# Patient Readmissions After Hospital Discharge

by

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A thesis submitted in conformity with the requirements for the degree of Doctor of Philosophy Institute of Health Policy, Management & Evaluation University of Toronto

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### Abstract

Many readmissions after hospital discharge may be preventable through improved transitional care. This thesis seeks to inform clinical practice and policy development to reduce avoidable readmissions. The three included projects use health administrative data to examine the postdischarge care processes and outcomes for patients hospitalized in Ontario, Canada. In the first study, we compared the outcomes for patients discharged during the extended December holiday to outcomes for patients discharged from hospital at other times, over a 14 year period. We found that December holiday-discharged patients were at greater risk of 30-day death or readmission, while also being less likely to have outpatient physician follow-up within 14 days of discharge. The second study evaluated the effects of a physician financial incentive (an additional billing code) on timely follow-up after discharge. Despite physician uptake of the incentive code, there was no change in 14-day follow-up rates after incentive introduction, suggesting that it was not effective in changing physician behavior. In our third study, we compared the outcomes of postdischarge patients receiving a community pharmacy-based medication review to those not receiving one. Among older adults filling a prescription in a community pharmacy, receipt of a medication review was associated with a reduced rate of 30-day death or readmission. These thesis findings provide evidence to support decision- and policymaking relating to the clinical care of patients transitioning home from hospital.

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# List of Abbreviations

aOR: adjusted Odds Ratio ARIMA: Auto-Regressive Integrated Moving Average CI: Confidence Interval CIF: Cumulative Indicence Function CIHI: Canadian Institute for Health Information CIHR: Canadian Institutes of Health Research COPD: Chronic Obstructive Pulmonary Disease DAD: Discharge Abstract Database FFS: Fee-for-Service **GEE:** Generalized Estimating Equation HR: Hazard Ratio ICD-10-CA: International Classification of Disease, 10th Revision, Canadian version **ITS:** Interrupted Time Series IQR: Interquartile Range MOHLTC: Ministry of Health and Long-Term Care NACRS: National Ambulatory Care Reporting System NOS: Not Otherwise Specified OHIP: Ontario Health Insurance Plan **OPEN: Open Pharmacy Evidence Network** OR: Odds Ratio PCP: Primary Care Physician **PS:** Propensity Score RR: Rate Ratio SE: Socioeconomic Std. Diff: Standardized Difference of Means TCM: Transitional Care Management

# Chapter 1 Introduction

# 1.1 Thesis Background

# 1.1.1 Readmissions After Hospital Discharge

The rate of 30-day readmissions after discharge has been of growing interest since the early 1990s.(1) Beyond their cost, readmissions have been linked to suboptimal quality of hospital care.(2, 3) However, in the past five years 30-day readmission rates have experienced heightened scrutiny. In 2012, the U.S. Affordable Care Act and the Hospital Readmissions Reduction Program (HRRP) started tying 30-day readmission rates to hospital budgets.(4) Hospitals with higher-than-expected rates were penalised financially. This spurred innovation in the area of preventing hospital readmissions. In the U.S., the median hospital-level 30-day readmission rates for Medicare beneficiaries (age 65 and above) was 15.6% in 2014-2015.(5) Since the introduction of the HRRP, 30-day readmission rates have dropped by an absolute 2-4%.(6, 7)

In Canada, 2.8 million patient discharges occur each year.(8) Of these, 9.1% experienced an urgent 30-day readmission in 2015-2016.(9) Those with medical reasons for their original admission have higher readmission rates, most recently reported in Canada to be 14%.(9) Certain admission diagnoses carry an even greater risk: the 30-day readmission rate is 19-22% among patients with chronic obstructive pulmonary disease and 25-27% among patients with congestive heart failure.(3, 10, 11) Readmissions to hospitals in Canada were estimated to have cost \$2 billion in 2012.(12)

# 1.1.2 Causes and Risk Factors

Hospital readmissions are caused by patient, provider and environmental factors. In most cases, patients are readmitted for a diagnosis other than their original reason for admission.(3) Patients remain prone to readmissions for many causes due to a fragile physiologic state after hospitalization.(13, 14) "Post-hospital syndrome" is characterized by a period of generalized risk, thought to be caused by a combination of deconditioning, lack of sleep, poor nutrition and

impaired cognition.(14) Others have further characterized the effects of hospitalization on sleep, mobility, nutrition and mood as a form of trauma.(13)

The development of algorithms which accurately predict a patient's risk of readmission has been the focus of much study. Such algorithms are useful for both clinical practice (to identify patients who would benefit from more preventive efforts) and research (to allow for improved riskadjustment in observational studies). In the most recent systematic review, 73 such predictive scores had been reported, with discriminative abilities (c-statistic) ranging from 0.21 to 0.88 (very poor to very good).(15) Even the performance of a single algorithm has varied widely across study settings.(15) Patient characteristics which have been repeatedly found to be predictive of hospital readmission include the intrinsic patient characteristics of age, sex, comorbidities, functional impairment, socioeconomic status and previous healthcare usage.(15-18) In addition, hospitalization-related characteristics such as most responsible diagnosis, hospitalization acuity, length of stay, and medications prescribed are also significant predictors.(15) More recent predictive algorithms have included laboratory data such as hemoglobin and serum sodium.(19)

Another consistent contributor to the risk of hospital readmission is in-hospital care. Several care deficits likely underlie many avoidable readmissions. The period following hospital discharge is marred by discontinuity between inpatient and outpatient providers, treatment errors, failure to follow-up on results, lack of clinical monitoring and avoidable adverse drug events.(20-30) Hospital-level performance and in-hospital care quality have been linked to readmissions. (2, 5, 31, 32) However, readmissions cannot be solely ascribed to the perils of disorganized hospital care. In fact, performance on hospital process measures are only weakly correlated with readmission rates.(31) Rather, suboptimal care practices combine with intrinsic patient vulnerabilities to enable deterioration and subsequent readmission. The risk imparted by some patient characteristics (like functional impairment) may be addressed with better discharge practices. However, other patient factors (like a chronic mental health condition or substance addiction) may not be so easily overcome.(33)

In an attempt to identify problematic or exemplary care practices, others have attempted to focus on provider or hospital characteristics which are predictive of hospital readmission. While most commonly-used health administrative data sources do not hold detailed information on processes of care, studies of provider and hospital characteristics hint at the effect that practice differences can have on readmission rates. For instance, hospitals with the following characteristics have higher readmission rates: for-profit status, small community size, teaching status, or large urban status.(11, 34, 35) Hospitals with higher spending intensity attain higher scores on quality of care criteria and have lower standardized 30-day readmission rates.(36) Similarly, higher hospitalist staffing levels are associated with lower readmission rates. (37) At the physician level, the patients of women hospitalists have fewer readmissions.(38) That higher staffing levels, higher spending intensity and not-for-profit status have all been linked to lower readmission rates suggests that an abundance of resources (people, time, money) may enable better discharge processes.

#### 1.1.3 Avoidability

Hospital readmissions can be divided into those that, with better care practices, might have been avoided, and others which would not have been reasonably preventable. The avoidable proportion better reflects the opportunity for improvement. This was most recently estimated at 27% in the U.S. Medicare population; previous estimates in various populations have ranged from 5-79%, with a median of 27%.(39, 40) The causes and probability of readmission change depending on the time since discharge.(41, 42) Readmissions which occur in the first 7 days are more likely to be deemed preventable and linked to instability in the 24 hours prior to discharge.(40, 41, 43) Some have called for governmental authorities to instead use such a shorter-term metric.(44)

Overall, the majority of hospital readmissions fall within the "not avoidable" category. If most of an individual patient's risk is not modifiable, the traditional approach of targeting high risk patients for discharge interventions may need to be reconsidered. Instead, it would be useful to prospectively identify patients with high baseline risk that is most likely to be modified by improved quality of care.(45, 46) In other words, elucidating which patient risk factors predict avoidability of readmission would be advantageous. Yet, out of 73 predictive models for readmission, only two were designed to identify patients at risk of avoidable hospital readmissions, rather than all unplanned readmissions.(15, 47, 48)

#### 1.1.4 Interventions

Burke et al. and Naylor et al. have suggested comprehensive frameworks with which to approach the care transitions literature.(49, 50) Interventions aimed at preventing readmission can be categorized according to their type or timing. The components found most commonly in studies of transitional care interventions are patient education, medication safety, and coordination of care.(50) Canadian and U.S. groups have published hospital discharge checklists, which are effectively practice guidelines for hospital discharge.(51, 52)

Studies of the effect of interventions on readmissions are numerous and heterogeneous in terms of interventions, populations, and outcome definitions. Fortunately, recent systematic reviews and one review of reviews highlight some cross-cutting themes. Burke et al. (2014) found that the number of included process domains was the greatest predictor of interventional success. The domains with stronger association with reducing readmissions were: "Monitoring and Managing Symptoms after Discharge", "Enlisting Help of Social and Community Supports", and "Educating Patients to Promote Self-Management." (50) In a review which included a meta-regression, Leppin et al. (2014) reported that the degree of "comprehensive support" had an incremental effect on reducing readmissions. They also noted that studies published prior to 2002 reported greater interventional benefits than those published thereafter. Proposed explanations include an improving standard of transitional care and increasing research focus on testing single interventions rather than more effective comprehensive transition bundles.(53)

Consistent with these two earlier reviews, the authors of a review of systematic reviews found that most successful interventions were comprehensive and bridged the care transition, with both pre- and post-discharge components. They further reported that there was moderate strength evidence supporting the use of 1) structured and individually tailored discharge planning as well as 2) hospital-at-home initiatives to reduce readmissions in the general medical populations and patients with congestive heart failure.(54)

#### 1.1.5 Policy Interventions to Reduce Readmissions

Policy interventions operating at the provider, hospital or regional level have been introduced with the aim of improving transitional care. These often depend upon financial rewards or penalties to incentivise a change in care practice. Some incentives, linked only to readmissions, are broad in scope, and may stimulate innovation or the adoption of multicomponent discharge bundles. Others are narrower, and tie monetary consequences to the completion of certain specific process measures.

The largest policy intervention relating to hospital readmissions has been U.S. Medicare's Hospital Readmissions Reduction Program (HRRP), which ties hospital funding to standardized readmission rates for patients with acute myocardial infarction, heart failure, pneumonia, chronic obstructive pulmonary disease, and elective total hip and knee arthroplasty.(55) Since its introduction, U.S. hospitals funded through HRRP have reduced the 30-day readmission rate for target and non-target conditions by an absolute 2-4%.(6, 7) Hospitals that participated in any of 3 additional value-based programs in addition to HRRP had even greater reductions in readmission rates.(56) The effects of the HRRP may have even extended to non-Medicare populations, including the privately-insured.(57) However, there is concern that some of the drop in readmissions under HRRP may be explained by changes in coded severity and increased usage of observation units to avert readmissions.(7, 58)

As an example of a process-focused policy change, Medicare's Transitional Care Management (TCM) Service Codes provide additional funding for post-discharge management by outpatient physicians. In addition to early follow-up, the service includes telephone follow-up within two days of discharge.(59) Although there was very low uptake of the TCM service by outpatient providers, patients who received this service were less likely to die within 30 days, and had lower 30-day healthcare costs than those who did not receive the TCM service.(60)

# 1.1.6 Development of a Research Agenda with Policy Relevance for the Province of Ontario

Ontario is Canada's most populous province, with 14 million residents.(61) Residents of the province receive hospital care and physician services free of charge, as long as they have a valid provincial health card. Adults at or over age 65 also benefit from provincial drug coverage, with a small income-based copayment. The 30-day hospital readmission rate in Ontario was 0.1% above the national average in 2016-2017, at 9.2%.(9)

Over the past decade, the Ontario Ministry of Health and Long-Term Care has implemented a series of healthcare funding reforms. Hospitals, which were previously funded entirely through

global budgets, now receive some funding tied to each episode of care for patients with target conditions or procedures.(62-64) Among others, these include heart failure, chronic obstructive lung disease, pneumonia and hip fracture. These funding reforms do not currently link readmission rates to financial penalties or rewards, and their impact on return to hospital and other outcomes is presently being studied.

Over a similar time period, the Ontario Ministry of Health and Long-Term Care has made changes to physician and pharmacist remuneration. By adding fee codes which support followup after hospital discharge, the Ministry of Health added financial resources to the provision of transitional care. In this context, we developed a program of research centered on healthcare policy and hospital readmissions in Ontario. All three projects aim to improve understanding of the causes of and possible solutions to hospital readmissions for Ontario patients.

# 1.2 Thesis Structure

This thesis consists of three projects designed to inform policy development to reduce avoidable readmissions. The first compares the outcomes of patients discharged during the extended December holiday to the outcomes of patients discharged from hospital at other times. The second examines the effects of a fee code incentive introduced to Ontario physicians on physician follow-up and hospital readmissions rates. The third evaluates the effects of a program of community pharmacist medication review on outcomes after discharge from hospital.

#### 1.2.1 Physician Follow-Up and Readmissions (Projects #1 and #2)

#### 1.2.1.1 Background

Early follow-up with an outpatient physician has been proposed as one means of reducing hospital readmissions.(65) It is one of the top three most common components of transitional care interventions, along with care coordination and patient education.(50) Timely follow-up after hospital discharge has been associated with a lower risk of readmission in patients admitted for chronic obstructive pulmonary disease and congestive heart failure.(66-71) Findings have been mixed in other populations.(72-76) Conclusions on the benefits of follow-up have been limited as studies of follow-up alone are observational, while trials have combined follow-up

with other transitional care interventions.(65) Early follow-up after hospital discharge is now a quality indicator for all primary care practices in Ontario.(77)

Barriers to follow-up arise at the intersection of patient factors and limitations of inpatient and outpatient care. Patients may miss attending follow-up due to ongoing symptoms, language barriers, low health literacy, restricted mobility, a lack of transportation, insufficient money, or a shortfall of time. Inpatient physicians may fail to: 1) inquire about or accommodate for such factors, 2) convey the importance of follow-up, and 3) inform outpatient providers of the need for a timely appointment. Finally, outpatient providers may be inaccessible (due to office closures) or may not prioritize follow-up, resulting in significant delays.

Several studies have shown that providing patients with an appointment before they leave the hospital increases follow-up.(78-80) Yet, the most commonly reported post-discharge problem relates to scheduling.(81) In many cases, discharging physicians do not speak to community physicians, and the discharge summary is not available within 2 weeks of discharge.(29, 30) Patients are expected to convey information across providers, but do not feel prepared to do so.(82) This means outpatient physicians are likely unaware of the need for follow-up until the window for an early visit has already closed. Patient factors such as poor mobility and low socioeconomic status are associated with a lower likelihood of attendance at follow-up.(72, 83-85) Patients who lack a familiar physician or live in rural areas are also less likely to follow-up.(86, 87) The 2016 Commonwealth Fund Survey suggests that timely access to outpatient care continues to be a weakness of the Canadian healthcare system. Despite having a primary care provider, only 43% of Canadians reported that they could obtain an appointment within 1-2 days.(88, 89)

### 1.2.1.2 Project #1: Death and Readmissions After Hospital Discharge During the December Holiday

We suspected that the December holiday period is a vulnerable time for patients being discharged from hospital. Reduced staffing levels inside and outside of hospital can result in decreased transitional care coordination and access to follow-up care. Both of these might be expected to lead to an increased risk of readmission in holiday-discharged patients.

Specific Aim: To determine whether patients discharged during the December holiday period have less outpatient follow-up and higher rates of death or readmission than patients discharged from hospital at other times.

# 1.2.1.3 Project #2: Effectiveness of a financial incentive to physicians for timely follow-up after hospital discharge

In October 2006, the Ontario Ministry of Health and Long-Term Care introduced a new fee code, e080. This code provides a \$25 premium to a primary care provider for an outpatient visit within two weeks of a patient's hospital discharge.(90) In 2013, Medicare introduced a similar fee code.(91) We questioned whether such incentives were successful in their most proximate goal, to increase rates of follow-up, or in their downstream goal of reducing rates of readmission.

Specific Aim: To evaluate whether the introduction of an incentive fee code increased rates of timely physician follow-up after discharge and decreased unplanned return to hospital

#### 1.2.2 Community Pharmacy Follow-Up and Readmissions (Project #3)

#### 1.2.2.1 Background

Medications are the most frequent cause of adverse events following hospital discharge, accounting for 13-16% of readmissions.(20, 22, 92) Medication-related avoidable readmissions most commonly occur as a result of prescription errors or failure to implement proper monitoring.(92) Discharged patients have little understanding of medication changes, further impeding adherence and follow-up.(25) Medication reconciliation by in-hospital pharmacists is used to ensure that pre-existing outpatient medications are not inadvertently excluded from discharge medication lists. Although this practice has been found in some cases to reduce potential medication errors, drug-related readmissions and emergency department visits, it has not decreased all-cause readmissions.(93-96) Medication review in older patients has been associated with reductions in the number of prescriptions, improved knowledge and adherence.(97) In-hospital medication review and reconciliation frequently form part of successful multicomponent discharge interventions.(54, 95, 98, 99)

Yet, there are comparatively few studies of the effect of community pharmacy interventions on readmission rates. Use of community pharmacist-led medication review and reconciliation has

been increasing, supported by health insurers in the U.S., Canada and the United Kingdom.(100-103) A recent systematic review of community-based pharmacist-led medication reconciliation after discharge identified 5 randomized controlled trials and 6 cohort studies, and found no overall effect on hospital readmissions.(104) Of these, only 1 reported an intervention conducted in a community pharmacy setting, yet this study did not report readmission rates.(105) We identified three additional observational studies not included in this review, which report a reduction in hospital readmissions associated with a community pharmacist intervention; two out of three studies report phone-based interventions, and one employed an in-pharmacy face-to-face visit.(106-108) Community pharmacy interventions may be combined with other transitional care measures, including inpatient pharmacist counselling, to optimize transitional medication management. For example, a statewide initiative combining the efforts of in-hospital and community pharmacists reduced hospital medication-related admission rates in Hawaii. Allcause readmissions were not compared.(109)

# 1.2.2.2 Project #3: Community pharmacy medication review, death and readmissions after hospital discharge

In 2007, the Ontario Ministry of Health and Long-Term Care introduced MedsCheck, a program of funded medication review and counselling by community pharmacists for all Ontarians, regardless of age. The introduction of pharmacist professional services to the fee schedule was intended to offset the negative financial impact of removing pharmaceutical manufacturer rebates, a major source of pharmacy revenue to that point.(110) Under the MedsCheck program, patients presenting to pharmacy with two weeks of hospital discharge are eligible for a Follow-Up, if they take at least three chronic medications.(111) The effect of this intervention on hospital readmissions has not previously been studied.

Specific Aim: To determine if patients receiving MedsCheck after hospital discharge have lower rates of readmission than other patients who filled a prescription but did not receive MedsCheck.

# 1.3 Thesis Methods

#### 1.3.1 Perspective and Conceptual Framework

This thesis was approached through a positivist lens, using quantitative methods intended to uncover whether pre-specified risk factors and interventions were associated with differences in outcomes. Questions were answered using frequentist statistics and tested with reference to the null hypothesis. Based on the Donabedian structure/process/outcome model, we developed a conceptual framework to help understand the relationships under study, and to guide methodology.(112) The framework (Figure 1.1) includes patient and hospitalization risk factors, as well as care processes contributing to the risk of readmission. For example, patient socioeconomic status may directly affect risk of readmission. It may also affect the likelihood of follow-up, which itself may affect the risk of readmission. The potential interventions included in Figure 1.1 are care processes that fall within the domains described in the Ideal Transitions of Care framework.(50, 113)

Figure 1.1. Theoretical framework for the relationship between patient and hospitalization characteristics, transitional care, and readmissions after hospital discharge. Black boxes contain unmeasured factors, blue boxes contain measured factors which contribute to patient's quality of care and risk of readmission. The green box contains examples of inhospital and post-discharge care processes or interventions. SE=socioeconomic.



#### 1.3.2 Common Methods

#### 1.3.2.1 Outcome

In all studies, we report on the composite outcome of 30-day death, urgent re-hospitalization, or emergency department visit. This composite outcome was the primary outcome for projects # 1 and # 3, and a secondary outcome for project # 2. We included unplanned emergency department visits as these also represent costly returns to hospital in a recently-discharged patient. Although much previous research has centered on re-hospitalizations alone, emergency department visits after discharge reflect a similar underlying process: decompensation once a patient returns home, leading them to seek unplanned, hospital-based care. Further, post-discharge emergency department visits, observations stays and re-hospitalization are known to have many of the same risk factors.(11, 35)

#### 1.3.2.2 Data Sources

The administrative databases used in this study are the multiply-linked health administrative databases at ICES in Toronto, Canada. Patient-level data are de-identified and linked across datasets using an encrypted patient identifier, in accordance with the Ontario Personal Health Information Protection Act. Data are available on all Ontario residents with a valid health insurance card. The universal nature of health insurance coverage in Ontario means that studies using these data sources are population-based.

The ICES databases used in this thesis are described below:

The Registered Persons Database (RPDB) contains information about anyone who has ever received an Ontario health card number, i.e. all Ontarians alive at any time since 1990 (over 16 million records).(114) The main data elements are: demographic information (date of birth, sex, date of death), geographic information (postal code of residence at different times), eligibility for health insurance coverage over time, and date of last contact with the healthcare system. The date of death in RPDB captured over 98% of Ontario health planning death counts.(115)

The Discharge Abstract Database (DAD) includes information on all admissions to acute care hospitals in Ontario. This includes dates of admission as well as diagnostic and procedural codes. Overall, diagnostic codes were found to be 82% sensitive for primary diagnosis when verified

against chart abstraction.(116) The date of readmission in the DAD has also been validated, with an accuracy of 99.9% when compared to chart abstraction.(116)

The National Ambulatory Care Reporting System (NACRS) includes information for all emergency department visits since 2000. The date of emergency department visit in NACRS is 100% complete (none missing) but has not been previously validated. It can be expected to have similar accuracy to the date of admission in the DAD, since both are entered by the same trained hospital coders.

The Ontario Health Insurance Plan (OHIP) database contains information on all billing claims submitted by Ontario physicians, including consultations and procedures. Fee for service is the primary method of remuneration for 95% of specialist physicians and 50% of primary care physicians in Ontario. However, physicians practicing in non fee-for-service models submit shadow billings to OHIP, which appear as billing claims with a payment value of \$0.(117)

The Home Care Database (HCD) contains information on home care services provided by the Ontario Association of Community Care Access Centres to Ontario residents.

The ICES Physician Database (IPDB) contains demographic information, age, certification and self-reported specialty information for all Ontario physicians.(118)

The Client Agency Program Enrolment Database (CAPE) identifies patients rostered to primary care physicians under several patient enrolment models of clinical practice. These funding models include enhanced fee for service, non-team capitation, and team-based capitation.(119)

The Ontario Drug Benefit (ODB) database includes information on medications provided to residents over the age of 65, as well as through the Trillium program, which provides coverage for individuals with high drug costs relative to income level. Information available through this database includes drug name, dose, amount and date dispensed. ODB claims data are highly accurate, with a 0.7% error rate when compared to audited prescriptions.(120)

The Citizenship and Immigration Canada (CIC) database contains information on immigrants who have landed in Ontario since 1985. This database has been used in previous studies.(121, 122)

# 1.4 Thesis Format

This thesis consists of an introductory chapter, three projects, a concluding chapter, and an appendix. Chapters 2-4 consist of the three thesis projects. At the time of thesis submission, Chapter 2 was accepted for publication and Chapter 3 had been published, both in peer-reviewed medical journals. Chapter 4 will be submitted for publication following thesis submission.

# 1.5 Thesis Summary

This thesis provides new evidence on preventing readmissions after hospital discharge. It describes the post-discharge outcomes of patients discharged during the December holiday, with the aim of informing future interventions and policy development. It evaluates the effect of two policy interventions (an incentive code for early follow-up and a community pharmacy medication review) on post-discharge outcomes in the province of Ontario. Given the growing cost of healthcare, evidence-based policy-making is an essential component of responsible governance. In addition to informing clinicians in their transitional care decision-making, this thesis builds the knowledge base upon which important policy decisions are made.

# Chapter 2 Death and Readmissions After Hospital Discharge During the December Holiday

# 2.1 Chapter Overview

A version of this chapter was accepted for publication as:

Lapointe-Shaw L, Austin PC, Ivers NM, Luo J, Redelmeier DA, Bell CM. Death and Readmissions After Hospital Discharge During the December Holiday: Cohort Study. BMJ. 2018; 363:k4481.

