be treated at an early stage and a further worsening of asthma may possibly be prevented. The SMART inhaler is not a recommended yet part of Canadian guidelines, however, with emerging evidence of its benefits for marinating control compared to other alternatives, [27, 28] it will be included in the next version of guidelines and become more commonly prescribed for Canadian patients. Individuals who were not well controlled were in the 40-59 age range, and had a more complex health profile with greater comorbidity, including a higher proportion with a diagnosis of anxiety or depression as compared to those well-controlled. The logistic regression analysis in our study also supported these conclusions. These individuals represent a more vulnerable sub-group of the asthma population, and place a greater burden on the healthcare system given the higher proportion that had an ED visit or hospitalization. As such, they require closer monitoring and review of medication to reach doses sufficient to maintain asthma control, or to review reasons for failed treatment.

In this study we were not able to generate a recommendation for a larger proportion of individuals not well controlled compared to controlled either because they were dispensed prescriptions for an inappropriate combination of medications that the ADSS could not reconcile to provide an appropriate recommendation, or they were dispensed two medications that resulted in a duplication of therapy. These cases in themselves represent a segment of the asthma population that requires closer review of their prescribed medication.

The generation of asthma recommendations at a population level using an administrative database allows individuals not receiving treatment based on guidelines to be identified. We found that many individuals

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with non-controlled asthma visit a physician 3 or more times per year, and potentially represent missed opportunities to optimize treatment. Possible reasons for our findings may include the lack of knowledge of PCPs of guidelines in general, especially for more complicated cases. It may also be, however, that patients are not going to see the same physician, or are switching physicians to ensure access to SABAs. In such situations, physicians may be reluctant to conduct a complete medication review if they do not perceive themselves as the primary provider for the patient.

Other physician concerns may be the reluctance to prescribe ICS and/or concern regarding polypharmacy with multiple inhalers. [29] This is where the role of pharmacists is important as they can see individuals' entire medication dispensing history and have been shown to be effective in managing asthma patients in particular if supported by an ADSS. [30]

Previous studies have also found that physicians do not adopt guidelines in their practice because of perceived appropriateness of the guidelines. [13, 31] Surveys have shown that they believe that guidelines do not take into account the heterogeneity of asthma and do not account for individual patient variations in response to treatment, [32] and other factors that impact response to asthma therapy such as age and co-morbidities.

Further, patient non-adherence to prescribed therapy and not having prescribed medications filled may also explain the findings from our study. Patient beliefs about the negative impact and benefits of their medications, [33] their confidence to manage their asthma, and not seeking care early enough to prevent exacerbations have all been identified as contributors to poor outcomes for asthma.

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Mechanisms to identify patients who need closer follow-up and evaluation have been identified as an important need for primary healthcare. [3, 34, 35] Future initiatives can include linking administrative databases to decision support systems that can help identify individuals who need closer monitoring and follow-up and allow for targeted services such as visit reminders sent to patients or to their care provider. The ongoing implementation of electronic health records and patient health portals will facilitate this approach. Information can be fed back to physicians and pharmacists to improve patient management, and initiate care early on, before individuals experience deteriorations in health.

# Conclusions

This study demonstrated how a decision support system linked to an administrative database could be used to identify individuals in the population that require a review of asthma treatment. Such an approach can help identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment to intervene early. This study provides a model for monitoring adherence to guidelines for other chronic conditions such as hypertension and diabetes.

# Limitations

Our approach for identifying individuals with asthma and assessing asthma status may have underestimated the percentage out of control in our study. We examined asthma control on two index dates, and went back 3 months prior to the index date to assess control status. A more sensitive algorithm

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that treats control as a time varying covariate would likely provide a more accurate evaluation of control status. In addition, at the time that the ADSS was being developed, the SMART treatments, that allow for the same inhaler to be used as a preventative and rescue inhaler were not commonly used or part of the guidelines. Therefore, they were not programmed as part of the ADSS and not included in the recommendations.

Further, use of decision support during clinical encounters allow for a patient-reported assessment of symptoms at the time when recommendations are generated, and allow for a more accurate assessment of asthma control. We were also limited to generating recommendations for those provincially insured that represent a more vulnerable segment of the population.

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**Contributorship Statement** 

SA RT and NW were involved in:

- the conception and design, analysis and interpretation of data,

- drafting the article and revising it critically for important intellectual content,

- final approval of the version to be published.

# **Competing Interests**

No competing interests

# **Data Sharing Statement**

Additional data regarding the study sample characteristics and guidelines generated from the decision support system can be provided upon request from the corresponding author.

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Using decision support for population tracking of adherence to recommended asthma guidelines

# Running head: Decision Support for Population Tracking of Adherence

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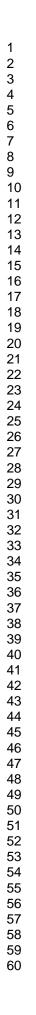
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# Article Summary

1) Article Focus –

The objective of this study was to evaluate the discrepancy between actual asthma treatments prescribed by primary care physicians-compared to those recommended by evidence-based guidelines using a decision support tool linked to a provincial health administrative database.
2) Key Messages - up to three bullet points outlining the key messages and significance of the study.

- Decision support systems that define evidence-based guidelines, linked to an administrative database, can be used to identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment at a population level.

- When connected to the point of care, discrepancies between decision support and actual care can provide an opportunity for physicians to intervene early.

- The methods and approach from the currentin this study can be used applied in future work to evaluate adherence to evidence-based guidelines and indicators of disease management for other patient populations, at a population level if administrative databases are available, or at the point of care if linked to an electronic health record.

3) Strengths and Limitations

The availability of a provincial administrative database and decision support system allowed us to assess guideline adherence, and to identify sub-groups of individuals at risk of poor outcomes.
The administrative database only includes individuals who are provincially insured and therefore discrepancies could not be examined for individuals with private insurance.

- The proportion of individuals with poor asthma control may have been underestimated as control status was evaluated over a 3-month period.

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Abstract

Background: Decision support systems linked to administrative databases provide a unique opportunity to monitor adherence to guidelines and target disease management strategies to patients not receiving guideline-based therapy. Objective: The objective of this study was to evaluate the discrepancy between actual asthma treatments prescribed by primary care physicians compared to those recommended by evidence-based guidelines using a decision support tool linked to a provincial health administrative database. Methods: The drug and medical services information of individuals with asthma were identified from the provincial health database and were pushed through an asthma decision support system (ADSS). Recommendations aimed at optimizing asthma treatment were generated on two index dates, September 15 2007 (index date 1) and March 15 2008 (index date 2).

Results: 16, 803 individuals with asthma and provincial health insurance were identified on index date 1, and 18, 103 on index date 2. The distribution of recommendation categories were similar on both index dates. 94% were classified as well controlled and 7% as not well controlled. Among individuals well controlled, the largest proportion of individuals were in the *maintain treatment* category (50.6%), followed by *maintain/decrease treatment* (28.2%), and *decrease treatment* (2.7%). Almost all individuals not well controlled had the recommendation to *increase treatment* (88%) with a small proportion in the *refer* category (1%). Conclusions: The ADSS was able to identify sub-groups of patients from an administrative database that could benefit from a medication review and possible change. Decision support systems linked to an administrative database can be used to identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment. When connected to the point of care, this can provide an opportunity for physicians to intervene early.

### Introduction

Asthma poses a significant burden on healthcare resources and costs, (1) and results in reduced individual functioning and quality of life. (2, 3) Over the past 10 years there have been tremendous improvements in the scientific understanding of asthma and its treatment, and these findings have been made available to clinicians through the development of clinical practice guidelines. Despite achieving such sentinel milestones in asthma care, over 50% (4, 5) of individuals remain poorly controlled in the U.S. and Canada, with similar estimates worldwide. (6) This has translated into \$306-654 million and 7189 million dollars (equivalent to US dollars in 2008) per year inin one year for direct and indirect in Canada and the US, respectively costs for providing health management for approximately 2.2 million Canadians diagnosed with asthma. With appropriate disease management over \$135 million in costs and reductions in physical and mental health can be prevented. (7)

Healthcare organizations worldwide have been charged with improving asthma outcomes over the next 2-3 years, with the aim of reducing hospitalizations and deaths related to asthma. (8) Several barriers for optimal management result in poor outcomes for asthma, (9) including clinician-related (non-adherence to guidelines), patient-related (non-adherence to treatment), and treatment- related barriers (cost, complexity of treatment). In moving towards improving clinical outcomes potentially modifiable barriers must be identified and targeted through appropriate interventions. A mechanism is needed to identify problematic asthma management so that gaps in care and barriers can be further evaluated and managed.

One potentially modifiable barrier is the gap between optimal versus actual asthma management as

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reflected by the lack of adoption of guidelines by clinicians or non-adherence of patients to recommended care. (10, 11) Much of the costs of asthma care are related to poor disease control due to under-use of effective prophylactic therapies, and inadequate monitoring of disease control. (7)At a population level there are few mechanisms available for tracking disease-management indicators for asthma to evaluate the current application of guidelines. Several studies have evaluated divergence from asthma guidelines, (12, 13) but have not been able to accurately estimate non-adherence to guidelines among a representative sample of individuals. Evaluations of adherence have mostly relied on chart reviews and clinician or patient reports which are difficult to complete for a large number of patients across several healthcare settings. (14-16)

Decision support systems are designed to facilitate uptake of evidence- based guidelines with the expectation that adherence to such guidelines will improve health outcomes. (17) Typically, decision support systems are used at the point of care. Such systems, however, may also have an alternate benefit of allowing population monitoring of adherence to disease management guidelines when the decision support algorithms are linked to administrative databases. By pushing through administrative health data including diagnoses, healthcare utilization and medication information, algorithms can be used to generate recommendations for optimizing treatment. In turn, patterns of under-optimization of treatment can be identified to monitor adherence to guidelines and target specific physician and patient sub-groups with disease management interventions.

The implementation of an asthma decision support system linked to provincial health insurance information represents a novel approach and facilitates the evaluation of the gap between recommended and actual treatment. We have developed a new methodology for assessing the quality of asthma management and asthma control in the population. Using evidence based

decision-support systems developed to guide physicians using computerized physician order entry and electronic medical record systems, we developed a program for sequentially entering, assessing and extracting individual and summarized population level quality monitoring and control status indicators. Using population level administrative data for over 16,000 asthma patients, we then used this program to evaluate asthma status and quality of adherence to national guidelines in a Quebec population on two randomly selected days in the springfall 2007 and spring 2008fall. This information is needed for asthma management, and can be used for identifying opportunities to target interventions and improve asthma outcomes.

In this study we examined the discrepancy between actual asthma treatments as recorded in the provincial administrative database compared to those recommended by evidence-based guidelines as defined in the asthma decision support system on two index dates.

### METHODS

#### Study population

The drug and medical services information of patients cared for by primary care physicians (PCP) participating in the Medical Office of the 21st Century(MOXXI) study (18) in a large metropolitan area was used to evaluate adherence to asthma treatment guidelines. PCPs were identified by professional association master lists and contacted by letter and telephone to determine their interest in participating in the MOXXI project. Patients of these physicians were identified from the Quebec provincial health data base (RAMQ) medical service claims, physician, and beneficiary files. McGill University IRB approval was obtained for this study and PCPs who accepted provided consent for the research team to receive patient anonymised administrative data.

All patients with an ICD\_-9 code for asthma, with no prior diagnosis for <u>Chronic Obstructuve</u> <u>Pulmonary Disease (COPD)</u>, and who were  $\geq 5$  years old were identified from RAMQ based on algorithms validated in prior research. (19) For the purposes of this study, only patients with full drug coverage by RAMQ were included to ensure that all drugs dispensed were captured.

### The provincial drug and administrative database (RAMQ)

The RAMQ beneficiary demographic database provided data on individual age, gender, and mortality, and census data provided income and education. (20) Information on each drug dispensed was obtained from the prescription claims database and included the drug name, quantity, date, and duration for each prescription. The medical services claims database provided information on the beneficiary, date, type, provider, and location of service delivery (e.g., inpatient, emergency, clinic) for all medical services remunerated on a fee-for-service basis.

# Study Procedure: Evaluating the gap between actual and recommended asthma treatment using the Asthma Decision Support System (ADSS)

The ADSS is integrated into the MOXXI electronic prescribing drug management application with patient information retrieved by real-time integration with the beneficiary, prescription and medical services claims files of the RAMQ. Using information from the prescription drug management platform, the ADSS uses the profile of existing drugs and health problems to customize recommended changes in asthma drug therapy. For this study, recommendations aimed at optimizing asthma treatment were generated on two index dates, September 15 2007 (index date 1) and March 15 2008 (index date 2), representing peak times for asthma symptoms.

In the ADSS, asthma control is determined based on overuse of short acting beta agonists (SABA) and visits to the Emergency Department (ED) for a respiratory problem over a 3 month period before the index date. Based on a previously validated algorithm, a patient is considered to be not well controlled if the sum of the quantity of all SABA medications dispensed to the patient within the last 3 months exceeds 250 doses1, (21) and/or they visited an ED for a respiratory related problem in the last 3 months. Only asthma drugs that were 1) prescribed and dispensed within one year of the index date, and 2) active (i.e. based on prescription algorithms it is likely that the person has a supply of the medication) or expired within 30 days prior to the index date were considered when generating the recommendations.

Patient-specific recommendations related to drug therapy are translated into pre-formatted prescriptions in the drug management platform. The ADSS is structured to support the Canadian Consensus guidelines for Asthma Management. (22) Recommendations are categorised based on control status. For individuals in control, recommendations generated are one of three categories: maintain treatment, decrease treatment, or maintain or decrease treatment. Recommendations also include options for action plan prescriptions for patients who are in control. For individuals not well controlled recommendations are either to increase treatment or to refer to a specialist. Within each recommendation category, physicians are presented with specific recommendations for medications and doses to achieve the desired level of drug treatment.

#### **Data Analysis**

Results were calculated for each index date. Descriptive statistics were used to characterize the study population and to evaluate differences between individuals with and without RAMQ coverage

<sup>&</sup>lt;sup>1</sup> 250 doses is based on the most commonly prescribed SABA salbutamol 100mcg, 2 inhalations at a time, or the equivalent for other fast acting bronchodilators in the last three months.

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for prescription drugs. For individuals with RAMQ coverage, the proportion of individuals under each recommendation category was evaluated among individuals classified as 'well controlled' and 'not well controlled', and descriptive statistics were used to compare the characteristics of patients across categories. Multivariable logistic regression was used to estimate the probability of being classified in control or not well controlled as a function of sociodemographic characteristics and healthcare utilization.

### Results

Study Population and Insured Compared to Non-Insured

<u>A total of 47, 614</u> individuals with an asthma diagnosis were identified on index date 1, after removing individuals with a prior diagnosis of COPD (6018) and those  $\leq 5$  years old (Figure 1). Thirty five percent of individuals were RAMQ insured for prescription drugs at least 75% of the year prior to the index date, for both dates. On index date 2, 51, 306 individuals with an asthma diagnosis were identified (Figure 2). Approximately the same proportion of individuals was classified as well controlled on index date 1 (93 %) and index date 2 (94%). As the distribution of individual characteristics, control status, and recommendation categories were similar on both index dates, we only report the results from index date 2 from this point on (Table 1).

Individuals who were RAMQ insured were on average older (mean= $38\pm22$ ) as compared to non-RAMQ insured individuals (mean= $31\pm18$ ) and had a greater percentage of individuals  $\geq 60$  years old, a larger proportion was female (61% versus 56%), and in the lower <u>socioeconomic status (SES)</u> category (21% versus 6%). A greater proportion of RAMQ insured patients had 3 or more ED (16 versus 9%) and hospital visits (8 versus 3%) one year prior to the index date, and a diagnostic code for anxiety (11 compared to 7%) or depression (8 compared to 5%).

 Table 1 Characteristics of Study Participants with and without provincial health coverage (RAMQ)
 on index date 2\*

	RAMQ Coverage	No RAMQ Coverage
	n=18 013	n=33 293
Age mean (sd)	38,3 (21.8)	30,81 (17,5)
Age n (%)		
≤17	3 963 (22.0 )	10 273 (30,9)
18-39	5 129 (28.6)	9 926 (29,8)
40-59	5 254 (29,2)	11 277 (33.9)
$\geq$ 60	3 637 (20,2)	1 817 (5.5)
Sex n (% female)	11 035 (61,3)	18 665 (56.1)
Income n (%) *		
Low SES	3 490 (19.4)	2 665 (8.0)
Middle SES	13 148 (73.0)	25 947 (78.0)
High SES	1 230 (6.8 )	4 298 (13.0)
Healthcare Utilization over 1 year	prior to March 15. 2008	
Medical <i>Phycisian Physician</i>		
Visits <sup>**</sup> n (%)		
0 visit	1 736 (9.6 )	3 855 (11.6)
1 visit	1 998 (11.1)	4 453 (13.4)
2 visits	1 895 (10.5)	4 154 (12.5)
3 or more visits	12.384 (68.8)	20 831 (62.6)
Emergency Department	( ),	
Visits n (%)		
0 visit	10 435 (57.9)	22 738 (68.0)
1 visit	3 139 (17.4)	5 445 (16.4)
2 visits	1 698 (9.4)	2 416 (7.3)
3 or more visits	2 741 (15.2)	2 694 (8.1)
Emergency Department	1 313 (7.3)	1 644 (4.9)
Visits for asthma n (%)	1 515 (7.5)	1011(1.5)
Hospitalization		
0 day	14 890 (82.7)	29 445 (88.4)
1 day	1 340 (7.4)	2 072 (6.2)
2 days	445 (2.5)	658 (2.0)
3 or more days	1 338 (7.4)	1 118 (3.4)
Co-Morbidity n (%)	1 330 (7.4)	1 110 (3.4)
Depression	1 400 (7.77)	1 724 (5.2)
Anxiety	1 400 (7.77) 1 913 (10.62)	2 361 (7.1)
* Around 1 % of missing values for	1 713 (10.02) each category: All differences h	
RAMQ insured are significant, p<0.		CIWCEII INAINIQ allu INOII-
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#### Control Status and Recommendation Categories

Among the 18 013 individuals who were RAMQ insured for prescription drugs, 93% were classified as well controlled and 7% as not well controlled over 3 months prior to the index date (Figure 1).

63 % of individuals who were not well controlled were in the  $\geq$  40 age group and 26% in the low SES category compared to 49% and 19%, respectively, in the well controlled group. These individuals also had a higher Charlson Co-morbidity Index of 2.11 as compared to 1.6 among those well controlled. A larger proportion of individuals among those not well controlled had a diagnostic code for depression, anxiety, mental illness, and a cardiac related condition. Among those not well controlled 69% (n=667) had at least 1 ED visit (past 3 months), and 74% a medical visit associated with a respiratory problem (in the past year). In comparison 13% (n=2,039) of those well controlled had at least one ED visit and 52% medical visit related to a respiratory problem.

53% of patients in the not well controlled group had an active prescription for an ICS, 20% a combination therapy, and 14% as compared to 36%, 10%, and 6% in the well controlled group. 63% and 42% of not well and well controlled, respectively, had an active prescription for a fast-acting beta agonist (FABA). At index date 1, all individuals not well controlled had asthma drugs as compared to 9.2 % of those well controlled who had no asthma drugs dispensed.

