BMJ Open

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| Journal: | *BMJ Open* |
| Manuscript ID | bmjopen-2017-015877 |
| Article Type: | Research |
| Date Submitted by the Author: | 10-Jan-2017 |
| Complete List of Authors: | Winslade, Nancy; McGill University, Medicine<br>Tamblyn, Robyn; McGill University, Department of Medicine and Department of Epidemiology and Biostatistics |
| Primary Subject Heading: | Health services research |
| Secondary Subject Heading: | Health policy, Cardiovascular medicine, Evidence based practice |
| Keywords: | Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Hypertension < CARDIOLOGY, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT |
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# Determinants of Community Pharmacists' Quality of Care: A Population-Based Cohort Study Using Pharmacy Administrative Claims Data

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**Abstract**

**Objective:** To determine if a prototype pharmacists' services evaluation program that uses linked community pharmacy claims and health administrative data to measure pharmacists' performance can be used to identify characteristics of pharmacies providing higher quality of care.

**Design:** Population-based cohort study using community pharmacy claims from November 1, 2009 to June 30, 2010.

**Setting:** All community pharmacies in Quebec, Canada.

**Participants:** 1742 pharmacies dispensing 8,655,348 antihypertensive prescriptions to 760,700 patients.

**Primary outcome measure:** Patient adherence to antihypertensive medications.

**Predictors**: Pharmacy-level: dispensing workload, volume of professional services, location, banner/chain, pharmacist overlap, within-pharmacy continuity of care. Patient-level: sex, age, income, patient prescription cost, new/chronic therapy, single/multiple antihypertensives, single/multiple prescribers and single/multiple dispensing pharmacies. Dispensing level: duration of prescription, time of day dispensed, antihypertensive class. Multivariate alternating logistic regression estimated predictors of the primary outcome, accounting for patient and pharmacy clustering.

**Results**: 9.2% of dispensings of antihypertensive medications were provided to non-adherent patients. Male sex, increasing age, new treatment, multiple prescribers and multiple dispensing pharmacies were risk factors for increased non-adherence. Pharmacies who provided more professional services for their clientele were less likely to have non-adherent hypertensive patients (OR: 0.60; 95% CI: 0.57-0.62) as were those with better scores on the Within-Pharmacy Continuity of Care Index©. Neither increased pharmacists' services specifically for improving antihypertensive adherence per se nor increased pharmacist overlap impacted the odds of non-adherence. However, pharmacist overlap was strongly correlated with dispensing workload. There was significant unexplained variability among pharmacies belonging to different banners and chains.

**Conclusions:** Pharmacy administrative claims data can be used to calculate pharmacy-level characteristics associated with improved quality of care. This study supports the importance of professional services and continuity of pharmacist's care.

**Strengths and limitations of this study:**

1. The trial directly measured community pharmacy characteristics using pharmacy claims and health administrative data.
2. The primary quality of care outcome used a standardized method for measuring patient adherence to medications.
3. The trial was population-based and included a large sample of dispensings from community pharmacies in Quebec.
4. Performance on only one quality of medication-use indicator was evaluated and results may not apply to additional measures of pharmacists' quality of care.
5. Administrative data are limited in the extent to which they can measure services provided by pharmacists that were not billed.

Green Shield Canada Foundation and the Quebec Order of Pharmacists supported this work.

## INTRODUCTION

**Background**:

Misuse of prescription medications, ranging from inappropriate prescribing to patient non-adherence, remains a significant and costly challenge to health systems around the world (1). The medication-related expertise and accessibility of community pharmacists has led policy-makers to re-evaluate the role community pharmacists play in managing medication misuse (2, 3). Emphasis has been placed on both the care provided by pharmacists as part of medication-dispensing and expansion of pharmacists' scope of practice to provide professional services that aim to decrease specific medication-misuse problems (4, 5). Although research has shown that care provided by community pharmacists can improve patient's medication use, in daily practice community pharmacists struggle to incorporate patient care services into the myriad of technical demands of drug distribution (6, 7). As a result, payers continue to seek evidence of the real-world impact of pharmacists' services in decreasing medication misuse (4, 8, 9). To improve the quality of care provided by community pharmacists requires methodologies to systematically measure the quality and outcomes of care provided and the pharmacy-level characteristics that optimize best practice (10). As community pharmacists are responsible for ensuring that dispensed medications are safe and effective for patients, and that patients take their medications as prescribed, quality indicators have been defined that standardize the method of measuring safe medication use and patient adherence (11). Developments in the use of community pharmacy administrative claims data have enabled the measurement of both pharmacy-level performance on these pharmacy quality indicators and the impact of targeted pharmacists' services (12-14).

More problematic has been the determination of pharmacy-level characteristics that consistently support high levels of pharmacists' performance on these standardized quality indicators. Pharmacy characteristics such as workload, continuity of care, culture, workflow and overlap of pharmacists have been evaluated through primarily surveys and self-report, and with varying definitions of quality performance (15-17). The few studies that used the standardized quality measures utilized an ecologic approach to estimate pharmacy characteristics by determining a population-based quality metric in the geographical area and then assigning these population-based results to all pharmacies within that area (18-

20). The resulting ecological bias has limited the ability to identify pharmacy characteristics associated with quality care (21). More robust methodologies are needed to measure the actual characteristics of not only the pharmacy, but of the individual medication dispensing and the patient receiving the medication. This enables comparisons between pharmacies to be adjusted for differences in patient and dispensing characteristics that affect performance (22).

One potentially powerful option is to use pharmacy administrative claims data to measure salient pharmacy characteristics such as pharmacist workload or overlap. To date use of such data has been limited to identifying whether the pharmacy is a chain or independent, and the volume of dispensing (20, 23). This is primarily due to challenges in using the large volume of pharmacy administrative data to create accurate measures, as well as challenges to date to link pharmacy claims data to other health administrative databases to obtain information on patient and pharmacy characteristics. Increasingly, these linkages among administrative databases have been enabled through interest by payers in monitoring performance and researchers in conducting population-based studies (24, 25).

The objective of this trial was to determine if a prototype pharmacists' services evaluation program that uses linked pharmacy administrative claims and health administrative data to measure pharmacists' performance can be used to identify characteristics of pharmacies providing higher quality of care.

## METHODS

**Setting:** This study was conducted in Quebec, the second largest province in Canada, with a population of 8 million patients of whom approximately 3.5 million receive government support for payment of their medications via the Régie de l'Assurance Maladie du Québec (RAMQ). Like many healthcare systems around the world, all provinces across Canada maintain central, electronic databases of information about medications dispensed and professional pharmacists' services provided. For reimbursement of pharmacists' services, the RAMQ requires the following information: the date, hour, drug identification number, therapeutic drug class, format, strength, quantity, duration of treatment, type of pharmacist service provided (e.g. dispensing, refusal to dispense, recommendations for changes in

therapy), the reason for the service (e.g. previous adverse effect or management of under-use of antihypertensive medications), and costs to RAMQ, the patient and for the overall prescription. All data are coded in a standardized format that can be linked to other health administrative data using unique encrypted identifiers for patients, prescribers, pharmacists and pharmacies. For patients, age, sex and postal code depicting the geographic location of the patient's residence are maintained. Postal code is linked to the average household income in the patient geographic area based on Statistics Canada census data (approximately 466 households per area). For pharmacies, the location (e.g. shopping centre), and type of pharmacy (independent or not) are maintained, along with the specific chain or banner to which the pharmacy belongs.

**Study Design:** A population-based prospective cohort of patients was assembled for whom Quebec pharmacists billed for dispensings of antihypertensive medications or provision of pharmacists' professional services between November 1, 2009 to June 30, 2010. Each time there was a dispensing for an antihypertensive medication, non-adherent patients were identified if they had received less than 80% of the prescribed amount of the same drug in the 90 days prior to the dispensing. Using dispensing as the unit of analysis, characteristics of each dispensing of the antihypertensive medication, the patient receiving the medication and the pharmacy where the medication was dispensed were measured using linked administrative claims data. Multi-level analysis was used to identify predictors of dispensing to a non-adherent patient allowing adjustment for clustering of dispensings and patients within pharmacies.

**Participants:** All 1891 pharmacies in Quebec were included unless they opted out of participating, were open for less than 61 days, or had dispensed >165,317 prescriptions over the eight-month study period. Cut-offs for these exclusion criteria were determined by identifying outliers with Z-scores >2.5 (26). Shorter open-days were removed as these pharmacies did not have sufficient data for reliable calculation of characteristics. Very high dispensing volumes indicated pharmacies that were not representative of traditional community pharmacy practice in Quebec. We had sufficient sample size to have 90% power to detect a difference in antihypertensive adherence of 5% for most potential predictors.

**Primary Outcome:** Dispensing of antihypertensive medications to non-adherent patients was the primary quality of care outcome. For each dispensing, we created a record of all dispensings of the same antihypertensive medication to the same patient from all pharmacies in Quebec over the previous 180 days. Using the number of days of supply of each medication and adjusting for early refills, we calculated the number of days of medication the patient had received over the previous 90 days. If they had received less than 72 days' supply (80%), then the dispensing was considered to be to a non-adherent patient.

**Potential Predictors: Dispensing-level characteristics** included the type of antihypertensive medication dispensed, the total cost and the cost to the patient of the prescription as these have been demonstrated to affect patient compliance (27). Additional characteristics related to constructs hypothesized to affect patient compliance such as the duration of medication supplied. Although in Quebec the standard supply of medications is for 30 days, patients who are felt to be at risk for non-adherence can receive weekly medication supply and patients stabilized on chronic therapies can receive 90 day supplies. Compliance was, therefore, expected to be worse for patients receiving less than 30 days' supply and better for patients receiving more than 30 days' supply.

**Potential Predictors: Patient-level characteristics** were those known to affect compliance such as sex, age and income, with older males and patients with higher income anticipated to be more compliant (20, 28). As our previous work indicated that patients new to antihypertensive therapy are less compliant as are those on single drug therapy, these variables were also included (13). Since continuity of care has been shown to improve medication adherence, we included variables specifying whether the patient had received all antihypertensive medications from the same pharmacy and the same physician over the previous 6 months (29-31).