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### 2.2 Abstract

Background: Reduced healthcare staffing around major holidays may affect patient outcomes after hospital discharge. Our objective was to determine whether patients discharged during the December holiday period have less outpatient follow-up and higher rates of death or readmission than patients discharged from hospital at other times.

Methods: This was a population-based retrospective cohort study of patients discharged home following an urgent admission to an acute care hospital in Ontario, Canada, from 2002 to 2016. Patients discharged during the 15-day December holiday, as determined by the school-year calendar, were compared to those discharged during two control periods in late November and January. The primary outcome was death or readmission, defined as an emergency department visit or urgent re-hospitalization, within 30 days. Secondary outcomes measured at 7- and 14- days were death or readmission as well as outpatient physician follow-up. Multivariable logistic regression with generalized estimating equations was used to adjust for patient, admission, and hospital characteristics.

Results: The 217,305 (32.4%) patients discharged from hospital during the December holiday and 453,641 (67.6%) patients discharged during control periods had similar baseline characteristics and prior healthcare utilization. Patients discharged during a December holiday were less likely to have outpatient physician follow-up within 7 days (36.3% vs 47.8%, adjusted OR 0.61, 95% CI 0.60-0.62) and 14 days (59.5% vs 68.7%, adjusted OR 0.65, 95% CI 0.64-0.66) after leaving hospital. Holiday-discharged patients were also at higher risk of death or readmission at 30 days (25.9% vs 24.7%, adjusted OR 1.09, 95% CI 1.07-1.10). This relative increase was also seen at 7 days (13.2% vs 11.7%, adjusted OR 1.16, 95% CI 1.14-1.18) and 14 days (18.6% vs 17.0%, adjusted OR 1.14, 95%CI 1.12-1.15). Per 100,000 patients, there were 2,999 fewer 14-day follow-up appointments, 26 excess deaths, 188 excess hospitalizations and 483 excess emergency department visits attributable to December holiday discharge.

Conclusions: Patients discharged from hospital during the December holiday are less likely to have prompt outpatient follow-up, and are at higher risk of death or readmission.

## 2.3 Introduction

Each December, school-aged children enjoy a two-week Christmas Holiday. This extended period is characterized by festivities, social commitments, and highly synchronous time off work for parents and employed persons in general. Meanwhile, patient demand for urgent medical care continues during this busy time, when influenza and other respiratory viruses may trigger a rise in hospital visits.(123-128) Acute hospital-based services usually remain available throughout this period, but this may not be the case for outpatient care. Early outpatient physician follow-up provides an opportunity for education, medication reconciliation, review of pending results, and detection of clinical deterioration following hospital discharge.(129) This practice is associated with reduced readmissions in patients admitted for some chronic diseases(66-68) and is now a quality indicator for primary care practices.(77)

Studies of the "weekend effect" have described increased mortality in patients admitted to hospital on weekends compared to weekdays.(130-132) One proposed mechanism is decreased staffing of hospitals during off-hours.(133) Delays in tests and procedures on weekends provide further evidence of real differences in weekend care.(134, 135) The comparatively few studies examining the effect of timing of hospital discharge on patient outcomes have reported mixed results.(136-140) Weekend-discharged patients have tended to be younger, have fewer comorbidities, and shorter lengths-of-stay.(138, 140, 141)

We hypothesized that the December holiday is a vulnerable time for patients discharged from hospital. Reduced staffing levels may affect care coordination and access to follow-up. We sought to test whether patients discharged from hospital during the December holiday experienced greater risk of death or readmission than patients discharged at other times. In addition, we compared outpatient physician follow-up in these two groups.

#### 2.4 Methods

#### 2.4.1 Setting, Design and Data Sources

We conducted a population-based retrospective cohort study of patients discharged from acute care hospitals between April 1<sup>st</sup> 2002 and January 31<sup>st</sup> 2016, in Ontario, Canada. ICES in Toronto, Canada, collects de-identified health administrative data for all residents with a health

insurance number, including information on hospital admissions, (116) emergency department visits, (142) outpatient physician visits, (143, 144) demographics and vital statistics. (115) This project was approved by the Research Ethics Boards of the University of Toronto and Sunnybrook Health Sciences Centre.

#### 2.4.2 Study Population

We identified all patients discharged to the community (not transferred to a nursing home, rehabilitation centre, or another acute care facility) after an urgent hospitalization in Ontario between April 1<sup>st</sup> 2002 and January 31<sup>st</sup> 2016. We excluded three groups likely to have markedly different follow-up needs and readmission risk: newborns, patients admitted for an obstetrical delivery or palliative care, or those with a length of stay greater than 100 days (Figure 2.1). We excluded individuals with missing age, sex, invalid home locations or invalid death dates, as well as patient discharges that did not occur during the December holiday or control periods. We selected each patient's first hospital discharge, and excluded all others.

# Figure 2.1. Flow chart detailing exclusions for study population. OHIP= Ontario Health Insurance Plan.



# 2.4.3 Exposure

The exposure was the period of hospital discharge: December holiday or control. The December holiday, which always contained both Christmas and New Year's days, was defined based on the two-week winter break described in the school year calendar in the province of Ontario.(145) The precise start and end dates shifted each year to always begin and end with a weekend. We

defined the start and end as Fridays to ensure that the follow-up window most closely aligned with the December holiday period (Table 2.1).

Table 2.1. Holiday and control period start and end dates. These dates always correspond to the last Friday working to last Friday of vacation period. All date ranges are inclusive. Holiday periods will be compared to control periods beginning 4 weeks prior and 4 weeks following the first day of the holiday period (period B).

Fiscal Year (April- March)	Period A	Period B (December Holiday period)	Period C
2002	Nov 22-Dec 6	Dec 20-Jan 3	Jan 17-31
2003	Nov 21-Dec 5	Dec 19-Jan 2	Jan 16-30
2004	Nov 19-Dec 3	Dec 17-Dec 31	Jan 14-28
2005	Nov 25-Dec 9	Dec 23- Jan 6	Jan 20-Feb 3
2006	Nov 24-Dec 8	Dec 22-Jan 5	Jan 19-Feb 2
2007	Nov 23-Dec 7	Dec 21-Jan 4	Jan 18-Feb 1
2008	Nov 21-Dec 5	Dec 19-Jan 2	Jan 16-30
2009	Nov 20-Dec 4	Dec 18-Jan 1	Jan 15-29
2010	Nov 19-Dec 3	Dec 17-Dec 31	Jan 14-28
2011	Nov 25-Dec 9	Dec 23-Jan 6	Jan 20-Feb 3
2012	Nov 23-Dec 7	Dec 21-Jan 4	Jan 18-Feb 1
2013	Nov 22-Dec 6	Dec 20-Jan 3	Jan 17-31
2014	Nov 21-Dec 5	Dec 19-Jan 2	Jan 16-30
2015	Nov 20-Dec 4	Dec 18-Jan 1	Jan 15-29

Two control periods were selected based on their corresponding winter timing, as well as their separation from the December holiday season. Accordingly, these control periods began exactly four weeks prior to and following the start of that year's December holiday period, in November

and January. Control periods contained the same number of Fridays, weekdays and weekends as the December holiday period, and never contained statutory holidays.

#### 2.4.4 Patient and Hospital Characteristics

We examined hospital type and the following patient and admission characteristics: year of hospital discharge, age, sex, rural residence, Charlson comorbidity score(146), socioeconomic status (as measured using the median neighborhood income quintile), hospital length of stay, arrival by ambulance, diagnosis, discharge disposition, and previous healthcare usage (emergency department visits, hospitalizations, outpatient visits, home care visits).

#### 2.4.5 Outcomes

The primary outcome was a 30-day composite of death or readmission. Readmission was defined as either an emergency department visit or urgent re-hospitalization. Secondary outcomes included outpatient follow-up with any physician within 7- and 14-days following hospital discharge (Table 2.2). We also reported 7 and 14-day death or readmission, as well as the 7-, 14- and 30-day sub-components of this composite outcome: death, urgent re-hospitalization, or emergency department visit. We selected discrete outcomes for our main analyses due to their intuitive interpretation and policy relevance, as performance indicators are frequently based on binary outcomes at 7, 14 and 30 days.

Term	Details
Outpatient physician follow-up	A billing code in the Ontario Health Insurance Plan database (Setting: office or home (location in 'O','H''), exclude codes starting with: X, J, L, H, E, Q. E, G310, G313, G538, G590, G373, G489, or any laboratory test. This definition includes visits to walk-in clinics, however would exclude visits to emergency departments. This definition does not include non-physician providers such as nurse practitioners. As physician assistants require supervision by physicians, visits with physician assistants would be captured as physician visits.
Ontario Health Insurance Plan (OHIP) database	Contains all physician billing claims for insured physician services in Ontario.

Table 2.2. Definition of outpatient physician follow-up

#### 2.4.6 Statistical Analysis

Patients discharged during the December holiday were compared to patients discharged during control periods. Univariate comparisons of baseline variables were made using standardized differences of means, with a difference of less than 0.10 (10%) considered minor. Baseline characteristics with standardized differences below this threshold have negligible correlation with the exposure group.(147) Standardized differences are often used to compare propensity score-matched groups, and can also be used to compare characteristics in unmatched observational studies.(147, 148) With large sample sizes, very small differences in means can result in statistically significant p-values, yet standardized differences provide an estimate of the magnitude of the difference between groups.

For illustrative purposes, we plotted time to death or readmission using a Kaplan-Meier curve. For all outcome comparisons, we reported unadjusted and adjusted odds ratios (with 95% confidence intervals). Adjusted odds ratios were obtained with logistic regression models estimated using generalized estimating equations (GEE) methods, and including all measured patient and hospital characteristics.(149) An exchangeable correlation structure was used to account for clustering of patients within discharging hospitals.(150) Where information on income quintile was missing, this was set to a level of "0" and included in the model.

We reported the absolute difference in outpatient follow-up visits, emergency department visits, re-hospitalizations and deaths attributable to holiday discharge. We first calculated the observed outcome rates per 100,000 discharges by dividing the number of patients reaching each outcome by the total cohort size, then multiplying by 100,000. We compared the observed rates per 100,000 patient discharges to the rates expected if, contrary to fact, all holiday-discharged patients had been discharged during control periods. The number of patients expected to experience each outcome was obtained by setting the coefficient for holiday discharge to 0, and summing the statistical model's predicted probabilities across all individuals in the cohort. This number was then divided by the total number in the cohort, and multiplied by 100,000 to obtain the expected outcome rate by 100,000 patient discharges.

We undertook a confirmatory analysis using a propensity score-matched cohort and time-toevent analysis for the primary outcome (Table 2.3).

Creation of propensity scores	Derived from a logistic regression model to predict discharge during holiday or control periods. All baseline covariates were predictors in this model (including year of discharge, and additionally the top 10 most common admission diagnoses).
Matching	Matching 1:1 on the logit of the propensity score within a caliper distance of 0.2*Standard Deviation of the logit of the propensity score.(151)
Comparison of matched pairs	Using standardized differences between the matched groups, for all variables included in the propensity score model, to confirm <10% difference between groups.(148)
Analysis	Cox proportional hazards modelling for the primary outcome (30-day death or readmission), with robust standard errors to account for the paired nature of the data.(152) Report hazard ratios and 95% confidence intervals.

Table 2.3. Methods used for propensity score-matched survival analysis

We further evaluated the temporal relationship between Christmas Day and short-term outcomes by plotting the proportion of patients experiencing each 7-day outcome according to their day of discharge, for the period 30 days before to 30 days following Christmas day.

#### 2.4.7 Subgroup Analyses

We examined outcomes for adult patients with a hospitalization diagnosis of heart failure or chronic obstructive pulmonary disease (COPD). Patients with these high risk chronic conditions may benefit from early follow-up.(66-68)

We also tested for effect modification by baseline readmission risk, as estimated by the LACE score, a validated tool to predict 30-day death or readmission in adult patients after hospital discharge.(153) The LACE score is calculated using patient length of stay, acuity of admission, Charlson score and count of emergency department visits in the 6 months prior to hospital admission. We defined high risk, as others have done, as a LACE score of  $\geq 10$ , corresponding to a predicted risk of 30-day death or readmission of  $\geq 12\%$ .(154, 155) We modified our earlier logistic regression model by including an interaction term between holiday discharge and risk group to obtain adjusted odds ratios for the effect of holiday admission in high- and low-risk groups.

We similarly tested for an interaction term between holiday discharge and time period (2002-2008 or 2009-2015). All analyses were performed using SAS software, version 9.4 (SAS Institute Inc., Carey, NC).

# 2.5 Results

#### 2.5.1 Patient Characteristics

Of the 670,946 people included, 93,092 (13.9%) were children, 303,579 (45.3%) were adults under age 65 and 274,275 (40.9%) were older adults. Half (n=335,715, 50.0%) of the patients were female, and half had no baseline comorbidities (n= 354,130, 52.8%). Most (n=477,044, n=71.1%) had no hospital admission in the previous year, though the majority had visited an emergency department at least once in the past six months (n=390,612, 58.2%). The most common hospitalization diagnoses were diseases of the circulatory system (n=113,013, 16.8%),

digestive system (n=105, 571, 15.7%) and respiratory system (n=89,781, 13.4%). The median length of stay in hospital was 3 days (IQR 2-7 days).

Overall, 217,305 (32.4%) patients were discharged during the December holiday and 453,641 (67.6%) patients were discharged during the two control periods. Patients discharged during the December holiday were similar to those discharged during control periods (Table 2.4).

Table 2.4. Baseline patient and hospitalization characteristics, for patients discharged during the December holiday and control periods. Std. Diff.=standardized difference of means.

Characteristic	Holiday	Control	Std.
	n= 217,305	n=453,641	Diff.
Year of discharge from hospital <sup>a</sup> , n (%)			
2002	17,485 (8.0)	37,411 (8.2)	0.01
2003	18,329 (8.4)	37,072 (8.2)	0.01
2004	17,324 (8.0)	35,678 (7.9)	0.00
2005	15,327 (7.1)	33,978 (7.5)	0.02
2006	15,004 (6.9)	30,956 (6.8)	0.00
2007	14,349 (6.6)	30,167 (6.6)	0.00
2008	14,053 (6.5)	29,955 (6.6)	0.01
2009	14,265 (6.6)	30,234 (6.7)	0.00
2010	14,724 (6.8)	29,764 (6.6)	0.01
2011	14,418 (6.6)	31,193 (6.9)	0.01
2012	15,509 (7.1)	31,366 (6.9)	0.01
2013	15,498 (7.1)	31,773 (7.0)	0.00
2014	15,896 (7.3)	32,001 (7.1)	0.01
2015	15,124 (7.0)	32,093 (7.1)	0.00
Patient age (years) <sup>b</sup> , n (%)			
<18 years	30,195 (13.9)	62,897 (13.9)	0.00
18-64 years	96,895 (44.6)	206,684 (45.6)	0.02
65+ years	90,215 (41.5)	184,060 (40.6)	0.02
Sex female, n (%)	107,466 (49.5)	228,249 (50.3)	0.02
Rural, n (%)	32,016 (14.7)	68,815 (15.2)	0.01
Income quintile, n (%) <sup>c</sup>			
1	49,491 (22.8)	103,747 (22.9)	0.00
2	45,452 (20.9)	94,616 (20.9)	0.00
3	42,039 (19.3)	88,370 (19.5)	0.00
4	41,637 (19.2)	85,902 (18.9)	0.01
5	37,569 (17.3)	78,547 (17.3)	0.00
Length of hospital stay (days), median (IQR)	3 (2-6)	3 (2-7)	0.08
Arrival by ambulance at index admission, n (%)	71,036 (32.7)	141,767 (31.3)	0.03

Characteristic	Holiday	Control	Std. Diff.
	n= 217,305	n=453,641	2
Charlson comorbidity score, n (%) 0 1	113,977 (52.5) 43.413 (20.0)	240,153 (52.9) 86,556 (19.1)	0.01 0.02
2 3 4+	24,728 (11.4) 14,198 (6.5) 20,989 (9.7)	52,023 (11.5) 29,772 (6.6) 45,137 (9.9)	0.00 0.00 0.01
Discharged against medical advice, n (%)	3,027 (1.4)	5,658 (1.2)	0.01
Discharged with support services, n (%)	34,783 (16.0)	78,155 (17.2)	0.03
Outpatient visits with all physicians in previous year <sup>d</sup> , n (%) 0-5	73.248 (33.7)	150.037 (33.1)	0.01
6-10 11-15 >15	52,313 (24.1) 36,623 (16.9) 55 121 (25.4)	109,320 (24.1) 77,413 (17.1) 116 871 (25.8)	0.00 0.01 0.01
Assigned primary care provider, n (%)	207,160 (95.3)	433,365 (95.5)	0.01
Emergency department visits in previous 6 months <sup>e</sup> , n (%)			
0 1 2+	90,716 (41.7) 64,674 (29.8) 61,915 (28.5)	189,618 (41.8) 132,115 (29.1) 131,908 (29.1)	0.00 0.01 0.01
At least one urgent hospitalization in previous year, n (%)	57,177 (26.3)	121,453 (26.8)	0.01
At least one elective hospitalization in previous year, n (%)	18,292 (8.4)	38,576 (8.5)	0.00
At least one home care visits in previous six months, n (%)	16,078 (7.4)	34,211 (7.5)	0.01

Table 2.4 (continued). Baseline patient and hospitalization characteristics, for patients discharged during the December holiday and control periods. Std. Diff.=standardized difference of means.
Characteristic	Holiday	Control	Std.
	n= 217,305	n=453,641	DIII.
Hospital type, n (%) Teaching Community Small Pediatric Rural Missing	54,481 (25.1) 144,601 (66.5) 8,803 (4.1) 6,220 (2.9) 32,016 (14.7) 3 200 (1 5)	114,760 (25.3) 299,320 (66.0) 19,138 (4.2) 13,016 (2.9) 68,815 (15.2) 7 407 (1 6)	0.01 0.01 0.01 0.00 0.01 0.01
Diagnostic category for most responsible diagnosis <sup>f</sup> , n (%)		.,	
Diseases of the circulatory system Diseases of the digestive system Diseases of the respiratory system	35,757 (16.5) 33,963 (15.6) 33,696 (15.5)	77,256 (17.0) 71,608 (15.8) 56,085 (12.4)	0.02 0.00 0.09
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified Injury, poisoning and certain other consequences of external causes	21,041 (9.7) 22,049 (10.1)	46,743 (10.3) 44,670 (9.8)	0.02
Diseases of the genitourinary system Mental and behavioral disorders	10,416 (4.8) 8,630 (4.0)	22,613 (5.0) 22,052 (4.9)	0.01 0.04
Neoplasms Pregnancy, childbirth and the puerperium Endocrine, nutritional and metabolic diseases	7,032 (3.2) 6,090 (2.8) 6,753 (3.1)	15,981 (3.5) 12,787 (2.8) 13,905 (3.1)	0.02 0.00 0.00

Table 2.4 (continued). Baseline patient and hospitalization characteristics, for patients discharged during the December holiday and control periods. Std. Diff.=standardized difference of means.

<sup>a</sup> Fiscal year running from April 1<sup>st</sup>-March 31<sup>st</sup>.

<sup>b</sup> Grouped by life stage: children, adults and older adults.

<sup>c</sup> Missing observations n=1,117 for holiday, n=2,459 for control

<sup>d,e</sup> Categorized based on most common values

<sup>f</sup> The top ten most frequent diagnostic categories (for holiday and control groups combined) are listed here

# 2.5.2 Physician Follow-Up

Patients discharged during the December holiday were less likely to have physician follow-up within 7 (36.3% vs 47.8%, aOR 0.61, 95% CI 0.60-0.62) and 14 days of discharge (59.5% vs 68.7%, aOR 0.65, 95% CI 0.64-0.66, Table 2.5). Per 100,000 patients, there were 2,999 fewer 14-day follow-up appointments attributable to December holiday discharge. The decreased likelihood of follow-up associated with holiday discharge was observed across patient characteristics (Table 2.6).

Outcome Measure	Holiday, n (%) n=217,305	Control, n (%) n=453,641	Unadjusted Risk Difference, % (95% CI)	Unadjusted OR (95% Cl)	Adjusted OR (95% Cl)
		Primary O	utcome	I	
30-day death or readmission	56,253 (25.9)	111,929 (24.7)	1.2 (1.0-1.4)	1.07 (1.05-1.08)	1.09 (1.07-1.10)
30-day emergency department visit	52,704 (24.3)	104,468 (23.0)	1.2 (1.0-1.4)	1.07 (1.06-1.08)	1.09 (1.07-1.10)
30-day urgent re- hospitalization	25,624 (11.8)	51,802 (11.4)	0.4 (0.2-0.5)	1.04 (1.02-1.05)	1.06 (1.04-1.08)
30-day death	3,216 (1.5)	6,570 (1.5)	0.0 (0.0-0.1)	1.02 (0.98-1.07)	1.06 (1.02-1.10)
	1	Secondary C	Outcomes	I	
7-day outpatient follow-up	78,838 (36.3)	216,592 (47.8)	11.5 (11.2- 11.7)	0.62 (0.62-0.63)	0.61 (0.60-0.62)
14-day outpatient follow-up	129,337 (59.5)	311,648 (68.7)	9.2 (8.9-9.4)	0.67 (0.66-0.68)	0.65 (0.64-0.66)
7-day death or readmission	28,665 (13.2)	53,191 (11.7)	1.5 (1.3-1.6)	1.14 (1.13-1.16)	1.16 (1.14-1.18)
7-day emergency department visit	27,240 (12.5)	49,888 (11.0)	1.5 (1.4-1.7)	1.16 (1.14-1.18)	1.17 (1.15-1.19)
7-day urgent re- hospitalization	10,549 (4.9)	21,023 (4.6)	0.2 (0.1-0.3)	1.05 (1.03-1.08)	1.07 (1.04-1.09)
7-day death	683 (0.3)	1,278 (0.3)	0.0 (0.0-0.1)	1.12 (1.02-1.22)	1.14 (1.04-1.25)
14-day death or readmission	40,433 (18.6)	77,010 (17.0)	1.6 (1.4-1.8)	1.12 (1.10-1.13)	1.14 (1.12-1.15)
14-day emergency department visit	38,168 (17.6)	71,882 (15.9)	1.7 (1.5-1.9)	1.13 (1.12-1.15)	1.15 (1.13-1.16)
14-day urgent re- hospitalization	16,697 (7.7)	33,321 (7.4)	0.3 (0.2-0.5)	1.05 (1.03-1.07)	1.07 (1.05-1.09)
14-day death	1,444 (0.7)	2,872 (0.6)	0.03 (0.0-0.1)	1.05 (0.99-1.1 <sup>2</sup> )	1.08 (1.02-1.14)

Table 2.5. Unadjusted and adjusted\* outcomes of patients discharged from hospital during holiday and control periods.

Patient Group	7-day outpatient follow-up, OR (95% CI)	14-day outpatient follow-up, OR (95% CI)
Year of discharge 2002-2008 2009-2016	0.63 (0.62-0.64) 0.62 (0.61-0.63)	0.69 (0.68-0.70) 0.65 (0.64-0.66)
Patient age <18 years 18-64 years 65 years+	0.69 (0.67-0.71) 0.62 (0.61-0.63) 0.60 (0.59-0.61)	0.75 (0.73-0.77) 0.67 (0.66-0.68) 0.64 (0.63-0.65)
Sex female	0.62 (0.62-0.63)	0.67 (0.66-0.68)
Sex male	0.62 (0.61-0.63)	0.67 (0.66-0.68)
Rural	0.63 (0.61-0.65)	0.67 (0.65-0.68)
Not rural	0.62 (0.61-0.63)	0.67 (0.66-0.68)
Income quintile 1 2 3 4 5	0.62 (0.61-0.64) 0.63 (0.61-0.64) 0.62 (0.61-0.64) 0.62 (0.61-0.64) 0.62 (0.60-0.63)	0.67 (0.66-0.69) 0.67 (0.65-0.68) 0.67 (0.65-0.68) 0.68 (0.66-0.69) 0.67 (0.65-0.68)
Length of hospital stay 0-3 days >3 days	0.63 (0.62-0.64) 0.62 (0.61-0.63)	0.68 (0.67-0.69) 0.66 (0.65-0.67)
Arrival by ambulance at index admission	0.61 (0.60-0.62)	0.66 (0.65-0.68)
Not arriving by ambulance	0.63 (0.62-0.64)	0.67 (0.67-0.68)
Charlson comorbidity score 0 1 2 3 4+	0.65 (0.64-0.66) 0.60 (0.59-0.61) 0.59 (0.57-0.61) 0.59 (0.56-0.61) 0.59 (0.57-0.61)	0.70 (0.69-0.71) 0.65 (0.63-0.66) 0.62 (0.60-0.64) 0.63 (0.61-0.66) 0.62 (0.60-0.64)
Discharged against medical advice	0.60 (0.55-0.66)	0.68 (0.62-0.74)

Table 2.6. Secondary follow-up outcomes unadjusted odds ratios stratified by baseline patient and hospital characteristics.