Table 2 presents the incremental regression coefficients for the demographic, healthcare utilization, and co-morbidity variables hypothesized to be associated with control status. Healthcare utilization including,  $\geq$  3 days of hospitalization (OR=4.58), and  $\geq$  3 visits to the ED (for reasons other than a

respiratory problem) (OR=2.32), was found to be most strongly associated with control status.

Being male (OR=.85), from a low SES (OR= 1.9), and in the 40-59 age group increased the odds of

having asthma that was not well controlled.

 Table 2 Multivariable Logistic Regression Models for Identifying Individuals Controlled and Not

 Well Controlled

Variable	OR (95%CI)
Age mean (sd)	Control Status
8	Reference
$\leq 17$	
18-39	0.56 (0.44, 0.72)
40-59	2.19(1.73, 2.77)
$\geq 60$	1.19 (1, 1.42)
Sex n (% female)	
Male	Reference
Female	85 (.74, .98)
Income n (%) *	
High SES	Reference
Middle SES	1.44 (1.04, 1.98)
Low SES	1.90 (1.35, 2.68)
Healthcare Utilization over	
1 year prior to March 15,	
2008	
Medical <i>Physician</i> *Visits n	
(%)	
( <sup>70</sup> ) 0 visit	Reference
1 visit	.73 (.47,1.2)
2 visits	.82 (.53,1.28)
$\geq$ 3 visits	1.62 (1.162.27)
Emergency Department	
Visits (other than resp)n	
(%)	
0 visit	Reference
1 visit	1.38(1.14,1.66)
2 visits	1.46(1.16,1.84)
$\geq$ 3 visits	2.32(1.94,2.8)
visits	(,)
Hospitalisation	
0 day	Reference
1 day	2.24(1.55,3.27)
2 days	
5	2.88(1.79,4.6)
3  or more days	4.58 (3.36,6.22)
Co-Morbidity n (%)	1.04 (1.01. 1.02)
Charlson co-morbidity index	1.04 (1.01, 1.08)
Anxiety No	Reference

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Yes
\* General practitioner and specialist

### Recommendation category by control group

The distribution of individuals across recommendation categories is presented in Table 3. For 8% (1198/15843) in control, and 21% (201/960) of those not well controlled, a recommendation could not be determined by the ADSS either because the patient 1) had dispensed prescriptions for an inappropriate combination of medications that the ADSS could not reconcile to provide an appropriate recommendation (e.g. a LABA with two prescriptions for combination therapy) or, 2) dispensed two medications that resulted in a duplication of therapy. For those not well controlled, those in the *duplicate/inappropriate* category had a larger proportion in the lower SES, a higher co-morbidity index and more frequent ambulatory and hospital visits.

1.26 (1.05,1.52)

Among individuals well controlled, the largest proportion of individuals were in the *maintain treatment* category (50.6%), followed by *maintain/decrease treatment* (28.2%), and *decrease treatment* (2.7%). Almost all individuals not well controlled had the recommendation to *increase treatment* (88%) with a small proportion in the *refer* category (1%). Reasons for the low referral to specialty care needs to be closely examined, and may be related to uncertainty of primary care physicians of when to refer patients, and/or patients may not go see specialists once referred. (23) Regardless of the recommendation category, the largest proportion of individuals was in the 40-59 age group; except for *maintain treatment* that had a larger proportion of individuals in the 18-39 age group. The middle SES was the largest for all recommendation groups and the proportion of females was the same across all categories. Individuals in the *refer* category were on average older than those in the other categories, but comparable on many of the other characteristics.

1 2

8 9

10 11 **Table 3** Comparison of characteristics of individuals in each recommendation category (based on primary recommendation)\*

12 13 Not Well Controlled In Control N=14989 N=1245 14 Maintain Maintain/Dec Decrease **Duplicate**/ Increase Refer **Duplicate**/ 15 n=1 090 n=17 Inappropriate Inappropriate rease 16 n=4349 n=9564 n=474 n=602 n=138 41.8 (19.2) 38.2 44.8 (21.6) 45.9 (20.3) 40.4 (21.5) 57.1 (9.3) Age mean (sd) 46.6 (16.0) (22.7)18 Age n (%) 919 (9.6) 1 115 (25.6) 74 (15.6) 6 (4.4)  $\leq 17$ 68 (11.3) 189 (17.3) 0 20 18-39 310 (28.4) 0 33 (23.9) 3 561 (37.2) 996 (22.9) 86 (18.1) 123 (20.4) 21 40-59 2 987 (31.2) 1 269 (29.2) 195 (41.1) 260 (43.2) 372 (34.1) 10 (58.8) 79 (57.2) 2 097 (21.9) 119 (25.1) 969 (22.3) 151 (25.1) 219 (20.1) 20 (14.5) 22  $\geq 60$ 7(41.2)Sex n (% F) 6 073 (63.5) 2 659 (61.1) 303 (63.9) 381 (63.3) 709 (65.0) 12 (70.6) 101 (73.2) Income n (%) Low SES 1 684 (17.6) 923 (21.2) 117 (24.7) 156 (25.9) 237 (21.7) 4 (23.5) 43 (31.2) 25 Middle SES 7 028 (73.5) 3 161 (72.7) 330 (69.6) 420 (69.8) 802 (73.6) 13 (76.5) 90 (65.2) High SES 763 (8.0) 228 (5.2) 25 (5.3) 22 (3.6) 47 (4.3) 0 5 (3.6) 26 Medical Visits mean (sd) past year All8.78 (13.1) 9.68 (13.8) 12.62(13.3) 12.87(13.4) 16.52 (22.2) 29.29 (21.3) 24.99 (26.1) 28 Ambulatory 10.89 (9.5) 19.94 (10.0) 20.01 (18.1) 7.72 (9.6) 8.31 (9.2) 11.13 (9.5) 13.53(15.0) 29 Hospitalized 1.07 (6.8) 1.37 (7.7) 1.73 (7.4) 1.73 (7.6) 2.99 (11.6) 9.35 (16.4) 4.98 (13.3) Modical Visits n (%) past year Phycisian 31 1 036 (10.8) 265 (6.1) 14 (3.0) 22 (3.6) 62 (5.7) 0 7 (5.1) 0 visit 32 1 visit 1048 (10.96) 451 (10.4) 31 (6.5) 40 (6.6) 76 (7.0) 0 5 (3.6) 33 2 visits 1000 (10.5) 486 (11.2) 41 26 (4.3) 81 (7.4) 0 2 (1.4) (8.6)34 3 or more visits 6 480 (67.8) 3 147 (72.4) 388 (81.9) 514 (85.4) 871 (79.9) 17 (100) 124 (89.9) 35 ER 36 0 visit 5 995 (62.7) 2 501 (57.5) 240 (50.6) 289 (48.0) 200 (18.4) 1(5.9)25 (18.1) 1 565 (16.4) 790 (18.2) 89 (18.8) 118 (19.6) 221 (20.3) 3 (17.6) 21 (15.2) 1 visit 37 2 visits 846 (8.8) 414 (9.5) 59 (12.4) 63 (10.5) 172 (15.8) 1 (5.9) 9 (6.5) 38 644 (14.8) 86 (18.1) 497 (45.6) 3 or more visits 1 158 (12.1) 132 (21.9) 12 (70.6) 83 (60.2) 39 20- for respiratory problems 394 (83.1) 491 (81.6) 4 (23.5) 3 792 (87.2) 294 (27.0) 38 (27.5) 0 visit 8 781 (91.8) 41 402 (9.2) 52 (11.0) 64 (10.6) 450 (41.3) 4 (23.5) 27 (19.6) 1 visit 593 (6.2) 42 142 (1.5) 105 (2.4) 25 (4.2) 188 (17.2) 3 (17.65) 2 visits 15 (3.2) 22 (15.9) **43** 3 or more visits 50 (1.2) 13 (2.7) 22 (3.7) 158 (14.5) 6 (35.3) 51 (37.0) 48 (0.5) 44 ED-NOT for respiratory problems 45 (32.6) 2 712 (62.4) 265 (55.9) 326 (54.2) 456 0 visit 6 268 (65.5) 4 (23.5) 46 (41.8)47 1 visit 1 535 (16.1) 742 (17.1) 94 (19.8) 118 (19.6) 205 (18.8) 3 (17.6) 29 (21.0) 49 (10.3) 58 (9.6) 117 (10.7) 2 visits 746 (7.8) 370(8.5) 3 (17.6) 14 (10.1) 48 3 or more visits 66 (13.9) 100 (16.6) 312 (28.6) 50 (36.2) 1 015 (10.6) 525 (12.1) 7 (41.2) 49 Hospitalization 50 8 046 (84.1) 3 581 (82.3) 356 (75.1) 449 (74.6) 774 (71.0) 5 (29.4) 78 (56.5) 0 day 3 (17.6) 1 day 697 (7.3) 318 (7.3) 39 (8.2) 62 (10.3) 100 (9.2) 17 (12.3) 51 2 days 215 (2.2) 107 (2.5) 20 (4.2) 23 (3.8) 44 (4.0) 1 (5.9) 3 (2.2) 52 3 or more days 343 (7.9) 59 (12.4) 68 (11.3) 172 (15.8) 8 (47.1) 40 (29.0) 606 (6.3) 53

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9		In Control N=14989					Not Well Contro N=1245	olled
10		Maintain	Maintain/Dec	Decrease	Duplicate/	Increase	Refer	Duplicate/
11		0=44	rease		Inappropriate	n=1 090	n=17	Inappropriate
12		n=9564	n=4349	n=474	n=602			n=138
Hos	pitalization- for r							
13	0 day	9 370 (98.0)	4 210 (96.8)	447 (94.3)	563 (93.5)	990 (90.8)	14 (82.4)	109 (79.0)
14	1 day	100 (1.0)	60 (1.4)	7 (1.5)	20 (3.3)	33 (3.0)	0	7 (5.1)
15	2 days	32 (0.3)	32 (0.74)	4 (0.8)	5 (0.8)	14 (1.3)	0	3 (2.2)
	3 or more days	62 (0.6)	47 (1.1)	16 (3.4)	14 (2.3)	53 (4.9)	3 (17.6)	19 (13.8)
16								
Asth	ma Medications	mean (sd) range	e past year					
18	FABA	0.61 (1.7)	2.93 (3.8)	4.32 (5.2)	4.95 (5.1)	2.50 (4.4)	5.00 (5.2)	6.82 (6.8)
19	ICS	0.2 (0.7)	2.3(2.9)	1.4(2.6)	3.6(3.8)	1.4(2.4)	0.9 (1.7)	3.5(3.9)
	Leukotrienes	0.1 (1.4)	0.4(3.0)	6.7(10.0)	1.5 (4.8)	0.8(4.4)	3.3(5.1)	3.9 (11.5)
20	Combination	0.0 (0.4)	1.2 (2.9)	5.1(4.9)	2.18 (3.9)	1.0 (2.7)	7.7 (4.5)	3.0 (4.3)
21	Therapy							
	Other	0.2(1.8)	0.8(3.4)	2.9(6.8)	2.36 (3.9)	1.8(17.0)	2.1 (2.5)	4.45 (6.6)
Ćán	Other trol Status n (%) Overuse FABA							
23	Overuse FABA	0	0	0	0	1 (0.1)	0	0
24	visits for Asthma	0	0	0	0	1 076 (98.7)	17 (100)	135 (97.8)
25	ER or FABA	0	0	0	0	1 076 (98.7)	17 (100)	135 (97.8)
ଢ଼ୋ	Morbidity	1.6 (1.5)	1.6 (1.5)	1.8 (1.6)	1.9 (1.9)	1.8(2.0)	2.2 (1.4)	2.6 (2.5)
Inde	Morbidity ex							
-27		0% (n= missin	g for well contr	olled and 7%	for not well cor	trolled Less	than 1 % of mis	sino

\*10% (n= missing for well controlled and 7% for not well controlled; Less than 1 % of missing % for not ... epartment values for each category; ED=emergency department

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### DISCUSSION

The purpose of this study was to evaluate the discrepancy between current asthma management and recommended guidelines using the provincial administrative databases and an ADSS. The present study represents an example of how decision support systems can be used to monitor guideline adherence, and to identify individuals at risk of poor outcomes to provide targeted interventions. To our knowledge this is the first time that a decision support system has been used to evaluate disease management at a population level.

As expected, individuals who were provincially insured were on average older, from a lower SES, and a higher proportion used healthcare services. A larger proportion compared to those non-provincially insured also had a diagnosis code for anxiety and depression.

The algorithms used to identify individuals with asthma and evaluate control status were validated in previous work. (24, 25) The majority of individuals well controlled were on an appropriate quantity of asthma treatment. We found, however, that ~ 31% of those well controlled could benefit from a medication review and potentially lower doses of asthma medications.

The majority of individuals not well controlled had the recommendation to increase treatment and for these individuals there was an opportunity to change therapy according to the existing guidelines. (26) The SMART inhaler helps address needs for increase in therapy, as it allows patients to use their as-needed medication because of declining asthma control—as is very often the case—evolving exacerbations will possibly be treated at an early stage and a further worsening of asthma may possibly be prevented. The SMART inhaler is not a recommended yet part of Canadian guidelines, however, with emerging evidence of its benefits for marinating control

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compared to other alternatives, (27, 28) it will be included in the next version of guidelines and become more commonly prescribed for Canadian patients. Individuals who were not well controlled were in the 40-59 age range, and had a more complex health profile with greater co-morbidity, including a higher proportion with a diagnosis of anxiety or depression as compared to those wellcontrolled. The logistic regression analysis in our study also supported these conclusions. These individuals represent a more vulnerable sub-group of the asthma population, and place a greater burden on the healthcare system given the higher proportion that had an ED visit or hospitalization. As such, they require closer monitoring and review of medication to reach doses sufficient to maintain asthma control, or to review reasons for failed treatment.

In this study we were not able to generate a recommendation for a larger proportion of individuals not well controlled compared to controlled either because they were dispensed prescriptions for an inappropriate combination of medications that the ADSS could not reconcile to provide an appropriate recommendation, or they were dispensed two medications that resulted in a duplication of therapy. These cases in themselves represent a segment of the asthma population that requires closer review of their prescribed medication.

The generation of asthma recommendations at a population level using an administrative database allows individuals not receiving treatment based on guidelines to be identified. We found that many individuals with non-controlled asthma visit a physician 3 or more times per year, and potentially represent missed opportunities to optimize treatment. Possible reasons for our findings may include the lack of knowledge of PCPs of guidelines in general, especially for more complicated cases. It may also be, however, that patients are not going to see the same physician, or are switching physicians to ensure access to SABAs. In such situations, physicians may be reluctant to conduct a

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complete medication review if they do not perceive themselves as the primary provider for the patient.

Other physician concerns may be the reluctance to prescribe ICS and/or concern regarding polypharmacy with multiple inhalers. (29) This is where the role of pharmacists is important as they can see individuals' entire medication dispensing history and have been shown to be effective in managing asthma patients in particular if supported by an ADSS. (30)

Previous studies have also found that physicians do not adopt guidelines in their practice because of perceived appropriateness of the guidelines. (13, 31) Surveys have shown that they believe that guidelines do not take into account the heterogeneity of asthma and do not account for individual patient variations in response to treatment, (32) and other factors that impact response to asthma therapy such as age and co-morbidities.

Further, patient non-adherence to prescribed therapy and not having prescribed medications filled may also explain the findings from our study. Patient beliefs about the negative impact and benefits of their medications, (33) their confidence to manage their asthma, and not seeking care early enough to prevent exacerbations have all been identified as contributors to poor outcomes for asthma.(34)

Mechanisms to identify patients who need closer follow-up and evaluation have been identified as an important need for primary healthcare. (3, 34, 35) Future initiatives can include linking administrative databases to decision support systems that can help identify individuals who need closer monitoring and follow-up and allow for targeted services such as visit reminders sent to

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### Limitations

Our approach for identifying individuals with asthma and assessing asthma status may have underestimated the percentage out of control in our study. We examined asthma control on two index dates, and went back 3 months prior to the index date to assess control status. A more sensitive algorithm that treats control as a time varying covariate would likely provide a more accurate evaluation of control status. Also, because we used administrative data and not clinical information from an electronic medical record to generate recommendations, we were not able to use asthma severity and relapse as part of the asthma control algorithm, algorithm. Finally, previous studies that have reported higher levels of not well-controlled individuals were based on self-reports as opposed to administrative data. In addition,

<u>A</u>at the time that the ADSS was being developed, the SMART treatments, that allow for the same inhaler to be used as a preventative and rescue inhaler were not commonly used or part of the guidelines. Therefore, they were not programmed as part of the ADSS and not included in the recommendations.-<u>Further, the ADSS does not distinguish between SABA nebulizer and MDL</u>--<u>FurtheFinally</u>r, use of decision support during clinical encounters allow for a patient-reported assessment of symptoms at the time when recommendations are generated, and allow for a more accurate assessment of asthma control. We were also limited to generating recommendations for those provincially insured that represent a more vulnerable segment of the population.

### Conclusions

This study demonstrated how a decision support system linked to an administrative database could be used to identify individuals in the population that require a review of asthma treatment. Such an approach can help identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment to intervene early. This study provides a model for monitoring adherence to guidelines for other chronic conditions such as hypertension and diabetes. 