**Potential Predictors: Pharmacy-level characteristics** included workload in terms of number of prescriptions dispensed as higher workload has been identified by community pharmacists as a factor limiting their ability to provide professional services (32) and a factor predisposing to dispensing errors (15, 17, 33). Various measures have been reported to

represent workload ranging from prescriptions dispensed per year, which can readily be determined from administrative claims data, to prescriptions per pharmacist per hour, which to date has only been reported using survey / self-reported estimates (17). We received from RAMQ the total number of billings and number of open days for each pharmacy over the 8-month study period and we used the administrative claims data received to calculate for each pharmacy, the average open hours per day, the average number of pharmacists billing per hour and the average number of prescriptions dispensed per hour. This allowed us to calculate the average number of prescriptions dispensed per pharmacist per hour using the community pharmacy administrative data rather than relying of self-reports. Related to workload, evidence suggests that having two or more pharmacists scheduled during busy times of the day enables one pharmacist to focus in an uninterrupted manner on the more cognitively demanding tasks of medication review (16, 34). Using the administrative claims data for each pharmacy we created a measure of pharmacist-overlap, calculating the average percent of each pharmacy's open hours where more than one pharmacist was billing (Pharmacist Overlap Index©). Finally, as care from the same pharmacist has been hypothesized to be important in creating the trusting, professional relationships required for good medication use (35), we determined the likelihood that a patient would be cared for by the same pharmacist on multiple visits to the pharmacy. To measure this, we calculated a Within-pharmacy Continuity of Care Index© by determining, for each pharmacy, the total number of pharmacists working over the 8-month study period (weighted to emphasize differences in high and low numbers of pharmacists) and divided this by the average number of pharmacists working per day at that pharmacy. The lowest value of the index is 1, which represents the best within-pharmacy continuity of care. This occurs when there is only one pharmacist working over the study period and this same pharmacist is working each day, thereby reflecting the greatest likelihood that the patient would receive care from the same pharmacist. To determine the culture within the pharmacy regarding emphasis on providing professional services, we calculated the total number of pharmacists' services billed per 100 prescriptions dispensed over the 8-month period. We also counted the number of pharmacists' services billed for management of under-use of antihypertensive medications.

**Data sources/ measurement:** As part of a previously reported randomized controlled trial, baseline anonymized community pharmacy administrative claims data for all dispensings of antihypertensive medications and pharmacist services were received from RAMQ for all Quebec community pharmacies for the period of October 1, 2008 to June 30, 2010 (14). Data for the 8-month period of November 1, 2009 to June 30, 2010 were used to calculate dispensing, patient and pharmacy-level characteristics and estimate determinants of non-adherence. Data from February 1, 2009 to November 1, 2009 was used to determine whether early dispensings were provided to a patient who: was within the first 6 months of therapy; was taking multiple antihypertensives, or; had multiple physicians prescribing or multiple pharmacies dispensing their antihypertensive medications in the previous 6 months.

**Control for Potential Bias:** Patient, pharmacy, pharmacy chain/banner group, pharmacist and prescriber identifiers were anonymized by RAMQ prior to data transfer to the research group. The McGill University Faculty of Medicine Institutional Review Board provided ethics approval.

**Statistical Methods:** Descriptive statistics summarized the characteristics of the dispensings, patients and pharmacies including the incidence of dispensing to non-adherent patients by type of antihypertensive, patient sex and age. Multivariate alternating logistic regression (ALR) was used to estimate the association among the dispensing, patient and pharmacy-level characteristics and non-adherence. All analyses were completed using SAS, version 9.4 (SAS Institute, Cary, North Carolina), with ALR using PROC GENMOD. Where multiple measures could be calculated to reflect a single construct, results for each measure were first compared with previously reported estimates (if available) to test the accuracy of the calculations. Next each measure was tested individually for association with non-adherence. For each construct, a single measure was selected for inclusion in the analysis based on the accuracy of the calculation, the strength of evidence supporting its use and the strength of association. Collinearity was evaluated for all variables considered for inclusion in the final analysis using the variance inflation factor. When collinearity was present, variables that were calculated as interim steps were considered for exclusion and the

variables retained were those that most directly measured the constructs of interest. To account for interactions between patient income and the cost of the medication to the patient, we divided both variables into low, medium and high categories and created dummy variables for each of the nine possible interactions, setting low income and low cost to the patient as the reference (36).

## RESULTS

**Study Participants:** 1872 pharmacies were enrolled in the study, after 19 (1%) opted out (Figure 1, Consort diagram). Ninety-one pharmacies open for < 61 days and 39 additional pharmacies dispensing >165,317 prescriptions over the 8-month period were removed from the analysis. 8,655,348 dispensings of antihypertensive medications to 760,700 patients in 1742 pharmacies were evaluated.

**Population Characteristics:** Angiotensin-receptor blockers (ARB) were the most commonly dispensed antihypertensive medications (23.2% of dispensings) with <1% of dispensings for each of alpha agonists, alpha blockers, potassium sparing diuretics and vasodilators (Table 1). Most prescriptions were dispensed in the morning and were for an approximate one-month duration. 74.1% of patients were prescribed their antihypertensive medications by a single physician and 86.0% went to a single pharmacy for all their antihypertensive medications over the previous six months. Most patients had been taking antihypertensive medications for more than six months (98.5%) and were on multiple antihypertensive medications (79.4%). The majority of pharmacies were either chains or banners (89.9%). Information on the distribution of pharmacies among the various chains and banners was supressed as it was anticipated that this information could unblind the identity of one or more chains. Pharmacists dispensed an average 18.4 prescriptions per pharmacist per hour, billing for 0.18 professional services for every 100 prescriptions dispensed. Most pharmacies did not have any billings for pharmacists' services for antihypertensive non-adherence, leading to an average of less than 1 billing over the 8 months (0.35 +/- 1.8). Pharmacies had more than 1 pharmacist billing for 15.5% of their open hours and an average of 9 different pharmacists worked in each pharmacy over the 8-month study period.

**Table 1. Characteristics of prescriptions dispensed, patients and their pharmacies.**

| Level of Characteristic | N (%) |
|---|---|
| **Dispensed Prescription Level (n=8,655,348)** | |
| **Time of Day Dispensed** | |
| Morning (>8-noon) | 4,273,894 (49.4%) |
| Afternoon (>noon-16) | 3,141,594 (36.3%) |
| Evening (>16-20) | 1,065,102 (12.3%) |
| Overnight (>20-8) | 174,758 (2.0%) |
| **Number of Days of Medication Supplied** | |
| <10 days | 180,524 (2.1%) |
| 10-32 days | 8,241,026(95.2%) |
| >32 days | 233,798 (2.7%) |
| **Type of Antihypertensive Medication Dispensed** | |
| ARB | 2,004,146 (23.2%) |
| Beta Blockers | 1,853,835 (21.4%) |
| Calcium Channel Blockers | 1,828,320 (21.1%) |
| ACE Inhibitors | 1,391,246 (16.1%) |
| Thiazide diuretics | 672,041 (7.8%) |
| Loop diuretics | 368,466 (4.3%) |
| Diuretic combinations | 184,101 (2.1%) |
| Other diuretics | 145,051 (1.7%) |
| Alpha Agonists | 74,278 (0.9%) |
| Alpha Blockers | 68,367 (0.8%) |
| Potassium sparing diuretics | 56,693 (0.7%) |
| Vasodilators | 8,804 (0.1%) |
| **Cost** | **Mean (SD)** |
| Total cost of the prescription | $28.36($17.48) |
| Cost to the patient of the prescription | $8.55 ($8.56) |
| **Pharmacy Client Level[†] (n-760,700)** | |
| **Sex** | |
| Female | 4,858,885 (56.1%) |
| Male | 3,800,463 (43.9%) |
| **Age** | |
| < 65 years | 2,055,518 (23.8%) |
| 65-69 | 1,595,657 (18.4%) |
| 70-79 | 3,106,633 (35.9%) |
| >79 | 1,897,540 (21.9%) |
| **Income** | |
| Low (<$31,700) | 647,805 (7.5%) |
| Middle ($31,700-$80,000) | 7,096,041 (82.0%) |
| High (>$80,000) | 911,502 (11.5%) |
| **Antihypertensive Therapy** | |
| New Therapy (< 6 months) | 126,812 (1.5%) |
| Chronic Therapy (≥6 months) | 8,528,536 (98.5%) |
| Single Antihypertensive Drug | 1,782,490 (20.6%) |
| Multiple Antihypertensive Drugs | 6,872,858 (79.4%) |
| **Continuity of Care** | |
| Single Pharmacy Dispensed antihypertensives over previous 6 months | 7,440,825 (86.0%) |
| Multiple Pharmacies Dispensed antihypertensives over previous 6 months | 1,214,523 (14.0%) |
| Single Prescriber of antihypertensives over previous 6 months | 6,412,928 (74.1%) |
| Multiple Prescribers of antihypertensives over previous 6 months | 2,242,420 (25.9%) |

[†]Considering all patients who received eligible dispensings over 8 months' follow-up.

| **Community Pharmacy Level (n=1742)** | |
|---|---|
| **Pharmacy Type** | **N (%)** |
| Chain/banner | 1,566 (89.9%) |
| Independent | 176 (10.1%) |
| **Pharmacy Location** | |
| Neighborhood pharmacy | 457 (26.2%) |
| Shopping Centre | 281 (16.1%) |
| Medical Clinic | 283 (16.2%) |
| Other | 53 (3.1%) |
| Missing | 668 (38.3%) |
| **Professional Services Provided over 8 months** | |
| Total pharmacist services billed per 100 prescriptions | |
| <0.12 | 544 (31.2%) |
| 0.13-0.2 | 588 (33.8%) |
| >0.2 | 610 (35.0%) |
| Recommendations for non-adherence with antihypertensive medications | |
| 0 | 1485 (85.3%) |
| 1-5 | 237 (13.6%) |
| 6-10 | 17 (0.1%) |
| >10 | 3 (0.2%) |
| **Workload** | **Mean (SD)** |
| Total prescriptions dispensed over 8 months | 53,308 (36,749) |
| Total days open over 8 months | 214 (42.8) |
| Hours open per day | 14.4 (3.3) |
| Pharmacists working/day | 1.8 (0.7) |
| Pharmacists working/hour | 1.1 (0.1) |
| Prescriptions dispensed/day | 244.6(156.6) |
| Prescriptions dispensed/hour | 20.5 (13.0) |
| Prescriptions dispensed/pharmacist/hour | 18.4 (10.5) |
| **Pharmacist Overlap Index©** (average percent of open hours with >1 pharmacist) | 15.48 (9.14) |
| **Within Pharmacy Continuity of Care** | |
| Distinct Pharmacists employed over 8 months | 9.0 (6.7) |
| Within Pharmacy COC Index© (weighted # of pharmacist in 8 months/# pharmacists per day) | 17.3 (20.1) |

**Non-adherence:** Over eight months, 9.2% of all dispensings of antihypertensive medications were provided to non-adherent patients (795,031 of 8,655,348 dispensings) (Table 2). These dispensings were provided to 760,700 distinct patients, 31% of whom were non-adherent to their antihypertensive medication at least once over the study period (235,885 of 760,700). The highest incidence of non-adherence occurred with dispensings of alpha agonists (21.49%) and for dispensings provided in the evening (12.03%). The incidence of non-adherence was also higher if the patient was <65 years old (12.41%), new to therapy (18.29%) or on a single antihypertensive medication (12.47%).