Patient Group	7-day outpatient follow-up,	14-day outpatient follow-up,
	OR (95% CI)	OR (95% CI)
Discharged home with support services, n (%)	0.65 (0.63-0.66)	0.67 (0.65-0.69)
Outpatient visits with all physicians in previous year		
0-5 6-10	0.67 (0.66-0.68) 0.62 (0.61-0.64)	0.72 (0.71-0.74) 0.66 (0.65-0.68)
11-15 >15	0.60 (0.58-0.61)	0.64 (0.62-0.65)
	0.00 (0.07-0.00)	0.00 (0.00-0.01)
No assigned primary care provider	0.69 (0.66-0.73)	0.76 (0.72-0.79)
Emergency department visits in previous 6 months		
0	0.63 (0.62-0.64)	0.69 (0.68-0.70)
2+	0.63 (0.62-0.64)	0.67 (0.66-0.69)
At least one urgent hospitalization in previous year	0.60 (0.58-0.61)	0.63 (0.62-0.65)
At least one elective hospitalization in previous year	0.60 (0.58-0.62)	0.62 (0.60-0.65)
At least one home care visits in previous 6 months	0.64 (0.61-0.66)	0.68 (0.65-0.70)
Hospital type Teaching Community Small Pediatric Rural	0.60 (0.59-0.62) 0.63 (0.62-0.64) 0.59 (0.56-0.62) 0.65 (0.62-0.70) 0.63 (0.60-0.65)	0.65 (0.63-0.66) 0.68 (0.67-0.69) 0.65 (0.62-0.69) 0.70 (0.66-0.74) 0.66 (0.64-0.69)

Table 2.6 (continued). Secondary follow-up outcomes unadjusted odds ratios stratified by baseline patient and hospital characteristics.

Patient Group	7-day outpatient follow-up,	14-day outpatient follow-up,	
	OR (95% CI)	OR (95% CI)	
Diagnostic category of most responsible diagnosis Diseases of the circulatory system	0.60 (0.58-0.61)	0 64 (0 62-0 66)	
Diseases of the digestive system	0.62 (0.60-0.63)	0.65 (0.63-0.66)	
Diseases of the respiratory system	0.62 (0.61-0.64)	0.68 (0.66-0.70)	
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	0.60 (0.58-0.62)	0.66 (0.63-0.68)	
Injury, poisoning and certain other consequences of external causes	0.62 (0.60-0.64)	0.69 (0.67-0.71)	
Diseases of the genitourinary system	0.63 (0.61-0.67)	0.69 (0.66-0.73)	
Mental and behavioral disorders	0.62 (0.59-0.65)	0.68 (0.65-0.71)	
Neoplasms	0.60 (0.56-0.63)	0.60 (0.56-0.63)	
Pregnancy, childbirth and the puerperium	0.75 (0.70-0.80)	0.80 (0.74-0.85)	
Endocrine, nutritional and metabolic diseases	0.61 (0.58-0.65)	0.65 (0.61-0.69)	

Table 2.6 (continued). Secondary follow-up outcomes unadjusted odds ratios stratified by baseline patient and hospital characteristics.

#### 2.5.3 Death or Readmission

Time to death or readmission differed between holiday and control patients (log-rank test P<0.0001, Figure 2.2). Patients discharged during the December holiday were at increased risk for the primary outcome at 30 days (25.9% vs 24.7%, aOR 1.09, 9% CI 1.07-1.10). This was explained by an increased risk of return to the emergency department (24.3% vs 23.0%, aOR 1.09, 95% CI 1.07-1.10), re-hospitalization (11.8% vs 11.4%, aOR 1.06, 95% CI 1.04-1.08) and death (1.5% vs 1.5%, aOR 1.06, 95% CI 1.02-1.10) at 30 days (Table 2.5). The increased risk of death or readmission associated with holiday discharge was further accentuated at 7 days (13.2% vs 11.7%, aOR 1.16, 95% CI 1.14-1.18), and 14 days (18.6% in holidays group versus 17.0%, aOR 1.14, 95%CI 1.12-1.15). A confirmatory time-to-event analysis in a propensity scorematched cohort (Table 2.7) had consistent results (death or readmission Hazard Ratio 1.08, 95% CI 1.07-1.09).



Figure 2.2. Kaplan-Meier curve depicting time to composite of death or readmission after discharge.

Characteristic	<b>Holiday</b> n= 217,303*	<b>Control</b> n= 217,303	Std. Diff.
Year of discharge from hospital in (%)			
2002	17 485 (8 0)	17 550 (8 1)	0.00
2003	18,329 (8,4)	17,624 (8.1)	0.01
2004	17.324 (8.0)	17.046 (7.8)	0.00
2005	15,327 (7.1)	15,926 (7.3)	0.01
2006	15,004 (6.9)	14,940 (6.9)	0.00
2007	14,349 (6.6)	14,719 (6.8)	0.01
2008	14,052 (6.5)	14,199 (6.5)	0.00
2009	14,265 (6.6)	14,535 (6.7)	0.00
2010	14,724 (6.8)	14,405 (6.6)	0.01
2011	14,417 (6.6)	15,004 (6.9)	0.01
2012	15,509 (7.1)	15,343 (7.1)	0.00
2013	15,498 (7.1)	15,207 (7.0)	0.01
2014	15,896 (7.3)	15,404 (7.1)	0.01
2015	15,124 (7.0)	15,401 (7.1)	0.00
Patient age (vears) n (%)			
<18 years	30 195 (13 9)	29 912 (13 8)	0.00
18-64 years	96 895 (44 6)	98 214 (45 2)	0.00
65+ years	90.213 (41.5)	89.177 (41.0)	0.01
Sex female, n (%)	107,466 (49.5)	107,132 (49.3)	0.00
Rural, n (%)	32,016 (14.7)	31,306 (14.4)	0.01
Length of hospital stay (days), median (IQR)	3 (2-6)	3 (2-6)	0.03
Arrival by ambulance at index admission, n (%)	71,035 (32.7)	70,825 (32.6)	0.00
Charison comorbidity score, n (%)		444.040 (50.0)	0.04
	113,977 (52.5)	114,918 (52.9)	0.01
	43,411 (20.0)	43,420 (20.0)	0.00
2	24,720 (11.4)	24,330 (11.2)	0.01
	20 080 (0.5)	13,955 (0.4)	0.00
- <b>4</b> ⊤	20,909 (9.7)	20,074 (9.5)	0.00
Income quintile, n (%)			
1	49,491 (22 8)	49,365 (22 7)	0.00
2	45.451 (20.9)	45.611 (21.0)	0.00
3	42.039 (19.3)	42.059 (19.4)	0.00
4	41,637 (19.2)	41,712 (19.2)	0.00
5	37,568 (17.3)	37,485 (17.3)	0.00

Table 2.7. Balance diagnostics for propensity score matched sample. Std.Diff.=standardized difference of means.

Characteristic	<b>Holiday</b> n= 217,303*	<b>Control</b> n= 217,303	Std. Diff.
Discharged against medical advice, n (%)	3,025 (1.4)	2,998 (1.4)	0.00
Discharged with support services, n (%)	34,783 (16.0)	34,106 (15.7)	0.01
Emergency department visits in previous 6 months, n (%) 0 1 2+	90,716 (41.7) 64,673 (29.8) 61,914 (28.5)	92,312 (42.5) 63,584 (29.3) 61,407 (28.3)	0.01 0.01 0.01
At least one urgent hospitalization in previous year, n (%)	51,105 (23.5)	50,055 (23.0)	0.01
At least one elective hospitalization in previous year, n (%)	18,292 (8.4)	18,056 (8.3)	0.00
At least one home care visits in previous six months, n (%)	16,077 (7.4)	15,741 (7.2)	0.01
Outpatient visits with all physicians in previous year, n (%)			
0-5	73,247 (33.7)	74,065 (34.1)	0.01
6-10	52,312 (24.1)	52,418 (24.1)	0.00
11-15	36,623 (16.9)	36,336 (16.7)	0.00
>15	55,121 (25.4)	54,484 (25.1)	0.01
Assigned primary care provider, n (%)	207,159 (95.3)	207,007 (95.3)	0.00
Hospital type, n (%) Teaching	54 480 (25 1)	53 943 (24 8)	0.01
Community	144 600 (66 5)	145 640 (67 0)	0.01
Small	8.803 (4.1)	8.523 (3.9)	0.01
Pediatric	6.220 (2.9)	6.065 (2.8)	0.00
Rural	14,219 (6.5)	13,880 (6.4)	0.01

Table 2.7 (continued). Balance diagnostics for propensity score matched sample. Std. Diff.=standardized difference of means.

\* Overall 217,303 cases matched, 2 cases unmatched (over 99.9% matched).

 Table 2.7 (continued). Balance diagnostics for propensity score matched sample. Std.

 Diff.=standardized difference of means.

Characteristic	Holiday	Control	Std
Characteristic	пониау n= 217 202*	0000000 000000000000000000000000000000	Siu. Diff
	11-217,303	11-217,303	DIII.
Diagnostic category for most responsible			
diagnosis, n (%)			
Diseases of the circulatory system	35,757 (16.5)	36,321 (16.7)	0.01
Diseases of the digestive system	33,963 (15.6)	34,788 (16.0)	0.01
Diseases of the respiratory system	33,694 (15.5)	30,784 (14.2)	0.04
Symptoms, signs and abnormal clinical and	21,041 (9.7)	21,736 (10.0)	0.01
laboratory findings, not elsewhere classified			
Injury, poisoning and certain other	22,049 (10.1)	21,018 (9.7)	0.02
consequences of external causes			
Diseases of the genitourinary system	10,416 (4.8)	10,611 (4.9)	0.00
Mental and behavioral disorders	8,630 (4.0)	9,930 (4.6)	0.03
Neoplasms	7,032 (3.2)	7,352 (3.4)	0.01
Pregnancy, childbirth and the puerperium	6,090 (2.8)	6,381 (2.9)	0.01
Endocrine, nutritional and metabolic diseases	6,753 (3.1)	6,727 (3.1)	0.00
Admission Diagnosis, n (%)			
Pneumonia, unspecified (J189)	7,289 (3.4)	7,586 (3.5)	0.01
Congestive Heart Failure (I500)	5,869 (2.7)	5,809 (2.7)	0.00
Chronic Obstructive Pulmonary Disease with	4,845 (2.2)	4,906 (2.3)	0.00
acute exacerbation, unspecified (J441)			
Chronic obstructive pulmonary disease with	3,512 (1.6)	3,523 (1.6)	0.00
acute lower respiratory infection (J440)			
Chest pain, unspecified (R074)	3,325 (1.5)	3,195 (1.5)	0.00
Urinary tract infection, site not specified	3,067 (1.4)	2,988 (1.4)	0.00
(N390)			
Atherosclerotic heart disease (I251)	2,783 (1.3)	2,822 (1.3)	0.00
Unstable angina (I200)	2,515 (1.2)	2,385 (1.1)	0.01
Syncope and collapse (R55)	2,484 (1.1)	2,439 (1.1)	0.00
Convalescence following surgery (Z540)	1,849 (0.9)	2,032 (0.9)	0.01

\* Overall 217,303 cases matched, 2 cases unmatched (over 99.9% matched).

The increased unadjusted risk of death or readmission at 7, 14, and 30 days was observed across many patient characteristics (Table 2.8 and Figure 2.3), and no group demonstrated a significantly decreased risk of death or readmission at 30 days (Figure 2.3). The holiday-related risk appeared greatest for patients with a diagnosis of injury, a genitourinary condition, a neoplasm, or a pregnancy-related condition. Overall, per 100,000 patients, there were 26 excess deaths, 188 excess hospitalizations and 483 excess emergency department visits attributable to December holiday discharge.

Patient Group	7-day death or	14-day death or
	readmission,	readmission,
	OR (95% CI)	OR (95% CI)
Year of discharge		
2002-2008	1.16 (1.14-1.19)	1.13 (1.11-1.15)
2009-2016	1.12 (1.10-1.15)	1.11 (1.09-1.13)
Patient age		
<18 years	1.16 (1.11-1.22)	1.12 (1.08-1.16)
18-64 years	1.17 (1.14-1.19)	1.15 (1.13-1.17)
65 years+	1.12 (1.09-1.14)	1.09 (1.07-1.11)
Sex female	1.15(1.12-1.17)	1.13 (1.11-1.15)
Sex male	1.14 (1.12-1.17)	1.11 (1.09-1.13)
Rural	1.20 (1.16-1.25)	1.19 (1.16-1.23)
Not rural	1.13 (1.11-1.15)	1.11 (1.09-1.12)
Income quintile		
1	1.14 (1.10-1.17)	1.12 (1.09-1.15)
2	1.13 (1.10-1.17)	1.08 (1.05-1.11)
3	1.16 (1.12-1.20)	1.14 (1.11-1.18)
4	1.13 (1.09-1.18)	1.11 (1.07-1.14)
5	1.17 (1.12-1.21)	1.16 (1.12-1.19)
Length of hospital stay		
0-3 days	1.14 (1.12-1.16)	1.13 (1.11-1.15)
>3 days	1.14 (1.11-1.16)	1.11 (1.08-1.13)
Arrival by ambulance at index admission	1.10 (1.07-1.13)	1.08 (1.06-1.11)
Not arriving by ambulance	1.16 (1.14-1.19)	1.14 (1.12-1.15)
Charlson comorbidity score		
0	1.16 (1.14-1.19)	1.14 (1.12-1.16)
1	1.15 (1.10-1.19)	1.11 (1.08-1.15)
2	1.13 (1.08-1.18)	1.08 (1.04-1.13)
3	1.14 (1.08-1.21)	1.10 (1.05-1.16)
4+	1.10 (1.05-1.15)	1.10 (1.06-1.14)
Discharged against medical advice	1.05 (0.96-1.16)	1.08 (0.99-1.18)
Discharged home with support services, n (%)	1.14 (1.10-1.18)	1.10 (1.07-1.13)

Table 2.8. Secondary death or readmission outcomes unadjusted odds ratios stratified by baseline patient and hospital characteristics.

Patient Group	7-day death or readmission, OR (95% Cl)	14-day death or readmission, OR (95% Cl)
Outpatient visits with all physicians in previous		
year,		
0-5	1.18 (1.15-1.21)	1.15 (1.12-1.18)
6-10	1.15 (1.12-1.19)	1.14 (1.11-1.17
11-15	1.12 (1.08-1.16)	1.10 (1.07-1.14)
>15	1.12 (1.08-1.15)	1.09 (1.06-1.12)
No assigned primary care provider	1.18 (1.10-1.27)	1.14 (1.06-1.21)
Emergency department visits in previous 6		
months		
0	1.19 (1.16-1.22)	1.17 (1.14-1.20)
1	1.12 (1.09-1.16)	1.09 (1.06-1.12)
2+	1.12 (1.10-1.15)	1.11 (1.08-1.13)
At least one urgent hospitalization in previous year	1.09 (1.06-1.12)	1.08 (1.05-1.10)
At least one elective hospitalization in previous year	1.16 (1.10-1.22)	1.16 (1.11-1.21)
At least one home care visits in previous 6 months	1.11 (1.05-1.17)	1.10 (1.05-1.15)
Hospital type		
Teaching	1.14 (1.10-1.17)	1.11 (1.08-1.14)
Community	1.15 (1.13-1.17)	1.13 (1.11-1.14)
Small	1.18 (1.11-1.27)	1.19 (1.12-1.26)
Pediatric	1.14 (1.03-1.25)	1.04 (0.96-1.13)
Rural	1.23 (1.17-1.30)	1.20 (1.14-1.25)
Diagnostic category of most responsible diagnosis		
Diseases of the circulatory system	1.17 (1.13-1.21)	1.14 (1.10-1.18)
Diseases of the digestive system	1.14 (1.10-1.19)	1.11 (1.07-1.15)
Diseases of the respiratory system	1.13 (1.08-1.18)	1.07 (1.03-1.11)
Symptoms, signs and abnormal clinical and	1.14 (1.09-1.20)	1.14 (1.09-1.19)
laboratory findings, not elsewhere classified		
Injury, poisoning and certain other	1.20 (1.14-1.26)	1,19 (1,14-1,24)
consequences of external causes		
Diseases of the genitourinary system	1.20 (1.12-1.28)	1.21 (1.14-1.28)
Mental and behavioral disorders	1.11 (1.03-1.19)	1.07 (1.00-1.14)
Neoplasms	1.14 (1.06-1.22)	1.14 (1.08-1.22)
Pregnancy, childbirth and the puerperium	1.19 (1.10-1.29)	1.17 (1.09-1.26)
Endocrine, nutritional and metabolic diseases	1.11 (1.01-1.21)	1.05 (0.97-1.14)

Table 2.8 (continued). Secondary death or readmission outcomes unadjusted odds ratios stratified by baseline patient and hospital characteristics.

Patient Group	Holiday, n <mark>(%</mark> )	Control, n (%)	30-day Death or Readmission, Odds Ratio (95% CI)	
Year of discharge				
2002-2008	28,660 (25.6)	57,042 (24.3)	1.08 (1.06-1.09)	+
2009-2016	27,593 (26.2)	54,887 (25.1)	1.06 (1.04-1.07)	+
Patient age				-
<18 years	6,184 (20.5)	12,573 (20.0)	1.03 (1.00-1.07)	-+
18-64 years	25,549 (26.4)	50,651 (24.5)	1.10 (1.08-1.12)	+
65 years+	24,520 (27.2)	48,705 (26.5)	1.04 (1.02-1.06)	-
Sex				-
Female	27,579 (25.7)	55,751 <mark>(</mark> 24.4)	1.07 (1.05-1.09)	+
Male	28,674 (26.1)	56,178 (24.9)	1.06 (1.05-1.08)	+
Rural	10,061 (31.4)	20,140 (29.3)	1.11 (1.08-1.14)	+
Not rural	46,192 (24.9)	91,789 (23.9)	1.06 (1.05-1.07)	+
Income quintile				-
1 (Lowest)	13,652 (27.6)	27,385 (26.4)	1.06 (1.04-1.09)	+
2	11,685 (25.7)	23,759 (25.1)	1.03 (1.01-1.06)	
3	10,741 (25.6)	21,356 (24.2)	1.08 (1.05-1.11)	+
4	10,367 (24.9)	20,369 (23.7)	1.07 (1.04-1.10)	
5 (Highest)	9,493 (25.3)	18,359 (23.4)	1.11 (1.08-1.14)	
Length of hospital stay				
0-3 days	28,771 (24.2)	52,485 (22.6)	1.09 (1.08-1.11)	+
>3 days	27,482 (27.9)	59,444 <mark>(</mark> 26.8)	1.06 (1.04-1.07)	+
Arrival by ambulance	19,016 (26.8)	37,180 (26.2)	1.02 (1.01-1.05)	+
Not arriving by ambulance	37,237 (25.5)	74,749 (24.0)	1.08 (1.07-1.10)	+
Charlson comorbid score				
0	26,065 (22.9)	51,131 <mark>(</mark> 21.3)	1.10 (1.08-1.11)	+
1	10,210 (23.5)	19,685 (22.7)	1.04 (1.02-1.07)	+
2	7,229 (29.2)	14,75 <mark>2 (</mark> 28.4)	1.04 (1.01-1.08)	_
3	4,430 (31.2)	8,9 <mark>21 (</mark> 30.0)	1.06 (1.02-1.11)	
4+	8,319 (39.6)	17,440 <mark>(</mark> 38.6)	1.04 (1.01-1.08)	
			c	.9 1.0 1.1 1.2

#### Figure 2.3. Forest plot of unadjusted primary outcome results, stratified by baseline patient characteristics.

Unadjusted Odds Ratio (95% CI)

Patient Group	Holiday, n (%)	Control, n (%)	30-day Death or Readmission, Odds Ratio (95% CI)	
Discharged against medical advice	1,461 (48.3)	2,607 (46.1)	1.09 (1.00-1.19)	<u> </u>
Discharged home with support services	11,368 (32.7)	24,838 (31.8)	1.04 (1.01-1.07)	+
Outpatient visits with all physicians in previous year				
0-5	15,995 (21.8)	30,409 (20,3)	1.10 (1.08-1.12)	+
6-10	12,831 (24.5)	25,287 (23.1)	1.08 (1.05-1.11)	-
11-15	9,755 (26.6)	19,810 (25.6)	1.06 (1.03-1.09)	+
>15	17,672 (32,1)	36,423 (31.2)	1.04 (1.02-1.07)	+
No assigned primary care provider	2,263 (22.3)	4,211 (20.8)	1.10 (1.03-1.16)	-+
Emergency department visits in previous 6 months				
0	19,082 (21. <mark>0</mark> )	36,684 (19.4)	1.11 (1.09-1.13)	+
1	15,070 (23.3)	29,734 (22.5)	1.05 (1.02-1.07)	+
2+	22,101 (35.7)	45,511 (34.5)	1.05 (1.03-1.08)	+
At least one urgent hospitalisation in previous year	17,890 (35.0)	38,021 (34.3)	1.03 (1.01-1.06)	+
At least one elective hospitalisation in previous year	5,992 (32.8)	11,800 (30.6)	1.11 (1.06-1.15)	-+-
At least one home care visits in previous 6 months	5,497 (34.2)	11,368 (33.2)	1.04 (1.00-1.09)	
Hospital type				
Teaching	14,599 (26.8)	29,596 (25.8)	1.05 (1.03-1.08)	+-
Community	36,405 (25.2)	71,326 (23.8)	1.08 (1.06-1.09)	+
Small	3,081 (35.0)	6,307 (33.0)	1.10 (1.04-1.16)	
Pediatric	1,443 (23.2)	2,993 (23.0)	1.01 (0.94-1.09)	<del></del>
Rural	50,691 (25.4)	100,447 (24.2)	1.10 (1.06-1.15)	-+
Category of most responsible diagnosis, n (%)				
Diseases of the circulatory system	9,883 (27.6)	19,932 (25.8)	1.10 (1.07-1.13)	+
Diseases of the digestive system	7,992 (23.5)	15,963 (22.3)	1.07 (1.04-1.11)	+
Diseases of the respiratory system	7,659 (22.7)	13 <mark>,080 (</mark> 23.3)	0.97 (0.94-1.00)	+
Symptoms, signs and abnormal findings	5,455 (25.9)	11,239 (24.0)	1.11 (1.07-1.15)	
Injury, poisoning	5,175 (23.5)	9,603 (21.5)	1.12 (1.08-1.16)	+
Diseases of the genitourinary system	2,935 (28.2)	5,768 (25.5)	1.15 (1.09-1.21)	-+
Mental and behavioural disorders	2,415 (28.0)	5,998 (27.2)	1.04 (0.98-1.10)	
Neoplasms	2,993 (42.6)	6,356 (39.8)	1.12 (1.06-1.19)	
Pregnancy, childbirth and the puerperium	1,991 (32.7)	3,823 (29.9)	1.14 (1.07-1.22)	
Endocrine, nutritional and metabolic diseases	1,746 (25.9)	3,655 (26.3)	0.98 (0.91-1.04)	<u> </u>

# Figure 2.3 (continued). Forest plot of unadjusted primary outcome results, stratified by baseline patient and hospital characteristics.

Unadjusted Odds Ratio (95% CI)

#### 2.5.4 Analysis of the "Christmas Effect"

Patients discharged home during the week preceding or following Christmas Day were distinctly less likely to have 7-day follow-up (33.6% vs 47.6%, OR 0.56, 95% CI 0.55-0.56) than those discharged prior to, or following this period (Figure 2.4a). Patients discharged home during the week preceding or following Christmas day were at higher risk of 7-day death or readmission (14.2% vs 12.4%, OR 1.17, 95% 1.15-1.18) than those discharged prior to, or following this period (Figures 2.4b and 2.5). The absolute risk difference between Christmas +/- 7 days and the surrounding time period was 14.0% (95% CI 13.8%-14.2%) for 7-day follow-up, and 1.8% (1.6%-1.9%) for 7-day death or readmission.



Figure 2.4ab. Proportion of patients with a) 7-day outpatient physician follow-up and b) 7day death or readmission, by day of discharge, relative to Christmas day. Each line represents the unadjusted results of a single year, for years 2002-2015.