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# Declaration of Interest

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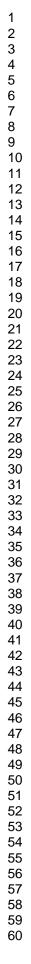
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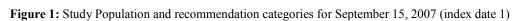
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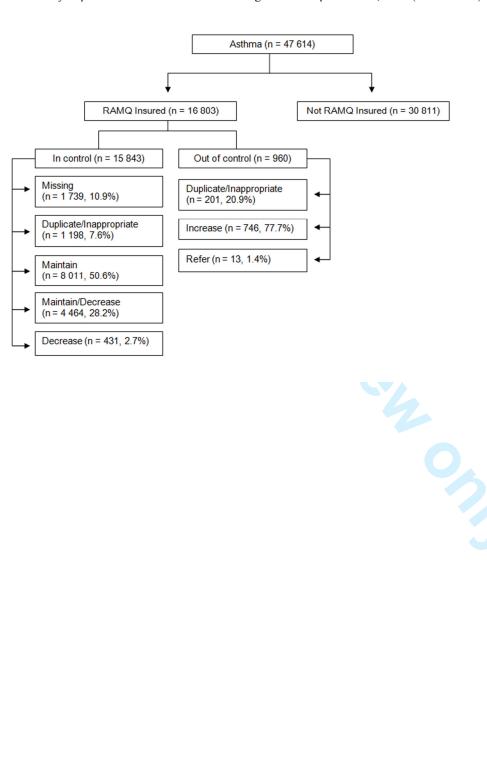
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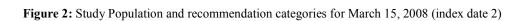


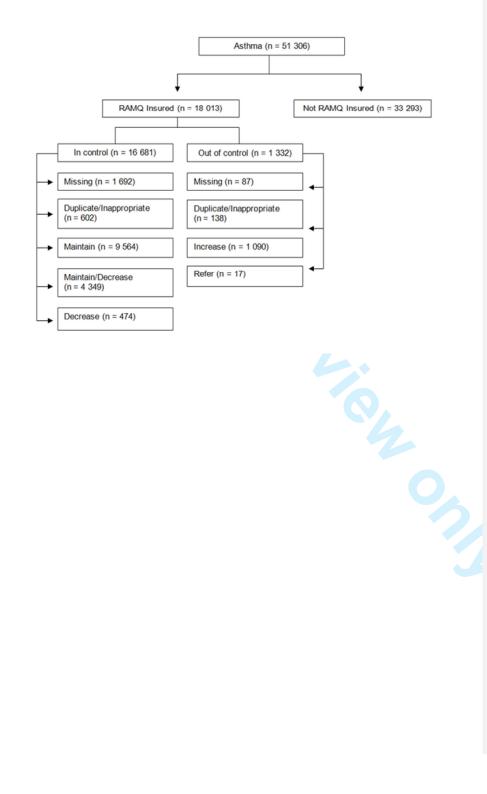




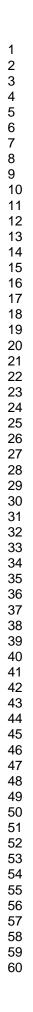
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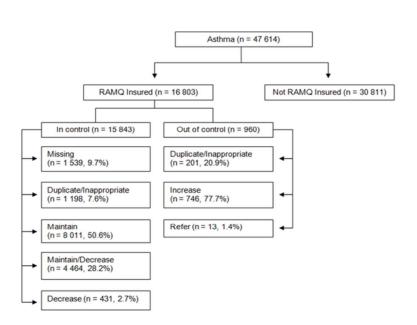
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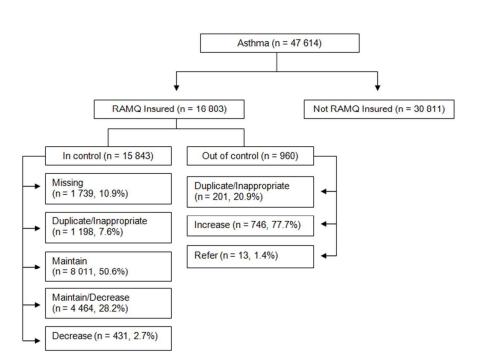
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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies* 

Item No	Recommendation
1	(a) Indicate the study's design with a commonly used term in the title or the abstract
	(page 1)
	(b) Provide in the abstract an informative and balanced summary of what was done
	and what was found (page 3)
2	Explain the scientific background and rationale for the investigation being reported
	(page 4)
3	State specific objectives, including any prespecified hypotheses (page 5 and 6)
4	Present key elements of study design early in the paper (page 7)
5	Describe the setting, locations, and relevant dates, including periods of recruitment,
	exposure, follow-up, and data collection (page 6-7)
6	(a) Give the eligibility criteria, and the sources and methods of selection of
	participants (page 7)
7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect
	modifiers. Give diagnostic criteria, if applicable (page 8)
8*	For each variable of interest, give sources of data and details of methods of
	assessment (measurement). Describe comparability of assessment methods if there is
	more than one group (page 8-9)
9	Describe any efforts to address potential sources of bias (page 8)
10	Explain how the study size was arrived at (page 7)
11	Explain how quantitative variables were handled in the analyses. If applicable,
	describe which groupings were chosen and why (page 8)
12	(a) Describe all statistical methods, including those used to control for confounding
	(page 8)
	(b) Describe any methods used to examine subgroups and interactions (page 8)
	(c) Explain how missing data were addressed (n/a)
	( <i>d</i> ) If applicable, describe analytical methods taking account of sampling strategy
	(n/a)
	( <u>e</u> ) Describe any sensitivity analyses (n/a)
13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially
	eligible, examined for eligibility, confirmed eligible, included in the study,
	completing follow-up, and analysed (page 9)
	(b) Give reasons for non-participation at each stage (n/a)
	(c) Consider use of a flow diagram (refer to figures 1 and 2)
14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and
	information on exposures and potential confounders (table on page 10)
	(b) Indicate number of participants with missing data for each variable of interest (in
	figures 1 and 2)
15*	Report numbers of outcome events or summary measures (page 13)
16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and
10	their precision (eg, 95% confidence interval). Make clear which confounders were
	1 2 3 4 5 6 7 8* 9 10 11 11 12 12 13*

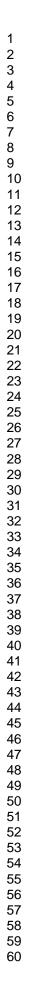
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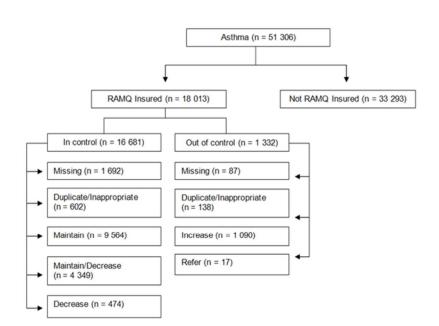
	-	<ul> <li>(b) Report category boundaries when continuous variables were categorized (n/a)</li> <li>(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period (n/a)</li> </ul>
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses $(n/a)$
Discussion		
Key results	18	Summarise key results with reference to study objectives (page 16-17)
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or
		imprecision. Discuss both direction and magnitude of any potential bias (page 19)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations,
		multiplicity of analyses, results from similar studies, and other relevant evidence
		(page 17-18)
Generalisability	21	Discuss the generalisability (external validity) of the study results (end of page 17-
		18)
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if
		applicable, for the original study on which the present article is based (page 21)

\*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Study Population and recommendation categories for March 15, 2008 (index date 2) 110x71mm (300 x 300 DPI)

Using decision support for population tracking of adherence to recommended asthma guidelines

### Running head: Decision Support for Population Tracking of Adherence

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#### **Corresponding author**

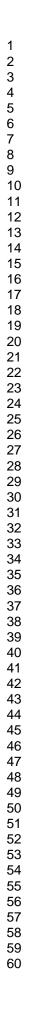
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Word Count: 3092 Figures: 2 Tables: 3

**Keywords**: Asthma, clinical practice guidelines, disease management, decision support,

administrative database

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### Article Summary

1) Article Focus –

The objective of this study was to evaluate the discrepancy between actual asthma treatments prescribed by primary care physicians-compared to those recommended by evidence-based guidelines using a decision support tool linked to a provincial health administrative database.
2) Key Messages - up to three bullet points outlining the key messages and significance of the study.

- Decision support systems that define evidence-based guidelines, linked to an administrative database, can be used to identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment at a population level.

- When connected to the point of care, discrepancies between decision support and actual care can provide an opportunity for physicians to intervene early.

- The methods and approach from the currentin this study can be used applied in future work to evaluate adherence to evidence-based guidelines and indicators of disease management for other patient populations, at a population level if administrative databases are available, or at the point of care if linked to an electronic health record.

3) Strengths and Limitations

The availability of a provincial administrative database and decision support system allowed us to assess guideline adherence, and to identify sub-groups of individuals at risk of poor outcomes.
The administrative database only includes individuals who are provincially insured and therefore discrepancies could not be examined for individuals with private insurance.

- The proportion of individuals with poor asthma control may have been underestimated as control status was evaluated over a 3-month period.

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Abstract
Background: Objective: Decision support systems linked to administrative databases provide a
unique opportunity to monitor adherence to guidelines and target disease management strategies to
patients not receiving guideline-based therapy. Objective: The objective of this study was to
evaluate the discrepancy between actual asthma treatments prescribed by primary care physicians
compared to those recommended by evidence-based guidelines using a decision support tool linked
to a provincial health administrative database.
DesignMethods: The drug and medical services information of individuals with asthma were
identified from the provincial health database and were pushed through an asthma decision support

system (ADSS). Recommendations aimed at optimizing asthma treatment were generated on two

index dates, September 15 2007 (index date 1) and March 15 2008 (index date 2).

Setting: Primary care settings in a large Canadian metropolitan area.

Participants: Individuals with asthma and provincial health insurance

Primary and secondary outcome measures: well controlled asthma

Results: 16, 803 eligible individuals were identified on index date 1, and 18, 103 on index date 2. The distribution of recommendation categories were similar on both index dates. 94% were classified as well controlled and 7% as not well controlled. Among individuals well controlled, the largest proportion of individuals were in the *maintain treatment* category (50.6%), followed by *maintain/decrease treatment* (28.2%), and *decrease treatment* (2.7%). Almost all individuals not well controlled had the recommendation to *increase treatment* (88%) with a small proportion in the *refer* category (1%).

Conclusions: The ADSS was able to identify sub-groups of patients from an administrative database that could benefit from a medication review and possible change. Decision support systems linked to an administrative database can be used to identify individuals with uncontrolled asthma or

prescriptions that deviate from recommended treatment. When connected to the point of care, this

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#### Introduction

Asthma poses a significant burden on healthcare resources and costs, (1) and results in reduced individual functioning and quality of life. (2, 3) Over the past 10 years there have been tremendous improvements in the scientific understanding of asthma and its treatment, and these findings have been made available to clinicians through the development of clinical practice guidelines. Despite achieving such sentinel milestones in asthma care, over 50% (4, 5) of individuals remain poorly controlled in the U.S. and Canada, with similar estimates worldwide. (6) This has translated into \$306-654 million and 7189 million dollars (equivalent to US dollars in 2008) per year inin one year for direct and indirect in Canada and the US, respectively eosts for providing health management for approximately 2.2 million Canadians diagnosed with asthma. With appropriate disease management over \$135 million in costs and reductions in physical and mental health can be prevented. (7)

Healthcare organizations worldwide have been charged with improving asthma outcomes over the next 2-3 years, with the aim of reducing hospitalizations and deaths related to asthma. (8) Several barriers for optimal management result in poor outcomes for asthma, (9) including clinician-related (non-adherence to guidelines), patient-related (non-adherence to treatment), and treatment- related barriers (cost, complexity of treatment). In moving towards improving clinical outcomes potentially modifiable barriers must be identified and targeted through appropriate interventions. A mechanism is needed to identify problematic asthma management so that gaps in care and barriers can be further evaluated and managed.

One potentially modifiable barrier is the gap between optimal versus actual asthma management as

reflected by the lack of adoption of guidelines by clinicians or non-adherence of patients to recommended care. (10, 11) Much of the costs of asthma care are related to poor disease control due to under-use of effective prophylactic therapies, and inadequate monitoring of disease control. (7)At a population level there are few mechanisms available for tracking disease-management indicators for asthma to evaluate the current application of guidelines. Several studies have evaluated divergence from asthma guidelines, (12, 13) but have not been able to accurately estimate non-adherence to guidelines among a representative sample of individuals. Evaluations of adherence have mostly relied on chart reviews and clinician or patient reports which are difficult to complete for a large number of patients across several healthcare settings. (14-16)

Decision support systems are designed to facilitate uptake of evidence- based guidelines with the expectation that adherence to such guidelines will improve health outcomes. (17) Typically, decision support systems are used at the point of care. Such systems, however, may also have an alternate benefit of allowing population monitoring of adherence to disease management guidelines when the decision support algorithms are linked to administrative databases. By pushing through administrative health data including diagnoses, healthcare utilization and medication information, algorithms can be used to generate recommendations for optimizing treatment. In turn, patterns of under-optimization of treatment can be identified to monitor adherence to guidelines and target specific physician and patient sub-groups with disease management interventions.

The implementation of an asthma decision support system linked to provincial health insurance information represents a novel approach and facilitates the evaluation of the gap between recommended and actual treatment. We have developed a new methodology for assessing the quality of asthma management and asthma control in the population. Using evidence based

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decision-support systems developed to guide physicians using computerized physician order entry and electronic medical record systems, we developed a program for sequentially entering, assessing and extracting individual and summarized population level quality monitoring and control status indicators. Using population level administrative data for over 16,000 asthma patients, we then used this program to evaluate asthma status and quality of adherence to national guidelines in a Quebec population on two randomly selected days in the springfall 2007 and spring 2008fall. This information is needed for asthma management, and can be used for identifying opportunities to target interventions and improve asthma outcomes.

In this study we examined the discrepancy between actual asthma treatments as recorded in the provincial administrative database compared to those recommended by evidence-based guidelines as defined in the asthma decision support system on two index dates.

# METHODS

#### Study population

The drug and medical services information of patients cared for by primary care physicians (PCP) participating in the Medical Office of the 21st Century(MOXXI) study (18) in a large metropolitan area was used to evaluate adherence to asthma treatment guidelines. PCPs were identified by professional association master lists and contacted by letter and telephone to determine their interest in participating in the MOXXI project. Patients of these physicians were identified from the Quebec provincial health data base (RAMQ) medical service claims, physician, and beneficiary files. McGill University IRB approval was obtained for this study and PCPs who accepted provided consent for the research team to receive patient anonymised administrative data.

All patients with an ICD\_-9 code for asthma, with no prior diagnosis for <u>Chronic Obstructuve</u> <u>Pulmonary Disease (COPD)</u>, and who were  $\geq 5$  years old were identified from RAMQ based on algorithms validated in prior research. (19) For the purposes of this study, only patients with full drug coverage by RAMQ were included to ensure that all drugs dispensed were captured.

# The provincial drug and administrative database (RAMQ)

The RAMQ beneficiary demographic database provided data on individual age, gender, and mortality, and census data provided income and education. (20) Information on each drug dispensed was obtained from the prescription claims database and included the drug name, quantity, date, and duration for each prescription. The medical services claims database provided information on the beneficiary, date, type, provider, and location of service delivery (e.g., inpatient, emergency, clinic) for all medical services remunerated on a fee-for-service basis.

# Study Procedure: Evaluating the gap between actual and recommended asthma treatment using the Asthma Decision Support System (ADSS)

The ADSS is integrated into the MOXXI electronic prescribing drug management application with patient information retrieved by real-time integration with the beneficiary, prescription and medical services claims files of the RAMQ. Using information from the prescription drug management platform, the ADSS uses the profile of existing drugs and health problems to customize recommended changes in asthma drug therapy. For this study, recommendations aimed at optimizing asthma treatment were generated on two index dates, September 15 2007 (index date 1) and March 15 2008 (index date 2), representing peak times for asthma symptoms.

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In the ADSS, asthma control is determined based on overuse of short acting beta agonists (SABA) and visits to the Emergency Department (ED) for a respiratory problem over a 3 month period before the index date. Based on a previously validated algorithm, a patient is considered to be not well controlled if the sum of the quantity of all SABA medications dispensed to the patient within the last 3 months exceeds 250 doses1, (21) and/or they visited an ED for a respiratory related problem in the last 3 months. Only asthma drugs that were 1) prescribed and dispensed within one year of the index date, and 2) active (i.e. based on prescription algorithms it is likely that the person has a supply of the medication) or expired within 30 days prior to the index date were considered when generating the recommendations.

Patient-specific recommendations related to drug therapy are translated into pre-formatted prescriptions in the drug management platform. The ADSS is structured to support the Canadian Consensus guidelines for Asthma Management. (22) Recommendations are categorised based on control status. For individuals in control, recommendations generated are one of three categories: maintain treatment, decrease treatment, or maintain or decrease treatment. Recommendations also include options for action plan prescriptions for patients who are in control. For individuals not well controlled recommendations are either to increase treatment or to refer to a specialist. Within each recommendation category, physicians are presented with specific recommendations for medications and doses to achieve the desired level of drug treatment.

#### **Data Analysis**

Results were calculated for each index date. Descriptive statistics were used to characterize the study population and to evaluate differences between individuals with and without RAMQ coverage

<sup>&</sup>lt;sup>1</sup> 250 doses is based on the most commonly prescribed SABA salbutamol 100mcg, 2 inhalations at a time, or the equivalent for other fast acting bronchodilators in the last three months.

for prescription drugs. For individuals with RAMQ coverage, the proportion of individuals under each recommendation category was evaluated among individuals classified as 'well controlled' and 'not well controlled', and descriptive statistics were used to compare the characteristics of patients across categories. Multivariable logistic regression was used to estimate the probability of being classified in control or not well controlled as a function of sociodemographic characteristics and healthcare utilization.

# Results

Study Population and Insured Compared to Non-Insured

<u>A total of 47, 614</u> individuals with an asthma diagnosis were identified on index date 1, after removing individuals with a prior diagnosis of COPD (6018) and those  $\leq 5$  years old (Figure 1). Thirty five percent of individuals were RAMQ insured for prescription drugs at least 75% of the year prior to the index date, for both dates. On index date 2, 51, 306 individuals with an asthma diagnosis were identified (Figure 2). Approximately the same proportion of individuals was classified as well controlled on index date 1 (93 %) and index date 2 (94%). As the distribution of individual characteristics, control status, and recommendation categories were similar on both index dates, we only report the results from index date 2 from this point on (Table 1).

Individuals who were RAMQ insured were on average older (mean= $38\pm22$ ) as compared to non-RAMQ insured individuals (mean= $31\pm18$ ) and had a greater percentage of individuals  $\geq 60$  years old, a larger proportion was female (61% versus 56%), and in the lower <u>socioeconomic status (SES</u>) category (21% versus 6%). A greater proportion of RAMQ insured patients had 3 or more ED (16versus 9%) and hospital visits (8 versus 3%) one year prior to the index date, and a diagnostic code for anxiety ( compared to 7%) or depression (8 compared to 5%).

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 Table 1 Characteristics of Study Participants with and without provincial health coverage (RAMQ)
 on index date 2\*

	<b>RAMQ</b> Coverage	No RAMQ Coverage
	n=18 013	n=33 293
Age mean (sd)	38,3 (21.8)	30,81 (17,5)
Age n (%)		
≤17	3 963 (22.0)	10 273 (30,9)
18-39	5 129 (28.6)	9 926 (29,8)
40-59	5 254 (29,2)	11 277 (33.9)
$\geq 60$	3 637 (20,2)	1 817 (5.5)
Sex n (% female)	11 035 (61,3)	18 665 (56.1)
Income n (%) * Low SES	3 490 (19.4)	2 665 (8.0)
Middle SES	13 148 (73.0)	25 947 (78.0)
High SES	1 230 (6.8)	4 298 (13.0)
Healthcare Utilization over 1 year		4 298 (13.0)
Medical <i>Phycisian Physician</i>	prior to March 13. 2008	
Visits** n (%)		
0 visit	1 736 (9.6 )	3 855 (11.6)
1 visit	1 998 (11.1)	4 453 (13.4)
2 visits	1 895 (10.5)	4 154 (12.5)
3 or more visits	12.384 (68.8)	20 831 (62.6)
Emergency Department		
Visits n (%)		
0 visit	10 435 (57.9)	22 738 (68.0 )
1 visit	3 139 (17.4)	5 445 (16.4)
2 visits	1 698 (9.4)	2 416 (7.3)
3 or more visits	2 741 (15.2)	2 694 (8.1)
Emergency Department	1 313 (7.3)	1 644 (4.9)
Visits for asthma n (%)		
Hospitalization		
0 day	14 890 (82.7)	29 445 (88.4)
1 day	1 340 (7.4)	2 072 (6.2)
2 days	445 (2.5)	658 (2.0)
3 or more days	1 338 (7.4)	1 118 (3.4)
Co-Morbidity n (%)		- ()
Depression	1 400 (7.77)	1 724 (5.2)
Anxiety	1 913 (10.62)	2 361 (7.1)
* Around 1 % of missing values for		
RAMQ insured are significant, p<0.0		

#### Control Status and Recommendation Categories

Among the 18 013 individuals who were RAMQ insured for prescription drugs, 93% were classified as well controlled and 7% as not well controlled over 3 months prior to the index date (Figure 1).