When adjusted for the three levels of variables and clustering, among the dispensing characteristics measured the odds of non-adherence were significantly greater for medications supplied for less than 10 days and for medications dispensed at times other than morning (Table 2). Relative to beta-blockers, the odds of dispensing an ARB or angiotensin-converting enzyme inhibitor (ACE) to a non-adherent patient were decreased by 17% (OR: 0.83; 95%CI: 0.82-0.84).

Older, female patients were less likely to be non-adherent at the time of receiving an antihypertensive medication, with a 41% decrease in the odds for patients ≥80 years relative to patients < 65 years old (OR: 0.59; 95%CI: 0.58-0.60). Patients newly started on their antihypertensive medication within the past six months experienced a 27% increase in odds of non-adherence at the time of dispensing. Patients with decreased continuity of care were also more likely to be non-adherent at the time of dispensing, with the odds of non-adherence increased by 10% if the patient had used multiple pharmacies and 16% if she/he had used multiple physicians for their antihypertensive medications over the past 6 months. The impact of cost of the medication to the patient was modified by the patient's income and, in contrast to the unadjusted incidence of non-adherence where increasing out-of-pocket costs lead to higher non-adherence, when adjusted for all three levels of characteristics, higher out-of-pocket costs resulted in a decreased odds of non-adherence within all of low, middle and high income patients. High income patients with low out-of-pocket medication costs were 15% more likely to be non-adherent at the time of dispensing as compared to low income patients with low medication costs (OR: 1.15, 95%CI: 1.12-1.18).

At the pharmacy level, most striking was the decrease in odds of non-adherence associated with increased pharmacists' billings for professional services. The odds of non-adherence decreased by 40% per 1 increase in the number of professional services billed per 100 prescriptions dispensed (OR: 0.60; 95%CI: 0.57-0.62). Neither the number of billings for pharmacists' services targeted at managing non-adherence with antihypertensive medications nor the percentage of open-hours with overlapping pharmacists influenced the odds. However, pharmacist overlap was highly correlated with dispensing volume (Pearson correlation coefficient 0.51, p<.0001). Higher workload decreased the odds of non-adherence by 4% per 10 prescription increase in number of prescriptions dispensed per

pharmacist per hour (OR: 0.96; 95%CI: 0.96-0.97). Higher scores on the Within-Pharmacy Continuity Care Index©, indicating a decreased chance of patients being cared for by the same pharmacist, slightly but significantly increased the odds of non-adherence (OR: 1.003; 95%CI: 1.001-1.005). There was significant variability in the odds of non-adherence among pharmacies belonging to various banners or chains and the odds of non-adherence were significantly higher for chains/banners relative to independent pharmacies (OR: 1.02; 95%CI: 1.00-1.05).

**Table 2. Dispensed prescription, patient and pharmacy characteristics associated with risk of non-adherence with antihypertensive medications.**

| | N | Non-Adherence | Multivariate Alternating Logistic Regression | | |
|---|---|---|---|---|---|
| | | (%) | Odds Ratio | 95% Confidence Interval | P-Value |
| **Dispensed Prescription Level** | | | | | |
| All dispensings | 8,655,348 | 9.19 | | | |
| **Time of Day Dispensed** | | | | | |
| Morning (8-noon) | 4,273,894 | 7.89 | Reference | | |
| Afternoon (noon-16) | 3,141,594 | 9.86 | 1.03 | 1.03-1.04 | <.0001 |
| Evening (16-20) | 1,065,102 | 12.03 | 1.06 | 1.05-1.06 | <.0001 |
| Overnight (20-8) | 174,758 | 11.37 | 1.03 | 1.02-1.05 | <.0001 |
| **Number of Days Supplied** | | | | | |
| 10-32 days | 8,241,026 | 9.10 | Reference | | |
| <10 days | 180,524 | 8.12 | 1.16 | 1.12-1.19 | <.0001 |
| >32 days | 233,798 | 13.13 | 0.84 | 0.82-0.86 | <.0001 |
| **Type of Antihypertensive** | | | | | |
| Beta Blockers | 1,853,835 | 9.16 | Reference | | |
| ARB | 2,004,146 | 8.63 | 0.83 | 0.82-0.84 | <.0001 |
| Calcium Channel Blockers | 1,828,320 | 8.93 | 0.98 | 0.97-0.99 | <.0001 |
| ACE Inhibitors | 1,391,246 | 8.13 | 0.83 | 0.83-0.84 | <.0001 |
| Thiazide diuretics | 672,041 | 9.51 | 0.98 | 0.97-0.99 | <.0001 |
| Loop diuretics | 368,466 | 12.70 | 1.50 | 1.48-1.52 | <.0001 |
| Diuretic combinations | 184,191 | 12.23 | 1.19 | 1.17-1.22 | <.0001 |
| Other diuretics | 145,051 | 8.28 | 0.89 | 0.87-0.91 | <.0001 |
| Alpha Agonists | 74,278 | 21.49 | 2.71 | 2.63-2.79 | <.0001 |
| Alpha Blockers | 68,367 | 8.72 | 1.12 | 1.08-1.15 | <.0001 |
| Potassium sparing diuretics | 56,693 | 13.44 | 1.28 | 1.24-1.32 | <.0001 |
| Vasodilators | 8,804 | 15.19 | 1.87 | 1.70-2.05 | <.0001 |
| **Patient Characteristics** | | | | | |
| **Sex** | | | | | |
| Male | 3,800,463 | 9.69 | Reference | | |
| Female | 4,854,885 | 8.79 | 0.90 | 0.90-0.92 | <.0001 |
| **Age** | | | | | |
| <65 | 2,055,518 | 12.41 | Reference | | |
| 65-69 | 1,595,657 | 8.70 | 0.66 | 0.64-0.66 | <.0001 |
| 70-79 | 3,106,633 | 8.02 | 0.60 | 0.59-0.61 | <.0001 |
| ≥80 | 1,897,540 | 8.00 | 0.59 | 0.48-0.60 | <.0001 |

| | | | | | |
|---|---|---|---|---|---|
| **Patient Income*patient cost interaction** | | | | | |
| Low income & low cost | 301,826 | 8.67 | Reference | | |
| Low income & middle cost | 184,565 | 9.59 | 0.93 | 0.91-0.95 | <.0001 |
| Low income & high cost | 161,414 | 9.89 | 0.88 | 0.87-0.90 | <.0001 |
| Middle income & low cost | 2,286,651 | 8.47 | 0.99 | 0.97-1.01 | 0.241 |
| Middle income & middle cost | 2,459,139 | 9.28 | 0.97 | 0.95-0.99 | 0.003 |
| Middle income & high cost | 2,350,251 | 9.27 | 0.95 | 0.93-0.97 | <.0001 |
| High income & low cost | 210,972 | 10.31 | 1.15 | 1.12-1.18 | <.0001 |
| High income & middle cost | 339,456 | 10.53 | 1.07 | 1.04-1.09 | <.0001 |
| High income & high cost | 361,074 | 10.50 | 1.01 | 0.99-1.04 | 0.336 |
| **Antihypertensive Therapy** | | | | | |
| Chronic Therapy (≥6 months) | 8,528,536 | 9.05 | Reference | | |
| New Therapy (< 6 months) | 126,812 | 18.29 | 1.27 | 1.25-1.30 | <.0001 |
| Multiple Antihypertensive Drugs | 6,872,858 | 8.33 | Reference | | |
| Single Antihypertensive Drug | 1,782,490 | 12.47 | 1.04 | 1.04-1.05 | <.0001 |
| **Continuity of Care** | | | | | |
| Single Dispensing Pharmacy | 7,440,825 | 8.86 | Reference | | |
| Multiple Dispensing Pharmacies | 1,214,523 | 11.16 | 1.10 | 1.08-1.11 | <.0001 |
| Single Prescriber | 6,412,928 | 8.65 | Reference | | |
| Multiple Prescribers | 2,242,420 | 10.72 | 1.16 | 1.15-1.17 | <.0001 |
| | | | | | |
| **Pharmacy Characteristics** | | | | | |
| **Pharmacy Type** | | | | | |
| Independent | 444,956 | 9.69 | Reference | | |
| Chain/banner | 8,210,392 | 9.16 | 1.02 | 1.00-1.05 | 0.034 |
| **Anonymized Pharmacy Chain/Banner/Independent** | | | | | |
| UUU | 2,495,701 | 9.68 | Reference | | |
| VVV | 1,071,922 | 8.01 | 0.84 | 0.80-0.83 | <.0001 |
| TTT | 572,422 | 8.83 | 0.91 | 0.89-0.93 | <.0001 |
| SSS | 840,234 | 10.46 | 1.04 | 1.02-1.06 | <.0001 |
| HHH | 657,249 | 8.12 | 0.84 | 0.83-0.86 | <.0001 |
| EEE | 1,104,215 | 9.06 | 0.94 | 0.93-0.96 | <.0001 |
| Other | 1,913,605 | 9.18 | 0.94 | 0.92-0.95 | <.0001 |
| **Pharmacy Location** | | | | | |
| Shopping Centre | 1,912,484 | 9.39 | Reference | | |
| Neighborhood pharmacy | 2,704,536 | 9.17 | 1.01 | 1.00-1.02 | 0.139 |
| Medical Clinic | 1,300,939 | 8.41 | 0.96 | 0.95-0.98 | <.0001 |
| Medical Offices | 73,561 | 7.99 | 0.98 | 0.93-1.03 | 0.461 |
| Other | 180,417 | 8.34 | 0.96 | 0.93-1.00 | 0.047 |
| Missing | 2,483,411 | 9.54 | 1.01 | 1.00-1.03 | 0.081 |
| **Workload** | | | | | |
| Prescriptions/pharmacist/hour | | | | | |
| <12 | 947,400 | 11.0 | | | |
| 12-<22 | 2,755,796 | 31.8 | | | |
| 22-<34 | 3,668,952 | 42.4 | | | |
| ≥34 | 1,283,200 | 14.8 | | | |
| Odds per 10 increase | | | 0.96 | 0.96-0.97 | <.0001 |
| **Professional Services** | | | | | |
| Total Pharmacist Services | | | | | |
| <0.11 | 2,519,258 | 10.13 | | | |
| 0.11-0.22 | 3,118,481 | 9.05 | | | |
| ≥0.22 | 3,017,609 | 8.54 | | | |
| Odds per 1/100 Rx increase | | | 0.60 | 0.57-0.62 | <.0001 |

| | | | | | |
|---|---|---|---|---|---|
| HTN compliance services | | | | | |
| 0 | 6,936,363 | 9.23 | | | |
| 1-5 | 1,553,820 | 8.95 | | | |
| 6-10 | 145,393 | 9.80 | | | |
| ≥10 | 19,772 | 8.74 | | | |
| Odds per 1/8month increase | | | 1.00 | 1.00-1.00 | 0.083 |
| Pharmacist Overlap Index | | | | | |
| <10% | 1,242,727 | 14.4 | | | |
| 10%-<16% | 2,780,707 | 32.1 | | | |
| 16%-<22% | 1,532,245 | 17.7 | | | |
| ≥22% | 3,099,669 | 35.8 | | | |
| Odds per 1% increase | | | 0.95 | 0.90-1.00 | 0.068 |
| Within Pharmacy Continuity of Care Index | | | | | |
| 1-5 | 1282931 | 8.75 | | | |
| >5-10 | 2554425 | 8.93 | | | |
| >10-20 | 2331227 | 9.37 | | | |
| >20 | 2486765 | 9.50 | | | |
| Odds per 10 increase | | | 1.003 | 1.001-1.005 | 0.012 |

1

## DISCUSSION

**Statement of Principal Findings:** This study is the first to document that linked community pharmacy claims and health administrative data can be used to directly measure a range of pharmacy-level characteristics. It is also the first study that investigated the association between the provision of pharmacists' professional services and better within-pharmacy continuity of care with adherence, showing that each of these pharmacists' practices are associated with a decreased odds of dispensing antihypertensive medications to non-adherent patients.