#### 2.5.5 Subgroup Analyses

Patients hospitalized for heart failure were significantly less likely to have follow-up at 7 days (36.5% vs 50.6%, aOR 0.55, 95% CI 0.51-0.58) and at 14 days (60.7% vs 72.2%, aOR 0.58, 95% CI 0.54-0.61) if discharged during the December holiday. They were also at increased risk of 30-day death or readmission if discharged during the holidays (31.9% vs 30.9%, aOR 1.06, 95% CI 1.01-1.12). This was explained by an increased risk of emergency department visits (Table 2.9). A similar pattern was observed at 7 and 14 days after discharge.

Outcome	Holiday, n	Control, n	Unadjusted	Adjusted OR	
	(%)	(%)	OR (95% CI)	(95% CI)	
	Primary Outcome				
30-day death or	1,986 (31.9)	4,128 (30.9)	1.04 (0.98-1.11)	1.06 (1.01-1.12)	
readmission					
30-day emergency	1,902 (30.5)	3,874 (29.0)	1.07 (1.01-1.15)	1.09 (1.03-1.16)	
department visit					
30-day urgent re-	1,251(20.1)	2,612 (19.6)	1.03 (0.96-1.11)	1.05 (0.98-1.12)	
hospitalization					
30-day death	231 (3.7)	496 (3.7)	1.00 (0.85-1.17)	1.02 (0.88-1.19)	
Secondary Outcomes					
7-day outpatient follow-	2,274 (36.5)	6,761 (50.6)	0.56 (0.53-0.60)	0.55 (0.51-0.58)	
up					
14-day outpatient follow-	3,786 (60.7)	9,636 (72.2)	0.60 (0.56-0.64)	0.58 (0.54-0.61)	
up					
7-day death or	804 (12.9)	1,547 (11.6)	1.13 (1.03-1.24)	1.14 (1.05-1.24)	
readmission					
7-day emergency	774 (12.4)	1,450 (10.9)	1.16 (1.06-1.28)	1.18 (1.08-1.28)	
department visit					
7-day urgent re-	422 (6.8)	849 (6.4)	1.07 (0.95-1.21)	1.08 (0.96-1.11)	
hospitalization					
7-day death	49 (0.8)	112 (0.8)	0.94 (0.67-1.31)	0.96 (0.67-1.37)	
14-day death or	1,281 (20.6)	2,586 (19.4)	1.08 (1.00-1.16)	1.04 (1.01-1.18)	
readmission					
14-day emergency	1,233 (19.8)	2,422 (18.1)	1.11 (1.03-1.20)	1.13 (1.05-1.22)	
department visit					
14-day urgent re-	748 (12.0)	1,524 (11.4)	1.06 (0.96-1.16)	1.08 (0.98-1.18)	
hospitalization					
14-day death	96 (1.5)	221 (1.7)	0.93 (0.73-1.18)	0.96 (0.75-1.23)	

Table 2.9. Unadjusted and adjusted outcomes of adult patients with a diagnosis of congestive heart failure discharged from hospital during holiday and control periods.

Patients hospitalized for COPD were significantly less likely to have follow-up at 7 days (29.9% vs 41.2%, aOR 0.59, 95% CI 0.55-0.63) and 14 days (54.6% vs 64.1%, aOR 0.64, 95% CI 0.60-0.68) if discharged during the December holiday. The holiday-associated risk of death or readmission was not significant at 30 days (26.4% vs 27.8%, aOR 0.99, 95% CI 0.93-1.05), yet it was elevated at 7 days (10.9% vs 9.7%, aOR 1.19, 95% CI 1.09-1.30) and 14 days (17.5% vs 16.5%, aOR 1.13, 95% CI 1.05-1.21), driven by an increased risk of emergency department visits and re-hospitalization (Table 2.10).

Table 2.10. Unadjusted and adjusted outcomes of adult patients with a diagnosis of chronic obstructive pulmonary disease discharged from hospital during holiday and control periods.

Outcome	Holiday, n	Control, n	Unadjusted OR	Adjusted OR
	(%)	(%)	(95% CI)	(95% CI)
	Prim	nary Outcome		
30-day death or	2,360 (26.4)	4,064 (27.8)	0.94 (0.88-0.99)	0.99 (0.93-1.05)
readmission				
30-day emergency	2,293 (25.7)	3,915 (26.8)	0.95 (0.89-1.01)	1.00 (0.94-1.06)
department visit				
30-day urgent re-	1,384 (15.5)	2,396 (16.4)	0.94 (0.87-1.01)	1.00 (0.94-1.08)
hospitalization				
30-day death	198 (2.2)	405 (2.8)	0.80 (0.67-0.95)	0.90 (0.76-1.07)
Secondary Outcomes				
7-day outpatient follow-up	2,669 (29.9)	6,030 (41.2)	0.61 (0.58-0.64)	0.59 (0.55-0.63)
14-day outpatient follow-	4,875 (54.6)	9,383 (64.1)	0.67 (0.64-0.71)	0.64 (0.60-0.68)
up				
7-day death or	977 (10.9)	1,422 (9.7)	1.14 (1.05-1.24)	1.19 (1.09-1.30)
readmission				
7-day emergency	949 (10.6)	1,364 (9.3)	1.16 (1.06-1.26)	1.20 (1.10-1.31)
department visit				
7-day urgent re-	480 (5.5)	744 (5.1)	1.08 (0.96-1.22)	1.15 (1.03-1.28)
hospitalization				
7-day death	53 (0.6)	73 (0.5)	1.19 (0.84-1.70)	1.39 (0.98-1.97)
14-day death or	1,564 (17.5)	2,420 (16.5)	1.07 (1.00-1.15)	1.13 (1.05-1.21)
readmission				
14-day emergency	1,523 (17.1)	2,321 (15.9)	1.09 (1.02-1.17)	1.14 (1.06-1.22)
department visit				
14-day urgent re-	845 (9.5)	1,336 (9.1)	1.04 (0.95-1.14)	1.11 (1.01-1.22)
hospitalization				
14-day death	102 (1.1)	182 (1.2)	0.92 (0.72-1.17)	1.05 (0.85-1.30)

Of adult patients discharged during the holiday, 69,840 (35.7%) had a LACE score of 10 or greater, indicating a higher baseline risk of readmission; 148,601 patients (38.0%) discharged during control periods had a LACE score of 10 or greater (Standardized Difference in LACE scores between groups was 0.05). Patients with high (holiday 60.4% vs control 70.8%, adjusted OR 0.60, 95% CI 0.59-0.62) and low (holiday 59.2% vs control 68.2%, adjusted OR 0.67, 95% CI 0.66-0.68) LACE scores were less likely to have 14-day follow-up if discharged during the

December holiday. The holiday-related decrease in follow-up was more pronounced in patients with a high risk LACE score (p < 0.0001 for interaction between LACE score group and holiday discharge). A similar pattern was seen for 7-day follow-up (Table 2.11).

Table 2.11. Adjusted results for outcomes of patients at high and low baseline risk of readmission (as predicted by LACE score) discharged from hospital during holiday and control periods.

Outcome	High Risk Group	Low Risk Group	P for
	Adjusted OR	Adjusted OR	interaction
	(95% CI)	(95% CI)	
Primary Outcome			
30-day death or readmission	1.06 (1.04-1.09)	1.12 (1.10-1.13)	0.0001
30-day emergency department visit	1.07 (1.05-1.09)	1.11 (1.09-1.13)	0.002
30-day urgent re-hospitalization	1.05 (1.03-1.08)	1.08 (1.06-1.11)	0.08
30-day death	1.02 (0.98-1.07)	1.17 (1.10-1.25)	0.001
Secondary Outcomes			
7-day outpatient follow-up	0.58 (0.56-0.59)	0.62 (0.61-0.63)	<0.0001
14-day outpatient follow-up	0.60 (0.59-0.62)	0.67 (0.66-0.68)	<0.0001
7-day death or readmission	1.14 (1.11-1.17)	1.16 (1.14-1.19)	0.25
7-day emergency department visit	1.16 (1.13-1.19)	1.17 (1.14-1.20)	0.57
7-day urgent re-hospitalization	1.06 (1.03-1.09)	1.08 (1.04-1.12)	0.45
7-day death	1.07 (0.96-1.18)	1.36 (1.14-1.63)	0.02
14-day death or readmission	1.11 (1.08-1.13)	1.13 (1.13-1.17)	0.003
14-day emergency department visit	1.13 (1.10-1.15)	1.16 (1.14-1.18)	0.02
14-day urgent re-hospitalization	1.06 (1.03-1.09)	1.09 (1.06-1.12)	0.17
14-day death	1.03 (0.97-1.10)	1.25 (1.11-1.40)	0.008

The holiday-related risk of 30-day death or readmission was more pronounced in patients with a low risk LACE score (holiday 22.5% vs control 20.8%, adjusted OR 1.12, 95% CI 1.10-1.13) than those with a high risk LACE score (holiday 34.4% vs control 33.1%, adjusted OR 1.06, 95% CI 1.04-1.09, p interaction=0.0001, Table 2.11). A similar pattern was observed at 14 days, however at 7 days this distinction between high- and low-risk groups was not apparent (p interaction 0.25).

Patients discharged from hospital in 2009-2015 had a greater holiday-related drop in follow-up at 7 and 14 days (2002-2008 aOR 0.67, 95% CI 0.66-0.68, 2009-2015 aOR 0.63, 95% CI 0.62-0.65, p interaction <0.0001). The time period (2002-2008 or 2009-2015) of discharge did not significantly alter the relationship between holiday discharge and the risk of 30-day death or readmission (p=0.09, Table 2.12). However, patients discharged from hospital in 2002-2008 had

a significantly greater holiday-related risk for 7-day death or readmission (holiday 13.2% vs control 11.5%, aOR 1.18, 95% CI 1.15-1.20) than those discharged in 2009-2015 (holiday 13.2% vs control 11.9%, aOR 1.13, 95% CI 1.11-1.16, p for interaction=0.008).

Table 2.12. Adjusted results for outcomes of patients discharged from hospital during holiday and control periods, according to year of hospital discharge.

Outcome Measure	Year of Discharge 2002- 2008	Year of Discharge 2009- 2015	P for interaction
	Adjusted OR (95% Cl)	Adjusted OR (95% CI)	
F	Primary Outcome		
30-day death or readmission	1.10 (1.08-1.12)	1.08 (1.06-1.09)	0.09
30-day emergency department	1.10 (1.07-1.12)	1.08 (1.06-1.10)	0.23
visit			
30-day urgent re-hospitalization	1.07 (1.04-1.09)	1.05 (1.03-1.07)	0.24
30-day death	1.07 (1.01-1.13)	1.05 (1.00-1.10)	0.62
Secondary Outcomes			
7-day outpatient follow-up	0.62 (0.61-0.63)	0.60 (0.59-0.61)	0.02
14-day outpatient follow-up	0.67 (0.66-0.68)	0.63 (0.62-0.65)	<0.0001
7-day death or readmission	1.18 (1.15-1.20)	1.13 (1.11-1.16)	0.008
7-day emergency department visit	1.19 (1.17-1.22)	1.14 (1.12-1.17)	0.007
7-day urgent re-hospitalization	1.08 (1.04-1.11)	1.05 (1.02-1.08)	0.30
7-day death	1.17 (1.03-1.32)	1.11 (0.96-1.28)	0.62
14-day death or readmission	1.15 (1.12-1.17)	1.12 (1.10-1.14)	0.09
14-day emergency department	1.16 (1.14-1.19)	1.13 (1.11-1.15)	0.07
visit		. , ,	
14-day urgent re-hospitalization	1.07 (1.05-1.10)	1.07 (1.04-1.09)	0.67
14-day death	1.09 (1.01-1.17)	1.07 (0.99-1.16)	0.79

# 2.6 Discussion

We found that patients discharged during the December holiday had an increased risk of 30-day death or readmission compared to patients discharged at other times. This risk was front-loaded: the greatest holiday-related risk increase was within 7 days of hospital discharge. Patients discharged during the December holiday were also less likely to have physician follow-up within 7- and 14- days of hospital discharge. Per 100,000 patients, 26 excess deaths, 188 excess hospitalizations, 483 excess emergency department visits and 2,999 fewer 14-day follow-up appointments could be attributed to December holiday discharge.

The differences in outcomes could not be explained by observed hospital or patient characteristics, including their admission diagnosis. Moreover, the increased unadjusted risk of death or readmission at 30 days was observed across many patient characteristics, and no group demonstrated a significantly decreased risk of death or readmission at 30 days. Although patients admitted to hospital on weekends may be sicker than their weekday counterparts, (156) patients discharged from hospital on weekends typically have characteristics associated with a lower risk for readmission, such as younger age, lower complexity, and shorter length of stay. (138) We similarly observed that patients discharged during holiday periods had a slightly lower baseline risk of readmission, as predicted by the LACE score. We found that higher risk patients had a lower holiday-attributable risk for 30-day death or readmission than did patients at lower readmission risk. Similarly, the 30-day risk of death or readmission for patients with COPD was not significantly increased by holiday discharge. The seemingly paradoxical findings observed in these key patient subgroups might suggest that holiday-related risk is not proportional to baseline risk, and could predominantly affect an otherwise lower risk group of patients. One example of how this could occur would be if clinicians, in a setting of reduced resources over the holidays, prioritize higher risk patients for more thorough discharge planning.

Several possible mechanisms might explain how the December holiday could lead to decreased follow-up. First, the December holiday may be a time of reduced access to outpatient care, as clinic staff suspend work for a prolonged, coordinated, holiday. Patients may not be able to contact their physician at all, or may encounter scheduling difficulties. Second, patients may prefer to postpone their follow-up until their usual physician returns, or until the end of holiday festivities or travel. Third, hospital-based follow-up care coordination may be reduced over the holidays, with staffing reductions mirroring those in outpatient clinics. Similar to procedural delays encountered during off-hours,(134, 135) elements of discharge planning (e.g., medication review, patient education, care coordination) may be limited by December holiday staffing reductions.

The relationship between December holiday discharge and death or readmission may also be explained in several ways. Firstly, for many the holiday period is filled with festivities and potential physiological stressors (e.g. tense interpersonal exchanges, lack of sleep, increased intake of alcohol, sodium and sugar). These altered circumstances may destabilize an acute

medical condition during what should be a period of recovery. Second, off-work family may in some cases prompt an early return to the emergency department. Yet, the increased risk of rehospitalization and death observed in our study suggests that such visits are not limited to minor conditions. Third, decreased follow-up, as identified in our study, may signal a failure to rescue patients from avoidable complications or early deterioration. In this study, we have not tested whether differences in follow-up explain the association between holiday discharge and death or readmission; our findings only provide an ecological clue that decreased follow-up and increased death or readmissions may coexist.(157) To determine whether follow-up is a mediator of the relationship between holiday discharge and death or readmission, there is a need to develop tools to test a time-varying binary mediator of a time-to-event outcome.

Our study has several limitations. We used many strategies to increase the comparability of groups and minimize bias where possible. Although length of stay, comorbidity and prior emergency department use are known predictors of post-discharge outcomes,(153, 158) they are imperfect proxies for more detailed clinical information on severity of illness. Thus, the possibility of confounding due to unmeasured differences remains. Further, it is possible that increased out-of-province travel during the December holiday led us to underestimate rates of death or readmission in the holiday group. Yet, this would be expected to bias our findings toward the null hypothesis. Finally, the decrease in outpatient follow-up among holiday patients in our study may not be generalizable to all jurisdictions. In particular, follow-up rates can be expected to vary according to local community practices.

We found that discharge from hospital during the December holiday is a novel risk factor for both reduced follow-up and increased death or readmission. More detailed information on patient severity of illness would strengthen the argument for causation between holiday discharge and health outcomes. As well, further study of the potential role of follow-up in mediating this relationship is now justified. Rather than rushing to get patients home, hospital clinicians should pay extra attention to discharge planning for this vulnerable group, ensuring optimal patient education, medication reconciliation and follow-up care. Discharged patients, unlike unwanted gifts, should not be returned after the holidays.

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# Chapter 3 Effectiveness of a financial incentive to physicians for timely follow-up after hospital discharge

# 3.1 Chapter Overview

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## 3.1 Abstract

Background: Timely follow-up after hospital discharge may decrease hospital readmission. Financial incentives to improve follow-up have been introduced in the United States and Canada, but it is unknown whether they are effective. We examined the impact of an incentive program on timely physician follow-up after hospital discharge.

Methods: This was an interventional time series analysis of all medical and surgical patients discharged home from hospital between April 1<sup>st</sup>, 2002 and January 30<sup>th</sup>, 2015 in Ontario, Canada. The intervention was a supplemental billing code (value of \$25) for physician follow-up within 14 days of discharge from hospital, introduced in 2006. The primary outcome was an outpatient visit within 14 days of discharge. Secondary outcomes were 7-day follow-up and a composite of emergency department visits, non-elective hospital readmission, and death within 14 days.

Results: 8,008,934 patient discharges were included. The incentive code was claimed in 31% of eligible visits, by 51% of eligible physicians, and cost \$17.5 million over the study period. There was no change in the average monthly rate of outcomes in the year following incentive introduction as compared to the year prior to introduction: 14-day follow-up (66.5% vs 67.0%, overall p=0.5), 7-day follow-up (44.9% vs 44.9%, overall p=0.5), and the composite outcome (16.7% vs 16.9%, overall p=0.2).

Interpretation: Despite uptake by physicians, a financial incentive did not alter follow-up after hospital discharge. This lack of effect may be explained by features of the incentive or by extra-physician barriers to follow-up. These should be considered by policymakers before introducing similar initiatives.

## 3.2 Introduction

Readmissions after hospital discharge are common, occurring in approximately 14% of U.S. patients at 30 days and costing \$41 billion annually.(159) Just how much hospital readmissions may be preventable through improved continuity of care is uncertain.(39, 40, 160) The period following hospital discharge is marked by a high risk of adverse events and omissions of care, including failure to follow-up on in-hospital testing or implement a recommended workup.(20, 22, 23, 161) Timely follow-up may mitigate some of these risks by providing an opportunity for education, medication reconciliation, review of hospitalist recommendations, and recognition of clinical deterioration. Early visits after hospital discharge reduce readmissions in high-risk patients, such as those hospitalized for chronic obstructive pulmonary disease or heart failure.(66-68, 70, 71) Results have been mixed in other populations.(72-76, 162)

In 2009, Jenks et al. reported that only half of all discharged Medicare patients had seen a physician prior to their hospital readmission.(3) Possible reasons for lack of timely follow-up include limited patient health literacy, mobility, provider accessibility and awareness of patient's hospitalization.(29, 30, 81) It is uncertain whether physician financial incentives improve quality of care.(163-165) However, such incentives may be one way to increase rates of early follow-up. In 2013, the Centers for Medicare introduced Transitional Care Management codes to the United States, providing additional reimbursement to physicians who provide early patient follow-up.(166) On October 1<sup>st</sup> 2006, the Ontario Ministry of Health introduced a similar incentive, providing a \$25 premium for an outpatient visit within two weeks of hospital discharge.(90) It is unknown whether such incentives are effective in their proximate goal, to increase rates of collow-up, or in their downstream goal of reducing readmissions. Our primary objective was to evaluate the impact of this incentive on rates of timely physician follow-up.

### 3.3 Methods

#### 3.3.1 Setting and Design

We conducted a population-based retrospective time series study of patients discharged from acute care inpatient beds between April 1<sup>st</sup> 2002 and January 30<sup>th</sup> 2015, in Ontario, Canada. This project was approved by the Research Ethics Board of Sunnybrook Health Sciences Centre.

#### 3.3.2 Data Sources

The multiple databases at the Institute for Clinical Evaluative Sciences contain coded linked health administrative data for all Ontario residents. This includes information on all acute hospitalizations in the province,(116) all emergency department visits,(142) physician billing claims submitted to the public health insurance program,(143) demographic information and vital statistics.(115)

#### 3.3.3 Study Population

We identified all patients discharged to the community from an acute care hospital between April 1<sup>st</sup> 2002 and January 30<sup>th</sup> 2015. We excluded: newborns; patients admitted for an obstetrical delivery or a psychiatric problem; patients receiving palliative care during the index hospital admission; or patients with a length of stay greater than 100 days. In addition, we excluded observations with a missing age, gender, invalid Ontario postal code or invalid death date (Figure 3.1).



#### Figure 3.1. Study flowchart. OHIP= Ontario Health Insurance Plan

#### 3.3.4 Exposure

The incentive fee code was introduced in October 2006, and provides an additional \$25 for a physician visit in an office or home setting within two weeks of hospital discharge.(90) The premium is not offered for visits: in nursing homes, following admission for obstetrical delivery routine in-hospital care of the newborn, or day surgery. The incentive code is a supplement to commonly-used primary care codes that range in value from \$21.50 to \$104.80 (Table 2.1). Incentive payment is received between 3 weeks and 2 months following submission, alongside other fee-for-service claims. The existence of the incentive was first communicated to physicians through a single mailed bulletin, dated October 1<sup>st</sup>, 2006, and was included in the updated physician fee schedule.(90)

Code	Description	Monetary Value (\$ Canadian)
A001	Minor assessment	21.70
A003	General assessment	77.20
A004	General re-assessment	38.35
A007	Intermediate assessment or well-baby care	33.70
A008	Mini-assessment (with disability insurance visit)	13.05
A261	Level 1 Pediatric assessment	21.50
A262	Level 2 Pediatric assessment	42.15
A263	Medical specific assessment	77.70
A264	Medical specific re-assessment	59.45
A888	Emergency department equivalent - partial assessment	35.40
A900	Complex house call assessment	45.15
A901	House call assessment	45.15
A903	Pre-dental/pre-operative general assessment	65.05
K004	Family psychotherapy	68.10 per 30 minutes
K005	Primary mental healthcare, individual	62.75
K006	Hypnotherapy, individual care	62.75 per 30 minutes
K007	Psychotherapy, individual care	62.75 per 30 minutes
K008	Diagnostic interviewing and/or counselling with child and/or parent	62.75 per 30 minutes
K013	Counselling	62.75 per 30 minutes
K014	Counselling for transplant recipients, donors or families of recipients and donors	62.75 per 30 minutes
K022	HIV primary care	62.75 per 30 minutes
K023	Palliative care support	62.75 per 30 minutes
K028	STD management	62.75 per 30 minutes
K029	Insulin therapy support	62.75 per 30 minutes
K030	Diabetic Management Assessment	39.20
K032	Specific neurocognitive assessment	62.75

 Table 3.1. Billing codes eligible to be accompanied by the incentive code (e080)

Code	Description	Monetary Value (\$ Canadian)
K033	Counselling (after first three sessions in 12-month period)	38.15 per 30 minutes
K037	Fibromyalgia/chronic fatigue syndrome care	62.75 per 30 minutes
K623	Completion of Form 1- Request for psychiatric assessment	104.80
P003	General assessment (major prenatal visit)	77.20
P004	Minor prenatal assessment	33.70
P008	Postnatal care in office	33.70

Table 3.1 (continued). Billing codes eligible to be accompanied by the incentive code (e080)

## 3.3.5 Patient Characteristics

We examined baseline characteristics such as patient age, sex, hospital length of stay, Charlson comorbidity score,(146) socioeconomic status, previous healthcare usage (emergency department visits, hospitalizations, outpatient visits and home care visits), and whether the index admission was elective or urgent.

## 3.3.6 Outcomes

The primary outcome was follow-up with any physician within 14 days of hospital discharge. Visits were included if they occurred in an office or home setting, and excluded medical imaging or laboratory testing. Secondary outcomes included follow-up at 7 days, as well as a composite of return to the emergency department, non-elective hospital readmission, or death within 14 days.

## 3.3.7 Descriptive Analysis at the Patient-Discharge Level

The characteristics of patients who did or did not reach the primary outcome were compared using standardized differences (Std. Diff.). Baseline characteristics that differed by at least 10% were plotted over time.

## 3.3.8 Time Series Analysis of Primary and Secondary Outcomes

Primary and secondary outcomes were reported monthly as a proportion of all discharges and plotted over time. Autoregressive, integrated moving average (ARIMA) methods were used to

model these monthly proportions, accounting for auto-correlation, seasonality and trends. An interventional term was used to test for the effect of the introduction of the incentive on the outcome, over and above any background trends. Where follow-up rates appeared on visual inspection to shift in October 2005, we accounted for this with an additional interventional term. Model selection was guided by visual inspection of correlograms. Stationarity was assessed using the augmented Dickey Fuller test and autocorrelation at various lags was assessed using the Ljung-Box Chi-square test.(167) All significance testing was two-tailed with a significance threshold set at p<0.05. Analyses were performed using SAS/ETS software, 9.4 (SAS Institute Inc., Carey, NC).