63 % of individuals who were not well controlled were in the  $\geq$  40 age group and 26% in the low SES category compared to 49% and 19%, respectively, in the well controlled group. These individuals also had a higher Charlson Co-morbidity Index of 2.11 as compared to 1.6 among those well controlled. A larger proportion of individuals among those not well controlled had a diagnostic code for depression, anxiety, mental illness, and a cardiac related condition. Among those not well controlled 69% (n=667) had at least 1 ED visit (past 3 months), and 74% a medical visit associated with a respiratory problem (in the past year). In comparison 13% (n=2,039) of those well controlled had at least one ED visit and 52% medical visit related to a respiratory problem.

53% of patients in the not well controlled group had an active prescription for an ICS, 20% a combination therapy, and 14% as compared to 36%, 10%, and 6% in the well controlled group. 63% and 42% of not well and well controlled, respectively, had an active prescription for a fast-acting beta agonist (FABA). At index date 1, all individuals not well controlled had asthma drugs as compared to 9.2 % of those well controlled who had no asthma drugs dispensed.

Table 2 presents the incremental regression coefficients for the demographic, healthcare utilization, and co-morbidity variables hypothesized to be associated with control status. Healthcare utilization including,  $\geq 3$  days of hospitalization (OR=4.58), and  $\geq 3$  visits to the ED (for reasons other than a

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respiratory problem) (OR=2.32), was found to be most strongly associated with control status.

Being male (OR=.85), from a low SES (OR= 1.9), and in the 40-59 age group increased the odds of

having asthma that was not well controlled.

 Table 2 Multivariable Logistic Regression Models for Identifying Individuals Controlled and Not

 Well Controlled

Variable	OR (95%CI)
Age mean (sd)	Control Status
<b>e</b>	Reference
$\leq 17$ 18-39	
	0.56 (0.44, 0.72)
40-59	2.19(1.73, 2.77)
$\geq 60$	1.19 (1, 1.42)
Sex n (% female)	
Male	Reference
Female	85 (.74, .98)
Income n (%) *	
High SES	Reference
Middle SES	1.44 (1.04, 1.98)
Low SES	1.90 (1.35, 2.68)
Healthcare Utilization over	
1 year prior to March 15, 2008	
Medical <i>Physician</i> *Visits n (%)	
0 visit	Reference
1 visit	.73 (.47,1.2)
2 visits	.82 (.53,1.28)
$\geq$ 3 visits	1.62 (1.162.27)
Emergency Department	
Visits (other than resp)n	
(%)	
0 visit	Reference
1 visit	1.38(1.14,1.66)
2 visits	1.46(1.16,1.84)
$\geq 3$ visits	2.32(1.94,2.8)
≥5 visits	2.32(1.94,2.0)
Hospitalisation	
0 day	Reference
1 day	2.24(1.55,3.27)
2 days	2.88(1.79,4.6)
3 or more days	4.58 (3.36,6.22)
Co-Morbidity n (%)	ч.30 (3.30,0.22)
Charlson co-morbidity index	1.04 (1.01, 1.08)
	1.04 (1.01, 1.08)

1.26 (1.05,1.52)

\* General practitioner and specialist

#### Recommendation category by control group

Yes

The distribution of individuals across recommendation categories is presented in Table 3. For 8% (1198/15843) in control, and 21% (201/960) of those not well controlled, a recommendation could not be determined by the ADSS either because the patient 1) had dispensed prescriptions for an inappropriate combination of medications that the ADSS could not reconcile to provide an appropriate recommendation (e.g. a LABA with two prescriptions for combination therapy) or, 2) dispensed two medications that resulted in a duplication of therapy. For those not well controlled, those in the *duplicate/inappropriate* category had a larger proportion in the lower SES, a higher co-morbidity index and more frequent ambulatory and hospital visits.

Among individuals well controlled, the largest proportion of individuals were in the *maintain treatment* category (50.6%), followed by *maintain/decrease treatment* (28.2%), and *decrease treatment* (2.7%). Almost all individuals not well controlled had the recommendation to *increase treatment* (88%) with a small proportion in the *refer* category (1%). Reasons for the low referral to specialty care needs to be closely examined, and may be related to uncertainty of primary care physicians of when to refer patients, and/or patients may not go see specialists once referred. (23) Regardless of the recommendation category, the largest proportion of individuals was in the 40-59 age group; except for *maintain treatment* that had a larger proportion of individuals in the 18-39 age group. The middle SES was the largest for all recommendation groups and the proportion of females was the same across all categories. Individuals in the *refer* category were on average older than those in the other categories, but comparable on many of the other characteristics.

Table 3 Comparison of characteristics of individuals in each recommendation category (based on primary recommendation)\*

12								
13		In Control					Not Well Contro	olled
14		N=14989 Maintain	Maintain/Dec	Decrease	Duplicate/	Increase	N=1245 Refer	Duplicate/
15		TAIIItaiii	rease	Decrease	Inappropriate	n=1 090	n=17	Inappropriate
16		n=9564	n=4349	n=474	n=602	II-1 090	<b>II</b> -17	n=138
Aze	mean (sd)	41.8 (19.2)	38.2	44.8 (21.6)	45.9 (20.3)	40.4 (21.5)	57.1 (9.3)	46.6
18	incun (su)		(22.7)		(20.0)	(21.0)	0,().0)	(16.0)
Age	n (%)							
	≤17	919 (9.6)	1 115 (25.6)	74 (15.6)	68 (11.3)	189 (17.3)	0	6 (4.4)
20	18-39	3 561 (37.2)	996 (22.9)	86 (18.1)	123 (20.4)	310 (28.4)	0	33 (23.9)
21	40-59	2 987 (31.2)	1 269 (29.2)	195 (41.1)	260 (43.2)	372 (34.1)	10 (58.8)	79 (57.2)
22	$\geq 60$	2 097 (21.9)	969 (22.3)	119 (25.1)	151 (25.1)	219 (20.1)	7 (41.2)	20 (14.5)
Sex 1	n (% F) me n (%) * Low SES	6 073 (63.5)	2 659 (61.1)	303 (63.9)	381 (63.3)	709 (65.0)	12 (70.6)	101 (73.2)
Ínço	men (%) *							
-24		1 684 (17.6)	923 (21.2)	117 (24.7)	156 (25.9)	237 (21.7)	4 (23.5)	43 (31.2)
25	Middle SES	7 028 (73.5)	3 161 (72.7)	330 (69.6)	420 (69.8)	802 (73.6)	13 (76.5)	90 (65.2)
26	High SES	763 (8.0)	228 (5.2)	25 (5.3)	22 (3.6)	47 (4.3)	0	5 (3.6)
Med	ical Visits mean	(sd) past year				i.		
	All	8.78(13.1)	9.68 (13.8)	12.62(13.3)	12.87(13.4)	16.52 (22.2)	29.29 (21.3)	24.99 (26.1)
28	Ambulatory	7.72 (9.6)	8.31 (9.2)	10.89 (9.5)	11.13 (9.5)	13.53(15.0)	19.94 (10.0)	20.01 (18.1)
29	Hospitalized	1.07 (6.8)	1.37 (7.7)	1.73 (7.4)	1.73 (7.6)	2.99 (11.6)	9.35 (16.4)	4.98 (13.3)
Mgod		(%) past year						
31	<b>Phycisian</b>	1.02((10.9))	2(5((1)	14 (2.0)	22 (2 ()	(2(5,7))	0	7 (5 1)
32	0 visit 1 visit	1 036 (10.8) 1048 (10.96)	265 (6.1) 451 (10.4)	14 (3.0) 31 (6.5)	22 (3.6) 40 (6.6)	62 (5.7) 76 (7.0)	0 0	7 (5.1) 5 (3.6)
	2 visits	1048 (10.98)	486 (11.2)	41	26 (4.3)	81 (7.4)	0	2 (1.4)
33	2 115115	1000 (10.3)	460 (11.2)	(8.6)	20 (4.3)	01 (7.4)	0	2 (1.4)
34	3 or more visits	6 480 (67.8)	3 147 (72.4)	388 (81.9)	514 (85.4)	871 (79.9)	17 (100)	124 (89.9)
35	ER	0 400 (07.0)	5 147 (72.4)	500 (01.7)	514 (05.4)	0/1 (/9.9)	17 (100)	124 (09.9)
36	0 visit	5 995 (62.7)	2 501 (57.5)	240 (50.6)	289 (48.0)	200 (18.4)	1 (5.9)	25 (18.1)
37	1 visit	1 565 (16.4)	790 (18.2)	89 (18.8)	118 (19.6)	221 (20.3)	3 (17.6)	21 (15.2)
	2 visits	846 (8.8)	414 (9.5)	59 (12.4)	63 (10.5)	172 (15.8)	1 (5.9)	9 (6.5)
38	3 or more visits	1 158 (12.1)	644 (14.8)	86 (18.1)	132 (21.9)	497 (45.6)	12 (70.6)	83 (60.2)
39								
<b>E410</b> -	for respiratory <b>j</b>							
41		8 781 (91.8)	3 792 (87.2)	394 (83.1)	491 (81.6)	294 (27.0)	4 (23.5)	38 (27.5)
42	1 visit	593 (6.2)	402 (9.2)	52 (11.0)	64 (10.6)	450 (41.3)	4 (23.5)	27 (19.6)
	2 visits	142 (1.5)	105 (2.4)	15 (3.2)	25 (4.2)	188 (17.2)	3 (17.65)	22 (15.9)
	3 or more visits		50 (1.2)	13 (2.7)	22 (3.7)	158 (14.5)	6 (35.3)	51 (37.0)
44						1		
45	NOT for respira	6 268 (65.5)	2 712 (62 4)	265 (55 0)	226 (54.2)	156	4 (22.5)	15 (22 6)
46	U VISIT	0 208 (03.3)	2 712 (62.4)	265 (55.9)	326 (54.2)	456 (41.8)	4 (23.5)	45 (32.6)
40	1 wight	1 535 (16.1)	742 (17.1)	94 (19.8)	118 (19.6)	(41.8) 205 (18.8)	3 (17.6)	29 (21.0)
	2 visits	746 (7.8)	370(8.5)	49 (10.3)	58 (9.6)	117 (10.7)	3 (17.6)	14(10.1)
48	3 or more visits	1 015 (10.6)	525 (12.1)	66 (13.9)	100 (16.6)	312 (28.6)	7 (41.2)	50 (36.2)
49	Hospitalization	1 015 (10.0)	525 (12.1)	50 (15.7)	100 (10.0)	512 (20.0)	, (+1.2)	50 (50.2)
50	0 day	8 046 (84.1)	3 581 (82.3)	356 (75.1)	449 (74.6)	774 (71.0)	5 (29.4)	78 (56.5)
51	1 day	697 (7.3)	318 (7.3)	39 (8.2)	62 (10.3)	100 (9.2)	3 (17.6)	17 (12.3)
	2 days	215 (2.2)	107 (2.5)	20 (4.2)	23 (3.8)	44 (4.0)	1 (5.9)	3 (2.2)
52	3 or more days	606 (6.3)	343 (7.9)	59 (12.4)	68 (11.3)	172 (15.8)	8 (47.1)	40 (29.0)
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<del>-12</del>	pitalization- for r			,.	1 002			1 100
13	0 day	9 370 (98.0)	4 210 (96.8)	447 (94.3)	563 (93.5)	990 (90.8)	14 (82.4)	109 (79.0)
14	1 day	100 (1.0)	60 (1.4)	7 (1.5)	20 (3.3)	33 (3.0)	0	7 (5.1)
15	2 days	32 (0.3)	32 (0.74)	4 (0.8)	5 (0.8)	14 (1.3)	0	3 (2.2)
	3 or more days	62 (0.6)	47 (1.1)	16 (3.4)	14 (2.3)	53 (4.9)	3 (17.6)	19 (13.8)
16	-							
Asth	ma Medications	mean (sd) range	e past year					
18	FABA	0.61 (1.7)	2.93 (3.8)	4.32 (5.2)	4.95 (5.1)	2.50 (4.4)	5.00 (5.2)	6.82 (6.8)
19	ICS	0.2 (0.7)	2.3(2.9)	1.4(2.6)	3.6(3.8)	1.4(2.4)	0.9 (1.7)	3.5(3.9)
	Leukotrienes	0.1 (1.4)	0.4(3.0)	6.7(10.0)	1.5 (4.8)	0.8(4.4)	3.3(5.1)	3.9 (11.5)
20	Combination	0.0 (0.4)	1.2 (2.9)	5.1(4.9)	2.18 (3.9)	1.0 (2.7)	7.7 (4.5)	3.0 (4.3)
21	Therapy							
22	Other	0.2(1.8)	0.8(3.4)	2.9(6.8)	2.36 (3.9)	1.8(17.0)	2.1 (2.5)	4.45 (6.6)
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	O verase i i ibi i	0	0	0	0	1 (0.1)	0	0
		0	0	0	0	1 076 (98.7)	17 (100)	135 (97.8)
25	ER or FABA		0	0	0	1 076 (98.7)	17 (100)	135 (97.8)
୍ରଟେ	Morbidity	1.6 (1.5)	1.6 (1.5)	1.8 (1.6)	1.9 (1.9)	1.8(2.0)	2.2 (1.4)	2.6 (2.5)
Inde	X							

\*10% (n= missing for well controlled and 7% for not well controlled; Less than 1 % of missing Sr nor ... tment

values for each category; ED=emergency department

# DISCUSSION

The purpose of this study was to evaluate the discrepancy between current asthma management and recommended guidelines using the provincial administrative databases and an ADSS. The present study represents an example of how decision support systems can be used to monitor guideline adherence, and to identify individuals at risk of poor outcomes to provide targeted interventions. To our knowledge this is the first time that a decision support system has been used to evaluate disease management at a population level.

As expected, individuals who were provincially insured were on average older, from a lower SES, and a higher proportion used healthcare services. A larger proportion compared to those non-provincially insured also had a diagnosis code for anxiety and depression.

The algorithms used to identify individuals with asthma and evaluate control status were validated in previous work. (24, 25) The majority of individuals well controlled were on an appropriate quantity of asthma treatment. We found, however, that ~ 31% of those well controlled could benefit from a medication review and potentially lower doses of asthma medications.

The majority of individuals not well controlled had the recommendation to increase treatment and for these individuals there was an opportunity to change therapy according to the existing guidelines. (26) The SMART inhaler helps address needs for increase in therapy, as it allows patients to use their as-needed medication because of declining asthma control—as is very often the case—evolving exacerbations will possibly be treated at an early stage and a further worsening of asthma may possibly be prevented. The SMART inhaler is not a recommended yet part of Canadian guidelines, however, with emerging evidence of its benefits for marinating control

compared to other alternatives, (27, 28) it will be included in the next version of guidelines and become more commonly prescribed for Canadian patients. Individuals who were not well controlled were in the 40-59 age range, and had a more complex health profile with greater co-morbidity, including a higher proportion with a diagnosis of anxiety or depression as compared to those wellcontrolled. The logistic regression analysis in our study also supported these conclusions. These individuals represent a more vulnerable sub-group of the asthma population, and place a greater burden on the healthcare system given the higher proportion that had an ED visit or hospitalization. As such, they require closer monitoring and review of medication to reach doses sufficient to maintain asthma control, or to review reasons for failed treatment.

In this study we were not able to generate a recommendation for a larger proportion of individuals not well controlled compared to controlled either because they were dispensed prescriptions for an inappropriate combination of medications that the ADSS could not reconcile to provide an appropriate recommendation, or they were dispensed two medications that resulted in a duplication of therapy. These cases in themselves represent a segment of the asthma population that requires closer review of their prescribed medication.

The generation of asthma recommendations at a population level using an administrative database allows individuals not receiving treatment based on guidelines to be identified. We found that many individuals with non-controlled asthma visit a physician 3 or more times per year, and potentially represent missed opportunities to optimize treatment. Possible reasons for our findings may include the lack of knowledge of PCPs of guidelines in general, especially for more complicated cases. It may also be, however, that patients are not going to see the same physician, or are switching physicians to ensure access to SABAs. In such situations, physicians may be reluctant to conduct a

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complete medication review if they do not perceive themselves as the primary provider for the patient.

Other physician concerns may be the reluctance to prescribe ICS and/or concern regarding polypharmacy with multiple inhalers. (29) This is where the role of pharmacists is important as they can see individuals' entire medication dispensing history and have been shown to be effective in managing asthma patients in particular if supported by an ADSS. (30)

Previous studies have also found that physicians do not adopt guidelines in their practice because of perceived appropriateness of the guidelines. (13, 31) Surveys have shown that they believe that guidelines do not take into account the heterogeneity of asthma and do not account for individual patient variations in response to treatment, (32) and other factors that impact response to asthma therapy such as age and co-morbidities.

Further, patient non-adherence to prescribed therapy and not having prescribed medications filled may also explain the findings from our study. Patient beliefs about the negative impact and benefits of their medications, (33) their confidence to manage their asthma, and not seeking care early enough to prevent exacerbations have all been identified as contributors to poor outcomes for asthma.(34)

Mechanisms to identify patients who need closer follow-up and evaluation have been identified as an important need for primary healthcare. (3, 34, 35) Future initiatives can include linking administrative databases to decision support systems that can help identify individuals who need closer monitoring and follow-up and allow for targeted services such as visit reminders sent to patients or to their care provider. The ongoing implementation of electronic health records and patient health portals will facilitate this approach. Information can be fed back to physicians and pharmacists to improve patient management, and initiate care early on, before individuals experience deteriorations in health----

# Limitations

Our approach for identifying individuals with asthma and assessing asthma status may have underestimated the percentage out of control in our study. We examined asthma control on two index dates, and went back 3 months prior to the index date to assess control status. A more sensitive algorithm that treats control as a time varying covariate would likely provide a more accurate evaluation of control status. Also, because we used administrative data and not clinical information from an electronic medical record to generate recommendations, we were not able to use asthma severity and relapse as part of the asthma control algorithm. Finally, previous studies that have reported higher levels of not well-controlled individuals were based on self-reports as opposed to administrative data. In addition,

<u>A</u>at the time that the ADSS was being developed, the SMART treatments, that allow for the same inhaler to be used as a preventative and rescue inhaler were not commonly used or part of the guidelines. Therefore, they were not programmed as part of the ADSS and not included in the recommendations.-<u>Further, the ADSS does not distinguish between SABA nebulizer and MDL.-</u><u>FurtheFinally</u>, use of decision support during clinical encounters allow for a patient-reported assessment of symptoms at the time when recommendations are generated, and allow for a more accurate assessment of asthma control. We were also limited to generating recommendations for those provincially insured that represent a more vulnerable segment of the population.

# Conclusions

This study demonstrated how a decision support system linked to an administrative database could be used to identify individuals in the population that require a review of asthma treatment. Such an approach can help identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment to intervene early. This study provides a model for monitoring adherence to guidelines for other chronic conditions such as hypertension and diabetes. 