**Strengths and Limitations:** The main strengths of this study are the direct measurement of pharmacy characteristics from administrative claims data, the population-based and large sample of dispensings and the use of an objective, validated quality of care measure of adherence (10, 11, 13). As significant variability in results has been reported from studies using differing measures of adherence, use of standardized methods for measuring adherence is particularly important in determining predictors of non-adherence (10). Limitations include that we evaluated performance on only one quality of medication-use measure. In addition, administrative claims data are limited in the extent to which they can measure whether pharmacists provided a service but did not bill for it (37-39).

**Interpretation:** Our overall rate of non-adherence is consistent with previous reports that utilize community pharmacy administrative claims data and similar measures of non-adherence (11, 40). Calculation of pharmacy-level characteristics required multiple steps and complex analysis and for characteristics that had previously been estimated via survey/self-report, such as prescriptions per pharmacist per hour, our results were higher (18.4 +/- 10.5 our study vs 14.1 +/- 4.9 )(17). This is consistent with national reports documenting higher total prescriptions dispensed in Quebec relative to other provinces (32). Results of the drug and patient characteristics affecting non-adherence agree with previous research documenting that there is higher adherence to antihypertensive medications with fewer side effects, such as ARB and ACE, and that increasing age is associated with increased compliance to antihypertensive medications (27, 41). However, given the variability in results of non-adherence rates and predictors from studies that used differing measurement methodologies, our results should be compared with studies using pharmacy administrative claims data and standardized methods for measuring non-adherence (10). To our knowledge, this literature is limited to the study that used an ecological approach to measuring pharmacy and patient characteristics (20). Our results differ from this ecological study for the impact of patient sex and income, and independent pharmacy ownership on the odds of dispensing to a non-adherent patient. Our results demonstrate the impact of measuring these characteristics directly for each dispensing and adjusting for clustering. When only considering whether the pharmacy is independent vs a chain/banner, the incidence of non-adherence is higher in independent pharmacies. However, when adjusted for clustering and the remaining dispensing, patient and pharmacy characteristics, this association reverses with chain / banner pharmacies demonstrating a greater odds of non-adherence. The same is true for the impact of patient costs relative to income. Without adjustment, the incidence of non-adherence increases as cost to the patient increases. However, when adjusted for all characteristics, this relationship reverses. As higher patient cost typically occurs with second-line treatments for hypertension, this may represent patients who required switches or additions to their therapies due to side or insufficient effects from their initial treatments, which has been shown to increase compliance (42).

The most striking results of our analysis are the reductions in the odds of non-adherence with both an increasing rate of provision of pharmacists' professional services and improved within-pharmacy continuity of care. In Quebec, pharmacists can bill for a number of professional services and it is hypothesized that the relationship between the rate of provision of these services and lower non-adherence indicates that improved quality of care is provided at pharmacies where pharmacists prioritize their provision of care and professional services vs involvement in technical distributive functions (43, 44). The relationship between improved within-pharmacy continuity of care and decreased odds of non-adherence supports such a hypothesis as patients can more easily develop trusting relationships with their pharmacist when continuity of care is improved (45). Our findings that increased workload is associated with lower odds of non-adherence would not appear to support that increased workload challenges pharmacists' provision of quality care. However, we had removed very high volume pharmacies so we did not see the previously reported results of lower quality of care in pharmacies with both very low and very high dispensing volumes (15). The strong positive correlation between workload and pharmacist-overlap suggests that pharmacists are not being scheduled to provide professional services but to enable increased number of prescriptions to be processed. As both culture and workflow are determined predominantly by the pharmacist owner, greater freedom to emphasize professional pharmacists' practice by owners of independent pharmacies could account for their lower odds of non-adherence relative to chains / banners (46). Similarly, differences in practice philosophy among the chains / banners could account for the variability in performance among the different banners and chains.

**Implications and Future Research:**

Our results indicate that emphasis on the caring role of pharmacists both during dispensing and via provision of professional services appears key to improving patients' use of medications. Results also support policies that encourage continuity of care and that focus adherence strategies on younger males, new to treatment and taking single antihypertensive therapy. Pharmacy administrative claims data can be used to directly measure dispensing, patient and pharmacy characteristics, thereby increasing the range and accuracy of pharmacy-level characteristics evaluated. Evaluation of additional measures both of non-adherence and dispensing of contraindicated medications is needed to

determine if there is consistency across the measures of pharmacy-level characteristics identified in our study as being related to pharmacists' performance.

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**Acknowledgements** We thank Danielle Fagnan, from the Quebec Order of Pharmacists, for the support provided throughout the project. We thank Sherry Shi for her analysis of the data. The critical review of the manuscript and recommendations for analysis by Drs Cees van der Vleuten and Lambert Schuwirth are gratefully acknowledged. We acknowledge the financial support of Green Shield Canada Foundation and the financial and administrative support of the Quebec Order of Pharmacists.

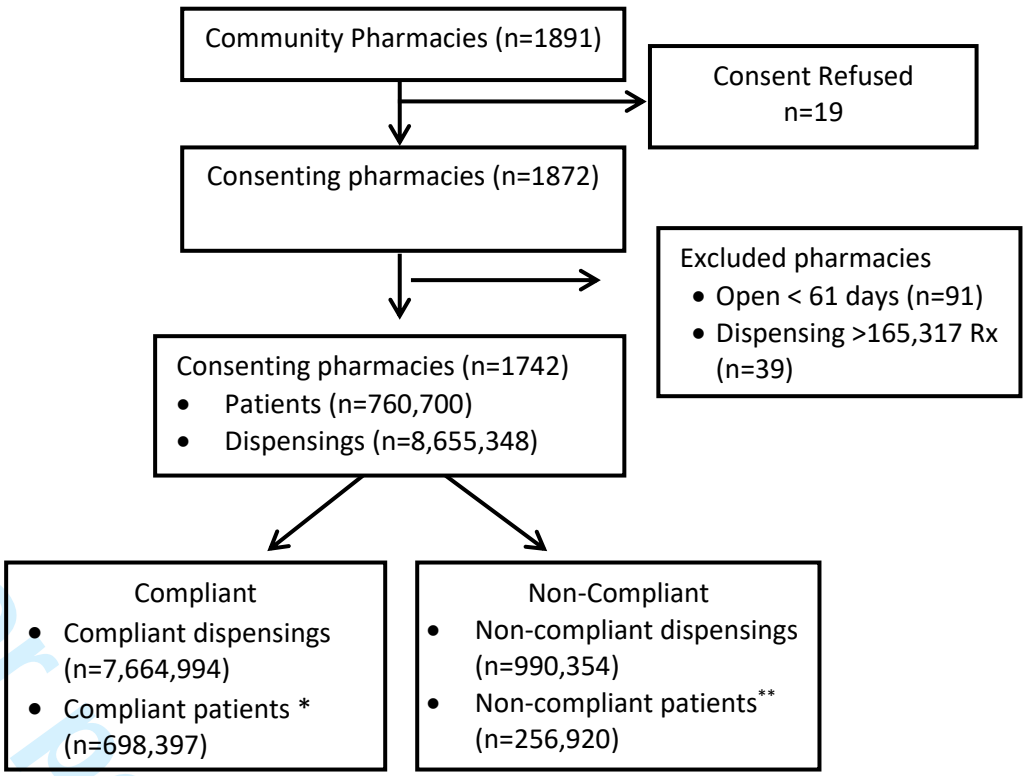
**Contributors** NW: conceived and designed the project, reviewed literature to determine relevant potential predictors, completed the basic analysis and wrote the manuscript. RT: guided the design of the project, provided key guidance to the statistical analysis, provided critical review of the manuscript.

**Competing Interests:** We have read and understood the BMJ policy on declaration of interests, and have completed the ICMJE uniform disclosure form and declare the following interests: Dr. Winslade reports grants from Green Shield Foundation Canada, personal fees and non-financial support from Quebec Order of Pharmacists, during the conduct of the study. Dr. Tamblyn reports grants from Green Shield Foundation Canada and non-financial support from Quebec Order of Pharmacists, during the conduct of the study.

**Ethics approval:** University's Faculty of Medicine Institutional review board # A05-E20-08B

**Funding:** Green Shield Foundation Canada provided a grant for completion of this project and was both informed of the decision to submit this paper and received a copy of the manuscript. The Quebec Order of Pharmacists provided a matching grant in the form of salary support, facilitated and paid the required data-access fees to RAMQ.

Eligibility




* Patients with at least one compliant dispensing.

** Patients with at least one non-compliant dispensing.

**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies***

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 4 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 6 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up | 6 |
| | | (*b*) For matched studies, give matching criteria and number of exposed and unexposed | n/a |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 7-8 |
| Data sources/ measurement | 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 | 9 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 9 |
| Study size | 10 | Explain how the study size was arrived at | 6 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 9 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 9-10 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | 9-10 |
| | | (*c*) Explain how missing data were addressed | n/a |
| | | (*d*) If applicable, explain how loss to follow-up was addressed | n/a |
| | | (*e*) 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 | 10 |
| | | (b) Give reasons for non-participation at each stage | 10 and figure 1 |
| | | (c) Consider use of a flow diagram | Figure 1 |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 10 and Table 1 |
| | | (b) Indicate number of participants with missing data for each variable of interest | Table 1 |
| | | (c) Summarise follow-up time (eg, average and total amount) | 10 |
| Outcome data | 15* | Report numbers of outcome events or summary measures over time | 12-14 and Table 2 |
| 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 | Table 2 |
| | | (*b*) Report category boundaries when continuous variables were categorized | Tables 1 and 2 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | n/a |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 17 |
| **Limitations** | | | |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 17 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 17-19 |
| **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 | 24 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**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.