#### 3.3.9 Sensitivity and Subgroup Analyses

To determine whether results were sensitive to the outcome definition, we conducted an analysis in which the outcome was 14-day follow-up with a previously known physician or a patient's assigned primary care physician. Previously known physicians had at least one office or home visit with the patient in the year prior to discharge from hospital. Primary care physicians were assigned using Ontario Client Agency Program Enrolment tables (for formally rostered patients) or through virtual rostering with commonly-used primary care codes (Table 2.2).(144) Analyses were also performed stratified by patient age at discharge (<18 years of age, 18-64 years, 65+ years), and for discharges following an urgent admission.

Code	Description
A001	Minor assessment
A002	18 month well baby check
A003	General assessment
A004	General re-assessment
A007	Intermediate assessment, well baby check
A268	Enhanced 18-month well-baby visit (billed by pediatrician)
A903	Preoperative assessment
E075	Geriatric general assessment premium
G212	Allergy injection alone
G271	Anticoagulant supervision
G365	Papanicolaou test
G372	Injection, with visit
G373	Injection, sole reason
G538	Immunization, with visit
G539	Immunization, sole reason
G590	Influenza immunization, with visit
G591	Influenza immunization, sole reason
K005	Primary mental health care
K013	Counselling, individual care
K017	Annual health exam, child after second birthday
P004	Minor prenatal assessment
K022	HIV primary care
K131	Adult periodic health visit age 18-64
K132	Adult periodic health visit over age 65
K039	Smoking cessation follow-up
A901	House call assessment
A900	Complex house call assessment
K267	Annual health exam, child 2–11 years (billed by pediatrician)
K269	Annual adolescent health exam (billed by pediatrician)

Table 3.2. Primary care billing codes used to virtually roster patients to primary care physicians.

## 3.4 Results

Our study included 8,008,934 patient discharges from 206 acute care hospitals. Of these, 550,742 discharges (6.9%) occurred on the same day as a follow-up visit. By 14 days after discharge, 5,284,742 patients (66.0%) had follow-up with any physician, 4,059,337 (50.7%) had follow-up with a previously known physician, and 2,736,785 (34.2%) had followed up with their primary care physician. Patients were followed up within 14 days by 33,676 distinct physicians. In the same time period, 1,369,382 (17.1%) reached the composite outcome of return to emergency department, non-elective readmission or death (see Figure 3.2).



Figure 3.2. Overall proportions of 14-day outcome measures after hospital discharge. PCP=primary care physician.

#### 3.4.1 Patient Characteristics

Patients who did not have a follow-up visit within 14 days of hospital discharge had fewer previous outpatient visits (Std. Diff. 0.39), comorbidities (Std. Diff. 0.14), a shorter length of stay (Std. Diff. 0.12), and were more likely to be assigned to a fee-for-service primary care physician (Std. Diff. 0.10). Over our study period, the proportion of patients with no comorbid diagnoses gradually decreased from 52.5% to 47.4% (Figure 3.3). Previous outpatient visits and length of stay remained stable throughout the study (Figure 3.4, median length of stay was consistently 3 days). The proportion of discharged patients assigned to an enhanced fee-for-service primary care physician increased from 18.2% to 40.0% in 2005 (Figure 3.5).


Figure 3.3. Proportion of patient discharges with a Charlson comorbidity score=0, by month of hospital discharge

Figure 3.4. Mean number of outpatient visits per patient in year prior to hospital discharge, by month of hospital discharge.





Figure 3.5. Proportion of patient discharges assigned to primary care providers in each funding group, by month of hospital discharge. FFS=fee-for-service

## 3.4.2 Physician-Level Analysis: Uptake of the Incentive

There was rapid uptake of the incentive in the first month following its introduction, with 19% of eligible visits accompanied by an incentive claim. Thereafter, this proportion gradually increased to 40.9 % by January 2015 (overall proportion 31.3%, median monthly 32.4%, Figure 3.6). Since its introduction, the incentive was claimed within two weeks of discharge a median of 7,023.5 times per month for a total cost of \$17.5 million (average \$2.1 million/year). In the most recent year studied (2014) the incentive cost \$2.7 million.



Figure 3.6. Uptake of the incentive code, by month of discharge. Dashed line identifies the time of incentive code introduction.

There were 10,057 distinct physicians who claimed the incentive in our cohort, which was 50.9% of the 19,742 physicians who claimed eligible services. Of the physicians performing eligible services (monthly median n=7,897), a median of 40.8% claimed the incentive each month.

#### 3.4.3 Primary Analysis: Effect of Incentive on Outcomes

The incentive had no significant impact on 14-day physician follow-up (average monthly 66.5% in the year prior to incentive introduction, 67.0% in the year following incentive introduction; p=0.5 for intervention effect; Figure 3.7) or 7-day physician follow-up (44.9% in the year prior to the incentive, 44.9% in the year following the incentive; p=0.5 for intervention effect; Figure 3.7). There was similarly no significant change following incentive introduction in the proportion of patients who experienced the composite outcome of return to the emergency department, non-elective hospital readmission, or death within 14 days of hospital discharge (monthly average of 16.7% in the year prior to the incentive, 16.9% in the year following the incentive, p=0.2 for intervention effect, see Figure 3.8).



Figure 3.7. Physician follow-up, by month of discharge. Dashed line identifies the time of incentive code introduction.

Figure 3.8. Proportion of patient discharges with an emergency department visit, unplanned readmission, or death within 14 days after hospital discharge. Dashed line identifies the time of incentive code introduction.



### 3.4.4 Sensitivity and Subgroup Analyses

There was no change in 14-day follow-up rates after incentive introduction when the outcome definition was changed to follow-up with a previously known physician (p=0.6) or assigned primary care physician (p=0.5) (Figure 3.9).

# Figure 3.9. Proportion of patient discharges with physician follow-up after hospital discharge, by physician type and month of discharge. Dashed line identifies timing of incentive code introduction



In patients with an urgent index admission, and across all patient age categories, there was no change in 14-day any physician follow-up after the incentive was introduced (Figures 3.10-Figure 3.13, p=0.8 for urgent patients, p=0.3 for age <18 years, p=0.9 for age 18-64, p=0.5 for age 65+).

Figure 3.10. Proportion of urgent hospital discharges with a physician follow-up within 14 days, by month. Dashed line identifies timing of incentive code introduction. N= 5,569,989



Figure 3.11. Proportion of pediatric discharges (age<18 years) with a physician follow-up within 14 days, by month. Dashed line identifies timing of incentive code introduction. N= 884,081



Figure 3.12. Proportion of adult discharges (age 18-64 years) with a physician follow-up within 14 days, by month. Dashed line identifies timing of incentive code introduction. N=3,886,964



Figure 3.13. Proportion of older adult discharges (age 65+) with a physician follow-up within 14 days, by month. Dashed line identifies timing of incentive code introduction. N=3,237,889.



Physicians in the highest quartile of uptake of the incentive similarly did not demonstrate a significant change in follow-up rates following introduction of the incentive (p=0.2). Both before and following introduction of the incentive, primary care physicians in the highest uptake quartile had the highest 14-day follow-up rates (Figure 3.14, 68.4% compared to 65.7%, p<0.0001).

Figure 3.14. Proportion of patient discharges having primary care physician (PCP) followup with 14 days of hospital discharge, by month, according to PCP quartile of incentive code uptake. Dashed line identifies timing of incentive code introduction. First quartile N=1,252,720, second quartile N=2,050,624, third quartile N=1,614,704, fourth quartile N=2,544,114.



An additional post-hoc analysis of follow-up with any physician according to primary care physician funding model was performed because of the observed increase in enhanced fee-for-service funding in 2005. There was no effect of the incentive on any physician follow-up in any of the major funding model groups (Figure 3.15).

**Figure 3.15.** Proportion of hospital discharges with any physician follow-up within 14 days, by month, according to primary care physician funding model. Dashed line identifies timing of incentive code introduction. FFS=fee-for-service. The intervention did not significantly affect the outcome in any funding group (p=0.6 for FFS, p=0.3 for capitation-based, p=0.8 for enhanced FFS). N=2,206,105 for Capitation-Based, N= 3,082,191 for FFS, N=2,262,531 for Enhanced FFS.



# 3.5 Discussion

In this time series study of patients discharged from hospital to home, a fee code to incentivize physician follow-up after hospital discharge was adopted by 51% of eligible physicians and cost an average of \$2.1 million annually. Despite this, there was no sizable impact on 14-day physician follow-up rates, or a 14-day composite of emergency department visits, readmissions or death. Physicians with the highest uptake of the incentive had the highest 14-day follow-up rates before and after the intervention, suggesting that the incentive rewarded the highest performing providers without modifying their behaviour.

Our findings indicate that follow-up rates have remained relatively stable over time, despite rising patient complexity. Other than the possibility that physician incentives in general may not be effective, there are several reasons that may explain the failure of this particular incentive to improve follow-up rates.(165) First, incentive payments were received along with other claim payments, possibly obscuring their effect on income. Second, payments were typically received weeks to a month later, doing little to reinforce the incentivized behaviour. Third, although the value of the incentive code compared favourably to the fee claimed for a regular physician visit, this may not be enough money to matter to clinicians, particularly if post-discharge patients represent a small percentage of their practice population.

Physician incentives should be designed with attention to principles of behavioural psychology.(168) In particular, lack of immediacy and mental accounting may have hindered this incentive's success. We add to this another consideration: that the person who is aware of the incentive payment also be responsible for the desirable action. In the case of follow-up, if scheduling staff are inflexible, unaware, or removed from the financial gains related to early follow-up, then the incentive may fail to translate to earlier scheduled appointments. Billing agents may also insulate decision-makers from monetary gains, if they are the only ones aware that the incentive is being claimed.

While a well-designed incentive may be motivating, without automated supporting processes, delivering early follow-up may simply hit against the limits of physician willpower. Patient mobility, health literacy, finances or social supports may prevent patients from reaching their appointment. Current outpatient care processes may be ill-adapted to meet the needs of functionally dependent, cognitively impaired, marginalized or socially isolated individuals. Further, the patient is often the only timely messenger between inpatient and outpatient systems. Primary care physicians have reported unawareness of hospitalization until weeks following discharge, after the window for "early" follow-up has closed.(29, 30, 81) This puts the onus on the patient to inform clinic staff of their hospitalization and need for urgent follow-up. Patients may not know that mentioning a recent hospitalization would trigger an earlier appointment booking. In a complex system, much of the responsibility is placed on the patient for ensuring their own continuity of care.

In the U.S., Medicare's codes differ from the incentive studied here in several ways. Transitional Care Management codes have a greater monetary value and are reserved for more complex patient discharges. Additionally, they are supported by an existing structure of aligned incentives operating at the hospital level, such as penalties for hospital readmissions. In this context, an incentive to outpatient physicians may be more successful, as processes would have already evolved to facilitate communication between inpatient and outpatient providers.

Strengths of our study include that it is population-based, and contains comprehensive outcome information as a result of linked administrative health data. Our study captured a twelve year time period, allowing for sufficient forecasting and accounting for long-term trends. We were also able to measure uptake of the intervention directly, which is not always possible in studies of health policy interventions. Our study has several limitations. First, temporal confounding is a potential threat to the validity of time series studies. Modelling was used to account for any background trends in the outcomes (including the effects of gradual changes in comorbidity over time) such that these would not confound testing of the effect of the intervention. In addition, we accounted for changes to follow-up in October 2005 (possibly due to the introduction of new medical subspecialty premium codes) by incorporating this into our models. After examining a range of characteristics and outcomes over time, as well as carefully reviewing Ministry billing policy bulletins from 2005-2007, we are confident that no large source of bias was missed. The consistency of our results across several sensitivity and stratified analyses is supportive. Second, it is possible that the incentive had other benefits and/or effects not measured here, such as allowing for longer or higher quality patient visits. Third, due to the complexity of behavioural interventions targeting physicians, the findings in this study remain limited by their context, in a single Canadian province. These results may not be generalizable to jurisdictions with different physician payment structures. However, our findings can still offer insights to organisations designing similar incentives.

Despite reasonable uptake, we found no effect of an incentive on physician follow-up after hospital discharge and no effect on subsequent emergency department visits, readmissions, or mortality. We believe the code's lack of effect may be explained by certain features of the incentive (lack of immediacy and separate payment) as well as barriers to follow-up that remain beyond the outpatient physician's control. Policymakers wishing to improve follow-up care using physician incentives should carefully consider incentive design and remaining barriers before widespread adoption.

# 3.6 Acknowledgements

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# Chapter 4 Community pharmacy medication review, death and readmissions after hospital discharge

# 4.1 Chapter Overview

This chapter is being prepared for submission to a peer-reviewed medical journal.

# 4.2 Abstract

Background: In-hospital medication review has been linked to improved outcomes after hospital discharge, yet there is little evidence to support the use of community pharmacy-based interventions as part of transitional care. MedsCheck is a medication reconciliation and review encounter provided by pharmacists in Ontario community pharmacies. Our objective was to determine if patients receiving a MedsCheck after hospital discharge had lower rates of subsequent death or readmission compared to patients not receiving a MedsCheck.

Methods: This was a population-based retrospective propensity score-matched cohort study of eligible patients discharged home from an Ontario hospital from April 1<sup>st</sup> 2007 to September 16<sup>th</sup> 2016. We included individuals who were 66 years of age on the day of hospital discharge and who filled a prescription at a community pharmacy within 7 days of discharge. The exposure of interest was receipt of MedsCheck. The primary outcome was time to death or readmission, with the latter defined as an emergency department visit or urgent re-hospitalization, within 30 days after MedsCheck receipt. Secondary outcomes were time to adverse drug event and the 30-day count of outpatient physician visits.

Results: Of 879,497 unique patients discharged, 77,459 (8.8%) received a MedsCheck. Of these, 67,163 patients (86.7%) were propensity score-matched 1:1 to patients who did not receive a MedsCheck. Recipients had a lower rate of 30-day death or readmission (23.4% vs 23.9%, HR 0.97, 95% CI 0.95-1.00, p=0.02), driven by a decreased risk of death (1.7% vs 2.1%, HR 0.79, 95% CI 0.73-0.86) and re-hospitalization (11.0% vs 11.4, HR 0.96, 95% 0.93-0.99). There was no significant difference in 30-day return to the emergency department (22.5% vs 22.8%, HR 0.99, 95%CI 0.96-1.01).

Interpretation: Among older adults filling a prescription in a community pharmacy after hospital discharge, receipt of a medication reconciliation and review encounter was associated with fewer deaths or readmissions in the following 30 days. Due to the possibility of unmeasured confounding, experimental studies are needed to confirm this finding.

# 4.3 Introduction

The period of transition home after a hospital stay presents numerous risks to patients. In addition to reduced functioning, many patients will experience a delayed clinical deterioration or complications from treatment. Medications are the single most frequent cause of adverse events following hospital discharge, with adverse drug events occurring after 13-16% of hospital admissions.(20, 22, 92) This high rate reflects unintentional errors in discharge medication lists, inappropriate prescribing, inadequate patient understanding of medication changes and insufficient monitoring after changes are made.(24, 25, 92) In some cases, medication-related adverse events lead to costly hospital readmissions.(21)

Medication safety is a pillar of optimal discharge practices, and appears in multiple safe discharge checklists.(51, 52, 169) Medication-related interventions are frequently included in multicomponent transitional care interventions, many of which have reduced all-cause hospital readmissions.(113) In Canada, medication review at discharge is a hospital accreditation standard.(170) Yet, studies investigating the effect of medication reconciliation alone have yielded inconsistent results.(54) Medication reconciliation by in-hospital pharmacists have been found to reduce potential medication errors and drug-related readmissions, but not all-cause readmissions.(93, 94) In a recent systematic review, medication reconciliation delivered by community pharmacists did not reduce the rate of readmissions.(104) Yet, none of the included interventions were conducted in a community pharmacy setting.

In 2007, the Ontario Ministry of Health and Long-Term Care introduced MedsCheck, a program of medication reconciliation and review by community pharmacists.(103) Patients filling a prescription in a community pharmacy within 7 days of hospital discharge were eligible for a MedsCheck if they were taking at least three chronic medications.(111) The effect of MedsCheck on death or readmission after hospital discharge has not previously been studied. Our objective was to determine if older adults receiving MedsCheck after hospital discharge have lower rates of subsequent death or readmission than patients not receiving a MedsCheck.

# 4.4 Methods

# 4.4.1 Setting, design and data sources

We conducted a retrospective propensity score-matched cohort study of patients discharged home from an Ontario hospital from April 1st 2007 to September 16th 2016. The start date aligned with the introduction of MedsCheck. Since complete administrative data were available up to December 2016, and the MedsCheck reporting requirements were significantly modified in October 2016, we selected an end date in mid-September. ICES in Toronto, Ontario, houses deidentified linked health administrative data for all Ontario residents who have a valid provincial health insurance card. This includes information on demographics,(114) hospitalizations,(116) emergency department visits,(142) outpatient visits,(143) home care visits, and time of death.(115) The Ontario Drug Benefit database includes information on medications and pharmacy services (including MedsCheck) provided to low-income patients and those over age 65.(120) As provincial health insurance is granted universally to all citizens and permanent residents, this study is population-based.

#### 4.4.2 Study Population

To minimize bias in the comparison of patients who did and did not receive a MedsCheck, we restricted our study sample to individuals who would have been eligible to receive a MedsCheck. This approach also ensured comparability of medication history between the exposed and control groups. ICES administrative data sources contain prescription medication information for all Ontario residents over age 65, since provincial health insurance coverage is extended to all seniors.(171) Thus, we included individuals who were 66 years of age on the day of hospital discharge, were eligible for MedsCheck and filled a prescription at a community pharmacy within 7 days of discharge. Eligibility for MedsCheck was defined, consistent with Ministry criteria for MedsCheck reimbursement, as taking three or more chronic medications over the previous six month period.(102)

The documentation for the MedsCheck program does not define "chronic medications" however we adopted a previous definition.(103, 172) This excluded non-medications and classes of medications that were most likely to be used for acute conditions or unlikely to be dispensed by a community pharmacist (see Table 4.1). The 7-day window for the prescription fill was selected to capture medication changes resulting from hospitalization.(173)

Acute and not included in Chronic definition	Rationale	Exceptions: can be included in chronic definition
Anti-infectives	Frequently short courses of treatment	HIV antivirals, some viral hepatitis medications that are typically given for more than 12 months
Anti-histamines	Frequently short courses of treatment	
Anti-neoplastics	Short courses of treatment, and usually not dispensed by a community pharmacist.	exception: oral Immunosuppressive, immunomodulatory agents, hormone blocking agents. Decisions based on usual dosing regimen. If dosage was cyclical, then excluded. If no cycle specified, assumed would be chronic. Of if specified "continue until disease progression or unacceptable toxicity" with a cycle, assumed to be chronic.
Muscle relaxants/ antispasticity drugs	Frequently short courses	
GI meds: anti-nauseants, anti- emetics, cathartics/laxatives, stool softener, antiflatulents	Frequently short courses of treatment	
Cough preparations	Frequently short courses of treatment	
Skin and mucous membrane preparations	Often short courses of treatment	
Injectable medication	Usually not dispensed by a community pharmacist	Pre-filled syringes and kits, insulins and low molecular weight heparins.
Intravenous medication	Would most often not be dispensed by a community pharmacist	
Erythropoetin analogs	Usually not dispensed by a community pharmacist	
Acetaminophen and codeine combinations	Short courses of treatment	
Electrolyte replacement solutions	Short courses of treatment	
Insulin test strips and supplies Vitamins and supplements Nutritional Supplies	Not medications in traditional sense	

Table 4.1. Exclusions to chronic medications list.

We restricted the analysis to patients who were discharged home to the community. Therefore, patients discharged or transferred to nursing homes, rehabilitation facilities, or other healthcare institutions were excluded. We also excluded three groups likely to have markedly different readmission risk: newborns, patients admitted for an obstetrical delivery, and patients receiving palliative care (Figure 4.1).



Figure 4.1. Study flowchart OHIP=Ontario health insurance plan, PS=propensity score

Did not receive a MedsCheck= 67,163

The MedsCheck eligibility date was the earliest date at which an eligible patient filled a prescription in a community pharmacy. We excluded patients who experienced an outcome prior to either their MedsCheck eligibility date or the date of their MedsCheck. We also excluded those who received a MedsCheck prior to their eligibility date, since inclusion of this group would introduce immortal time bias into the analysis. We excluded individuals with missing age, sex, invalid home locations or invalid death dates. We selected each patient's first hospital discharge, and excluded all others.

#### 4.4.3 Exposure

The exposure was receipt of any MedsCheck service, as identified in the Ontario Drug Benefit database. We allowed for the MedsCheck assessment to occur up to 14 days following hospital discharge as this is the period of time defined for a MedsCheck Follow-Up visit after hospital discharge.(174)

The MedsCheck service is offered, regardless of prior referral, by a community pharmacist at the point of contact. In addition to taking at least 3 chronic medications, requirement for the service include: i) agreement by the patient, ii) one-on-one interview in a private area and iii) provision of a complete list of medications to the patient at service completion.(102)

There are several MedsCheck billing codes, each offered to a specific patient population (Table 4.2). As an example, MedsCheck annual can be done once yearly (\$60), and MedsCheck followup (\$25) can be provided at any time for any of the following indications: i) hospital discharge in the previous 2 weeks, ii) before a planned hospital admission, iii) physician referral or iv) pharmacist decision based on previous non-adherence, changes to medications, or a change of pharmacy (Table 4.2).(174)

MedsCheck Name and	Year of	Monetarv	Criteria
Drug Identification Number (DIN)	Introduction	Value (\$ CAN)	
MedsCheck Annual (93899979)	2007	\$60*	At least three prescribed medications for chronic condition(s)
MedsCheck Follow-up Hospital Discharge (93899981)	2007	\$25	Meets criteria for MedsCheck Annual and has been discharged from hospital in the previous 2 weeks.
MedsCheck Follow-up for Pharmacist Referral (93899982)	2007	\$25	Meets criteria for MedsCheck Annual and significant medication changes, documented non-compliance, or change in residence/pharmacy
MedsCheck Follow-up for MD/RN referral (93899983)	2007	\$25	Meets criteria for MedsCheck Annual and has a physician or nurse practitioner referral
MedsCheck Follow-up for hospital admission (93899984)	2007	\$25	Meets criteria for MedsCheck Annual and has a planned hospital admission.
MedsCheck Diabetes Annual Assessment (93899988)	2010	\$75	Living with type 1 or 2 diabetes mellitus
MedsCheck Diabetes Follow- up Assessment (93899989)	2010	\$25	Living with type 1 or 2 diabetes mellitus
MedsCheck Annual at Home (93899987)	2010	\$150	Meets criteria for MedsCheck Annual and the patient is home bound, not able to physically attend the pharmacy due to physical/mental incapacity

#### Table 4.2. MedsCheck service codes, monetary value, and criteria

#### \* \$50 before 2010

#### 4.4.4 Other variables

We included patient, hospital and pharmacy-level variables which were likely to be associated with receipt of MedsCheck or an outcome.(172) This included patient demographics (age, sex, rural residence, neighborhood income quintile, French or English language ability) as well as such as Charlson comorbidity score, and history of diagnosis or treatment of dementia.(146) Hospitalization characteristics included length of stay, arrival by ambulance, and discharge with home care support services or against medical advice. Measures of previous healthcare usage included pharmacy visits, home care visits, home physician visits, outpatient physician visits,

hospitalizations, emergency department visits, adverse drug events, receipt of any previous MedsCheck services, and previous medication usage.

Medication usage variables included the total number of medications and history of potentially inappropriate or high risk medications in the previous year. Potentially inappropriate medications for elders are those identified on the 2012 and 2015 Beer's lists.(175, 176) High risk medications are those identified as the drugs most frequently implicated in adverse drug events (Table 4.3) (177-179). In addition, we included the number of new medications filled post-discharge, as well as whether a new high risk medication or potentially inappropriate medication was dispensed. Hospital characteristics included status as rural, small, medium/large community hospital, or teaching hospital. We categorized each pharmacy's annual MedsCheck volume/total volume into quartiles to account for differences in MedsCheck delivery patterns between pharmacies.