**Declaration of Interest** 

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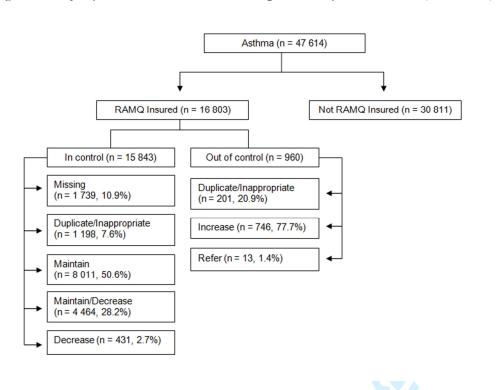
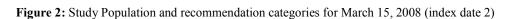
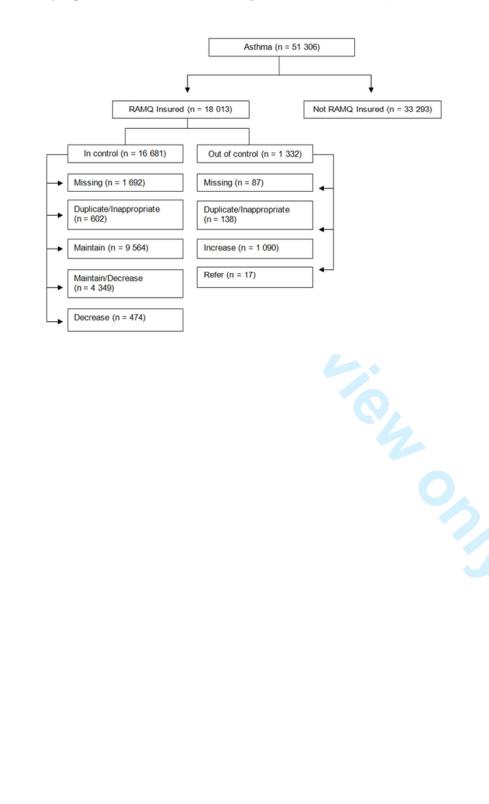


Figure 1: Study Population and recommendation categories for September 15, 2007 (index date 1)







# Using decision support for population tracking of adherence to recommended asthma guidelines

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# Ahmed, Tamblyn, Winslade

Using decision support for population tracking of adherence to recommended asthma guidelines

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What is the key question? What is the discrepancy between actual asthma treatments individuals' receive as recorded in the provincial administrative database as compared to those recommended by evidence-based guidelines as defined within an asthma decision support system.

What is the bottom line; and why read on? Decision support systems that define evidence-based guidelines, linked to an administrative database, can be used to identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment at a population level.

**Why read on?** The methods and approach from the current study can provide an opportunity for physicians to intervene early and can be used to evaluate adherence to evidence-based guidelines and indicators of disease management for other patient populations.

# Ahmed, Tamblyn, Winslade

#### Abstract

Objective: Decision support systems linked to administrative databases provide a unique opportunity to monitor adherence to guidelines and target disease management strategies to patients not receiving guideline-based therapy. The objective of this study was to evaluate the discrepancy between actual asthma treatments prescribed by primary care physicians compared to those recommended by evidence-based guidelines using a decision support tool linked to a provincial health administrative database. Design: The drug and medical services information of individuals with asthma were identified from the provincial health database and were pushed through an asthma decision support system (ADSS). Recommendations aimed at optimizing asthma treatment were generated on two index dates, September 15 2007 (index date 1) and March 15 2008 (index date 2).

Setting: Primary care settings in a large Canadian metropolitan area.

Participants: Individuals with asthma and provincial health insurance

Primary and secondary outcome measures: well controlled asthma

Results: 16, 803 eligible individuals were identified on index date 1, and 18, 103 on index date 2. The distribution of recommendation categories were similar on both index dates. 94% were classified as well controlled and 7% as not well controlled. Among individuals well controlled, the largest proportion of individuals were in the maintain treatment category (50.6%), followed by maintain/decrease treatment (28.2%), and decrease treatment (2.7%). Almost all individuals not well controlled had the recommendation to increase treatment (88%) with a small proportion in the refer category (1%).

Conclusions: The ADSS was able to identify sub-groups of patients from an administrative database that could benefit from a medication review and possible change. Decision support systems linked to an administrative database can be used to identify individuals with uncontrolled asthma or prescriptions that

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deviate from recommended treatment. When connected to the point of care, this can provide an

opportunity for physicians to intervene early.

# **Article Summary**

# 1) Article Focus -

- The objective of this study was to evaluate the discrepancy between actual asthma treatments prescribed by primary care physicians to those recommended by evidence-based guidelines using a decision support tool linked to a provincial health administrative database.

2) Key Messages - up to three bullet points outlining the key messages and significance of the study.

- Decision support systems that define evidence-based guidelines, linked to an administrative database, can be used to identify individuals with uncontrolled asthma or

prescriptions that deviate from recommended treatment at a population level.

- When connected to the point of care, discrepancies between decision support and actual

care can provide an opportunity for physicians to intervene early.

- The methods in this study can be applied in future work to evaluate adherence to evidence-based guidelines at a population level if administrative databases are available, or at the point

of care if linked to an electronic health record.

3) Strengths and Limitations

- The availability of a provincial administrative database and decision support system allowed us to assess guideline adherence, and to identify sub-groups of individuals at risk of poor outcomes.

- The administrative database only includes individuals who are provincially insured and

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therefore discrepancies could not be examined for individuals with private insurance.

- The proportion of individuals with poor asthma control may have been underestimated

as control status was evaluated over a 3-month period.

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# Introduction

Asthma poses a significant burden on healthcare resources and costs, [1] and results in reduced individual functioning and quality of life. [2, 3] Over the past 10 years there have been tremendous improvements in the scientific understanding of asthma and its treatment, and these findings have been made available to clinicians through the development of clinical practice guidelines. Despite achieving such sentinel milestones in asthma care, over 50% [4, 5] of individuals remain poorly controlled in the U.S. and Canada, with similar estimates worldwide. [6] This has translated into direct and indirect costs of 654 million and 7.2 billion dollars (equivalent to US dollars in 2008) in Canada and the US, respectively [7]

Healthcare organizations worldwide have been charged with improving asthma outcomes over the next 2-3 years, with the aim of reducing hospitalizations and deaths related to asthma. [8] Several barriers for optimal management result in poor outcomes for asthma, [9] including clinician-related (non-adherence to guidelines), patient-related (non-adherence to treatment), and treatment- related barriers (cost, complexity of treatment). In moving towards improving clinical outcomes potentially modifiable barriers must be identified and targeted through appropriate interventions. A mechanism is needed to identify problematic asthma management so that gaps in care and barriers can be further evaluated and managed.

One potentially modifiable barrier is the gap between optimal versus actual asthma management as reflected by the lack of adoption of guidelines by clinicians or non-adherence of patients to recommended care. [10, 11] Much of the costs of asthma care are related to poor disease control due to under-use of

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effective prophylactic therapies, and inadequate monitoring of disease control.[7] At a population level there are few mechanisms available for tracking disease-management indicators for asthma to evaluate the current application of guidelines. Several studies have evaluated divergence from asthma guidelines, [12, 13] but have not been able to accurately estimate non-adherence to guidelines among a representative sample of individuals. Evaluations of adherence have mostly relied on chart reviews and clinician or patient reports which are difficult to complete for a large number of patients across several healthcare settings. [14-16]

Decision support systems are designed to facilitate uptake of evidence- based guidelines with the expectation that adherence to such guidelines will improve health outcomes. [17] Typically, decision support systems are used at the point of care. Such systems, however, may also have an alternate benefit of allowing population monitoring of adherence to disease management guidelines when the decision support algorithms are linked to administrative databases. By pushing through administrative health data including diagnoses, healthcare utilization and medication information, algorithms can be used to generate recommendations for optimizing treatment. In turn, patterns of under-optimization of treatment can be identified to monitor adherence to guidelines and target specific physician and patient sub-groups with disease management interventions.

The implementation of an asthma decision support system linked to provincial health insurance information represents a novel approach and facilitates the evaluation of the gap between recommended and actual treatment. We have developed a new methodology for assessing the quality of asthma management and asthma control in the population. Using evidence based decision-support systems

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developed to guide physicians using computerized physician order entry and electronic medical record systems, we developed a program for sequentially entering, assessing and extracting individual and summarized population level quality monitoring and control status indicators. Using population level administrative data for over 16,000 asthma patients, we then used this program to evaluate asthma status and quality of adherence to national guidelines in a Quebec population on two randomly selected days in fall 2007 and spring 2008. This information is needed for asthma management, and can be used for identifying opportunities to target interventions and improve asthma outcomes.

In this study we examined the discrepancy between actual asthma treatments as recorded in the provincial administrative database compared to those recommended by evidence-based guidelines as defined in the asthma decision support system on two index dates.

# METHODS

# **Study population**

The drug and medical services information of patients cared for by primary care physicians (PCP) participating in the Medical Office of the 21st Century(MOXXI) study [18] in a large metropolitan area was used to evaluate adherence to asthma treatment guidelines. PCPs were identified by professional association master lists and contacted by letter and telephone to determine their interest in participating in the MOXXI project. Patients of these physicians were identified from the Quebec provincial health data base (RAMQ) medical service claims, physician, and beneficiary files. McGill University IRB approval was

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obtained for this study and PCPs who accepted provided consent for the research team to receive patient anonymised administrative data.

All patients with an ICD-9 code for asthma, with no prior diagnosis for Chronic Obstructive Pulmonary Disease (COPD), and who were  $\geq$  5 years old were identified from RAMQ based on algorithms validated in prior research. [19] For the purposes of this study, only patients with drug coverage by RAMQ for 75% of the year were included to ensure that all drugs dispensed were captured.

# The provincial drug and administrative database (RAMQ)

The RAMQ beneficiary demographic database provided data on individual age, gender, and mortality, and census data provided income and education. [20] Information on each drug dispensed was obtained from the prescription claims database and included the drug name, quantity, date, and duration for each prescription. The medical services claims database provided information on the beneficiary, date, type, provider, and location of service delivery (e.g., inpatient, emergency, clinic) for all medical services remunerated on a fee-for-service basis.

Study Procedure: Evaluating the gap between actual and recommended asthma treatment using the Asthma Decision Support System (ADSS)

The ADSS is integrated into the MOXXI electronic prescribing drug management application with patient information retrieved by real-time integration with the beneficiary, prescription and medical services

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claims files of the RAMQ. Using information from the prescription drug management platform, the ADSS uses the profile of existing drugs and health problems to customize recommended changes in asthma drug therapy. For this study, recommendations aimed at optimizing asthma treatment were generated on two index dates, September 15 2007 (index date 1) and March 15 2008 (index date 2), representing peak times for asthma symptoms.

In the ADSS, asthma control is determined based on overuse of short acting beta agonists (SABA) and visits to the Emergency Department (ED) for a respiratory problem over a 3 month period before the index date. Based on a previously validated algorithm, a patient is considered to be not well controlled if the sum of the quantity of all SABA medications dispensed to the patient within the last 3 months exceeds 250 doses1, [21] and/or they visited an ED for a respiratory related problem in the last 3 months. Only asthma drugs that were 1) prescribed and dispensed within one year of the index date, and 2) active (i.e. based on prescription algorithms it is likely that the person has a supply of the medication) or expired within 30 days prior to the index date were considered when generating the recommendations.

Patient-specific recommendations related to drug therapy are translated into pre-formatted prescriptions in the drug management platform. The ADSS is structured to support the Canadian Consensus guidelines for Asthma Management. [22] Recommendations are categorised based on control status. For individuals in control, recommendations generated are one of three categories: maintain treatment, decrease treatment, or maintain or decrease treatment. Recommendations also include options for action plan

<sup>&</sup>lt;sup>1</sup> 250 doses is based on the most commonly prescribed SABA salbutamol 100mcg, 2 inhalations at a time, or the equivalent for other fast acting bronchodilators in the last three months.

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prescriptions for patients who are in control. For individuals not well controlled recommendations are either to increase treatment or to refer to a specialist. Within each recommendation category, physicians are presented with specific recommendations for medications and doses to achieve the desired level of drug treatment.

# Data Analysis

Results were calculated for each index date. Descriptive statistics were used to characterize the study population and to evaluate differences between individuals with and without RAMQ coverage for prescription drugs. For individuals with RAMQ coverage, the proportion of individuals under each recommendation category was evaluated among individuals classified as 'well controlled' and 'not well controlled', and descriptive statistics were used to compare the characteristics of patients across categories. Multivariable logistic regression was used to estimate the probability of being classified in control or not well controlled as a function of sociodemographic characteristics and healthcare utilization.

# Results

# Study Population and Insured Compared to Non-Insured

A total of 47, 614 individuals with an asthma diagnosis were identified on index date 1, after removing individuals with a prior diagnosis of COPD (6018) and those  $\leq$  5 years old (Figure 1). Thirty five percent of individuals were RAMQ insured for prescription drugs at least 75% of the year prior to the index date, for both dates. On index date 2, 51 306 individuals with an asthma diagnosis were identified (Figure 2). Approximately the same proportion of individuals was classified as well controlled on index date 1 (93 %) and index date 2 (94%). As the distribution of individual characteristics, control status, and

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recommendation categories were similar on both index dates, we only report the results from index date 2 from this point on (Table 1).

Individuals who were RAMQ insured were on average older (mean=38±22) as compared to non-RAMQ. insured individuals (mean=31 $\pm$ 18) and had a greater percentage of individuals  $\geq$  60 years old, a larger proportion was female (61% versus 56%), and in the lower socioeconiomic status (SES) category (21% ha. La diagnost. versus 6%). A greater proportion of RAMQ insured patients had 3 or more ED (16 versus 9%) and hospital visits (8 versus 3%) one year prior to the index date, and a diagnostic code for anxiety (11 compared to 7%) or depression (8 compared to 5%).

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# Table 1: Characteristics of Study Participants with and without provincial health coverage (RAMQ) on index day 2\*

	RAMQ Coverage	No RAMQ Coverage
	n=18 013	n=33 293
Age mean (sd)	38,3 (21,8)	30,81 (17,5)
Age n (%)		
≤ 17	3 963 (22,0 )	10 273 (30,9)
18-39	5 129 (28,6 )	9 926 (29,8)
40-59	5 254 (29,2)	11 277 (33,9)
≥ 60	3 637 (20,2)	1 817 (5,5)
Sex n (% female)	11 035 (61,3)	18 665 (56,1)
Income n (%) *		
Low SES	3 490 (19,4)	2 665 (8,0)
Middle SES	13 148 (73.0)	25 947 (78,0)
High SES	1 230 (6,8 )	4 298 (13,0)
Healthcare Utilization over 1 year prior	to March 15, 2008	
Medical <i>Physician</i> Visits**  n (%)		
0 visit	1 736 (9,6 )	3 855 (11,6)
1 visit	1 998 (11,1)	4 453 (13,4)

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2 visits	1 895 (10,5)	4 154 (12,5)
3 or more visits	12,384 (68,8)	20 831 (62,6
Emergency Department Visits n (%)		
0 visit	10 435 (57,9)	22 738 (68,0
1 visit	3 139 (17,4)	5 445 (16,4)
2 visits	1 698 (9,4)	2 416 (7,3)
3 or more visits	2 741 (15,2)	2 694 (8,1)
Emergency Department Visits for asthma n (%)	1 313 (7,3)	1 644 (4,9)
Hospitalization		
0 day	14 890 (82,7)	29 445 (88,4
1 day	1 340 (7,4)	2 072 (6,2)
2 days	445 (2,5)	658 (2,0)
3 or more days	1 338 (7,4)	1 118 (3,4)
Co-Morbidity n (%)		
Depression	1 400 (7,77)	1 724 (5,2)
Anxiety	1 913 (10,62)	2 361 (7,1)

\* Around 1 % of missing values for each category; All differences between RAMQ and Non-RAMQ insured are significant, p<0.01

\*\* Ambulatory and specialty care

Control Status and Recommendation Categories

Among the 18 013 individuals who were RAMQ insured for prescription drugs, 93% were classified as well

controlled and 7% as not well controlled over 3 months prior to the index date (Figure 1).

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63 % of individuals who were not well controlled were in the  $\ge$  40 age group and 26% in the low SES category compared to 49% and 19%, respectively, in the well controlled group. These individuals also had a higher Charlson Co-morbidity Index of 2.11 as compared to 1.6 among those well controlled. A larger proportion of individuals among those not well controlled had a diagnostic code for depression, anxiety, mental illness, and a cardiac related condition. Among those not well controlled 69% (n=667) had at least 1 ED visit , and 74% a medical visit associated with a respiratory problem (in the past year). In comparison 13% (n=2,039) of those well controlled had at least one ED visit and 52% medical visit related to a respiratory problem in the past year.

53% of patients in the not well controlled group had an active prescription for an ICS, 20% a combination therapy, and 14% as compared to 36%, 10%, and 6% in the well controlled group. 63% and 42% of not well and well controlled, respectively, had an active prescription for a fast-acting beta agonist (FABA). At index date 1, all individuals not well controlled had asthma drugs as compared to 9.2 % of those well controlled who had no asthma drugs dispensed.

Table 2 presents the incremental regression coefficients for the demographic, healthcare utilization, and co-morbidity variables hypothesized to be associated with control status. Healthcare utilization including,  $\geq$ 3 days of hospitalization (OR=4.58), and  $\geq$  3 visits to the ED (for reasons other than a respiratory problem) (OR=2.32), was found to be most strongly associated with control status. Being male (OR=.85), from a low SES (OR= 1.9), and in the 40-59 age group increased the odds of having asthma that was not well controlled.

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Variable	OR (95%CI)	
	<b>Control Status</b>	
Age mean (sd)		
≤ 17	Reference	
18-39	0.56 (0.44, 0.72)	
40-59	2.19(1.73, 2.77)	
≥ 60	1.19 (1, 1.42)	
Sex n (% female)	2	
Male	Reference	
Female	85 (.74, .98)	
Income n (%) *		
High SES	Reference	
Middle SES	1.44 (1.04, 1.98)	
Low SES	1.90 (1.35, 2.68)	
Healthcare Utilization over 1 year prior to March 15, 2008		
Medical Physician *Visits n (%)		
0 visit	Reference	
1 visit	.73 (.47,1.2)	
2 visits	.82 (.53,1.28)	
$\geq$ 3 visits	1.62 (1.162.27)	
Emergency Department Visits (other than resp)n (%)		
0 visit	Reference	

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1 visit	1.38(1.14,1.66)
2 visits	1.46(1.16,1.84)
≥3 visits	2.32(1.94,2.8)
Hospitalisation	
0 day	Reference
1 day	2.24(1.55,3.27)
2 days	2.88(1.79,4.6)
3 or more days	4.58 (3.36,6.22)
Co-Morbidity n (%)	
Charlson co-morbidity index	1.04 (1.01, 1.08)
Anxiety No	Reference
Yes	1.26 (1.05,1.52 )
General practitioner and specialist	
Recommendation category by control	group
The distribution of individuals across re	commendation categories is presented in

For 8% (1198/15843) in control, and 21% (201/960) of those not well controlled, a recommendation could not be determined by the ADSS either because the patient 1) had dispensed prescriptions for an inappropriate combination of medications that the ADSS could not reconcile to provide an appropriate recommendation (e.g. a LABA with two prescriptions for combination therapy) or, 2) dispensed two medications that resulted in a duplication of therapy. For those not well controlled, those in the

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*duplicate/inappropriate* category had a larger proportion in the lower SES, a higher co-morbidity index and more frequent ambulatory and hospital visits.