BMJ Open

# Determinants of Community Pharmacists' Quality of Care: A Population-Based Cohort Study Using Pharmacy Administrative Claims Data



| | |
|---|---|
| Journal: | *BMJ Open* |
| Manuscript ID | bmjopen-2017-015877.R1 |
| Article Type: | Research |
| Date Submitted by the Author: | 02-Jun-2017 |
| Complete List of Authors: | Winslade, Nancy; McGill University, Medicine<br>Tamblyn, Robyn; McGill University, Department of Medicine and Department of Epidemiology and Biostatistics |
| Primary Subject Heading: | Health services research |
| Secondary Subject Heading: | Health policy, Cardiovascular medicine, Evidence based practice |
| Keywords: | Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Hypertension < CARDIOLOGY, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT |
| | |

# Determinants of Community Pharmacists' Quality of Care: A Population-Based Cohort Study Using Pharmacy Administrative Claims Data

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**Abstract**

**Objective:** To determine if a prototype pharmacists' services evaluation program that uses linked community pharmacy claims and health administrative data to measure pharmacists' performance can be used to identify characteristics of pharmacies providing higher quality of care.

**Design:** Population-based cohort study using community pharmacy claims from November 1, 2009 to June 30, 2010.

**Setting:** All community pharmacies in Quebec, Canada.

**Participants:** 1742 pharmacies dispensing 8,655,348 antihypertensive prescriptions to 760,700 patients.

**Primary outcome measure:** Patient adherence to antihypertensive medications.

**Predictors**: Pharmacy-level: dispensing workload, volume of pharmacist-provided professional services (e.g. refusals to dispense, pharmacotherapy recommendations), pharmacy location, banner/chain, pharmacist overlap, within-pharmacy continuity of care. Patient-level: sex, age, income, patient prescription cost, new/chronic therapy, single/multiple antihypertensive medications, single/multiple prescribers and single/multiple dispensing pharmacies. Dispensing level: prescription duration, time of day dispensed, antihypertensive class. Multivariate alternating logistic regression estimated predictors of the primary outcome, accounting for patient and pharmacy clustering.

**Results**: 9.2% of dispensings of antihypertensive medications were provided to non-adherent patients. Male sex, decreasing age, new treatment, multiple prescribers and multiple dispensing pharmacies were risk factors for increased non-adherence. Pharmacies who provided more professional services were less likely to dispense to non-adherent hypertensive patients (OR: 0.60; 95% CI: 0.57-0.62) as were those with better scores on the Within-Pharmacy Continuity of Care Index©. Neither increased pharmacists' services for improving antihypertensive adherence per se nor increased pharmacist overlap impacted the odds of non-adherence. However, pharmacist overlap was strongly correlated with dispensing workload. There was significant unexplained variability among pharmacies belonging to different banners and chains.

**Conclusions:** Pharmacy administrative claims data can be used to calculate pharmacy-level characteristics associated with improved quality of care. This study supports the importance of pharmacist's professional services and continuity of pharmacist's care.

**Strengths and limitations of this study:**

1. The trial directly measured community pharmacy characteristics using pharmacy claims and health administrative data.
2. The primary quality of care outcome used a standardized method for measuring patient adherence to medications.
3. The trial was population-based and included a large sample of patients from community pharmacies in Quebec.
4. Performance on only one quality of medication-use indicator was evaluated and results may not apply to additional measures of pharmacists' quality of care.
5. Administrative data are limited in the extent to which they can measure services provided by pharmacists that were not billed.

Green Shield Canada Foundation and the Quebec Order of Pharmacists supported this work.

## INTRODUCTION

**Background**:

Misuse of prescription medications, ranging from inappropriate prescribing to patient non-adherence, remains a significant and costly challenge to health systems (1). The medication-related expertise and accessibility of community pharmacists has led policy-makers to re-evaluate the role community pharmacists play in managing medication misuse (2, 3). Emphasis has been placed on the care provided by pharmacists both as part of medication-dispensing and via expanded professional services that target specific medication-misuse problems (4, 5). Although such care can improve patient's medication use, community pharmacists struggle to incorporate expanded professional services into their daily practice (6, 7). As a result, payers continue to seek evidence of the real-world impact of community pharmacists' services on medication misuse (4, 8, 9), and quality indicators of unsafe or interacting medications and management of non-adherent patients have been established as standardized outcome measures of pharmacists' quality of care (10-12). The services pharmacists provide to achieve high performance on these quality indicators can vary across jurisdictions (5). Developments in the use of community pharmacy administrative claims data have enabled the measurement of both pharmacy-level performance on these standardized quality indicators and the impact of pharmacists' professional services on patient outcomes (13, 14).

To date there has been no precise methods of determining pharmacy-level characteristics that consistently support high levels of pharmacists' performance and that could inform directions for pharmacy policy. Pharmacy characteristics such as workload, continuity of care, culture, workflow and overlap of pharmacists have been evaluated through self-report and with varying definitions of quality performance (15-17). The few studies that used standardized quality measures employed a potentially biased ecologic approach to estimate pharmacy characteristics by determining a population-based quality metric in the geographical area and then assigning these population-based results to all pharmacies within that area (18-21). More robust methodologies are needed to measure the characteristics of the patient, pharmacy and workload situation when the patient receives the medication (22).

One potentially powerful option is to use pharmacy administrative claims data to measure salient pharmacy characteristics. To date use of such data has been limited to identifying whether the pharmacy is a chain or independent, and the volume of dispensing (20, 23). This is primarily due to challenges in using the large volume of pharmacy administrative data to create accurate measures, as well as challenges linking pharmacy claims data to other health administrative databases to obtain information on patient and pharmacy characteristics. Increasingly these linkages have been enabled through interest by payers in monitoring performance and researchers in conducting population-based studies (24, 25). We developed a framework for pharmacists' services evaluation that uses linked pharmacy administrative claims and health administrative data to measure and feed back pharmacy-level performance on quality indicators, followed by diagnostic on-site assessments of lower performing pharmacies (26). The objective of this study was to determine if the linked administrative health data used within this prototype pharmacists' services evaluation program could be used to identify characteristics of pharmacies providing higher quality of care.

## METHODS

**Setting:** This study was conducted in Quebec, with a population of 8 million patients of whom approximately 3.5 million receive government support for payment of their medications via the Régie de l'Assurance Maladie du Québec (RAMQ). Since the late 1970s Quebec pharmacists have been authorized to bill RAMQ for professional services such as refusals to dispense medications and written pharmaceutical opinions for management of specific medication-use problems (27, 28). RAMQ requires the date, hour, drug identification number, therapeutic drug class, dosage form, strength, quantity, duration of treatment, specific type and reason for the pharmacist service (e.g. previous adverse effect or management of under-use of antihypertensive medications), and costs to RAMQ, the patient and for the overall prescription. All data are coded and can be linked to other health administrative data using unique encrypted identifiers for patients, prescribers, pharmacists and pharmacies. For patients, age, sex, postal code and average household income are recorded. For pharmacies, the location (e.g. shopping centre), and type of pharmacy (independent or not) are maintained, along with the specific chain or banner to which the pharmacy belongs.

**Study Design:** A population-based prospective cohort of patients was assembled for whom Quebec pharmacists billed for dispensings of antihypertensive medications between November 1, 2009 to June 30, 2010. A dispensing was defined as the preparation and provision of medications to a patient pursuant to a prescription, regardless of quantity of medication dispensed. Each time there was a dispensing for an antihypertensive medication we determined whether the dispensing was to a patient who was adherent or not over the 90 days prior to the dispensing. Characteristics of each dispensing, the patient and the pharmacy were measured and a multi-level model used to identify predictors of dispensing to a non-adherent patient.

**Participants:** All 1891 pharmacies in Quebec were included unless they had opted out of participating in a previously reported randomized controlled trial, were open < 61 days, or had dispensed >165,317 prescriptions over the eight-month study period, which represented outliers with Z-scores >2.5 (14, 29). Pharmacies with shorter open-days did not have sufficient data for reliable calculation of characteristics and very high dispensing volumes were not representative of traditional community pharmacy practice in Quebec. We had sufficient sample size to have 90% power to detect a difference in antihypertensive adherence of 5% for most potential predictors.

**Primary Outcome:** The primary outcome was whether a dispensing of an antihypertensive medication was provided to an adherent or non-adherent patient. Antihypertensive adherence was selected for this initial evaluation as antihypertensive medications are widely used and non-adherence is common (30). Our previous research had also documented that almost all community pharmacies in Quebec (99.7%) dispense antihypertensive medications, thereby allowing a population-based cohort for the current study (12).

For each antihypertensive dispensing, we created a record of all dispensings of the same antihypertensive medication to the same patient from all pharmacies in Quebec over the previous 180 days. 'Same medication' was defined as the same drug in the same dosage format, regardless of strength. Switches to a new medication in the same therapeutic class

were treated as new therapies. Dispensings of antihypertensive medications were excluded if the patient had not been treated with the same medication for at least 90 days or had not had continuous insurance coverage over the previous 180 days. As dispensing pharmacists are responsible for obtaining information on medications supplied from other pharmacies when determining adherence, each eligible dispensing was attributed to the dispensing pharmacy. We calculated the proportion of previous 90 days covered (PDC) for the same medication using the previous dispensing dates and number of days of supply provided at each dispensing and adjusting for early refills. If the PDC over the 90 days prior to the dispensing was less than 72 days (80%), then the dispensing was to a non-adherent patient (31).

**Potential Predictors: Dispensing-level characteristics** included the type of antihypertensive medication dispensed, the total prescription cost and the cost to the patient as these have been demonstrated to affect patient adherence (32). Although in Quebec the standard supply of medications is for 30 days, patients at risk for non-adherence can receive weekly medication supply and patients stabilized on chronic therapies can receive 90 day supplies. Adherence was, therefore, expected to be worse for patients receiving less than 30 days' supply and better for patients receiving more than 30 days' supply.

**Potential Predictors: Patient-level characteristics** were those known to affect adherence such as sex, age and income, with older males and patients with higher income anticipated to be more compliant (20, 33). As our previous work indicated that patients within their first six months of antihypertensive therapy are less compliant as are those on single drug therapy or receiving their antihypertensive medications from more than one physician or pharmacists, these variables were also included (12, 34-36).