Table 4.3. Community pharmacy-dispensed medications with high risk for adverse drug events\*

Drug classes/drugs
Oral hypoglycemic agents(179)
Insulin(179)
Anticoagulants (warfarin, direct oral anticoagulants, low molecular weight
heparins)(177-179)
Digoxin(177)
Beta blockers(177)
Diuretics(177)
Non-steroidal anti-inflammatories (NSAIDs)(177, 179)
Oral glucocorticoids & synthetic analogues(177, 179)
Opioids(177-179)
Antipsychotics(177)
Methotrexate (oral only) (179)
Antiretroviral agents (all oral) (179)
Chemotherapeutic/immunosuppressive agents (all oral) (177-179)

\*Exclusions: parenteral, nasal, ophthalmologic or otic solutions, as well as topical forms.

# 4.4.5 Main Outcome Measures

The primary outcome was time to death or readmission. We defined readmission as inclusive of both unscheduled return to the emergency department and urgent re-hospitalizations.

Secondary outcomes were time to adverse drug event requiring emergency department visit or hospitalization (ICD-10 codes listed in Tables 4.4 and 4.5).(178, 180, 181) An additional

secondary outcome was the count of outpatient physician visits. The outcome follow-up period was up to 30 days after MedsCheck receipt.

Table 4.4. ICD-10-CA	<b>A diagnosis</b>	codes related	to adverse	drug reactions
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	D52.1	Drug-induced folate deficiency anemia
	D59.0	Drug-induced autoimmune hemolytic anemia
	D59.2	Drug-induced nonautoimmune hemolytic anemia
D Diseases of	D61.1	Drug-induced aplastic anemia
	D64.2	Secondary sideroblastic anemia due to drugs or toxins
	D68.3	Hemorrhagic disorder due to circulating anticoagulants
	D89.3	Immune reconstitution syndrome
		Hypothyroidism due to medicaments and other
	E03.2	exogenous substances
E Endocrine,	E06.4	Drug-induced thyroiditis
nutritional and	E16.0	Drug-induced hypoglycemia without coma
metabolic	E23.1	Drug-induced hypopituitarism
diseases	E24.2	Drug-induced Cushing's syndrome
	E27.3	Drug-induced adrenocortical insufficiency
	E66.1	Drug-induced obesity
E Montol and	F11	Mental disorders due to opioids
	F13	Mental and behavioral disorders due to use of sedatives
disordors		or hypnotics
uisoruers	E10	Mental and behavioral disorders due to multiple drug use
	1 19	and use of other psychoactive substances
	G21.0	Malignant neuroleptic syndrome
	G21.1	Other drug-induced secondary parkinsonism
	G24.0	Drug-induced dystonia
<b>C</b> Discassos of the	G25.1	Drug-induced tremor
	G25.4	Drug-induced chorea
nervous system	G25.6	Drug-induced tics
	G44.4	Drug-induced headache, not elsewhere classified
	G62.0	Drug-induced polyneuropathy
	G72.0	Drug-induced myopathy
H Diseases of the	H26.3	Drug-induced cataract
ave and ears	H 40.6	Glaucoma secondary to drugs
Cyc and cars	H91.0	Ototoxic hearing loss
I Diseases of the	142.7	Cardiomyopathy due to drugs and other external agents
circulatory system	195.2	Hypotension due to drugs

# Table 4.4 (continued). ICD-10-CA diagnosis codes related to adverse drug reactions

J Diseases of the	J70.2	Acute drug-induced interstitial lung disorders		
respiratory	J70.3	Chronic drug-induced interstitial lung disorders		
system	J70.4	Drug-induced interstitial lung disorders, unspecified		
K Diseases of the	K71^	Toxic liver disease		
digestive system	K85.3	Drug-induced acute pancreatitis		
	L10.5	Drug-induced pemphigus		
	123.3	Irritant contact dermatitis due to drugs in contact with skin		
	1 24 4	Irritant contact dermatitis due to drugs in contact with skin		
		Unspecified contact dermatitis due to drugs in contact		
L Diseases of the	L25.1	with skin		
skin and		Generalized skin eruntions due to drugs and		
subcutaneous	L27.0	medicaments		
tissue	1 27 1	Localized skin eruptions due to drugs and medicaments		
	1/32	Lichenoid drug reaction		
	1512			
	L01.2	Drug phototoxic reapones		
	L30.0	Drug photoloxic response		
	L00.1	Drug photoallergic response		
		Postimmunization annopatny		
	M10.2 <sup>A</sup>	Drug-induced gout		
M Diseases of the	M32.0	Drug-induced systemic lupus erythematosus		
musculoskeletal	M34.2	Systemic sclerosis induced by drugs and chemicals		
system	M80.4^	Drug-induced osteoporosis with pathological fracture		
	M81.4	Drug-induced osteoporosis without pathological fracture		
	M83.5	Other drug-induced osteomalacia in adults		
	M87.1^	Osteonecrosis due to drugs		
	N14.0	Analgesic nephropathy		
N Diseases of the	N14 1	Nephropathy induced by other drugs, medicaments and		
genitourinary		biological substances		
system	N14 2	Nephropathy induced by unspecified drugs, medicaments		
	1111.2	and biological substances		
	R50.2	Drug-induced fever		
	T80 5	Complications following infusion, transfusion and		
	100.0	therapeutic injection: anaphylactic shock due to serum		
	T80 6	Complications following infusion, transfusion and		
	100.0	therapeutic injection: other serum reactions		
	T80 8	Other complications following infusion, transfusion and		
T Injuries and	100.0	therapeutic injection		
consequences of		Unspecified complication following infusion, transfusion		
external causes	100.3	and therapeutic injection		
	T88.0	Infection following immunization		
	T88.1	Infection complications following immunization		
	T88 6	Anaphylactic shock due to adverse effect of correct drug		
	100.0	or medicament properly administered		
	T88.7	Unspecified adverse event of drug or medicament		

Y40	<b>Systemic antibiotics</b> : Penicillins, cefalosporins and other beta-lactam antibiotics, chloramphenicol, macrolides, tetracyclines, aminoglycosides, rifamycins, antifungals, others
Y41	<b>Other systemic anti-infectives and antiparasitics:</b> Sulphonamides, other anti-mycobacterial, anti-malarials, anti-protozoal, antihelminthics, anti-virals
Y42	Hormones and substitutes: Glucocorticoids, thyroid hormones, anti-thyroids, insulin, oral hypoglycaemics, oral contraceptives, oestrogen and progestogen, anti-gonadotrophins, anti-oestrogens, anti-progestogens, androgens
Y43	<b>Systemic agents:</b> Anti-allergic and anti-emetic drugs, anti-neoplastic and immunosuppressive drugs, acidifying/alkalising agents
Y44	Agents affecting blood constituents: Iron preparations, anti-megaloblastic-anemia preparations, anticoagulants, anticoagulant antagonists, antithrombotic drugs, thrombolytic drugs, blood products, plasma substitutes
Y45	<b>Analgesics, anti-pyretics and anti-inflammatory drugs:</b> Opioids and related analgesics, salicylates, propionic acid derivatives, nonsteroidal anti-inflammatory drugs, antirheumatics, 4-aminophenol derivatives
Y46	Anti-epileptics and anti-parkinsonism drugs: Succinimides, oxazolidinediones, hydantoin derivatives, deoxybarbiturates, iminostilbenes, valproic acid, anti-parkinsonism drugs, anti-spasticity drugs
Y47	Sedatives, hypnotics and anti-anxiety drugs: Barbiturates, benzodiazepines, cloral derivatives, paraldehyde, bromine compounds, sedative, hypnotic and antianxiety drug, unspecified
Y48	Anesthetics and therapeutic gases: Inhaled/parenteral anesthetics, local anesthetics, therapeutic gases
Y49	<b>Psychotropic drugs:</b> Tricyclic and tetracyclic antidepressants, monoamine- oxidase-inhibitor, phenothiazine antipsychotics and neuroleptics, butyrophenone and thioxanthene neuroleptics, other antidepressants, antipsychotics and neuroleptics
Y50	<b>Central nervous system stimulants:</b> Analeptics, opioid receptor antagonists, methylxanthines, other central nervous system stimulants
Y51	<b>Drugs primarily affecting the autonomic nervous system:</b> Anticholinesterase agents, cholinergics, ganglionic blocking drugs, anticholinergics, antimuscarinics, spasmolytics, alpha-adrenoreceptor agonists/antagonists, beta-adrenoreceptor agonists/antagonists, centrally acting and adrenergic-neuron-blocking agents
Y52	Agents affecting the cardiovascular system: Cardiac-stimulant glycosides, calcium-channel blockers, other anti-dysrhythmic drugs, other coronary vasodilators, angiotensin-converting-enzyme inhibitors, other anti-hypertensives, anti-hyperlipidemic and antiarteriosclerotic drugs, peripheral vasodilators, anti-varicose drugs
Y53	Agents affecting the gastrointestinal system: Antacids, anti-gastric-secretion drugs, laxatives, anti-diarrheal, emetics
Y54	Agents affecting water-balance and mineral and uric acid metabolism: Mineralocorticoids, mineralocorticoid antagonists, carbonic-anhydrase inhibitors, benzothiadiazine derivatives, other diuretics, electrolytic, caloric and water-balance agents, agents affecting calcification, agents affecting uric acid metabolism

Table 4.5. ICD-10-CA diagnosis codes of 'external cause' for adverse drug reactions

Table 4.5 (continued). ICD-10-CA diagnosis codes of '*external cause*' for adverse drug reactions

Y55	Agents acting on smooth and skeletal muscles and the respiratory system: Oxytocic drugs, skeletal muscle relaxants, antitussives, expectorants, anti-common- cold drugs, anti-asthmatics
Y56	<b>Topical agents primarily affecting skin and mucous membrane:</b> Local anti- fungal, anti-infective, anti-inflammatory drugs, antipruritics, local detergents, emollients, keratolytics, ophthalmological drugs, otorhinolaryngological drugs, dental drugs
Y57	<b>Other and unspecified drugs:</b> Appetite depressants, lipotropic drugs, antidotes and chelating agents, alcohol deterrents, x-ray contrast media, vitamins
Y58	Bacterial vaccines
Y59	Other vaccines: Viral/rickettsial/protozoal vaccines, immunoglobulin

## 4.4.6 Propensity score matching and observation windows

A propensity score was derived from a logistic regression model to predict receipt of MedsCheck based on all other covariates. We then created pairs of exposed and control subjects by matching subjects who received a MedsCheck with those who did not. Subjects were matched on the logit of the propensity score using a caliper width of 0.2 of the standard deviation of the logit of the propensity score.(151) The matching algorithm included hard matching on variables to be used for subgroup analyses: admission diagnosis of heart failure or chronic obstructive pulmonary disease, or new high risk medication (Appendix 1). Due to imbalance between matched groups on the proportion of patients with a circulatory condition and with signs/symptoms not otherwise specified (Standardized difference at or above 10%), these variables were added as additional hard matching criteria.

In addition, several time criteria were specified in the matching algorithm to ensure equal observation time between MedsCheck recipients and controls. Controls were assigned a "match time", which was equal to the time from discharge to MedsCheck of their matched subject (Figure 4.2). The match/MedsCheck date was the start of the observation window for all outcomes. To ensure comparability, controls could not have experienced an outcome prior to their matching time, and had to meet criteria for MedsCheck eligibility (prescription fill and 3+ chronic medications in the previous 6 months) by the match date.





#### 4.4.7 Subgroups

We pre-specified three subgroups at potentially higher risk for outcomes, and for whom a MedsCheck might be beneficial: i) patients with an admitting diagnosis of heart failure or ii) chronic obstructive disease, and iii) patients filling a prescription for a new high risk medication (listed in Table 4.3).

#### 4.4.8 Analysis

Patient, hospital and pharmacy characteristics of those receiving and not receiving a MedsCheck were compared using descriptive statistics, including medians and interquartile range (IQR) for continuous or interval variables and counts and frequencies for categorical variables. Comparisons in baseline characteristics were made using standardized differences, with differences of 10% or greater considered to be meaningful.(147, 148)

We estimated Kaplan Meier survival curves for the primary composite outcome and death. We plotted Cumulative Incidence Function (CIF) curves for return to the emergency department and for urgent re-hospitalization, to account for the competing risk of death. We reported Hazard ratios (with 95% confidence intervals) for all time-to-event outcomes. Hazard ratios were

obtained from a Cox Proportional Hazards model estimated in the matched sample, in which the hazard of the outcome was regressed on a single variable denoting exposure to MedsCheck. A robust variance estimator was used to account for the paired nature of the data.(182) We report cause-specific hazard ratios for the outcomes of return to the emergency department, urgent rehospitalization, and adverse drug events. This latter set of analyses accounted for the competing risk of death.

Comparison of the 30-day count of outpatient visits was made using a negative binomial model with generalized estimating equation to account for clustering of data within matched pairs. We reported the risk ratio and 95% confidence intervals. Significance was defined as p<0.05 and all hypothesis testing was two-tailed. All analyses were performed in SAS software, version 9.4 (SAS Institute Inc., Carey, NC).

# 4.5 Results

We identified 1,840,288 patient discharges eligible for MedsCheck within 7 days of hospital discharge. Among these, 29,763 (1.6%) were excluded due to a prior primary or secondary outcome, and 2,748 (0.1%) were excluded because of a prior MedsCheck (study flowchart in Figure 4.1). The characteristics of patients excluded in each of these steps were compared to the remaining patients in Tables 4.6 and 4.7. Patients who reached an outcome before eligibility were more likely to be male, had a shorter hospital stay, and were more likely to have been discharged against medical advice or with home care support services. From the remaining 1,807,777 hospital discharges, we selected the first discharge per patient for a study sample of 879,497 patients.

Characteristic	Excluded	Not Excluded	Std.
	N=29,763	N=1,810,525	Diff. of
Verse of herewited discharges and disc (IOD)	0.040 (0.040	0.040 (0.000	Means
Year of nospital discharge, median (IQR)	2,012 (2,010-	2,012 (2,009-	0.1
Age at beenited discharge median (IOD)	2,014)	2,014)	0.02
Age at nospital discharge, median (IQR)	11 (11-83)	77 (71-83)	0.03
Female sex, n (%)	13,486 (45.3)	921,830 (50.9)	0.11
Rural residence, n (%)	5,658 (19.0)	300,099 (16.6)	0.06
Does not speak French or English, n (%)	738 (2.5%)	54,654 (3.0)	0.03
Charlson comorbidity score, n (%)			•
0	8,040 (27.0)	491,579 (27.2)	0
1	5,909 (19.9)	401,141 (22.2)	0.06
2	5,517 (18.5)	332,165 (18.3)	0
3	3,839 (12.9)	231,799 (12.8)	0
4+	6,458 (21.7)	353,841 (19.5)	0.05
Nearest Census Based Neighbourhood			
Income Quintile, n (%)			
Missing	165 (0.6)	7,679 (0.4)	0.02
1	6,825 (22.9)	386,542 (21.3)	0.04
2	6,131 (20.6)	378,609 (20.9)	0.01
3	5,639 (18.9)	358,205 (19.8)	0.02
4	5,704 (19.2)	351,101 (19.4)	0.01
5	5,299 (17.8)	328,389 (18.1)	0.01
Arrival by ambulance, n (%)	11,933 (40.1)	704,476 (38.9)	0.02
Elective admission, n (%)	5,172 (17.4)	410,441 (22.7)	0.13
Length of stay, median (IQR)	3 (1-6)	4 (2-8)	0.47
Discharged on a weekend, n (%)	12,630 (42.4)	685,662 (37.9)	0.09
Discharged against medical advice, n (%)	1,376 (4.6)	7,195 (0.4)	0.27
Discharged with homecare services, n (%)	8,585 (28.8)	663,668 (36.7)	0.17
Discharging hospital type, n (%)			
Teaching	8,521 (28.6)	519,287 (28.7)	0
Small community	1,809 (6.1)	87,371 (4.8)	0.06
Medium/large community	19,127 (64.3)	1,183,391 (65.4)	0.02
Rural	2,931 (9.8)	148,368 (8.2)	0.06

 Table 4.6. Comparison of characteristics of patients excluded due to an outcome date occurring prior to the MedsCheck eligibility date. Std. Diff.= standardized difference.

Characteristic	Excluded	Not Excluded	Std. Diff.
	N=29,763	N=1,810,525	of Means
Most responsible diagnosis, n (%)			
1- Infectious Diseases	794 (2.7)	50,843 (2.8)	0.01
2- Neoplasms	2,270 (7.6)	137,683 (7.6)	0
3- Diseases of the blood	518 (1.7)	26,342 (1.5)	0.02
4- Endocrine	1,183 (4.0)	55,728 (3.1)	0.05
5- Mental and behavioural	567 (1.9)	28,791 (1.6)	0.02
6- Nervous system	530 (1.8)	29,580 (1.6)	0.01
7- Eye	61 (0.2)	2,364 (0.1)	0.02
8- Ear	54 (0.2)	4,090 (0.2)	0.01
9- Circulatory	6,858 (23.0)	445,131 (24.6)	0.04
10- Respiratory	2,486 (8.4)	224,082 (12.4)	0.13
11- Digestive	3,598 (12.1)	181,841 (10.0)	0.07
12- Skin	275 (0.9)	19,380 (1.1)	0.01
13- Musculoskeletal	1,291 (4.3)	170,320 (9.4)	0.2
14- Genitourinary	1,983 (6.7)	129,783 (7.2)	0.02
17- Congenital	10 (0.0)	690 (0.0)	0
18 – Symptoms and findings NOS	4,336 (14.6)	145,553 (8.0)	0.21
19 - Injury/Poisoning	1,894 (6.4)	102,312 (5.7)	0.03
21- Factors influencing health status	1,055 (3.5)	56,010 (3.1)	0.03
Homecare support services in previous year, n (%)	5,567 (18.7)	323,275 (17.9)	0.02
At least one physician home visit in previous vear. n (%)	2,078 (7.0)	124,396 (6.9)	0
Outpatient physician visits in previous year, median (IQR)	14 (8-21)	13 (8-20)	0.12
Dementia diagnosis or medication in previous year, n (%)	2,667 (9.0)	155,036 (8.6)	0.01
MedsCheck in previous year, n (%)	11,587 (38.9)	625,749 (34.6)	0.09
Emergency department visits in previous 6	1 (0-3)	1 (0-2)	0.27
months, median (IQR)	, ,		
Pharmacies visited in previous year, median	1 (1-2)	1 (1-2)	0.1
(IQR)	, , , , , , , , , , , , , , , , , , ,	~ /	
Outpatient physicians seen in previous year.	5 (3-8)	5 (3-7)	0.1
median (IQR)	- ( )	- (- )	-
At least one elective hospitalization in previous	3.597 (12.1)	192.815 (10.6)	0.05
year, n (%)		- , ( /	
At least one urgent hospitalization in previous	13,041 (43.8)	656,241 (36.2)	0.15
vear, n (%)	, ( /	, ()	-
At least one adverse drug reaction in previous	3,512 (11.8)	167,987 (9.3)	0.08
year, n (%)			

Table 4.6 (continued). Comparison of characteristics of patients excluded due to an outcome date occurring prior to the MedsCheck eligibility date. Std. Diff.= standardized difference. NOS=not otherwise specified

Table 4.6 (continued). Comparison of characteristics of patients excluded due to an
outcome date occurring prior to the MedsCheck eligibility date. Std. Diff.= standardized
difference.

Characteristic	Excluded N=29,763	Not Excluded N=1,810,525	Std. Diff. of Means
Number of meds in previous year, median (IQR)	13 (9-18)	12 (8-17)	0.17
Number of high risk medications in previous year, median (IQR)	3 (2-5)	3 (2-5)	0.1
Number of potentially inappropriate medications in previous year, median (IQR)	1 (0-1)	1 (0-1)	0.06
Number of new medications filled after discharge, median (IQR)	1 (0-1)	1 (0-2)	0.44
At least one new high risk medication filled, n (%)	7,079 (23.8)	710,014 (39.2)	0.34
At least one new potentially inappropriate medication filled, n (%)	1,318 (4.4)	95,291 (5.3)	0.04
New pharmacy, n (%)	2,705 (9.1)	174,830 (9.7)	0.02

Table 4.7. Comparison of characteristics of patients excluded because of MedsCheck receipt before MedsCheck eligibility. Std. Diff.= standardized difference.

Characteristic	Excluded	Not Excluded	Std. Diff. of
	N=2,748	N=1,807,777	Means
Year of hospital discharge, median (IQR)	2,013 (2,012-	2,012 (2,009-	0.53
	2,015)	2,014)	
Age at hospital discharge, median (IQR)	79 (73-85)	77 (71-83)	0.2
Female sex, n (%)	1,404 (51.1)	920,426 (50.9)	0
Rural residence, n (%)	488 (17.8)	299,611 (16.6)	0.03
Does not speak French or English, n (%)	69 (2.5)	54,585 (3.0)	0.03
Charlson comorbidity score, n (%)			
0	607 (22.1)	490,972 (27.2)	0.12
1	574 (20.9)	400,567 (22.2)	0.03
2	542 (19.7)	331,623 (18.3)	0.04
3	395 (14.4)	231,404 (12.8)	0.05
4+	630 (22.9)	353,211 (19.5)	0.08
Nearest Census-Based Neighbourhood			
Income Quintile, n (%)			
Missing	17 (0.6)	7,662 (0.4)	0.03
1	611 (22.2)	385,931 (21.3)	0.02
2	605 (22.0)	378,004 (20.9)	0.03
3	556 (20.2)	357,649 (19.8)	0.01
4	498 (18.1)	350,603 (19.4)	0.03
5	461 (16.8)	327,928 (18.1)	0.04
Arrival by ambulance, n (%)	1,299 (47.3)	703,177 (38.9)	0.17
Elective admission, n (%)	314 (11.4)	410,127 (22.7)	0.3
Length of stay, median (IQR)	5 (3-10)	4 (2-8)	0.11

Table 4.7 (continued). Comparison of characteristics of patients excluded because of MedsCheck receipt before MedsCheck eligibility. Std. Diff.= standardized difference. NOS=not otherwise specified

Characteristic	Excluded	Not Excluded	Std. Diff.
	N=2,748	N=1,807,777	of Means
Most responsible diagnosis, n (%)			
1- Infectious Diseases	91 (3.3)	50,752 (2.8)	0.03
2- Neoplasms	134 (4.9)	137,549 (7.6)	0.11
3- Diseases of the blood	54 (2.0)	26,288 (1.5)	0.04
4- Endocrine	140 (5.1)	55,588 (3.1)	0.1
5- Mental and behavioural	81 (2.9)	28,710 (1.6)	0.09
6- Nervous system	80 (2.9)	29,500 (1.6)	0.09
8- Ear	13 (0.5)	4,077 (0.2)	0.04
9- Circulatory	708 (25.8)	444,423 (24.6)	0.03
10- Respiratory	241 (8.8)	223,841 (12.4)	0.12
11- Digestive	295 (10.7)	181,546 (10.0)	0.02
12- Skin	14 (0.5)	19,366 (1.1)	0.06
13- Musculoskeletal	120 (4.4)	170,200 (9.4)	0.2
14- Genitourinary	162 (5.9)	129,621 (7.2)	0.05
17- Congenital	<=5 (0.1)	686 (0.0)	0.04
18 – Symptoms and findings NOS	367 (13.4)	145,186 (8.0)	0.17
19 - Injury/Poisoning	121 (4.4)	102,191 (5.7)	0.06
21- Factors influencing health	119 (4.3)	55,891 (3.1)	0.07
status			
Discharged on a weekend, n (%)	1,051 (38.2)	684,611 (37.9)	0.01
Discharged against medical	11 (0.4)	7,184 (0.4)	0
advice, n (%)			
Discharged with homecare	1,219 (44.4)	662,449 (36.6)	0.16
services, n (%)			
Discharging hospital type, n (%)	762 (27.7)	518,525 (28.7)	0.02
Teaching	194 (7.1)	87,177 (4.8)	0.09
Small community	1,743 (63.4)	1,181,648 (65.4)	0.04
Medium/large community	305 (11.1)	148,063 (8.2)	0.1
Rural			
Homecare support services in	663 (24.1)	322,612 (17.8)	0.15
previous year, n (%)			
At least one physician home visit	201 (7.3)	124,195 (6.9)	0.02
in previous year, n (%)			
Outpatient physician visits in	13 (8-20)	13 (8-20)	0.01
previous year, median (IQR)			
Dementia diagnosis or medication	344 (12.5)	154,692 (8.6)	0.13
in previous year, n (%)	· · /		
MedsCheck in previous vear. n	1,568 (57.1)	624,181 (34.5)	0.46
(%)	,/	- ,	
Emergency department visits in	1 (0-2)	1 (0-2)	0,18
previous 6 months, median (IQR)	- ()	. (/	

Characteristic	Excluded N=2,748	Not Excluded N=1,807,777	Std. Diff. of Means
Pharmacies visited in previous	1 (1-2)	1 (1-2)	0.03
year, median (IQR)	- (0.0)		
Outpatient physicians seen in	5 (3-8)	5 (3-7)	0.05
previous year, median (IQR)	074 (0.0)		0.00
At least one elective	271 (9.9)	192,544 (10.7)	0.03
hospitalization in previous year, n (%)			
At least one urgent hospitalization	1,180 (42.9)	655,061 (36.2)	0.14
in previous year, n (%)			
At least one adverse drug	365 (13.3)	167,622 (9.3)	0.13
reaction in previous year, n (%)			
Number of medications in	14 (10-19)	12 (8-17)	0.34
previous year, median (IQR)			
Number of high risk medications	4 (2-5)	3 (2-5)	0.26
in previous year, median (IQR)			
Number of potentially	1 (0-1)	1 (0-1)	0
inappropriate medications in			
previous year, median (IQR)			
Number of new medications filled	0 (0-1)	1 (1-2)	0.85
after discharge, median (IQR)			
At least one new high risk	414 (15.1)	709,600 (39.3)	0.57
medication filled, n (%)			
At least one new potentially	80 (2.9)	95,211 (5.3)	0.12
inappropriate medication filled, n			
(%)			
New pharmacy, n (%)	121 (4.4)	174,709 (9.7)	0.21

 Table 4.7 (continued). Comparison of characteristics of patients excluded because of

 MedsCheck receipt before MedsCheck eligibility. Std. Diff.= standardized difference.