Among individuals well controlled, the largest proportion of individuals were in the *maintain treatment* category (50.6%), followed by *maintain/decrease treatment* (28.2%), and *decrease treatment* (2.7%). Almost all individuals not well controlled had the recommendation to *increase treatment* (88%) with a small proportion in the *refer* category (1%). Reasons for the low referral to specialty care needs to be closely examined, and may be related to uncertainty of primary care physicians of when to refer patients, and/or patients may not go see specialists once referred. [23] Regardless of the recommendation category, the largest proportion of individuals was in the 40-59 age group; except for *maintain treatment* that had a larger proportion of individuals in the 18-39 age group. The middle SES was the largest for all recommendation groups and the proportion of females was the same across all categories. Individuals in the *refer* category were on average older than those in the other categories, but comparable on many of the other characteristics.

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Table 3: Comparison of characteristics of individuals in each recommendation category (based on primary recommendation).

13								
14		In Control					Not Well Contro	olled
16								
17		N=14989					N=1245	
18 19			Maintain (Dec	Describerto	Duralizate/		2-6	Duralizate /
20		Maintain	Maintain/Dec	Decrease	Duplicate/	Increase	Refer	Duplicate/
21			rease		Inappropriate	n=1 090	n=17	Inappropriate
22			n=4349		n=602			n=138
23		n=9564		n=474				
24 25	( 1)							
	nean (sd)	41,8 (19,2)	38,2	44,8 (21,6)	45,9 (20,3)	40,4 (21,5)	57,1 (9,3)	46,6
27			(22,7)					(16,0)
28			(,,,					(10,0)
Age n	. (%)					1		
-31								
32	≤ 17	919 (9,6)	1 115 (25,6)	74 (15,6)	68 (11,3)	189 (17,3)	0	6 (4,4)
33	19 20	2 561 (27 2)	006 (22.0)	96 (19 1)	122 (20.4)	210 (29 4)	0	22 (22 0)
34 35	18-39	3 561 (37,2)	996 (22,9)	86 (18,1)	123 (20,4)	310 (28,4)	U	33 (23,9)
35 36	40-59	2 987 (31,2)	1 269 (29,2)	195 (41,1)	260 (43,2)	372 (34,1)	10 (58,8)	79 (57,2)
37			· · ·	• • •				· · ·
38	≥ 60	2 097 (21,9)	969 (22,3)	119 (25,1)	151 (25,1)	219 (20,1)	7 (41,2)	20 (14,5)
<u>39</u>	(-/ <b>-</b> )						12 (70 C)	
<b>Skex n</b> 41	(% F)	6 073 (63,5)	2 659 (61,1)	303 (63,9)	381 (63,3)	709 (65,0)	12 (70,6)	101 (73,2)
	ne n (%) *							
43								
44	Low SES	1 684 (17,6)	923 (21,2)	117 (24,7)	156 (25,9)	237 (21,7)	4 (23,5)	43 (31,2)
45 46								
46 47	Middle SES	7 028 (73,5)	3 161 (72,7)	330 (69,6)	420 (69,8)	802 (73,6)	13 (76,5)	90 (65,2)
48	High SES	763 (8,0)	228 (5,2)	25 (5,3)	22 (3,6)	47 (4,3)	0	5 (3,6)
49	-		220 (3,2)	23 (3,3)	22 (3,0)	47 (4,5)	0	5 (5,0)
Medi	cal Visits mean	(sd) past year				1		
51 52						1		
53	All	8,78 (13,1)	9,68 (13,8)	12,62(13,3)	12,87(13,4)	16,52 (22,2)	29,29 (21,3)	24,99 (26,1)
54	Ambulatory	7 72 (0 6)	9 21 /0 2)	10 80 (0 E)	11 12 (O E)	12 52(15 0)	10.04/10.0)	20.01 (19.1)
55	Ambulatory	7,72 (9,6)	8,31 (9,2)	10,89 (9,5)	11,13 (9,5)	13,53(15,0)	19,94 (10,0)	20,01 (18,1)
56	Hospitalized	1,07 (6,8)	1,37 (7,7)	1,73 (7,4)	1,73 (7,6)	2,99 (11,6)	9,35 (16,4)	4,98 (13,3)
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59								

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2 3	Ahmed, Tamblyn, Winslade							
4		In Control					Not Well Contro	olled
6 7 8		N=14989					N=1245	
9 10		Maintain	Maintain/Dec	Decrease	Duplicate/	Increase	Refer	Duplicate/
10 11 12			rease		Inappropriate	n=1 090	n=17	Inappropriate
12 13 14		n=9564	n=4349	n=474	n=602			n=138
	dical Visits n (	%) past year 🥢						
17 18	Physician							
19 20	0 visit	1 036 (10,8)	265 (6,1)	14 (3,0)	22 (3,6)	62 (5,7)	0	7 (5,1)
21 22	1 visit	1048 (10,96)	451 (10,4)	31 (6,5)	40 (6,6)	76 (7,0)	0	5 (3,6)
23 24	2 visits	1000 (10,5)	486 (11,2)	41	26 (4,3)	81 (7,4)	0	2 (1,4)
25 26				(8,6)				
27 28	3 or more visits	6 480 (67,8)	3 147 (72,4)	388 (81,9)	514 (85,4)	871 (79,9)	17 (100)	124 (89,9)
29 30	ER							
31 32	0 visit	5 995 (62,7)	2 501 (57,5)	240 (50,6)	289 (48,0)	200 (18,4)	1 (5,9)	25 (18,1)
33 34	1 visit	1 565 (16,4)	790 (18,2)	89 (18,8)	118 (19,6)	221 (20,3)	3 (17,6)	21 (15,2)
35 36 37	2 visits	846 (8,8)	414 (9,5)	59 (12,4)	63 (10,5)	172 (15,8)	1 (5,9)	9 (6,5)
37 38 39	3 or more visits	1 158 (12,1)	644 (14,8)	86 (18,1)	132 (21,9)	497 (45,6)	12 (70,6)	83 (60,2)
40 41						0.		
	for respiratory pr	oblems						
43 44 45	0 visit	8 781 (91,8)	3 792 (87,2)	394 (83,1)	491 (81,6)	294 (27,0)	4 (23,5)	38 (27,5)
46 47	1 visit	593 (6,2)	402 (9,2)	52 (11,0)	64 (10,6)	450 (41,3)	4 (23,5)	27 (19,6)
48 49	2 visits	142 (1,5)	105 (2,4)	15 (3,2)	25 (4,2)	188 (17,2)	3 (17,65)	22 (15,9)
50 51 52 53	3 or more visits	48 (0,5)	50 (1,2)	13 (2,7)	22 (3,7)	158 (14,5)	6 (35,3)	51 (37,0)
54 55	NOT for respirato	ry problems				I		
56 57 58 59 60	0 visit	6 268 (65,5)	2 712 (62,4)	265 (55,9)	326 (54,2)	456	4 (23,5)	45 (32,6)

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3 4			,					
5 6		In Control					Not Well Contro	lled
7 8	7 N=14989						N=1245	
9 10		Maintain	Maintain/Dec	Decrease	Duplicate/	Increase	Refer	Duplicate/
11			rease		Inappropriate	n=1 090	n=17	Inappropriate
12 13		n=9564	n=4349	n=474	n=602			n=138
14 15		11-5504		II				
16						(41,8)		
17 18	1 visit	1 535 (16,1)	742 (17,1)	94 (19,8)	118 (19,6)	205 (18,8)	3 (17,6)	29 (21,0)
19 20	2 visits	746 (7,8)	370(8,5)	49 (10,3)	58 (9,6)	117 (10,7)	3 (17,6)	14 (10,1)
21 22	3 or more visits	1 015 (10,6)	525 (12,1)	66 (13,9)	100 (16,6)	312 (28,6)	7 (41,2)	50 (36,2)
23 24	Hospitalization							
25 26 27	0 day	8 046 (84,1)	3 581 (82,3)	356 (75,1)	449 (74,6)	774 (71,0)	5 (29,4)	78 (56,5)
27 28 29	1 day	697 (7,3)	318 (7,3)	39 (8,2)	62 (10,3)	100 (9,2)	3 (17,6)	17 (12,3)
30 31	2 days	215 (2,2)	107 (2,5)	20 (4,2)	23 (3,8)	44 (4,0)	1 (5,9)	3 (2,2)
32 33	3 or more days	606 (6,3)	343 (7,9)	59 (12,4)	68 (11,3)	172 (15,8)	8 (47,1)	40 (29,0)
<b>84</b> s	pitalization- for re	espiratory problem	ns			1		
35 36 37	0 day	9 370 (98,0)	4 210 (96,8)	447 (94,3)	563 (93,5)	990 (90,8)	14 (82,4)	109 (79,0)
38 39	1 day	100 (1,0)	60 (1,4)	7 (1,5)	20 (3,3)	33 (3,0)	0	7 (5,1)
40 41	2 days	32 (0,3)	32 (0,74)	4 (0,8)	5 (0,8)	14 (1,3)	0	3 (2,2)
42 43	3 or more days	62 (0,6)	47 (1,1)	16 (3,4)	14 (2,3)	53 (4,9)	3 (17,6)	19 (13,8)
44 45								
	nma Medications	mean (sd) range	past year					
48 49	FABA	0,61 (1,7)	2,93 (3,8)	4,32 (5,2)	4,95 (5,1)	2,50 (4,4)	5,00 (5,2)	6,82 (6,8)
50 51	ICS	0,2 (0,7)	2,3(2,9)	1,4(2,6)	3,6(3,8)	1,4(2,4)	0,9 (1,7)	3,5(3,9)
52 53	Leukotrienes	0,1 (1,4)	0,4(3,0)	6,7(10,0)	1,5 (4,8)	0,8(4,4)	3,3(5,1)	3,9 (11,5)
54 55 56 57 58	Combination Therapy	0,0 (0,4)	1,2 (2,9)	5,1(4,9)	2,18 (3,9)	1,0 (2,7)	7,7 (4,5)	3,0 (4,3)

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	In Control					Not Well Cont	trolled
5 6 7 8	N=14989					N=1245	
9 10	Maintain	Maintain/Dec	Decrease	Duplicate/ Inappropriate	Increase	Refer	Duplicate/ Inappropriate
11 12		rease n=4349		n=602	n=1 090	n=17	n=138
13 14	n=9564	11-4349	n=474	11-002			11-130
15 Other 16	0,2(1,8)	0,8(3,4)	2,9(6,8)	2,36 (3,9)	1,8(17,0)	2,1 (2,5)	4,45 (6,6)
17 Control Status n (%) 18					1		
19 20 Overuse FABA	0	0	0	0	1 (0,1)	0	0
21 2R visits for Asthma 22	0	0	0	0	1 076 (98,7)	17 (100)	135 (97,8)
23 24 ER or FABA	0	0	0	0	1 076 (98,7)	17 (100)	135 (97,8)
25 Ge-Morbidity Index	1,6 (1,5)	1,6 (1,5)	1,8 (1,6)	1,9 (1,9)	1,8(2,0)	2,2 (1,4)	2,6 (2,5)
27 28 •	Less than 1 % o	f missing values	for each cate	gory			
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# DISCUSSION

The purpose of this study was to evaluate the discrepancy between current asthma management and recommended guidelines using the provincial administrative databases and an ADSS. The present study represents an example of how decision support systems can be used to monitor guideline adherence, and to identify individuals at risk of poor outcomes to provide targeted interventions. To our knowledge this is the first time that a decision support system has been used to evaluate disease management at a population level.

As expected, individuals who were provincially insured were on average older, from a lower SES, and a higher proportion used healthcare services. A larger proportion compared to those non-provincially insured also had a diagnosis code for anxiety and depression.

The algorithms used to identify individuals with asthma and evaluate control status were validated in previous work. [24, 25] The majority of individuals well controlled were on an appropriate quantity of asthma treatment. We found, however, that ~ 31% of those well controlled could benefit from a medication review and potentially lower doses of asthma medications.

The majority of individuals not well controlled had the recommendation to increase treatment and for these individuals there was an opportunity to change therapy according to the existing guidelines. [26] The SMART inhaler helps address needs for increase in therapy, as it allows patients to use their as-needed

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medication because of declining asthma control—as is very often the case—evolving exacerbations will possibly be treated at an early stage and a further worsening of asthma may possibly be prevented. The SMART inhaler is not a recommended yet part of Canadian guidelines, however, with emerging evidence of its benefits for marinating control compared to other alternatives, [27, 28] it will be included in the next version of guidelines and become more commonly prescribed for Canadian patients. Individuals who were not well controlled were in the 40-59 age range, and had a more complex health profile with greater comorbidity, including a higher proportion with a diagnosis of anxiety or depression as compared to those well-controlled. The logistic regression analysis in our study also supported these conclusions. These individuals represent a more vulnerable sub-group of the asthma population, and place a greater burden on the healthcare system given the higher proportion that had an ED visit or hospitalization. As such, they require closer monitoring and review of medication to reach doses sufficient to maintain asthma control, or to review reasons for failed treatment.

In this study we were not able to generate a recommendation for a larger proportion of individuals not well controlled compared to controlled either because they were dispensed prescriptions for an inappropriate combination of medications that the ADSS could not reconcile to provide an appropriate recommendation, or they were dispensed two medications that resulted in a duplication of therapy. These cases in themselves represent a segment of the asthma population that requires closer review of their prescribed medication.

The generation of asthma recommendations at a population level using an administrative database allows individuals not receiving treatment based on guidelines to be identified. We found that many individuals

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with non-controlled asthma visit a physician 3 or more times per year, and potentially represent missed opportunities to optimize treatment. Possible reasons for our findings may include the lack of knowledge of PCPs of guidelines in general, especially for more complicated cases. It may also be, however, that patients are not going to see the same physician, or are switching physicians to ensure access to SABAs. In such situations, physicians may be reluctant to conduct a complete medication review if they do not perceive themselves as the primary provider for the patient.

Other physician concerns may be the reluctance to prescribe ICS and/or concern regarding polypharmacy with multiple inhalers. [29] This is where the role of pharmacists is important as they can see individuals' entire medication dispensing history and have been shown to be effective in managing asthma patients in particular if supported by an ADSS. [30]

Previous studies have also found that physicians do not adopt guidelines in their practice because of perceived appropriateness of the guidelines. [13, 31] Surveys have shown that they believe that guidelines do not take into account the heterogeneity of asthma and do not account for individual patient variations in response to treatment, [32] and other factors that impact response to asthma therapy such as age and co-morbidities.

Further, patient non-adherence to prescribed therapy and not having prescribed medications filled may also explain the findings from our study. Patient beliefs about the negative impact and benefits of their

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medications, [33] their confidence to manage their asthma, and not seeking care early enough to prevent exacerbations have all been identified as contributors to poor outcomes for asthma. [34]

Mechanisms to identify patients who need closer follow-up and evaluation have been identified as an important need for primary healthcare. [3, 34, 35] Future initiatives can include linking administrative databases to decision support systems that can help identify individuals who need closer monitoring and follow-up and allow for targeted services such as visit reminders sent to patients or to their care provider. The ongoing implementation of electronic health records and patient health portals will facilitate this approach. Information can be fed back to physicians and pharmacists to improve patient management, and initiate care early on, before individuals experience deteriorations in health.

# Conclusions

This study demonstrated how a decision support system linked to an administrative database could be used to identify individuals in the population that require a review of asthma treatment. Such an approach can help identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment to intervene early. This study provides a model for monitoring adherence to guidelines for other chronic conditions such as hypertension and diabetes.

# Limitations

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Our approach for identifying individuals with asthma and assessing asthma status may have underestimated the percentage out of control in our study. We examined asthma control on two index dates, and went back 3 months prior to the index date to assess control status. A more sensitive algorithm that treats control as a time varying covariate would likely provide a more accurate evaluation of control status.

Also, our estimation of the percentage of well-controlled individuals may be an overestimate compared to previous studies because of our method of defining asthma control. A previous study conducted in the UK, [36] and another using a US administrative database [37] assumed 2 puffs of a SABA per day, the equivalent of 180 puffs over 3 months, would be the threshold for asthma control. With this measure of asthma control the authors reported 72% of patients were well controlled in the UK study and 56% in the US study. This estimate is substantially below the measure of 250 puffs we used in this study, and likely explains why we found a larger proportion of individuals who were well controlled.

Also, because we used administrative data and not clinical information from an electronic medical record to generate recommendations, we were not able to use asthma severity and relapse as part of the asthma control algorithm. Two previous studies used composite measures of asthma control including (1) no recorded hospital attendance for asthma (including admission or emergency department visit, out of hours, or outpatient department attendance); (2) no prescription for oral corticosteroid; and (3) no consultation, hospital admission, or emergency department attendance for lower respiratory tract infection requiring antibiotics. [36, 37] With this more stringent definition of asthma control they found proportions of wellcontrolled asthma control to be 72% [36], and 56% [37] which are lower compared the 94% were found to be well-controlled in our study.

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In addition, at the time that the ADSS was being developed, the SMART treatments, that allow for the same inhaler to be used as a preventative and rescue inhaler were not commonly used or part of the guidelines. Therefore, they were not programmed as part of the ADSS and not included in the recommendations.

Further, the ADSS does not distinguish between SABA nebulizer and MDI. Finally, use of decision support during clinical encounters allow for a patient-reported assessment of symptoms at the time when recommendations are generated, and allow for a more accurate assessment of asthma control. We were also limited to generating recommendations for those provincially insured that represent a more vulnerable segment of the population.

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**Contributorship Statement** 

SA RT and NW were involved in:

- the conception and design, analysis and interpretation of data,

- drafting the article and revising it critically for important intellectual content,

- final approval of the version to be published.

# **Competing Interests**

No competing interests

# **Data Sharing Statement**

Additional data regarding the study sample characteristics and guidelines generated from the decision support system can be provided upon request from the corresponding author.

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Using decision support for population tracking of adherence to recommended asthma guidelines
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Keywords: Asthn	na, clinical practice guidelines, disea	ase management, decision	support, administrative	
database				

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What is the key question? What is the discrepancy between actual asthma treatments individuals' receive as recorded in the provincial administrative database as compared to those recommended by evidence-based guidelines as defined within an asthma decision support system.

What is the bottom line; and why read on? Decision support systems that define evidence-based guidelines, linked to an administrative database, can be used to identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment at a population level.

Why read on? The methods and approach from the current study can provide an opportunity for physicians to intervene early and can be used to evaluate adherence to evidence-based guidelines and indicators of disease management for other patient populations.

#### Abstract

Objective: Decision support systems linked to administrative databases provide a unique opportunity to monitor adherence to guidelines and target disease management strategies to patients not receiving guideline-based therapy. The objective of this study was to evaluate the discrepancy between actual asthma treatments prescribed by primary care physicians compared to those recommended by evidencebased guidelines using a decision support tool linked to a provincial health administrative database. Design: The drug and medical services information of individuals with asthma were identified from the provincial health database and were pushed through an asthma decision support system (ADSS). Recommendations aimed at optimizing asthma treatment were generated on two index dates, September 15 2007 (index date 1) and March 15 2008 (index date 2). Setting: Primary care settings in a large Canadian metropolitan area. Participants: Individuals with asthma and provincial health insurance Primary and secondary outcome measures: well controlled asthma Results: 16, 803 eligible individuals were identified on index date 1, and 18, 103 on index date 2. The distribution of recommendation categories were similar on both index dates. 94% were classified as well controlled and 7% as not well controlled. Among individuals well controlled, the largest proportion of individuals were in the maintain treatment category (50.6%), followed by maintain/decrease treatment (28.2%), and decrease treatment (2.7%). Almost all individuals not well controlled had the recommendation to increase treatment (88%) with a small proportion in the refer category (1%). Conclusions: The ADSS was able to identify sub-groups of patients from an administrative database that could benefit from a medication review and possible change. Decision support systems linked to an administrative database can be used to identify individuals with uncontrolled asthma or prescriptions that

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deviate from recommended treatment. When connected to the point of care, this can provide an

opportunity for physicians to intervene early.