**Potential Predictors: Pharmacy-level characteristics** included workload as higher numbers of prescriptions dispensed has been identified as a factor limiting community pharmacists' ability to provide professional services (37) and predisposing to dispensing errors (15, 17, 38). Workload has been reported variously as prescriptions dispensed per year, which can readily be determined from administrative claims data, to prescriptions per pharmacist per hour, which has only been reported using self-reported estimates (17). We received from

RAMQ the total number of billings and open days for each pharmacy over the 8-month study period and used the administrative claims data to calculate for each pharmacy the average number of: open hours per day, pharmacists billing per hour, prescriptions dispensed per hour, and prescriptions dispensed per pharmacist per hour. Related to workload, as medication dispensing errors occur more frequently when only one pharmacist is working, there have been calls for mandatory overlapping of pharmacists' schedules to allow one pharmacist to focus uninterruptedly on prescription verification while a second pharmacist provides professional services (16, 39). To measure pharmacist-overlap for each pharmacy, we created a matrix of the number of pharmacists billing each open hour over each open day during the 8-month study period. From this we calculated the average percent of each pharmacy's open hours where more than one pharmacist was billing (Pharmacist Overlap Index©). Finally, although continuity of care measuring whether patients received all antihypertensive medications from a single pharmacy was included as a patient-level variable, based on evidence from other health professions that care from the same health care professional is important in creating trusting, professional relationships, we determined the likelihood that a patient would be cared for by the same pharmacist on multiple visits (Within-pharmacy Continuity of Care Index©)(34). We calculated, for each pharmacy, the total number of pharmacists working over the 8-month study period (weighted to emphasize differences in high and low numbers of pharmacists) and divided this by the average number of pharmacists working per day at that pharmacy. The lowest value of the index is 1, representing the best within-pharmacy continuity of care when there is only one single pharmacist working in the pharmacy over the 8 months. Increasing indices indicate a lower chance that the patient would be cared for by the same pharmacist at multiple visits. To determine the culture within the pharmacy we calculated the total number of pharmacists' professional services billed per 100 prescriptions dispensed over the 8-month period, including refusals to dispense, pharmaceutical opinions, transmission of medication profiles and emergency contraception. We also counted the number of professional services billed specifically for management of under-use of antihypertensive medications.

**Data sources/ measurement:** Baseline community pharmacy claims data for all dispensings of antihypertensive medications and pharmacist services were received from RAMQ for all Quebec community pharmacies for the period of October 1, 2008 to June 30, 2010 (14). Patient, pharmacy, pharmacy chain/banner group, pharmacist and prescriber identifiers were anonymized by RAMQ prior to data transfer. Data for the 8-month period of November 1, 2009 to June 30, 2010 were used to calculate dispensing, patient and pharmacy-level characteristics and estimate determinants of non-adherence.

**Statistical Methods:** Descriptive statistics summarized the characteristics of the dispensings, patients and pharmacies including the incidence of dispensing to non-adherent patients by type of antihypertensive, patient sex and age. Multivariate alternating logistic regression (ALR) estimated the association among the dispensing, patient and pharmacy-level characteristics and non-adherence. ALR allows analysis of dichotomous outcomes when observations have more than one level of clustering (40). For our results, ALR first measured the extent of clustering of non-adherence among multiple dispensings within the same patient and then for multiple patients receiving their medications from the same pharmacy. All analyses were completed using SAS, version 9.4 (SAS Institute, Cary, North Carolina), with ALR using PROC GENMOD.

Where multiple measures could be calculated to reflect a single construct, results for each measure were first compared with previously reported estimates (if available) to test the accuracy of the calculations. Next each measure was tested individually for association with non-adherence. A single measure of each construct was selected for inclusion based on the accuracy of the calculation, the strength of evidence supporting its use and the strength of association. Collinearity was evaluated for all variables considered for the final analysis using the variance inflation factor. When collinearity was present, variables that were calculated as interim steps were considered for exclusion and the variables retained were those most directly measuring the constructs of interest. To account for interactions between patient income and the cost of the medication to the patient, we divided both variables into low, medium and high categories and created dummy variables for each of the nine possible interactions, setting low income and low cost to the patient as the reference (41).

## RESULTS

**Study Participants:** 1872 pharmacies were enrolled in the study, after 19 (1%) opted out of the previous trial (Figure 1, Consort diagram). Ninety-one pharmacies open for < 61 days and 39 additional pharmacies dispensing >165,317 prescriptions over the 8-month period were removed from the analysis. 8,655,348 dispensings of antihypertensive medications to 760,700 patients in 1742 pharmacies were evaluated.

**Population Characteristics:** Angiotensin-receptor blockers (ARB) were the most commonly dispensed antihypertensive medications (23.2% of dispensings) with <1% of dispensings for each of alpha agonists, alpha blockers, potassium sparing diuretics and vasodilators (Table 1). Most prescriptions were dispensed in the morning and were for an approximate one-month duration. 74.1% of patients were prescribed their antihypertensive medications by a single physician and 86.0% went to a single pharmacy for all their antihypertensive medications over the previous six months. Most patients had been taking antihypertensive medications for more than six months (98.5%) and were on multiple antihypertensive medications (79.4%). The majority of pharmacies were either chains or banners (89.9%). Pharmacists dispensed an average 18.4 prescriptions per pharmacist per hour, billing for 0.18 professional services for every 100 prescriptions dispensed. Most pharmacies did not have any billings for pharmacists' services for antihypertensive non-adherence, leading to an average of less than 1 billing over the 8 months (0.35 +/- 1.8). Pharmacies had more than 1 pharmacist billing for 15.5% of their open hours and an average of 9 different pharmacists worked in each pharmacy over the 8-month study period.

**Table 1. Characteristics of prescriptions dispensed, patients and their pharmacies.**

| Level of Characteristic | N (%) |
|---|---|
| **Dispensed Prescription Level (n=8,655,348)** | |
| **Time of Day Dispensed** | |
| Morning (>8-noon) | 4,273,894 (49.4%) |
| Afternoon (>noon-16) | 3,141,594 (36.3%) |
| Evening (>16-20) | 1,065,102 (12.3%) |
| Overnight (>20-8) | 174,758 (2.0%) |
| **Number of Days of Medication Supplied** | |
| <10 days | 180,524 (2.1%) |
| 10-32 days | 8,241,026(95.2%) |
| >32 days | 233,798 (2.7%) |
| **Type of Antihypertensive Medication Dispensed** | |
| Angiotensin Receptor Blockers | 2,004,146 (23.2%) |
| Beta Blockers | 1,853,835 (21.4%) |
| Calcium Channel Blockers | 1,828,320 (21.1%) |
| Angiotensin Converting Enzyme Inhibitors | 1,391,246 (16.1%) |
| Thiazide diuretics | 672,041 (7.8%) |
| Loop diuretics | 368,466 (4.3%) |
| Diuretic combinations | 184,101 (2.1%) |
| Other diuretics | 145,051 (1.7%) |
| Alpha Agonists | 74,278 (0.9%) |
| Alpha Blockers | 68,367 (0.8%) |
| Potassium sparing diuretics | 56,693 (0.7%) |
| Vasodilators | 8,804 (0.1%) |
| **Cost** | **Mean (SD)** |
| Total cost of the prescription (Canadian $) | $28.36($17.48) |
| Cost to the patient of the prescription (Canadian $) | $8.55 ($8.56) |
| **Pharmacy Client Level[†] (n=760,700)** | |
| **Sex** | |
| Female | 4,858,885 (56.1%) |
| Male | 3,800,463 (43.9%) |
| **Age** | |
| < 65 years | 2,055,518 (23.8%) |
| 65-69 | 1,595,657 (18.4%) |
| 70-79 | 3,106,633 (35.9%) |
| >79 | 1,897,540 (21.9%) |
| **Income** | |
| Low (<$31,700 Canadian) | 647,805 (7.5%) |
| Middle ($31,700-$80,000 Canadian) | 7,096,041 (82.0%) |
| High (>$80,000 Canadian) | 911,502 (11.5%) |
| **Antihypertensive Therapy** | |
| New Therapy (< 6 months) | 126,812 (1.5%) |
| Chronic Therapy (≥6 months) | 8,528,536 (98.5%) |
| Single Antihypertensive Drug | 1,782,490 (20.6%) |
| Multiple Antihypertensive Drugs | 6,872,858 (79.4%) |
| **Continuity of Care** | |
| Single Pharmacy Dispensed antihypertensives over previous 6 months | 7,440,825 (86.0%) |
| Multiple Pharmacies Dispensed antihypertensives over previous 6 months | 1,214,523 (14.0%) |
| Single Prescriber of antihypertensives over previous 6 months | 6,412,928 (74.1%) |
| Multiple Prescribers of antihypertensives over previous 6 months | 2,242,420 (25.9%) |

[†]Considering all patients who received eligible dispensings over 8 months' follow-up.

| **Community Pharmacy Level (n=1742)** | |
|---|---|
| **Pharmacy Type** | **N (%)** |
| Chain/banner | 1,566 (89.9%) |
| Independent | 176 (10.1%) |
| **Pharmacy Location** | |
| Neighborhood pharmacy | 457 (26.2%) |
| Shopping Centre | 281 (16.1%) |
| Medical Clinic | 283 (16.2%) |
| Other | 53 (3.1%) |
| Missing | 668 (38.3%) |
| **Professional Services Provided over 8 months** | |
| Total pharmacist services billed per 100 prescriptions | |
| <0.12 | 544 (31.2%) |
| 0.13-0.2 | 588 (33.8%) |
| >0.2 | 610 (35.0%) |
| Recommendations for non-adherence with antihypertensive medications | |
| 0 | 1485 (85.3%) |
| 1-5 | 237 (13.6%) |
| 6-10 | 17 (0.1%) |
| >10 | 3 (0.2%) |
| **Workload** | **Mean (SD)** |
| Total prescriptions dispensed over 8 months | 53,308 (36,749) |
| Total days open over 8 months | 214 (42.8) |
| Hours open per day | 14.4 (3.3) |
| Pharmacists working/day | 1.8 (0.7) |
| Pharmacists working/hour | 1.1 (0.1) |
| Prescriptions dispensed/day | 244.6(156.6) |
| Prescriptions dispensed/hour | 20.5 (13.0) |
| Prescriptions dispensed/pharmacist/hour | 18.4 (10.5) |
| **Pharmacist Overlap Index**© (average percent of open hours with >1 pharmacist) | 15.48 (9.14) |
| **Within Pharmacy Continuity of Care** | |
| Distinct Pharmacists employed over 8 months | 9.0 (6.7) |
| Within Pharmacy COC Index© (weighted # of pharmacist in 8 months/# pharmacists per day) | 17.3 (20.1) |

**Non-adherence:** Over eight months, 9.2% of all dispensings of antihypertensive medications were provided to non-adherent patients (795,031 of 8,655,348 dispensings) (Table 2). Antihypertensive dispensings were provided to 760,700 distinct patients, 31% of whom were non-adherent to their antihypertensive medication at least once over the study period (235,885 of 760,700). The highest incidence of non-adherence occurred with alpha agonists (21.49%) and for dispensings provided in the evening (12.03%). The incidence of non-adherence was also higher if the patient was <65 years old (12.41%), new to therapy (18.29%) or on a single antihypertensive medication (12.47%).

When adjusted for the three levels of variables and clustering, the odds of non-adherence were significantly greater for medications supplied for less than 10 days and for medications dispensed at times other than morning (p<0.05)(Table 2). Relative to beta-blockers, the odds of dispensing an ARB or angiotensin-converting enzyme (ACE) inhibitor to a non-adherent patient were decreased by 17% (OR: 0.83; 95%CI: 0.82-0.84).