The median time from discharge to eligibility was 0 days (IQR 0-1 days) with 73.3% (n=644,998) being eligible on the day of discharge. Only 77,459 (8.8%) received a MedsCheck within 14 days of hospital discharge. Among this group, the time from eligibility to MedsCheck was a median 0 days (IQR 0-1 days), and 67.2% (n=52,081) received MedsCheck on the same day as their eligible prescription fill.

Patients receiving a MedsCheck differed from those not receiving a MedsCheck (Table 4.8). The greatest differences were in the median year of discharge (MedsCheck 2013 vs 2011, Std. Diff. 66%), the proportion with a Charlson score of 0 (MedsCheck 27.8% vs 38.3%, Std. Diff 22%), the proportion for whom the index admission was elective (MedsCheck 15.9% vs 30.1%, Std. Diff. 34%), the median length of hospital stay (MedsCheck 5 days vs 4 days, Std. Diff. 28%). In

addition, other major differences included the proportion admitted for a circulatory condition (MedsCheck 44.2% vs 23.6%, Std. Diff. 45%) or musculoskeletal condition (MedsCheck 6.2% vs 12.9%, Std. Diff. 23%), the median number of outpatient visits in the previous year (MedsCheck 10 vs 11, Std. Diff. 22%), the median number of new medications filled after discharge (MedsCheck 3 vs 1, Std. Diff. 62%), the proportion with a new high risk medication filled after discharge (MedsCheck 59.5% vs 46.7%, Std. Diff. 26%) and the proportion filling their prescription at a pharmacy in the highest MedsCheck volume quartile (MedsCheck 42.0% vs 16.8%, Std. Diff. 57%).

 Table 4.8. Comparison of all patients receiving a MedsCheck to those who did not receive a

 MedsCheck but were eligible. Std. Diff.= standardized difference.

Characteristic	Received MedsCheck	Did not receive MedsCheck	Std. Diff. of
	N=77,459	N=802,038	Means
Year of hospital discharge,	2,013 (2,011-2,015)	2,011 (2,008-	0.66
median (IQR)		2,013)	
Age at hospital discharge, median	76 (70-82)	76 (70-82)	0.02
(IQR)			
Female sex, n (%)	36,638 (47.3)	418,645 (52.2)	0.1
Rural residence, n (%)	10,991 (14.2)	128,041 (16.0)	0.05
Does not speak French or	3,110 (4.0)	26,081 (3.3)	0.04
English, n (%)			
Charlson comorbidity score, n (%)			
0	21,511 (27.8)	306,910 (38.3)	0.22
1	23,470 (30.3)	195,190 (24.3)	0.13
2	13,767 (17.8)	140,578 (17.5)	0.01
3	10,228 (13.2)	75,634 (9.4)	0.12
4+	8,483 (11.0)	83,726 (10.4)	0.02
Nearest Census Based			
Neighborhood Income Quintile, n			
(%)			
Missing	265 (0.3)	2,904 (0.4)	0
1	15,266 (19.7)	162,114 (20.2)	0.01
2	16,242 (21.0)	166,826 (20.8)	0
3	15,274 (19.7)	158,955 (19.8)	0
4	15,719 (20.3)	158,173 (19.7)	0.01
5	14,693 (19.0)	153,066 (19.1)	0
Arrival by ambulance, n (%)	30,398 (39.2)	258,491 (32.2)	0.15
Elective admission, n (%)	12,305 (15.9)	241,022 (30.1)	0.34
Length of stay, median (IQR)	5 (3-9)	4 (2-8)	0.28

Characteristic	Received	Did not receive	Std.
	NECSCHECK	MedsCheck	DITT. OT Moans
Most responsible diagnosis in (%)	N=77,433	11-002,030	Wearis
1- Infectious Diseases	1 670 (2 2)	17 371 (2 2)	0
2- Neoplasms	4.051 (5.2)	77,779 (9,7)	0.17
3- Diseases of the blood	812 (1.0)	9.687 (1.2)	0.02
4- Endocrine	2.476 (3.2)	22.107 (2.8)	0.03
5- Mental and behavioral	1,196 (1.5)	10,962 (1.4)	0.01
6- Nervous system	1,656 (2.1)	13,860 (1.7)	0.03
7- Eye	72 (0.1)	1,407 (0.2)	0.02
8- Ear	160 (0.2)	2,123 (0.3)	0.01
9- Circulatory	34,200 (44.2)	189,090 (23.6)	0.45
10- Respiratory	7,437 (9.6)	75,369 (9.4)	0.01
11- Digestive	4,914 (6.3)	81,681 (10.2)	0.14
12- Skin	548 (0.7)	7,226 (0.9)	0.02
13- Musculoskeletal	4,839 (6.2)	103,480 (12.9)	0.23
14- Genitourinary	3,577 (4.6)	58,982 (7.4)	0.12
17- Congenital	39 (0.1)	383 (0.0)	0
18 – Symptoms and findings NOS	5,091 (6.6)	58,448 (7.3)	0.03
19 - Injury/Poisoning	2,628 (3.4)	46,377 (5.8)	0.11
21- Factors influencing health status	2,093 (2.7)	25,706 (3.2)	0.03
Discharged on a weekend, n (%)	28,305 (36.5)	312,971 (39.0)	0.05
Discharged against medical advice, n	217 (0.3)	3,049 (0.4)	0.02
(%)			
Discharged with homecare services, n	23,751 (30.7)	253,041 (31.5)	0.02
(%)			
Discharging hospital type, n (%)			
Teaching	20,523 (26.5)	235,073 (29.3)	0.06
Small community	3,006 (3.9)	31,941 (4.0)	0.01
Medium/large community	52,122 (67.3)	524,910 (65.4)	0.04
Rural	4,953 (6.4)	55,943 (7.0)	0.02
Homecare support services in previous	5,607 (7.2)	76,535 (9.5)	0.08
year, n (%)			0.07
At least one physician home visit in	2,438 (3.1)	35,486 (4.4)	0.07
previous year, n (%)			0.00
Outpatient physician visits in previous year, median (IQR)	10 (5-15)	11 (7-17)	0.22

Table 4.8 (continued). Comparison of all patients receiving a MedsCheck to those who did not receive a MedsCheck but were eligible. Std. Diff.= standardized difference. NOS=not otherwise specified

Characteristic	Received MedsCheck	Did not receive MedsCheck	Std. Diff. of
	N=77,459	N=802,038	Means
Dementia diagnosis or medication in	4,645 (6.0)	54,813 (6.8)	0.03
MedsCheck in previous year in (%)	30 833 (39 8)	207 287 (25 8)	03
Emergency department visits in	0 (0-1)	0 (0-1)	0.0
previous 6 months, median (IQR)	0 (0 1)	0 (0 1)	0.01
Pharmacies visited in previous year, median (IQR)	1 (1-2)	1 (1-2)	0.1
Outpatient physicians seen in previous year, median (IQR)	4 (3-6)	5 (3-7)	0.1
At least one elective hospitalization in previous year, n (%)	2,234 (2.9)	33,443 (4.2)	0.07
At least one urgent hospitalization in previous year, n (%)	6,804 (8.8)	85,467 (10.7)	0.06
At least one adverse drug reaction in previous year, n (%)	5,077 (6.6)	44,320 (5.5)	0.04
Number of medications in previous year, median (IQR)	9 (6-13)	9 (6-13)	0.14
Number of high risk medications in previous year, median (IQR)	2 (1-4)	2 (1-4)	0.07
Number of potentially inappropriate medications in previous year, median (IQR)	0 (0-1)	1 (0-1)	0.15
Number of new medications filled after discharge, median (IQR)	3 (1-4)	1 (1-2)	0.62
At least one new high risk medication filled, n (%)	46,095 (59.5)	374,441 (46.7)	0.26
At least one new potentially	5,599 (7.2)	45,372 (5.7)	0.06
Now pharmacy, p (%)	7 605 (0 8)	07.034 (12.2)	0.08
Pharmacy MedsCheck/total volume	7,005 (9.0)	97,934 (12.2)	0.00
quartile n (%)			
1	5 164 (6 7)	260 634 (32 5)	0.69
2	16 220 (20 9)	220 301 (27 5)	0.15
3	23,578 (30 4)	186,468 (23.2)	0.16
4	32,497 (42.0)	134,635 (16.8)	0.57

Table 4.8 (continued). Comparison of all patients receiving a MedsCheck to those who did not receive a MedsCheck but were eligible. Std. Diff.= standardized difference.

# 4.5.1 Characteristics of Propensity-Score Matched Cohort

The propensity score matched cohort contained 67,163 MedsCheck recipients and 67,163 matched controls not receiving a MedsCheck. Of those who received a MedsCheck, 87% were successfully matched to a control subject. Unmatched patients who received MedsCheck were less likely to have filled a prescription for a new high risk medication (matched 62.2% vs unmatched 41.8%, Std. Diff. 42%), had filled fewer new medications after discharge (median in

matched 3 vs unmatched 2, Std. Diff. 22%), were less likely to have a diagnosis of a circulatory condition (matched 45.0% vs unmatched 38.6%, Std. Diff. 13%), and were more likely to have a diagnosis of non-specific signs and symptoms (matched 6.0% vs unmatched 10.6%, Std. Diff. 17%, Table 4.9).

Characteristic	Matched	Unmatched	Std. Diff.
	N=67,163	N=10,296	of
			Means
Year of hospital discharge, median (IQR)	2,013 (2,011-	2,013 (2,011-	0.04
	2,015)	2,015)	
Age at hospital discharge, median (IQR)	76 (70-82)	76 (70-83)	0.04
Female sex, n (%)	31,554 (47.0)	5,084 (49.4)	0.05
Rural residence, n (%)	9,455 (14.1)	1,536 (14.9)	0.02
Does not speak French or English, n (%)	2,688 (4.0)	422 (4.1)	0
Charlson comorbidity score, n (%)			
0	18,379 (27.4)	3,132 (30.4)	0.07
1	20,460 (30.5)	3,010 (29.2)	0.03
2	11,942 (17.8)	1,825 (17.7)	0
3	9,005 (13.4)	1,223 (11.9)	0.05
4+	7,377 (11.0)	1,106 (10.7)	0.01
Nearest Census Based Neighbourhood			
Income Quintile, n (%)			
Missing	230 (0.3)	35 (0.3)	0
1	13,244 (19.7)	2,022 (19.6)	0
2	14,047 (20.9)	2,195 (21.3)	0.01
3	13,270 (19.8)	2,004 (19.5)	0.01
4	13,665 (20.3)	2,054 (19.9)	0.01
5	12,707 (18.9)	1,986 (19.3)	0.01
Arrival by ambulance, n (%)	26,259 (39.1)	4,139 (40.2)	0.02
Elective admission, n (%)	10,805 (16.1)	1,500 (14.6)	0.04
Length of stay, median (IQR)	5 (3-9)	5 (3-9)	0.01
Most responsible diagnosis of heart failure, n	4,210 (6.3)	625 (6.1)	0.01
(%)			
Most responsible diagnosis of chronic	3,084 (4.6)	415 (4.0)	0.03
obstructive pulmonary disease, n (%)			
Discharged on a weekend, n (%)	24,534 (36.5)	3,771 (36.6)	0
Discharged against medical advice, n (%)	191 (0.3)	26 (0.3)	0.01
Discharged with homecare services, n (%)	20,493 (30.5)	3,258 (31.6)	0.02

Table 4.9. Characteristics of matched and unmatched MedsCheck recipients. Std. Diff.= standardized difference.
Characteristic	Matched	Unmatched	Std. Diff.
	N=67,163	N=10,296	of
			Means
Most responsible diagnosis, n (%)			
1- Infectious Diseases	1,414 (2.1)	256 (2.5)	0.03
2- Neoplasms	3,561 (5.3)	490 (4.8)	0.02
3- Diseases of the blood	685 (1.0)	127 (1.2)	0.02
4- Endocrine	2,120 (3.2)	356 (3.5)	0.02
5- Mental and behavioural	1,051 (1.6)	145 (1.4)	0.01
6- Nervous system	1,424 (2.1)	232 (2.3)	0.01
7- Eye	65 (0.1)	7 (0.1)	0.01
8- Ear	128 (0.2)	32 (0.3)	0.02
9- Circulatory	30,223 (45.0)	3,977 (38.6)	0.13
10- Respiratory	6,452 (9.6)	985 (9.6)	0
11- Digestive	4,171 (6.2)	743 (7.2)	0.04
12- Skin	461 (0.7)	87 (0.8)	0.02
13- Musculoskeletal	4,264 (6.3)	575 (5.6)	0.03
14- Genitourinary	3,008 (4.5)	569 (5.5)	0.05
18 – Symptoms and findings NOS	3,998 (6.0)	1,093 (10.6)	0.17
19 - Injury/Poisoning	2,276 (3.4)	352 (3.4)	0
21- Factors influencing health status	1,826 (2.7)	267 (2.6)	0.01
Discharging hospital type, n (%)			
Teaching	18,001 (26.8)	2,522 (24.5)	0.05
Small community	2,530 (3.8)	476 (4.6)	0.04
Medium/large community	44,997 (67.0)	7,125 (69.2)	0.05
Rural	4,186 (6.2)	767 (7.4)	0.05
Homecare support services in previous year,	4,772 (7.1)	835 (8.1)	0.04
n (%)			
At least one physician home visit in previous	2,094 (3.1)	344 (3.3)	0.01
year, n (%)			
Outpatient physician visits in previous year,	10 (5-15)	10 (5-15)	0.02
median (IQR)			
Dementia diagnosis or medication in previous	3,911 (5.8)	734 (7.1)	0.05
year, n (%)	00 700 (00 0)	4.0.40 (00.0)	0.01
MedsCheck in previous year, n (%)	26,790 (39.9)	4,043 (39.3)	0.01
Emergency department visits in previous 6	0 (0-1)	0 (0-1)	0.05
months, median (IQR)			
Pharmacies visited in previous year, median	1 (1-2)	1 (1-2)	0.01
(IQR)			
Outpatient physicians seen in previous year,	4 (3-6)	4 (3-6)	0.02
median (IQR)			
At least one elective hospitalization in	1,925 (2.9)	309 (3.0)	0.01
previous year, n (%)			
At least one urgent hospitalization in previous	5,887 (8.8)	917 (8.9)	0
vear. n (%)			

 Table 4.9 (continued). Characteristics of matched and unmatched MedsCheck recipients.

 Std. Diff.= standardized difference. NOS=not otherwise specified.

Characteristic	Matched N=67,163	Unmatched N=10,296	Std. Diff. of
	,		Means
At least one adverse drug reaction in	4,317 (6.4)	760 (7.4)	0.04
previous year, n (%)			
Number of medications in previous year,	9 (5-13)	9 (6-13)	0.05
median (IQR)			
Number of high risk medications in previous	2 (1-4)	2 (1-4)	0.04
year, median (IQR)			
Number of potentially inappropriate	0 (0-1)	0 (0-1)	0.03
medications in previous year, median (IQR)			
Number of new medications filled after	3 (1-4)	2 (1-4)	0.22
discharge, median (IQR)			
At least one new high risk medication filled, n	41,792 (62.2)	4,303 (41.8)	0.42
(%)			
At least one new potentially inappropriate	4,910 (7.3)	689 (6.7)	0.02
medication filled, n (%)			
New pharmacy, n (%)	6,627 (9.9)	978 (9.5)	0.01
Pharmacy MedsCheck/total volume quartile,			
n (%)			
1	4,412 (6.6)	752 (7.3)	0.03
2	13,808 (20.6)	2,412 (23.4)	0.07
3	20,358 (30.3)	3,220 (31.3)	0.02
4	28,585 (42,6)	3.912 (38.0)	0.09

 Table 4.9 (continued). Characteristics of matched and unmatched MedsCheck recipients.

 Std. Diff.= standardized difference.

Matched pairs were similar in terms of all covariates, with no standardized differences exceeding 10% (Table 4.10). The greatest difference was in the proportion of patients filling their prescription at a pharmacy in the highest MedsCheck volume quartile (MedsCheck 42.6% vs 39.1%, Std. Diff. 7%). Among the matched MedsCheck recipients, the median time from eligible prescription fill to MedsCheck was 0 days (IQR 0-1) and 63.8% (N=42,829) received MedsCheck on the day of prescription fill.

 Table 4.10. Comparison of characteristics of MedsCheck recipients and matched controls.

 Std. Diff.= standardized difference.

Characteristic	MedsCheck	Controls	Std. Diff.
	N=67,163	N=67,163	of Means
Year of hospital discharge, median (IQR)	2,013 (2,011-	2,013 (2,011-	0.03
	2,015)	2,015)	
Age at hospital discharge, median (IQR)	76 (70-82)	76 (70-83)	0.01
Female sex, n (%)	31,554 (47.0)	31,389 (46.7)	0
Rural residence, n (%)	9,455 (14.1)	9,672 (14.4)	0.01
Does not speak French or English, n (%)	2,688 (4.0)	2,515 (3.7)	0.01
Charlson comorbidity score, n (%)			
0	18,379 (27.4)	17,638 (26.3)	0.02
1	20,460 (30.5)	21,359 (31.8)	0.03
2	11,942 (17.8)	11,644 (17.3)	0.01
3	9,005 (13.4)	9,300 (13.8)	0.01
4+	7,377 (11.0)	7,222 (10.8)	0.01
Nearest Census Based Neighborhood			
Income Quintile (within CMA/CA)			
Missing	230 (0.3)	230 (0.3)	0
1	13,244 (19.7)	13,123 (19.5)	0
2	14,047 (20.9)	14,110 (21.0)	0
3	13,270 (19.8)	13,297 (19.8)	0
4	13,665 (20.3)	13,624 (20.3)	0
5	12,707 (18.9)	12,779 (19.0)	0
Arrival by ambulance, n (%)	26,259 (39.1)	26,638 (39.7)	0.01
Elective admission, n (%)	10,805 (16.1)	10,073 (15.0)	0.03
Length of stay, median (IQR)	5 (3-9)	5 (3-9)	0.05
Most responsible diagnosis, n (%)	, <i>,</i> ,		
1- Infectious Diseases	1,414 (2.1)	1,399 (2.1)	0
2- Neoplasms	3,561 (5.3)	4,153 (6.2)	0.04
3- Diseases of the blood	685 (1.0)	671 (1.0)	0
4- Endocrine	2,120 (3.2)	1,542 (2.3)	0.05
5- Mental and behavioral	1,051 (1.6)	812 (1.2)	0.03
6- Nervous system	1,424 (2.1)	962 (1.4)	0.05
7- Eye	65 (0.1)	66 (0.1)	0
8- Ear	128 (0.2)	93 (0.1)	0.01
9- Circulatory	30,223 (45.0)	30,223 (45.0)	0
10- Respiratory	6,452 (9.6)	6,490 (9.7)	0
11- Digestive	4,171 (6.2)	4,829 (7.2)	0.04
12- Skin	461 (0.7)	462 (0.7)	0
13- Musculoskeletal	4,264 (6.3)	4,514 (6.7)	0.02
14- Genitourinary	3,008 (4.5)	2,901 (4.3)	0.01
17- Congenital	36 (0.1)	15 (0.0)	0.02
18 – Symptoms and findings NOS	3,998 (6.0)	3,998 (6.0)	0
19 - Injury/Poisoning	2,276 (3.4)	2,565 (3.8)	0.02
21- Factors influencing health status	1,826 (2.7)	1,468 (2.2)	0.03

Characteristic	MedsCheck	Controls	Std. Diff.
	N=67,163	N=67,163	of
			Means
Discharged on a weekend, n (%)	24,534 (36.5)	23,941 (35.6)	0.02
Discharged against medical advice, n (%)	191 (0.3)	147 (0.2)	0.01
Discharged with homecare services, n (%)	20,493 (30.5)	20,143 (30.0)	0.01
Discharging hospital type, n (%)			
Teaching	18,001 (26.8)	18,466 (27.5)	0.02
Small community	2,530 (3.8)	2,593 (3.9)	0
Medium/large community	44,997 (67.0)	44,252 (65.9)	0.02
Rural	4,186 (6.2)	4,310 (6.4)	0.01
Homecare support services in previous year,	4,772 (7.1)	4,630 (6.9)	0.01
At least one physician home visit in previous	2 004 (3 1)	2 040 (3 0)	0
year, n (%)	2,094 (3.1)	2,040 (3.0)	0
Outpatient physician visits in previous year, median (IQR)	10 (5-15)	9 (5-15)	0.02
Dementia diagnosis or medication in previous year, n (%)	3,911 (5.8)	3,814 (5.7)	0.01
MedsCheck in previous year, n (%)	26,790 (39.9)	25,327 (37.7)	0.04
Emergency department visits in previous 6	0 (0-1)	0 (0-1)	0.01
months, median (IQR)	4 (4 0)	4 (4 0)	0.01
Pharmacies visited in previous year, median	1 (1-2)	1 (1-2)	0.01
Outpatient physiciana econ in providua year	1 (2 6)	1 (2 6)	0.02
median (IQR)	4 (3-0)	4 (3-0)	0.03
At least one elective hospitalization in	1,925 (2.9)	1,929 (2.9)	0
At least one urgent hospitalization in previous	5 887 (8 8)	5 653 (8 4)	0.01
year, n (%)	5,007 (0.0)	3,000 (0.4)	0.01
At least one adverse drug reaction in	4,317 (6.4)	4,271 (6.4)	0
previous year, n (%)			
Number of medications in previous year,	9 (5-13)	9 (5-12)	0.04
median (IQR)			
Number of high risk medications in previous	2 (1-4)	2 (1-4)	0.02
year, median (IQR)			
Number of potentially inappropriate	0 (0-1)	0 (0-1)	0.01
medications in previous year, median (IQR)			
Number of new medications filled after discharge, median (IQR)	3 (1-4)	3 (1-4)	0.03

Table 4.10 (continued). Comparison of characteristics of MedsCheck recipients and matched controls. Std. Diff.= standardized difference.

Characteristic	MedsCheck N=67,163	Controls N=67,163	Std. Diff. of Means
At least one new high risk medication filled, n (%)	41,792 (62.2)	41,792 (62.2)	0
At least one new potentially inappropriate medication filled, n (%)	4,910 (7.3)	4,828 (7.2)	0
New pharmacy, n (%)	6,627 (9.9)	6,995 (10.4)	0.02
Pharmacy MedsCheck volume/ total volume quartile, n (%)			
1 2 3 4	4,412 (6.6) 13,808 (20.6) 20,358 (30.3) 28,585 (42.6)	4,855 (7.2) 15,019 (22.4) 21,005 (31.3) 26,284 (39.1)	0.03 0.04 0.02 0.07

Table 4.10 (continued). Comparison of characteristics of MedsCheck recipients and matched controls. Std. Diff.= standardized difference.