#### **Article Summary**

1) Article Focus -

- The objective of this study was to evaluate the discrepancy between actual asthma

treatments prescribed by primary care physicians compared to those recommended by

evidence-based guidelines using a decision support tool linked to a provincial health

administrative database.

2) Key Messages - up to three bullet points outlining the key messages and significance of the study.

- Decision support systems that define evidence-based guidelines, linked to an

administrative database, can be used to identify individuals with uncontrolled asthma or

prescriptions that deviate from recommended treatment at a population level.

- When connected to the point of care, discrepancies between decision support and actual

care can provide an opportunity for physicians to intervene early.

- The methods and approach from the current in this study can be applied in future workused to evaluate adherence  $t_{\overline{OO}}$ 

evidence-based guidelines and indicators of disease management for other patient

populations, at a population level if administrative databases are available, or at the point

of care if linked to an electronic health record.

3) Strengths and Limitations

- The availability of a provincial administrative database and decision support system

allowed us to assess guideline adherence, and to identify sub-groups of individuals at risk

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10 11	of poor outcomes.
12	- The administrative database only includes individuals who are provincially insured and
13 14	therefore discrepancies could not be examined for individuals with private insurance.
15	<ul> <li>The administrative database only includes individuals who are provincially insured and therefore discrepancies could not be examined for individuals with private insurance.</li> <li>The proportion of individuals with poor asthma control may have been underestimated as control status was evaluated over a 3-month period.</li> </ul>
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#### Introduction

Asthma poses a significant burden on healthcare resources and costs, [1] and results in reduced individual functioning and quality of life. [2, 3] Over the past 10 years there have been tremendous improvements in the scientific understanding of asthma and its treatment, and these findings have been made available to clinicians through the development of clinical practice guidelines. Despite achieving such sentinel milestones in asthma care, over 50% [4, 5] of individuals remain poorly controlled in the U.S. and Canada, with similar estimates worldwide. [6] This has translated into direct and indirect costs of 654 million and 7.2 billion dollars (equivalent to US dollars in 2008) in Canada and the US, respectively This has translated into \$306 million per year in direct costs for providing health management for approximately 2.2 million Canadians diagnosed with asthma. With appropriate disease management over \$135 million in costs and reductions in physical and mental health can be prevented...[7]

Healthcare organizations worldwide have been charged with improving asthma outcomes over the next 2-3 years, with the aim of reducing hospitalizations and deaths related to asthma. [8] Several barriers for optimal management result in poor outcomes for asthma, [9] including clinician-related (non-adherence to guidelines), patient-related (non-adherence to treatment), and treatment- related barriers (cost, complexity of treatment). In moving towards improving clinical outcomes potentially modifiable barriers must be identified and targeted through appropriate interventions. A mechanism is needed to identify problematic asthma management so that gaps in care and barriers can be further evaluated and managed.

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One potentially modifiable barrier is the gap between optimal versus actual asthma management as reflected by the lack of adoption of guidelines by clinicians or non-adherence of patients to recommended care. [10, 11] Much of the costs of asthma care are related to poor disease control due to under-use of effective prophylactic therapies, and inadequate monitoring of disease control.[7] At a population level there are few mechanisms available for tracking disease-management indicators for asthma to evaluate the current application of guidelines. Several studies have evaluated divergence from asthma guidelines, [12, 13] but have not been able to accurately estimate non-adherence to guidelines among a representative sample of individuals. Evaluations of adherence have mostly relied on chart reviews and clinician or patient reports which are difficult to complete for a large number of patients across several healthcare settings. [14-16]

Decision support systems are designed to facilitate uptake of evidence- based guidelines with the expectation that adherence to such guidelines will improve health outcomes. [17] Typically, decision support systems are used at the point of care. Such systems, however, may also have an alternate benefit of allowing population monitoring of adherence to disease management guidelines when the decision support algorithms are linked to administrative databases. By pushing through administrative health data including diagnoses, healthcare utilization and medication information, algorithms can be used to generate recommendations for optimizing treatment. In turn, patterns of under-optimization of treatment can be identified to monitor adherence to guidelines and target specific physician and patient sub-groups with disease management interventions.

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The implementation of an asthma decision support system linked to provincial health insurance information represents a novel approach and facilitates the evaluation of the gap between recommended and actual treatment. We have developed a new methodology for assessing the quality of asthma management and asthma control in the population. Using evidence based decision-support systems developed to guide physicians using computerized physician order entry and electronic medical record systems, we developed a program for sequentially entering, assessing and extracting individual and summarized population level quality monitoring and control status indicators. Using population level administrative data for over 16,000 asthma patients, we then used this program to evaluate asthma status and quality of adherence to national guidelines in a Quebec population on two randomly selected days in <u>fall 2007</u>the spring and fall<u>spring 2008</u>. This information is needed for asthma management, and can be used for identifying opportunities to target interventions and improve asthma outcomes.

In this study we examined the discrepancy between actual asthma treatments as recorded in the provincial administrative database compared to those recommended by evidence-based guidelines as defined in the asthma decision support system on two index dates.

#### METHODS

#### Study population

The drug and medical services information of patients cared for by primary care physicians (PCP) participating in the Medical Office of the 21st Century(MOXXI) study [18] in a large metropolitan area was used to evaluate adherence to asthma treatment guidelines. PCPs were identified by professional

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Ahmed, Tamblyn, Winslade association master lists and contacted by letter and telephone to determine their interest in participating in the MOXXI project. Patients of these physicians were identified from the Quebec provincial health data base (RAMQ) medical service claims, physician, and beneficiary files. McGill University IRB approval was obtained for this study and PCPs who accepted provided consent for the research team to receive patient anonymised administrative data. All patients with an ICD\_-9 code for asthma, with no prior diagnosis for Chronic Obstructive Pulmonary Disease (COPD), and who were ≥ 5 years old were identified from RAMQ based on algorithms validated in prior research. [19] For the purposes of this study, only patients with full drug coverage by RAMQ for 75%

of the year were included to ensure that all drugs dispensed were captured.

#### The provincial drug and administrative database (RAMQ)

The RAMQ beneficiary demographic database provided data on individual age, gender, and mortality, and census data provided income and education. [20] Information on each drug dispensed was obtained from the prescription claims database and included the drug name, quantity, date, and duration for each prescription. The medical services claims database provided information on the beneficiary, date, type, provider, and location of service delivery (e.g., inpatient, emergency, clinic) for all medical services remunerated on a fee-for-service basis.

Study Procedure: Evaluating the gap between actual and recommended asthma treatment using the Asthma Decision Support System (ADSS)

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The ADSS is integrated into the MOXXI electronic prescribing drug management application with patient information retrieved by real-time integration with the beneficiary, prescription and medical services claims files of the RAMQ. Using information from the prescription drug management platform, the ADSS uses the profile of existing drugs and health problems to customize recommended changes in asthma drug therapy. For this study, recommendations aimed at optimizing asthma treatment were generated on two index dates, September 15 2007 (index date 1) and March 15 2008 (index date 2), representing peak times for asthma symptoms.

In the ADSS, asthma control is determined based on overuse of short acting beta agonists (SABA) and visits to the Emergency Department (ED) for a respiratory problem over a 3 month period before the index date. Based on a previously validated algorithm, a patient is considered to be not well controlled if the sum of the quantity of all SABA medications dispensed to the patient within the last 3 months exceeds 250 doses1, [21] and/or they visited an ED for a respiratory related problem in the last 3 months. Only asthma drugs that were 1) prescribed and dispensed within one year of the index date, and 2) active (i.e. based on prescription algorithms it is likely that the person has a supply of the medication) or expired within 30 days prior to the index date were considered when generating the recommendations.

Patient-specific recommendations related to drug therapy are translated into pre-formatted prescriptions in the drug management platform. The ADSS is structured to support the Canadian Consensus guidelines for Asthma Management. [22] Recommendations are categorised based on control status. For individuals in

<sup>&</sup>lt;sup>1</sup> 250 doses is based on the most commonly prescribed SABA salbutamol 100mcg, 2 inhalations at a time, or the equivalent for other fast acting bronchodilators in the last three months.

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control, recommendations generated are one of three categories: maintain treatment, decrease treatment, or maintain or decrease treatment. Recommendations also include options for action plan prescriptions for patients who are in control. For individuals not well controlled recommendations are either to increase treatment or to refer to a specialist. Within each recommendation category, physicians are presented with specific recommendations for medications and doses to achieve the desired level of drug treatment.

#### Data Analysis

Results were calculated for each index date. Descriptive statistics were used to characterize the study population and to evaluate differences between individuals with and without RAMQ coverage for prescription drugs. For individuals with RAMQ coverage, the proportion of individuals under each recommendation category was evaluated among individuals classified as 'well controlled' and 'not well controlled', and descriptive statistics were used to compare the characteristics of patients across categories. Multivariable logistic regression was used to estimate the probability of being classified in control or not well controlled as a function of sociodemographic characteristics and healthcare utilization.

#### Results

Study Population and Insured Compared to Non-Insured

<u>A total of 47, 614</u> individuals with an asthma diagnosis were identified on index date 1, after removing individuals with a prior diagnosis of COPD (6018) and those  $\leq$  5 years old (Figure 1). Thirty five percent of individuals were RAMQ insured for prescription drugs at least 75% of the year prior to the index date, for both dates. On index date 2, 51 306 individuals with an asthma diagnosis were identified (Figure 2).

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Approximately the same proportion of individuals was classified as well controlled on index date 1 (93 %) and index date 2 (94%). As the distribution of individual characteristics, control status, and recommendation categories were similar on both index dates, we only report the results from index date 2 from this point on (Table 1).

Individuals who were RAMQ insured were on average older (mean= $38\pm22$ ) as compared to non-RAMQ insured individuals (mean= $31\pm18$ ) and had a greater percentage of individuals  $\geq$  60 years old, a larger proportion was female (61% versus 56%), and in the lower <u>socioeconiomic status (-SES)</u> category (21% versus 6%). A greater proportion of RAMQ insured patients had 3 or more ED (16 versus 9%) and hospital visits (8 versus 3%) one year prior to the index date, and a diagnostic code for anxiety (11 compared to 7%) or depression (8 compared to 5%).

 Table 1: Characteristics of Study Participants with and without provincial health coverage (RAMQ) on index day 2\*

RAMQ Coverage

No RAMQ Coverage

Ahme	d, Tamblyn,Winslade	
	n=18 013	n=33 293
Age mean (sd)	38,3 (21,8)	30,81 (17,5)
Age n (%)		
		10 272 /20 0
≤ 17	3 963 (22,0 )	10 273 (30,9
18-39	5 129 (28,6 )	9 926 (29,8)
40-59	5 254 (29,2)	11 277 (33,9
≥ 60	3 637 (20,2)	1 817 (5,5)
Sex n (% female)	11 035 (61,3)	18 665 (56,1
Income n (%) *		
Low SES	3 490 (19,4)	2 665 (8,0)
Middle SES	13 148 (73.0)	25 947 (78,0
High SES	1 230 (6,8 )	4 298 (13,0)
Healthcare Utilization over 1 year prior	to March 15, 2008	
Medical <del>Phycisian<u>Physician</u></del>		
Visits** n (%)		
0 visit	1 736 (9,6 )	3 855 (11,6)
1 visit	1 998 (11,1)	4 453 (13,4)
2 visits	1 895 (10,5)	4 154 (12,5)
3 or more visits	12,384 (68,8)	20 831 (62,6
Emergency Department Visits n		
(%)		
0 visit	10 435 (57,9)	22 738 (68,0
1 visit	3 139 (17,4)	5 445 (16,4)
2 visits	1 698 (9,4)	2 416 (7,3)

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Ahmed, Tamblyn, Winslade						
3 or more visits	2 741 (15,2)	2 694 (8,1)				
Emergency Department Visits for asthma n (%)	1 313 (7,3)	1 644 (4,9)				
Hospitalization						
0 day	14 890 (82,7)	29 445 (88,4)				
1 day	1 340 (7,4)	2 072 (6,2)				
2 days	445 (2,5)	658 (2,0)				
3 or more days	1 338 (7,4)	1 118 (3,4)				
Co-Morbidity n (%)						
Depression	1 400 (7,77)	1 724 (5,2)				
Anxiety	1 913 (10,62)	2 361 (7,1)				
<ul> <li>* Around 1 % of missing values for each category; <u>All differences between RAMQ and Non-RAMQ insured</u> are significant, p&lt;0.01</li> <li>** Ambulatory and specialty care</li> </ul>						
Control Status and Recommendation Categories						
Among the 18 013 individuals who were RA	AMQ insured for prescription d	rugs, 9 <u>3</u> 4% were classified as well				
controlled and 7% as not well controlled ov	ver 3 months prior to the index	date (Figure 1).				

63 % of individuals who were not well controlled were in the  $\geq$  40 age group and 26% in the low SES category compared to 49% and 19%, respectively, in the well controlled group. These individuals also had a higher Charlson Co-morbidity Index of 2.11 as compared to 1.6 among those well controlled. A larger proportion of individuals among those not well controlled had a diagnostic code for depression, anxiety, mental illness, and a cardiac related condition. Among those not well controlled 69% (n=667) had at least 1

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#### Ahmed, Tamblyn, Winslade

ED visit (past 3 months), and 74% a medical visit associated with a respiratory problem (in the past year). In comparison 13% (n=2,039) of those well controlled had at least one ED visit and 52% medical visit related to a respiratory problem in the past year.

53% of patients in the not well controlled group had an active prescription for an ICS, 20% a combination therapy, and 14% as compared to 36%, 10%, and 6% in the well controlled group. 63% and 42% of not well and well controlled, respectively, had an active prescription for a fast-acting beta agonist (FABA). At index date 1, all individuals not well controlled had asthma drugs as compared to 9.2% of those well controlled who had no asthma drugs dispensed.

Table 2 presents the incremental regression coefficients for the demographic, healthcare utilization, and co-morbidity variables hypothesized to be associated with control status. Healthcare utilization including,  $\geq$ 3 days of hospitalization (OR=4.58), and  $\geq$  3 visits to the ED (for reasons other than a respiratory problem) (OR=2.32), was found to be most strongly associated with control status. Being male (OR=.85), from a low SES (OR= 1.9), and in the 40-59 age group increased the odds of having asthma that was not well

controlled.

 Table 2: Multivariable Logistic Regression Models for Identifying Individuals Controlled and Not Well

 Controlled

Variable

OR (95%CI)

Control Status

Reference

Age mean (sd)

≤ 17

		17	
Ahr	ned, Tamblyn,Winslade		
18-39	0.56 (0.44, 0.72)		
40-59	2.19(1.73, 2.77)		
≥ 60	1.19 (1, 1.42)		
Sex n (% female)			
Male	Reference		
Female	85 (.74, .98)		
Income n (%) *			
High SES	Reference		
Middle SES	1.44 (1.04, 1.98)		
Low SES	1.90 (1.35, 2.68)		
Healthcare Utilization over 1 year prior to March 15, 2008			
Medical Physician *Visits n (%)			
0 visit	Reference		
1 visit	.73 (.47,1.2)		
2 visits	.82 (.53,1.28)		
$\ge$ 3 visits	1.62 (1.162.27)		
Emergency Department Visits (other than resp)n (%)			
0 visit	Reference		
1 visit	1.38(1.14,1.66)		
2 visits	1.46(1.16,1.84)		
≥3 visits	2.32(1.94,2.8)		

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0 day	Reference
1 day	2.24(1.55,3.27)
2 days	2.88(1.79,4.6)
3 or more days	4.58 (3.36,6.22)
Co-Morbidity n (%)	
Charlson co-morbidity index	1.04 (1.01, 1.08)
Anxiety No	Reference
Yes	1.26 (1.05,1.52 )
* Concerned and estimate and encoded	

\* General practitioner and specialist

Recommendation category by control group

The distribution of individuals across recommendation categories is presented in Table 3.

For 8% (1198/15843) in control, and 21% (201/960) of those not well controlled, a recommendation could not be determined by the ADSS either because the patient 1) had dispensed prescriptions for an inappropriate combination of medications that the ADSS could not reconcile to provide an appropriate recommendation (e.g. a LABA with two prescriptions for combination therapy) or, 2) dispensed two medications that resulted in a duplication of therapy. For those not well controlled, those in the *duplicate/inappropriate* category had a larger proportion in the lower SES, a higher co-morbiditymorbidity index and more frequent ambulatory and hospital visits.

Among individuals well controlled, the largest proportion of individuals were in the *maintain treatment* category (50.6%), followed by *maintain/decrease treatment* (28.2%), and *decrease treatment* (2.7%).

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Almost all individuals not well controlled had the recommendation to increase treatment (88%) with a small proportion in the refer category (1%). Reasons for the low referral to specialty care needs to be closely examined, and may be related to uncertainty of primary care physicians of when to refer patients, and/or patients may not go see specialists once referred. [23] Regardless of the recommendation category, the largest proportion of individuals was in the 40-59 age group; except for maintain treatment that had a larger proportion of individuals in the 18-39 age group. The middle SES was the largest for all recommendation groups and the proportion of females was the same across all categories. Individuals in the refer category were on average older than those in the other categories, but comparable on many of the other characteristics.