Older, female patients were less likely to be non-adherent at the time of receiving an antihypertensive medication, with a 41% decrease in the odds for patients ≥80 years relative to patients < 65 years old (OR: 0.59; 95%CI: 0.58-0.60). Patients newly started on their antihypertensive medication within the past six months experienced a 27% increase in odds of non-adherence at the time of dispensing. Patients with decreased continuity of care were also more likely to be non-adherent at the time of dispensing, with the odds of non-adherence increased by 10% if the patient had used multiple pharmacies and 16% if she/he had used multiple physicians for their antihypertensive medications over the past 6 months. The impact of cost of the medication to the patient was modified by the patient's income and, in contrast to the unadjusted incidence of non-adherence where increasing out-of-pocket costs lead to higher non-adherence, when adjusted for all three levels of characteristics, higher out-of-pocket costs resulted in a decreased odds of non-adherence within all of low, middle and high income patients. High income patients with low out-of-pocket medication costs were 15% more likely to be non-adherent at the time of dispensing as compared to low income patients with low medication costs (OR: 1.15, 95%CI: 1.12-1.18).

At the pharmacy level, the odds of non-adherence decreased by 40% per 1 increase in the number of professional services billed per 100 prescriptions dispensed (OR: 0.60; 95%CI: 0.57-0.62). Neither the number of billings for pharmacists' services targeted at managing non-adherence with antihypertensive medications nor the percentage of open-hours with overlapping pharmacists influenced non-adherence. However, pharmacist overlap was highly correlated with dispensing volume (Pearson correlation coefficient 0.51, p<.0001). Higher workload decreased the odds of non-adherence by 4% per 10 prescription increase in number of prescriptions dispensed per pharmacist per hour (OR: 0.96; 95%CI: 0.96-0.97). Higher scores on the Within-Pharmacy Continuity Care Index©, indicating a decreased chance of patients being cared for by the same pharmacist, slightly but significantly

increased the odds of non-adherence (OR: 1.003; 95%CI: 1.001-1.005). There was significant variability in the odds of non-adherence among pharmacies belonging to various banners or chains and the odds of non-adherence were significantly higher for chains/banners relative to independent pharmacies (OR: 1.02; 95%CI: 1.00-1.05).

**Table 2. Dispensed prescription, patient and pharmacy characteristics associated with risk of non-adherence with antihypertensive medications.**

| | N | Non-Adherence | Multivariate Alternating Logistic Regression | | |
|---|---|---|---|---|---|
| | | (%) | Odds Ratio | 95% Confidence Interval | P-Value |
| **Dispensed Prescription Level** | | | | | |
| All dispensings | 8,655,348 | 9.19 | | | |
| **Time of Day Dispensed** | | | | | |
| Morning (8-noon) | 4,273,894 | 7.89 | Reference | | |
| Afternoon (noon-16) | 3,141,594 | 9.86 | 1.03 | 1.03-1.04 | <.0001 |
| Evening (16-20) | 1,065,102 | 12.03 | 1.06 | 1.05-1.06 | <.0001 |
| Overnight (20-8) | 174,758 | 11.37 | 1.03 | 1.02-1.05 | <.0001 |
| **Number of Days Supplied** | | | | | |
| 10-32 days | 8,241,026 | 9.10 | Reference | | |
| <10 days | 180,524 | 8.12 | 1.16 | 1.12-1.19 | <.0001 |
| >32 days | 233,798 | 13.13 | 0.84 | 0.82-0.86 | <.0001 |
| **Type of Antihypertensive** | | | | | |
| Beta Blockers | 1,853,835 | 9.16 | Reference | | |
| Angiotensin Receptor Blockers | 2,004,146 | 8.63 | 0.83 | 0.82-0.84 | <.0001 |
| Calcium Channel Blockers | 1,828,320 | 8.93 | 0.98 | 0.97-0.99 | <.0001 |
| ACE Inhibitors | 1,391,246 | 8.13 | 0.83 | 0.83-0.84 | <.0001 |
| Thiazide diuretics | 672,041 | 9.51 | 0.98 | 0.97-0.99 | <.0001 |
| Loop diuretics | 368,466 | 12.70 | 1.50 | 1.48-1.52 | <.0001 |
| Diuretic combinations | 184,191 | 12.23 | 1.19 | 1.17-1.22 | <.0001 |
| Other diuretics | 145,051 | 8.28 | 0.89 | 0.87-0.91 | <.0001 |
| Alpha Agonists | 74,278 | 21.49 | 2.71 | 2.63-2.79 | <.0001 |
| Alpha Blockers | 68,367 | 8.72 | 1.12 | 1.08-1.15 | <.0001 |
| Potassium sparing diuretics | 56,693 | 13.44 | 1.28 | 1.24-1.32 | <.0001 |
| Vasodilators | 8,804 | 15.19 | 1.87 | 1.70-2.05 | <.0001 |
| **Patient Characteristics** | | | | | |
| **Sex** | | | | | |
| Male | 3,800,463 | 9.69 | Reference | | |
| Female | 4,854,885 | 8.79 | 0.90 | 0.90-0.92 | <.0001 |
| **Age** | | | | | |
| <65 | 2,055,518 | 12.41 | Reference | | |
| 65-69 | 1,595,657 | 8.70 | 0.66 | 0.64-0.66 | <.0001 |
| 70-79 | 3,106,633 | 8.02 | 0.60 | 0.59-0.61 | <.0001 |
| ≥80 | 1,897,540 | 8.00 | 0.59 | 0.48-0.60 | <.0001 |
| **Patient Income*patient cost interaction** | | | | | |
| Low income & low cost | 301,826 | 8.67 | Reference | | |
| Low income & middle cost | 184,565 | 9.59 | 0.93 | 0.91-0.95 | <.0001 |

| | | | | | |
|---|---|---|---|---|---|
| Low income & high cost | 161,414 | 9.89 | 0.88 | 0.87-0.90 | <.0001 |
| Middle income & low cost | 2,286,651 | 8.47 | 0.99 | 0.97-1.01 | 0.241 |
| Middle income & middle cost | 2,459,139 | 9.28 | 0.97 | 0.95-0.99 | 0.003 |
| Middle income & high cost | 2,350,251 | 9.27 | 0.95 | 0.93-0.97 | <.0001 |
| High income & low cost | 210,972 | 10.31 | 1.15 | 1.12-1.18 | <.0001 |
| High income & middle cost | 339,456 | 10.53 | 1.07 | 1.04-1.09 | <.0001 |
| High income & high cost | 361,074 | 10.50 | 1.01 | 0.99-1.04 | 0.336 |
| **Antihypertensive Therapy** | | | | | |
| Chronic Therapy (≥6 months) | 8,528,536 | 9.05 | Reference | | |
| New Therapy (< 6 months) | 126,812 | 18.29 | 1.27 | 1.25-1.30 | <.0001 |
| Multiple Antihypertensive Drugs | 6,872,858 | 8.33 | Reference | | |
| Single Antihypertensive Drug | 1,782,490 | 12.47 | 1.04 | 1.04-1.05 | <.0001 |
| **Continuity of Care** | | | | | |
| Single Dispensing Pharmacy | 7,440,825 | 8.86 | Reference | | |
| Multiple Dispensing Pharmacies | 1,214,523 | 11.16 | 1.10 | 1.08-1.11 | <.0001 |
| Single Prescriber | 6,412,928 | 8.65 | Reference | | |
| Multiple Prescribers | 2,242,420 | 10.72 | 1.16 | 1.15-1.17 | <.0001 |
| | | | | | |
| **Pharmacy Characteristics** | | | | | |
| **Pharmacy Type** | | | | | |
| Independent | 444,956 | 9.69 | Reference | | |
| Chain/banner | 8,210,392 | 9.16 | 1.02 | 1.00-1.05 | 0.034 |
| **Anonymized Pharmacy Chain/Banner/Independent** | | | | | |
| UUU | 2,495,701 | 9.68 | Reference | | |
| VVV | 1,071,922 | 8.01 | 0.84 | 0.80-0.83 | <.0001 |
| TTT | 572,422 | 8.83 | 0.91 | 0.89-0.93 | <.0001 |
| SSS | 840,234 | 10.46 | 1.04 | 1.02-1.06 | <.0001 |
| HHH | 657,249 | 8.12 | 0.84 | 0.83-0.86 | <.0001 |
| EEE | 1,104,215 | 9.06 | 0.94 | 0.93-0.96 | <.0001 |
| Other | 1,913,605 | 9.18 | 0.94 | 0.92-0.95 | <.0001 |
| **Pharmacy Location** | | | | | |
| Shopping Centre | 1,912,484 | 9.39 | Reference | | |
| Neighborhood pharmacy | 2,704,536 | 9.17 | 1.01 | 1.00-1.02 | 0.139 |
| Medical Clinic | 1,300,939 | 8.41 | 0.96 | 0.95-0.98 | <.0001 |
| Medical Offices | 73,561 | 7.99 | 0.98 | 0.93-1.03 | 0.461 |
| Other | 180,417 | 8.34 | 0.96 | 0.93-1.00 | 0.047 |
| Missing | 2,483,411 | 9.54 | 1.01 | 1.00-1.03 | 0.081 |
| **Workload** | | | | | |
| Prescriptions/pharmacist/hour | | | | | |
| <12 | 947,400 | 11.0 | | | |
| 12-<22 | 2,755,796 | 31.8 | | | |
| 22-<34 | 3,668,952 | 42.4 | | | |
| ≥34 | 1,283,200 | 14.8 | | | |
| Odds per 10 increase | | | 0.96 | 0.96-0.97 | <.0001 |
| **Professional Services** | | | | | |
| Total Pharmacist Professional Services | | | | | |
| <0.11 | 2,519,258 | 10.13 | | | |
| 0.11-0.22 | 3,118,481 | 9.05 | | | |
| ≥0.22 | 3,017,609 | 8.54 | | | |
| Odds per 1/100 Rx increase | | | 0.60 | 0.57-0.62 | <.0001 |
| Hypertension adherence services | | | | | |
| 0 | 6,936,363 | 9.23 | | | |
| 1-5 | 1,553,820 | 8.95 | | | |
| 6-10 | 145,393 | 9.80 | | | |

| | | | | | |
|---|---|---|---|---|---|
| ≥10 | 19,772 | 8.74 | | | |
| Odds per 1 per 8 month increase | | | 1.00 | 1.00-1.00 | 0.083 |
| Pharmacist Overlap Index | | | | | |
| <10% | 1,242,727 | 14.4 | | | |
| 10%-<16% | 2,780,707 | 32.1 | | | |
| 16%-<22% | 1,532,245 | 17.7 | | | |
| ≥22% | 3,099,669 | 35.8 | | | |
| Odds per 1% increase | | | 0.95 | 0.90-1.00 | 0.068 |
| Within Pharmacy Continuity of Care Index | | | | | |
| 1-5 | 1282931 | 8.75 | | | |
| >5-10 | 2554425 | 8.93 | | | |
| >10-20 | 2331227 | 9.37 | | | |
| >20 | 2486765 | 9.50 | | | |
| Odds per 10 increase | | | 1.003 | 1.001-1.005 | 0.012 |

## DISCUSSION

**Statement of Principal Findings:** This study is the first to document that linked community pharmacy claims and health administrative data can be used to directly measure a range of pharmacy-level characteristics and quality measures. It is also the first study that investigated the association between the provision of pharmacists' professional services and better within-pharmacy continuity of care with adherence, showing that each of these pharmacists' practices are associated with a decreased odds of dispensing antihypertensive medications to non-adherent patients.