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4.4	3: Comparison o ry recommendat		of individuals	in each recomm	endation categ	ory (based on		
12	ry recommendation	lion).						
13								
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18	In Control					Not Well Contro	olled	
19								
20	N=14989					N=1245		
<del>21</del> 22	Maintain	Maintain/Dec	Decrease	Duplicate/	Increase	Refer	Duplicate/	
		rease		Inappropriate	n=1 090	n=17	Inappropria	ite
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23 24 25 26 26 27 28		n=4349		n=602			n=138	ite
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23 24 25 26 27 28 29 Agg n (%) 31 32 ≤ 17 33 18-39 34 35 40-59 36 ≥ 60 37 \$\$\$\$\$\$ n (% F)	41,8 (19,2) 919 (9,6) 3 561 (37,2) 2 987 (31,2)	n=4349 38,2 (22,7) 1 115 (25,6) 996 (22,9) 1 269 (29,2)	44,8 (21,6) 74 (15,6) 86 (18,1) 195 (41,1)	n=602 45,9 (20,3) 68 (11,3) 123 (20,4) 260 (43,2)	40,4 (21,5) 189 (17,3) 310 (28,4) 372 (34,1)	57,1 (9,3) 0 0 10 (58,8)	n=138 46,6 (16,0) 6 (4,4 33 (23, 79 (57,	) 9) 2) 5)
23 24 25 26 27 28 29 Age mean (sd) 27 28 29 Age n (%) 31 32 ≤ 17 33 18-39 34 35 40-59 36 ≥ 60 37 \$98 n (% F) 39	41,8 (19,2) 919 (9,6) 3 561 (37,2) 2 987 (31,2) 2 097 (21,9)	n=4349 38,2 (22,7) 1 115 (25,6) 996 (22,9) 1 269 (29,2) 969 (22,3)	44,8 (21,6) 74 (15,6) 86 (18,1) 195 (41,1) 119 (25,1)	n=602 45,9 (20,3) 68 (11,3) 123 (20,4) 260 (43,2) 151 (25,1)	40,4 (21,5) 189 (17,3) 310 (28,4) 372 (34,1) 219 (20,1)	57,1 (9,3) 0 0 10 (58,8) 7 (41,2)	n=138 46,6 (16,0) 6 (4,4 33 (23, 79 (57, 20 (14,	) 9) 2) 5)
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23 24 25 26 27 28 29 Age mean (sd) 27 28 29 Age n (%) 31 32 ≤ 17 33 18-39 34 35 40-59 36 ≥ 60 37 \$98 n (% F) 39 1400 me n (%) * 41 Low SES 42 43 Middle SES	41,8 (19,2) 919 (9,6) 3 561 (37,2) 2 987 (31,2) 2 097 (21,9) 6 073 (63,5)	n=4349 38,2 (22,7) 1 115 (25,6) 996 (22,9) 1 269 (29,2) 969 (22,3) 2 659 (61,1)	44,8 (21,6) 74 (15,6) 86 (18,1) 195 (41,1) 119 (25,1) 303 (63,9)	n=602 45,9 (20,3) 68 (11,3) 123 (20,4) 260 (43,2) 151 (25,1) 381 (63,3)	40,4 (21,5) 189 (17,3) 310 (28,4) 372 (34,1) 219 (20,1) 709 (65,0)	57,1 (9,3) 0 0 10 (58,8) 7 (41,2) 12 (70,6)	n=138 46,6 (16,0) 6 (4,4 33 (23, 79 (57, 20 (14, 101 (73	) 9) 2) 5) ,2) 2)
23 24 25 26 27 28 29 Age mean (sd) 27 28 29 Age n (%) 31 32 ≤ 17 33 18-39 34 35 40-59 36 ≥ 60 37 \$\$\$\$\$ n (% F) 39 1460me n (%) * 41 Low SES 42	41,8 (19,2) 919 (9,6) 3 561 (37,2) 2 987 (31,2) 2 097 (21,9) 6 073 (63,5) 1 684 (17,6)	n=4349 38,2 (22,7) 1 115 (25,6) 996 (22,9) 1 269 (29,2) 969 (22,3) 2 659 (61,1) 923 (21,2)	44,8 (21,6) 74 (15,6) 86 (18,1) 195 (41,1) 119 (25,1) 303 (63,9) 117 (24,7)	n=602 45,9 (20,3) 68 (11,3) 123 (20,4) 260 (43,2) 151 (25,1) 381 (63,3) 156 (25,9)	40,4 (21,5) 189 (17,3) 310 (28,4) 372 (34,1) 219 (20,1) 709 (65,0) 237 (21,7)	57,1 (9,3) 0 0 10 (58,8) 7 (41,2) 12 (70,6) 4 (23,5)	n=138 46,6 (16,0) 6 (4,4 33 (23, 79 (57, 20 (14, 101 (73) 43 (31,	) 9) 2) 5) ,2) 2) 2)

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48 49

50 51

52 53 All

Ambulatory

Hospitalized

8,78 (13,1)

7,72 (9,6)

1,07 (6,8)

9,68 (13,8)

8,31 (9,2)

1,37 (7,7)

12,62(13,3)

10,89 (9,5)

1,73 (7,4)

- 57
- 58
- 59

16,52 (22,2)

13,53(15,0)

2,99 (11,6)

29,29 (21,3)

19,94 (10,0)

9,35 (16,4)

24,99 (26,1)

20,01 (18,1)

4,98 (13,3)

12,87(13,4)

11,13 (9,5)

1,73 (7,6)

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<del>10</del> 11		In Control					Not Well Contr	olled
12		N=14989					N=1245	
-13								
14		Maintain	Maintain/Dec rease	Decrease	Duplicate/ Inappropriate	Increase	Refer	Duplicate/ Inappropriate
15						n=1 090	n=17	
16 17		n=9564	n=4349	n=474	n=602			n=138
18								
Med	lical Visits n (	%) past year						
	<del>ycisian<mark>Physician</mark></del>							
21 22	0 visit	1 036 (10,8)	265 (6,1)	14 (3,0)	22 (3,6)	62 (5,7)	0	7 (5,1)
22								
24	1 visit	1048 (10,96)	451 (10,4)	31 (6,5)	40 (6,6)	76 (7,0)	0	5 (3,6)
25	2 visits	1000 (10,5)	486 (11,2)	41	26 (4,3)	81 (7,4)	0	2 (1,4)
26				(8,6)				
27 28	o					074 (70.0)	17 (100)	
29	3 or more visits	6 480 (67,8)	3 147 (72,4)	388 (81,9)	514 (85,4)	871 (79,9)	17 (100)	124 (89,9)
30	ER							
31 32	0 visit	5 995 (62,7)	2 501 (57,5)	240 (50,6)	289 (48,0)	200 (18,4)	1 (5,9)	25 (18,1)
33 34	1 visit	1 565 (16,4)	790 (18,2)	89 (18,8)	118 (19,6)	221 (20,3)	3 (17,6)	21 (15,2)
35	2 visits	846 (8,8)	414 (9,5)	59 (12,4)	63 (10,5)	172 (15,8)	1 (5,9)	9 (6,5)
36 37	3 or more visits	1 158 (12,1)	644 (14,8)	86 (18,1)	132 (21,9)	497 (45,6)	12 (70,6)	83 (60,2)
38								
39 5410	for respiratory pr	oblems				I		
41		8 781 (91,8)	3 792 (87,2)	394 (83,1)	491 (81,6)	294 (27,0)	4 (23,5)	38 (27,5)
42 43	1 vicit	F02 (C 2)	402 (0.2)	F2 (11 0)	CA (10 C)	450 (41.2)	4 (22 5)	27 (10 C)
43 44	1 VISIL	593 (6,2)	402 (9,2)	52 (11,0)	64 (10,6)	450 (41,3)	4 (23,5)	27 (19,6)
45	2 visits	142 (1,5)	105 (2,4)	15 (3,2)	25 (4,2)	188 (17,2)	3 (17,65)	22 (15,9)
46 47	3 or more visits	48 (0,5)	50 (1,2)	13 (2,7)	22 (3,7)	158 (14,5)	6 (35,3)	51 (37,0)
47								
	NOT for respirato	ry problems						
51		6 268 (65,5)	2 712 (62,4)	265 (55,9)	326 (54,2)	456	4 (23,5)	45 (32,6)
52								
53								

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10		In Control					Not Well Control	led
11 12		N=14989					N=1245	
12								
14		Maintain	Maintain/Dec rease	Decrease	Duplicate/ Inappropriate	Increase	Refer	Duplicate/ Inappropriate
15 16						n=1 090	n=17	
17		n=9564	n=4349	n=474	n=602			n=138
-18						(41,8)		
19 20	1 vicit	1 535 (16,1)	742 (17,1)	94 (19,8)	118 (19,6)	205 (18,8)	3 (17,6)	29 (21,0)
21								
22	2 visits	746 (7,8)	370(8,5)	49 (10,3)	58 (9,6)	117 (10,7)	3 (17,6)	14 (10,1)
23 24	3 or more visits	1 015 (10,6)	525 (12,1)	66 (13,9)	100 (16,6)	312 (28,6)	7 (41,2)	50 (36,2)
25	Hospitalization							
26 27	0 day	8 046 (84,1)	3 581 (82,3)	356 (75,1)	449 (74,6)	774 (71,0)	5 (29,4)	78 (56,5)
28	1 day	697 (7,3)	318 (7,3)	39 (8,2)	62 (10,3)	100 (9,2)	3 (17,6)	17 (12,3)
29		,		,				
30 31	2 days	215 (2,2)	107 (2,5)	20 (4,2)	23 (3,8)	44 (4,0)	1 (5,9)	3 (2,2)
32	3 or more days	606 (6,3)	343 (7,9)	59 (12,4)	68 (11,3)	172 (15,8)	8 (47,1)	40 (29,0)
	oitalization- for re	spiratory problem	ns					
34 35	0 day	9 370 (98,0)	4 210 (96,8)	447 (94,3)	563 (93,5)	990 (90,8)	14 (82,4)	109 (79,0)
36	1 day	100 (1,0)	60 (1,4)	7 (1,5)	20 (3,3)	33 (3,0)	0	7 (5,1)
37		,		,				
38 39	2 days	32 (0,3)	32 (0,74)	4 (0,8)	5 (0,8)	14 (1,3)	0	3 (2,2)
40	3 or more days	62 (0,6)	47 (1,1)	16 (3,4)	14 (2,3)	53 (4,9)	3 (17,6)	19 (13,8)
41 42								
	ma Medications	mean (sd) range j	oast year					
44	FABA	0,61 (1,7)	2,93 (3,8)	4,32 (5,2)	4,95 (5,1)	2,50 (4,4)	5,00 (5,2)	6,82 (6,8)
45 46								
40 47	ICS	0,2 (0,7)	2,3(2,9)	1,4(2,6)	3,6(3,8)	1,4(2,4)	0,9 (1,7)	3,5(3,9)
48	Leukotrienes	0,1 (1,4)	0,4(3,0)	6,7(10,0)	1,5 (4,8)	0,8(4,4)	3,3(5,1)	3,9 (11,5)
49 50	Combination	0,0 (0,4)	1,2 (2,9)	5,1(4,9)	2,18 (3,9)	1,0 (2,7)	7,7 (4,5)	3,0 (4,3)
51	Therapy							
52						i.		

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10 11	In Control					Not Well Contro	lled
12	N=14989					N=1245	
<u>13</u> 14 15	Maintain	Maintain/Dec rease	Decrease	Duplicate/ Inappropriate	Increase n=1 090	Refer n=17	Duplicate/ Inappropriate
16 17	n=9564	n=4349	n=474	n=602			n=138
18 19 Other	0,2(1,8)	0,8(3,4)	2,9(6,8)	2,36 (3,9)	1,8(17,0)	2,1 (2,5)	4,45 (6,6)
ଉଦ୍ୟtrol Status n (%) 21					1		
22 Overuse FABA		0	0	0	1 (0,1)	0	0
23 ER visits for Asthma 24	0	0	0	0	1 076 (98,7)	17 (100)	135 (97,8)
25 ER or FABA		0	0	0	1 076 (98,7)	17 (100)	135 (97,8)
26 Co-Morbidity Index	1,6 (1,5)	1,6 (1,5)	1,8 (1,6)	1,9 (1,9)	1,8(2,0)	2,2 (1,4)	2,6 (2,5)
-28 29	Less than 1 % c	of missing values	for each categ	gory			
30       •         31       32         33       34         35       36         37       38         39       40         41       42         43       44         45       46         47       48         49       50         51       52         53       54         55       56         57       58	ED=emergency	r department					



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### DISCUSSION

The purpose of this study was to evaluate the discrepancy between current asthma management and recommended guidelines using the provincial administrative databases and an ADSS. The present study represents an example of how decision support systems can be used to monitor guideline adherence, and to identify individuals at risk of poor outcomes to provide targeted interventions. To our knowledge this is the first time that a decision support system has been used to evaluate disease management at a population level.

As expected, individuals who were provincially insured were on average older, from a lower SES, and a higher proportion used healthcare services. A larger proportion compared to those non-provincially insured also had a diagnosis code for anxiety and depression.

The algorithms used to identify individuals with asthma and evaluate control status were validated in previous work. [24, 25] The majority of individuals well controlled were on an appropriate quantity of asthma treatment. We found, however, that ~ 31% of those well controlled could benefit from a medication review and potentially lower doses of asthma medications.

The majority of individuals not well controlled had the recommendation to increase treatment and for these individuals there was an opportunity to change therapy according to the existing guidelines. [26] The SMART inhaler helps address needs for increase in therapy, as it allows patients to use their as-needed

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medication because of declining asthma control—as is very often the case—evolving exacerbations will possibly be treated at an early stage and a further worsening of asthma may possibly be prevented. The SMART inhaler is not a recommended yet part of Canadian guidelines, however, with emerging evidence of its benefits for marinating control compared to other alternatives, [27, 28] it will be included in the next version of guidelines and become more commonly prescribed for Canadian patients. Individuals who were not well controlled were in the 40-59 age range, and had a more complex health profile with greater comorbidity, including a higher proportion with a diagnosis of anxiety or depression as compared to those well-controlled. The logistic regression analysis in our study also supported these conclusions. These individuals represent a more vulnerable sub-group of the asthma population, and place a greater burden on the healthcare system given the higher proportion that had an ED visit or hospitalization. As such, they require closer monitoring and review of medication to reach doses sufficient to maintain asthma control, or to review reasons for failed treatment.

In this study we were not able to generate a recommendation for a larger proportion of individuals not well controlled compared to controlled either because they were dispensed prescriptions for an inappropriate combination of medications that the ADSS could not reconcile to provide an appropriate recommendation, or they were dispensed two medications that resulted in a duplication of therapy. These cases in themselves represent a segment of the asthma population that requires closer review of their prescribed medication.

The generation of asthma recommendations at a population level using an administrative database allows individuals not receiving treatment based on guidelines to be identified. We found that many individuals

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with non-controlled asthma visit a physician 3 or more times per year, and potentially represent missed
opportunities to optimize treatment. Possible reasons for our findings may include the lack of knowledge of
PCPs of guidelines in general, especially for more complicated cases. It may also be, however, that patients
are not going to see the same physician, or are switching physicians to ensure access to SABAs. In such
situations, physicians may be reluctant to conduct a complete medication review if they do not perceive
themselves as the primary provider for the patient.
Other physician concerns may be the reluctance to prescribe ICS and/or concern regarding polypharmacy
with multiple inhalers. [29] This is where the role of pharmacists is important as they can see individuals'
entire medication dispensing history and have been shown to be effective in managing asthma patients in
particular if supported by an ADSS. [30]
Previous studies have also found that physicians do not adopt guidelines in their practice because of
perceived appropriateness of the guidelines. [13, 31] Surveys have shown that they believe that guidelines
do not take into account the heterogeneity of asthma and do not account for individual patient variations
in response to treatment, [32] and other factors that impact response to asthma therapy such as age and
co-morbidities.
Further, patient non-adherence to prescribed therapy and not having prescribed medications filled may
also explain the findings from our study. Patient beliefs about the negative impact and benefits of their

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medications, [33] their confidence to manage their asthma, and not seeking care early enough to prevent exacerbations have all been identified as contributors to poor outcomes for asthma. [34]

Mechanisms to identify patients who need closer follow-up and evaluation have been identified as an important need for primary healthcare. [3, 34, 35] Future initiatives can include linking administrative databases to decision support systems that can help identify individuals who need closer monitoring and follow-up and allow for targeted services such as visit reminders sent to patients or to their care provider. The ongoing implementation of electronic health records and patient health portals will facilitate this approach. Information can be fed back to physicians and pharmacists to improve patient management, and initiate care early on, before individuals experience deteriorations in health.

#### Conclusions

This study demonstrated how a decision support system linked to an administrative database could be used to identify individuals in the population that require a review of asthma treatment. Such an approach can help identify individuals with uncontrolled asthma or prescriptions that deviate from recommended treatment to intervene early. This study provides a model for monitoring adherence to guidelines for other chronic conditions such as hypertension and diabetes.

### Limitations

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Our approach for ide	entifying individuals with asthma and assessing asthma status may have
underestimated the	percentage out of control in our study. We examined asthma control on two index
	k 3 months prior to the index date to assess control status. A more sensitive algorithm
that treats control a	s a time varying covariate would likely provide a more accurate evaluation of control
status.	
Also, our estimation	of the percentage of well-controlled individuals may be an overestimate compared to
previous studies bec	cause of our method of defining asthma control. A previous study conducted in the UK,
[36] and another usi	ng a US administrative database [37] assumed 2 puffs of a SABA per day, the equivalent
<u>of 180 puffs over 3 r</u>	nonths, would be the threshold for asthma control. With this measure of asthma
control the authors	reported 72% of patients were well controlled in the UK study and 56% in the US study.
This estimate is subs	stantially below the measure of 250 puffs we used in this study, and likely explains why
we found a larger pr	oportion of individuals who were well controlled.
Also, because we us	ed administrative data and not clinical information from an electronic medical record
to generate recomm	endations, we were not able to use asthma severity and relapse as part of the asthma
<u>control algorithm. Tr</u>	wo previous studies used composite measures of asthma control including (1) no
recorded hospital at	tendance for asthma (including admission or emergency department visit, out of hours,
or outpatient depart	tment attendance); (2) no prescription for oral corticosteroid; and (3) no consultation,
hospital admission, o	or emergency department attendance for lower respiratory tract infection requiring
antibiotics. [36, 37]	With this more stringent definition of asthma control they found proportions of well-
controlled asthma co	ontrol to be 72% [36], and 56% [37]which are lower compared the 94% were found to
<u>be well-controlled ir</u>	<u>i our study.</u>

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addition, at the time that the ADSS was being developed, the SMART treatments, that allow for the same haler to be used as a preventative and rescue inhaler were not commonly used or part of the guidelines. erefore, they were not programmed as part of the ADSS and not included in the recommendations. rther, the ADSS does not distinguish between SABA nebulizer and MDI. Finally, use of decision support

ring clinical encounters allow for a patient-reported assessment of symptoms at the time when usessi. commendations are generated, and allow for a more accurate assessment of asthma control. We were so limited to generating recommendations for those provincially insured that represent a more

Inerable segment of the population.

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Alexand Tranklus Müsslada
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SA RT and NW were involved in:
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- drafting the article and revising it critically for important intellectual content,
- final approval of the version to be published.
Competing Interests
Competing Interests No competing interests
Data Sharing Statement
Additional data regarding the study sample characteristics and guidelines generated from the decision
support system can be provided upon request from the corresponding author.
support system can be provided upon request from the corresponding author.

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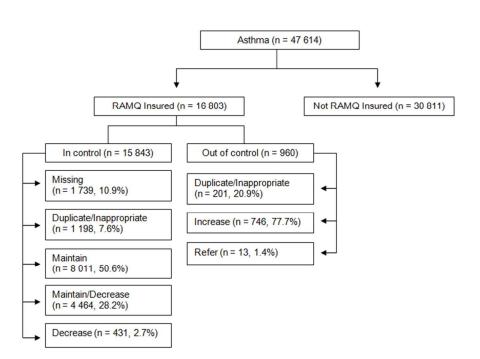
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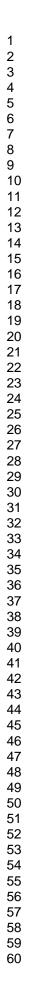
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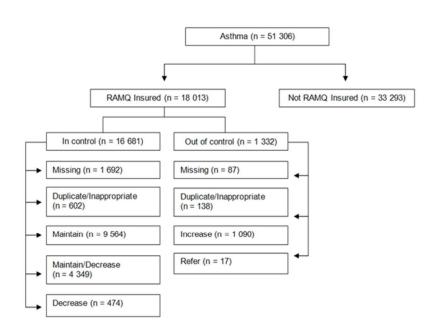
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254x190mm (300 x 300 DPI)





Study Population and recommendation categories for March 15, 2008 (index date 2) 110x71mm (300 x 300 DPI)