**Strengths and Limitations:** The main strengths of this study are the direct measurement of pharmacy characteristics from administrative claims data and the use of an objective, validated quality of care measure of adherence (10-12). As significant variability in results has been reported from studies using differing measures of adherence, use of standardized methods for measuring adherence is particularly important in determining predictors of non-adherence (10). As only 1% of community pharmacies in Quebec did not consent to participate (18 of 1891), a second strength is that the sample approximated a population-based cohort and selection-bias was minimized. Limitations include that we evaluated performance on only one quality of medication-use measure and results cannot be generalized to other measures of pharmacists' quality of care. Although underuse measures of other therapeutic categories such as lipid-lowering or diabetes may show similar results, determinants of performance on quality indicators measuring medication overuse (eg

rescue inhalers for asthma) or unsafe dispensing may differ as the professional services pharmacists provide to detect and manage these medication-use problems differ from those provided for medication underuse. Evaluation of performance on additional quality indicators measuring both adherence and unsafe dispensing is required to determine if results are generalizable. In addition, our methodology for calculating adherence did not allow for detection of primary non-adherence or non-adherence / non-persistence within the first 90 days of therapy. As these types of non-adherence are problematic with antihypertensive medications, our results may have underestimated non-adherence and measures of these additional types of non-adherence should be evaluated. Finally, administrative claims data are limited in the extent to which they can measure whether pharmacists provided a service but did not bill for it (42-44).

**Interpretation:** Our overall rate of non-adherence is consistent with previous reports that utilize community pharmacy administrative claims data and similar measures of non-adherence (10, 45). Calculation of pharmacy-level characteristics required multiple steps and complex analysis and for characteristics that had previously been estimated via self-report, such as prescriptions per pharmacist per hour, our results were higher (18.4 +/- 10.5 our study vs 14.1 +/- 4.9)(17). This is consistent with national reports documenting higher total prescriptions dispensed in Quebec relative to other provinces (37). Results of the drug and patient characteristics affecting non-adherence agree with previous research documenting that there is higher adherence to antihypertensive medications with fewer side effects, such as ARB and ACE, and that increasing age is associated with increased adherence to antihypertensive medications (32, 46). However, given the variability in results of non-adherence rates and predictors from studies that used differing measurement methodologies, our results should be compared with studies using pharmacy administrative claims data and standardized methods for measuring non-adherence (10). To our knowledge, this literature is limited to the study that used an ecological approach to measuring pharmacy and patient characteristics (20). Our results differ from this ecological study for the impact of patient sex and income, and independent pharmacy ownership on the odds of dispensing to a non-adherent patient. Our results demonstrate the impact of measuring these characteristics directly for each dispensing and adjusting for clustering. When only considering whether the pharmacy is independent vs a chain/banner, the

incidence of non-adherence is higher in independent pharmacies. However, when adjusted for clustering and the remaining dispensing, patient and pharmacy characteristics, this association reverses with chain / banner pharmacies demonstrating a greater odds of non-adherence. The same is true for the impact of patient costs relative to income. Without adjustment, the incidence of non-adherence increases as cost to the patient increases. However, when adjusted for all characteristics, this relationship reverses. As higher patient cost typically occurs with second-line treatments for hypertension, this may represent patients who required switches or additions to their therapies due to side or insufficient effects from their initial treatments, which has been shown to increase adherence (47).

The most striking results of our analysis are the reductions in the odds of non-adherence with both an increasing rate of provision of pharmacists' professional services and improved within-pharmacy continuity of care. It is hypothesized that the relationship between the rate of provision of these services and lower non-adherence indicates that improved quality of care is provided at pharmacies where pharmacists prioritize provision professional services vs involvement in technical distributive functions (48, 49). The relationship between improved within-pharmacy continuity of care and decreased odds of non-adherence supports such a hypothesis as patients can more easily develop trusting relationships with their pharmacist when continuity of care is improved. Our findings that increased workload is associated with lower odds of non-adherence would not appear to support that increased workload challenges pharmacists' provision of quality care. However, we had removed very high volume pharmacies so we did not see the previously reported results of lower quality of care in pharmacies with both very low and very high dispensing volumes (15). The strong positive correlation between workload and pharmacist-overlap suggests that pharmacists are not being scheduled to provide professional services but to enable increased number of prescriptions to be processed. As both culture and workflow are determined predominantly by the pharmacist owner, greater freedom to emphasize professional pharmacists' practice by owners of independent pharmacies could account for their lower odds of non-adherence relative to chains / banners (50). Similarly, differences in practice philosophy among the chains / banners could account for the variability in performance among the different banners and chains.

**Implications and Future Research:**

Our results indicate that emphasis on the caring role of pharmacists both during dispensing and via provision of professional services appears key to improving patients' use of medications. Results also support policies that encourage continuity of care and that focus adherence strategies on younger males, new to treatment and taking single antihypertensive therapy. Pharmacy administrative claims data can be used to directly measure dispensing, patient and pharmacy characteristics, thereby increasing the range and accuracy of pharmacy-level characteristics evaluated. Evaluation of additional measures both of non-adherence and dispensing of contraindicated medications is needed to determine if there is consistency across the measures of pharmacy-level characteristics identified in our study as being related to pharmacists' quality of care.

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**Acknowledgements** We thank Danielle Fagnan, from the Quebec Order of Pharmacists, for the support provided throughout the project. We thank Sherry Shi for her analysis of the data. The critical review of the manuscript and recommendations for analysis by Drs Cees van der Vleuten and Lambert Schuwirth are gratefully acknowledged. We acknowledge the financial support of Green Shield Canada Foundation and the financial and administrative support of the Quebec Order of Pharmacists.

**Contributors** NW and RT conceived and designed the project. NW reviewed literature to determine relevant potential predictors. RT provided expertise on the statistical analysis. NW completed the basic analysis and drafted the manuscript. RT contributed substantially to the manuscript revision. NW redrafted and finalized the manuscript following reviewers' recommendations. RT contributed substantially to the final revisions.

**Competing Interests:** We have read and understood the BMJ policy on declaration of interests, and have completed the ICMJE uniform disclosure form and declare the following interests: Dr. Winslade reports grants from Green Shield Foundation Canada, personal fees and non-financial support from Quebec Order of Pharmacists, during the conduct of the

study. Dr. Tamblyn reports grants from Green Shield Foundation Canada and non-financial support from Quebec Order of Pharmacists, during the conduct of the study.

**Ethics approval:** University's Faculty of Medicine Institutional review board # A05-E20-08B

**Funding:** Green Shield Foundation Canada provided a grant for completion of this project and was both informed of the decision to submit this paper and received a copy of the manuscript. The Quebec Order of Pharmacists provided a matching grant in the form of salary support, facilitated and paid the required data-access fees to RAMQ.

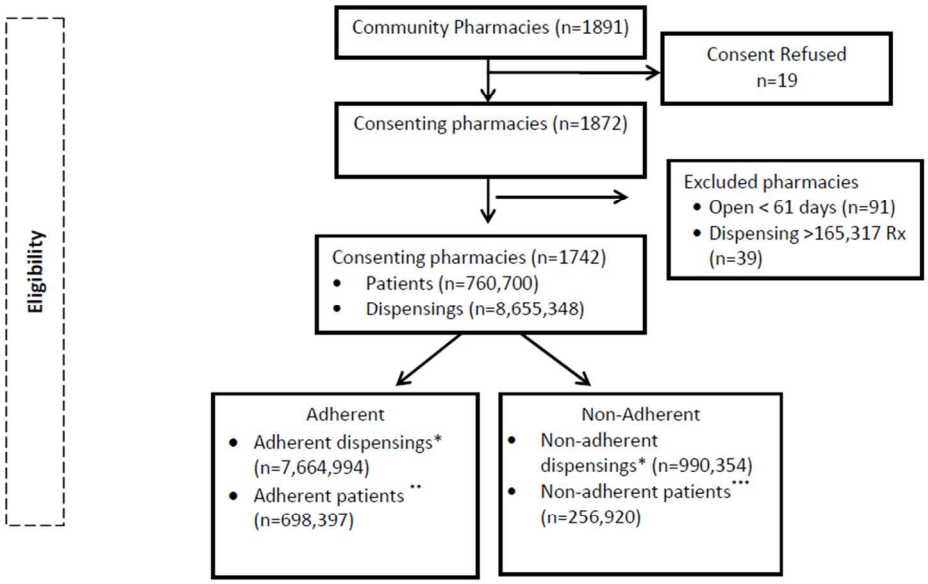


**Figure 1. Consort diagram.**

* Dispensings that were provided to patients who had been either adherent or non-adherent with their antihypertensive medication over the previous 90 days.

** Patients with at least one adherent dispensing over the 8 month study period.

*** Patients with at least one non-adherent dispensing over the 8 month study period. As patients received multiple dispensings, they could be counted as both adherent and non-adherent, therefore the total of adherent and non-adherent patients is more than 760,700.

Figure 1. Consort Diagram

255x240mm (96 x 96 DPI)

**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies***

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 4 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 6 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5 & 6 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up | 6 |
| | | (*b*) For matched studies, give matching criteria and number of exposed and unexposed | n/a |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6-8 |
| Data sources/ measurement | 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 | 9 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 9 |
| Study size | 10 | Explain how the study size was arrived at | 6 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 9 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 9 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | 9 |
| | | (*c*) Explain how missing data were addressed | n/a |
| | | (*d*) If applicable, explain how loss to follow-up was addressed | n/a |
| | | (*e*) 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 | 10 |
| | | (b) Give reasons for non-participation at each stage | 10 and figure 1 |
| | | (c) Consider use of a flow diagram | Figure 1 |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 10 and Table 1 |
| | | (b) Indicate number of participants with missing data for each variable of interest | Table 1 |
| | | (c) Summarise follow-up time (eg, average and total amount) | 10 |
| Outcome data | 15* | Report numbers of outcome events or summary measures over time | 12-14 and Table 2 |
| 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 | Table 2 |
| | | (*b*) Report category boundaries when continuous variables were categorized | Tables 1 and 2 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | n/a |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 17 |
| **Limitations** | | | |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 16-19 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 16-17 |
| **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 | 25 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**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.