#### 4.5.2 Outcomes

Those who received a MedsCheck after hospital discharge were less likely to experience death or readmission within 30 days (23.4% vs 23.9%, HR 0.97, 95% CI 0.95-1.00, p=0.02, Table 4.11 and Figure 4.3). This was explained by a decreased risk of death (1.7% vs 2.1%, HR 0.79, 95% CI 0.73-0.86, Figure 4.4) and re-hospitalization (11.0% vs 11.4, HR 0.96, 95% 0.93-0.99, Figure 4.5) at 30 days. We found no significant difference in 30-day return to the emergency department (22.5% vs 22.8%, HR 0.99, 95% CI 0.96-1.01, Figure 4.6).

	MedsCheck, n (%) Total N=67,163	Controls, n (%) Total N=67,163	Risk Difference, % (95% Cl)	Hazard Ratio (95% CI)
Death or readmission	15,723 (23.4)	16,057 (23.9)	0.5 (0.0-1.0)	0.97 (0.95-1.00) p=0.02
Death	1,126 (1.7)	1,421 (2.1)	0.4 (0.3-0.6)	0.79 (0.73-0.86)
Re-hospitalization	7,387 (11.0)	7,642 (11.4)	0.4 (0.0-0.7)	0.96 (0.93-0.99)
Return to ED	15,135 (22.5)	15,287 (22.8)	0.2 (-0.2-0.7)	0.99 (0.96-1.01)
Secondary Outcomes				
Adverse drug event	1,008 (1.5)	981 (1.5)	0.0 (-0.2-0.1)	1.03 (0.94-1.12)
Count of outpatient physician visits, median	2 (1-3)	2 (1-3)	-	Risk ratio 1.01 (1.00-1.02)
(IQK)				p=0.02

 Table 4.11. Outcomes comparison in the matched sample at 30 days



Figure 4.3. Kaplan-Meier curve of time to death or readmission\*

\* y-axis has been truncated for better visualization

Figure 4.4. Kaplan-Meier curve of time to death\*



\* y-axis has been truncated for better visualization



Figure 4.5. Cumulative Incidence Curve of time to urgent re-hospitalization

Figure 4.6. Cumulative Incidence Curve of time to return to the emergency department



There was no significant difference in the rate of adverse drug events between patients who did or did not receive a MedsCheck (1.5% vs 1.5%, HR 1.03, 95% CI 0.94-1.12). MedsCheck recipients had more outpatient visits than matched controls (mean 2.11 vs 2.09, RR 1.01, 95% CI 1.00-1.02, p=0.02).

#### 4.5.3 Subgroup Analyses

#### 4.5.3.1 Heart failure

Among the 8,420 (6.3%) patients hospitalized for a most responsible diagnosis of heart failure, 4,210 had a MedsCheck. Receipt of MedsCheck was not associated with any reduction in the composite outcome (MedsCheck 25.5% vs controls 27.2%, HR 0.93, 95% CI 0.85-1.01, Table 4.12). However, MedsCheck was associated with a reduced likelihood of death at 30-days (MedsCheck 2.1% vs 3.2%, HR 0.65, 95% CI 0.49-0.85). There was no difference in 30-day hospitalization (MedsCheck 14.9% vs controls 15.5%, HR 0.95, 95% CI 0.86-1.07) or emergency department visits (MedsCheck 24.5% vs controls 25.7%, HR 0.95, 95 % CI 0.87-1.03) between patients who did or did not receive a MedsCheck.

SUBGROUP: Admission Main Diagnosis of Heart Failure					
	MedsCheck	Controls	Risk	Hazard Ratio	
	n (%),	n (%),	Difference, %	(95% CI)	
	Total	Total	(95% CI)		
	N= 4,210	N=4,210			
Death or readmission	1,072 (25.5)	1,146 (27.2)	1.8 (-0.1-3.6)	0.93 (0.85-1.01)	
Death	87 (2.1)	134 (3.2)	1.0 (0.4-1.8)	0.65 (0.49-0.85)	
Re-hospitalization	628 (14.9)	653 (15.5)	0.6 (-0.9-2.1)	0.95 (0.86-1.07)	
Return to ED	1,032 (24.5)	1,082 (25.7)	1.2 (-0.7-3.0)	0.95 (0.87-1.03)	
Secondary Outcomes					
Adverse drug event	89 (2.1)	72 (1.7)	-0.4 (-1.0-0.0)	1.24 (0.91-1.69)	
Count of outpatient	2 (1-3)	2 (1-3)	-	Risk ratio	
physician visits, median				1.04 (1.00-1.07)	
(IQR)				p=0.03	
SUBGROUP: Admission Main Diagnosis of COPD					
	MedsCheck n	Controls	Risk	Hazard Ratio	
	(%),	n (%),	Difference, %	(95% CI)	
	Total	Total	(95% CI)		
	N=3,084	N=3,084			
Death or readmission	689 (22.3)	670 (21.7)	-0.6 (-2.7-1.5)	1.03 (0.92-1.14)	
Death	62 (2.0)	59 (1.9)	-0.1 (-0.8-0.6)	1.05 (0.74-1.50)	
Re-hospitalization	400 (13.0)	378 (12.3)	-0.7 (-2.4-0.9)	1.06 (0.92-1.22)	
Return to ED	674 (21.9)	644 (20.9)	-1.0 (-3.0-1.2)	1.05 (0.94-1.17)	
Secondary Outcomes					
Adverse drug event	36 (1.2)	41 (1.3)	0.2 (-0.4-0.7)	0.88 (0.56-1.38)	
Count of outpatient	1 (1-2)	1 (1-2)	-	Risk ratio	
physician visits, median (IQR)				1.10 (1.05-1.14)	

Table 4.12. Outcomes in Key Subgroups at 30 days. COPD= chronic obstructive pulmonary disease. ED=emergency department

SUBGROUP: New High Risk Medication Filled After Discharge					
	MedsCheck n (%), Total N=41,792	Controls n (%), Total N=41,792	Risk Difference, % (95% Cl)	Hazard Ratio (95% CI)	
Death or readmission	10,070 (24.1)	10,550 (25.2)	1.2 (0.6-1.7)	0.95 (0.92-0.97)	
Death	732 (1.8)	939 (2.3)	0.5 (0.3-0.7)	0.78 (0.71-0.86)	
Re-hospitalization	4,656 (11.1)	4,960 (11.9)	0.7 (0.3-1.2)	0.93 (0.9097)	
Return to ED	9,691 (23.2)	10,039 (24.0)	0.8 (0.3-1.4)	0.96 (0.93-0.98)	
Secondary Outcomes					
Adverse drug event	697 (1.7)	659 (1.6)	-0.1 (-0.3- 0.1)	1.06 (0.95-1.18)	
Count of outpatient physician visits, median (IQR)	2 (1-3)	2 (1-3)	-	1.02 (1.00-1.02) p=0.22	

Table 4.12 (continued). Outcomes in Key Subgroups

Among patients admitted for heart failure, there was no significant difference in the risk of adverse drug events between patients who did or did not receive a MedsCheck (2.1% vs controls 1.7%, HR 1.24, 95% CI 0.91-1.69). MedsCheck recipients had more outpatient visits in the subsequent 30 days than did controls (mean 2.27 vs 2.18, RR 1.04, 95% CI 1.00-1.07, p=0.03).

#### 4.5.3.2 Chronic Obstructive Pulmonary Disease

Among the 6,168 (4.6%) patients hospitalized for COPD, there was no association between receipt of MedsCheck and the primary composite outcome of death or readmission (MedsCheck 22.3% vs controls 21.7%, HR 1.03, 95% CI 0.92-1.14) or any of the subcomponents of death (2.0% vs 1.9%, HR 1.05, 95% CI 0.74-1.50), rehospitalization (13.0% vs 12.3%, HR 1.06, 95% CI 0.92-1.22) or return to the emergency department (21.9% vs 20.9%, HR 1.05, 95% CI 0.94-1.17). There was no significant difference in the risk of adverse drug event between patients who did or did not receive a MedsCheck (MedsCheck 1.2% vs controls 1.3%, HR 0.88, 95% CI 0.56-1.38). MedsCheck recipients had more outpatient visits in the subsequent 30 days than did controls (mean 1.78 vs 1.62, RR 1.10, 95% CI 1.05-1.14).

#### 4.5.3.3 New High Risk Medication

A total of 83,584 (62.2%) patients filled a prescription for a new high risk medication after discharge. Those who received a MedsCheck had a lower rate of experiencing the composite outcome (MedsCheck 24.1% vs controls 25.2%, HR 0.95, 95% CI 0.92-0.97). MedsCheck recipients were at reduced risk of each of the three components of the primary outcome: emergency department visits (MedsCheck 23.2% vs controls 24.0%, HR 0.96, 95% CI 0.93-0.98), re-hospitalization (MedsCheck 11.1% vs controls 11.9%, HR 0.93, 95% CI 0.90-0.97) and death (MedsCheck 1.8% vs controls 2.3%, HR 0.78, 95% CI 0.71-0.86).

Among patients filling a new prescription for a high risk medication, we found no significant difference in the rate of adverse drug event between patients who did or did not receive a MedsCheck (1.7% vs controls 1.6%, HR 1.06, 95% CI 0.95-1.18). There was no difference in the 30-day count of outpatient visits between MedsCheck recipients and controls (mean 2.17 vs 2.15, RR 1.02, 95% CI 1.00-1.02, p=0.27).

## 4.6 Discussion

Among eligible patients filling a prescription after discharge from hospital, receipt of a MedsCheck was associated with a small decrease in the rate of death or readmission over 30 days, driven by decreases in the rate of death and re-hospitalization. Patients admitted for heart failure had a decreased rate of death if they received a MedsCheck, though there was no difference in readmission. There was no difference in death or readmission for patients with COPD. Patients filling a prescription for a new high risk medication had a decreased rate of death or readmission if they received a MedsCheck, driven by an increased rate of all 3 sub-components: emergency department visits, re-hospitalization, and death. Receipt of MedsCheck was also associated with a small increase in outpatient physician visits in the whole cohort, as well as the heart failure and COPD patient subgroups.

The low rates of MedsCheck (9%) for eligible patients in our study suggests that the current pharmacist payment (ranging from \$25-\$150) may not be an adequate incentive for providing community pharmacy-based medication review. In addition, low rates of MedsCheck provision suggest that MedsCheck recipients may be highly selected. We could not distinguish which eligible patients declined to receive a MedsCheck, or were simply not offered the service despite

being eligible. Although we accounted for baseline differences in healthcare usage, MedsCheck recipients might be more likely to seek care or engage in self-management. The observed increased rate of outpatient visits in MedsCheck recipients is consistent with this explanation. Confounding on the basis of severity of illness or health-seeking behavior is a limitation of observational studies comparing healthcare services. The hazard ratio for mortality observed here is similar to that reported in another recent observational study of an enhanced healthcare service, Medicare's transitional care management visits.(60)

A recent systematic review reported that community-based medication reconciliation interventions did not always reduce the risk of readmission after hospital discharge.(104) Yet, the only included study conducted in a community pharmacy setting did not report readmission rates.(105) Moreover, most interventions were delivered by phone or in outpatient clinics. We identified one additional study conducted in a community pharmacy, that reported reductions in readmissions (adjusted OR 0.07, 95% CI 0.01-0.63) for patients choosing medication review instead of usual care.(108) In addition to confounding by indication, this study was also affected by immortal time bias since the outcome was measured from the time of discharge, not from the time of intervention.

How MedsCheck might reduce risk of death is uncertain. We found that patients filling a new high risk medication did better if they received a MedsCheck, yet we did not find a corresponding difference in the rates of adverse drug events between the two groups. One reason for this pattern may be that adverse drug event hospitalization or emergency department visit codes are specific yet insensitive for medication-related complications. Consistent with this, the overall rate of adverse drug events in our study was considerably lower than that reported in studies using chart review.(20-22) MedsCheck may also improve treatment adherence, thereby leading to increased clinical stability after discharge. For example, incorrect administration of a high-risk medication (e.g. a diuretic or insulin) could result in rapid clinical deterioration, and hence a return to the hospital. That a benefit was observed in the subgroup with heart failure but not those with COPD could point to differences in the effect of medications on each condition's underlying disease trajectory.

Our study was population-based and benefitted from multiple linked health administrative databases. As a result, we were able to account for differences between exposed patients and

controls in sociodemographic characteristics, previous healthcare usage, hospitalization and pharmacy characteristics, as well as medication usage profiles. We included several variables to account for factors that might affect the likelihood of receiving a MedsCheck. This included history of medications for dementia, lack of English or French language ability, and markers of decreased mobility (use of homecare and physician home visits). We also accounted for year of discharge since use of MedsCheck has increased over time.(103) To minimize immortal time bias, we carefully aligned follow-up periods between MedsCheck recipients and controls. We considered alternate starting points for the follow-up window, such as from the time of hospital discharge. However, because the time from discharge to MedsCheck cannot include an outcome, this would have introduced immortal time bias in favor of the MedsCheck group.

To ensure comparability of patient groups, we limited our selection criteria to patients over age 66 who would be eligible for MedsCheck. The age criterion was necessary to obtain medication histories for the year prior to hospital discharge, which would not be available for most people under age 65 years. Our study findings are thus limited to elders, and MedsCheck may have different effects or associations in younger patients.

While our propensity score-matched design accounted for differences in previous healthcare usage between groups, residual confounding remains a possibility. In particular, our findings of a moderate decrease in mortality with no difference in emergency department visits suggests that MedsCheck recipients may differ from controls in ways not measured in this study. For example, reduced mobility after discharge may prevent sicker patients from visiting a pharmacy in person. While a caregiver can easily fill prescribed medications on a patient's behalf, MedsCheck can only be provided to a caregiver with patient consent. A clinically deteriorating or frail patient may have a caregiver pick up medications, while being unlikely to present in person for a MedsCheck. Whether this or other differences could account for lower mortality observed after a MedsCheck is unknown. Experimental studies are needed to disentangle the possible mechanisms linking MedsCheck receipt to improved outcomes.

We did not include outcomes related to medication adherence. In Ontario, 90-day medication dispensation necessitates a longer follow-up period to measure drug adherence after discharge. This is further complicated by the discontinuity in medications which can occur around the time of hospitalization. As the health administrative databases we used do not hold information on in-

hospital medications, we could not detect primary non-adherence after hospital discharge.(173) Comparing long-term adherence to new medications initiated during hospitalization is an area for future research. Finally, MedsCheck is provided throughout Ontario in community pharmacies of all types. As a result, delivery likely varies across locations and providers, with local practices contributing to any potential effect of MedsCheck on recipients. Ensuring fidelity of the intervention is essential for effectiveness.

In this study of patients filling a prescription after hospital discharge, receiving a community pharmacy medication review was associated with a reduction in 30-day death or readmission. Despite this, patients receiving MedsCheck were no less likely to return to hospital for an adverse drug event. In the subgroup of patients filling a prescription for a new high risk medication, MedsCheck was associated with fewer emergency department visits, hospitalizations, and deaths. Since selection for MedsCheck depends on both pharmacist initiative and patient willingness, our findings remain limited by potential confounding from patient differences not measured in our study. As a result, there is a need for randomized studies to evaluate the potential benefit of community pharmacist-delivered medication review on post-discharge outcomes, including medication adherence.

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# Chapter 5 Discussion

## 5.1 Chapter Overview

The aims of this thesis were to further the evidence for decision- and policy-making related to transitional care for patients being discharged from hospital. This chapter contains discussion relating to the following six points: whether the specific project objectives were met, methodological limitations, responses to criticism, implications for clinical decision-making and policy, research implications, and knowledge translation.

# 5.2 Were the thesis objectives met?

## 5.2.1 Project #1

The specific aim of this project was to determine whether patients discharged home during the December holiday period received less outpatient follow-up and had higher rates of death or readmission than patients discharged from hospital at other times.

The study found that patients discharged from hospital during the December holiday period were less likely to have prompt outpatient follow-up, and were at greater risk of 30-day death or readmission. Decreased outpatient follow-up was observed across all patient characteristics, and an increased risk of death or readmission was noted in most patient groups. Patients at a lower baseline risk of readmission had a more pronounced increase in the holiday-related risk of death or readmission.

## 5.2.2 Project #2

The specific aim of this project was to evaluate whether an incentive fee code to outpatient physicians increased rates of timely physician follow-up after discharge, and decreased death, rehospitalization or return to the emergency department.

We found that, despite uptake by physicians, the incentive did not alter 7- or 14-day physician follow-up rates. This finding was robust to changing the definition of physician follow-up from all physicians to a previously known physician or the assigned primary care physician. These findings also extended across pediatric, adult, and older adult patient groups. The introduction of

the incentive did not change the composite of death, rehospitalization, or return to the emergency department.

## 5.2.3 Project #3

The specific aim of this project was to determine if patients receiving a community pharmacy medication review after hospital discharge had lower rates of death or readmission than other patients who filled a prescription but did not receive one.

We found that patients receiving a community pharmacy medication review (MedsCheck) were at decreased risk of death or readmission (including return to the emergency department) after discharge, compared to eligible patients who did not receive a MedsCheck. This decreased risk was explained by a decreased risk of death or re-hospitalization. There was no difference between groups in emergency department visits. Patients admitted for heart failure had a decreased rate of death if they received a MedsCheck, though there was no difference in the composite of 30-day death or readmission. There was no difference in death or readmission for patients with COPD who did or did not receive a MedsCheck. Patients filling a prescription for a new high risk medication had a decreased risk for all three events (death, re-hospitalization, or return to the emergency department) after receiving a MedsCheck.

## 5.2.4 Conclusion

The specific aims for all three projects were met.

# 5.3 Limitations

## 5.3.1 Accounting for Baseline Risk

In the real world, the study of hospital readmissions and prevention strategies is challenging. Although crude measurement is straightforward, interpreting rates of readmission is complicated by uncertainty as to preventability and the optimal method of adjustment. In large, heterogeneous populations such as those in Ontario, the diversity of diagnoses and other characteristics requires careful attention to baseline risk. When evaluating interventions or identifying risk factors for hospital readmission, it is essential to consider the effect of various forms of confounding on the relationships under study. In each of the three thesis projects, we took a different approach to this problem. In the first, multivariable regression was used to adjust for measured baseline differences between December holiday-discharged patients and control patients. For the second, a population-based time series analysis accounted for population-level changes in patient, hospital and provider characteristics over time. In the third, propensity score matching was used to ensure that MedsCheck recipients and controls were relatively indistinguishable in their measured baseline characteristics. Together, these diverse techniques proved feasible and reasonable.

Although we have attempted to manage possible sources of confounding within these three thesis projects, we lacked detailed information on patient severity of illness, mobility, frailty, health literacy, financial status and social supports. These factors may contribute to a patient's follow-up and readmission risk. Unfortunately, this information was not available in existing data sources.

#### 5.3.2 Confounding by Indication

A related limitation is the potential for confounding by indication.(1) This was an important limitation in thesis project #3, as the MedsCheck service required both pharmacist offer and patient consent. Because clinicians do not treat all patients the same, those who receive certain interventions may have been selected for a reason. Patients at greater risk may sometimes be more likely to receive an intervention. The inverse may also occur; namely, providers might select moderate risk patients over high risk patients. Such a decision might be motivated by self-interest or judgement as to how modifiable a patient's risk may be; some patients may be deemed too high risk for an intervention to make a difference.(2, 3)

In theory, all policy initiatives could first be studied in the setting of a randomized controlled trial, where such bias is eliminated. Yet, policy interventions may be implemented without this ever being undertaken or even considered. Once implemented, evaluations can be carefully planned and cautiously interpreted, acknowledging the limitations of real-world observational data.(4)

#### 5.3.3 Data Accuracy

The findings in this thesis depend upon the assumption that underlying data sources were accurate and reliable. The administrative data sources used in this study have been validated

against chart abstraction and used extensively to publish high-impact health services research.(5-9)

Validation studies have been mostly focused on the accuracy of diagnostic coding, which is high for the main diagnosis in hospital sources (DAD and NACRS) but generally less accurate for outpatient visits (OHIP). This thesis has used hospital-based diagnostic information only for risk adjustment and subgroup analyses. The main data elements in this thesis relate instead to dates of hospital discharge, emergency department visits, hospitalizations, outpatient visits, pharmacy visits, and death. Date of admission is highly accurate for emergency department visits, 99.9% accurate for hospitalization data, and death counts are consistent with Ontario health planning death counts.(5, 10, 11) Information on medications dispensed has similarly been found highly accurate (over 99%).(12)

There have been no validation studies of the date of outpatient visits, or non-medication pharmacy services. Most Ontario physicians are paid through fee-for-service or alternate models which mandate shadow billing.(13) Both pharmacist and physician billings are audited by the Ontario Ministry of Health and Long-Term care.(14, 15) As such, the date of outpatient visits and pharmacy services can be expected to be accurate. Moreover, there is no reason to expect errors in coding to occur differentially between exposure groups. Hence any resulting misclassification of outcome status can be expected to be non-differential with respect to the exposure group.

#### 5.3.4 Generalizability

Since this thesis was based in Ontario, its findings are most relevant within this Canadian province. Yet, many findings are also valuable beyond provincial borders. The variation in outcomes observed in December holiday-discharged patients could be expected in other populations where an extended and synchronous holiday period occurs every December (e.g., Western countries). The findings from our study of a physician follow-up incentive are also potentially relevant to policymakers in other jurisdictions who are designing similar measures. As well, our results relating to Ontario's MedsCheck program are potentially relevant where policymakers have introduced (or are planning to introduce) similar programs of community pharmacy medication review. Such programs, though not specifically targeted to a post-hospital discharge population, presently exist in the U.S. and United Kingdom.(16, 17)

# 5.4 Response to Criticism

As projects #1 and #2 have undergone peer review and several instances of oral presentation, the thesis has benefitted from external feedback. Common criticisms and responses are presented below.

## 5.4.1 Holiday-discharged patients are too different

Some reviewers expressed concerns that patients discharged home during the December holiday would be too different to be meaningfully compared to patients discharged at other times. In contrast, we did not find any evidence that December holiday discharged patients were inherently sicker than their control counterparts. In fact, we found that December holiday patients were at slightly lower baseline risk for the outcome of death or readmission. We also undertook several complementary analyses to confirm that differences in outcomes did not reflect large differences in case mix between groups. We undertook a confirmatory propensity score matched analysis, including the top 10 most common admission diagnoses in the propensity score model. The matched groups did not differ by more than 1% for any of the top 10 diagnosis, and the results of this propensity score-matched analysis were consistent with the main results.

## 5.4.2 No association between follow-up and death or readmission

Thesis project #1 findings included that December holiday discharge was associated with both decreased follow-up and a greater risk of death or readmission. Yet, our findings do not provide evidence of a causal relationship between holiday discharge, follow-up, and death or readmission. To test whether delays in follow-up explain the differences in outcomes would require the use of mediation analysis, with time to follow-up tested as a time-varying mediator of the relationship between holiday discharge and death or readmission. Our ability to undertake such an analysis was limited by the availability of approaches to mediation analysis with a time-varying mediator. Statistical tools for such an analysis are presently still in development.(18)

# 5.4.3 The interrupted time series analysis in Project #2 did not include multivariable adjustment

Several reviewers expressed concern that the analysis in project #2 did not account for changes in patient, provider or hospital characteristics over time since the time series analysis used only

unadjusted monthly outcome proportions. However, the analytic methods (ARIMA model) accounted for secular (background) trends in the data over time. Secular trends in unadjusted outcomes such as those resulting from steadily rising patient complexity are handled by the model as a nuisance factor. The effect tested for is a change in outcomes at the time of incentive code introduction, over and above any existing background trends. Only a sudden change in patient or provider characteristics coinciding with the time of incentive introduction would have the potential to introduce confounding. We have no reason to speculate that such a sudden change occurred.

## 5.5 Implications for Clinical Decision-Making and Policy

Building a sound evidence base to inform decision-making is essential, as healthcare leaders seek to keep discharged patients out of hospital. Although the literature surrounding hospital readmissions is voluminous, studies of the effects of population-wide policy changes are less common. This thesis has made three important contributions to clinical decision-making and policy in the area of preventing readmissions. First, we described the outcomes of Ontario patients discharged home during the December holiday period. Second, we demonstrated that an incentive provided to physicians for timely outpatient follow-up after hospital discharge changed neither follow-up rates nor the composite of death, re-hospitalization, or return to the emergency department. Third, we showed that community pharmacy medication review was associated with a decreased risk of death or readmission among eligible seniors filling a prescription after hospital discharge.

#### 5.5.1 Physician Follow-Up

Ensuring timely follow-up is an essential component of discharge planning. Yet, patients leaving hospital frequently encounter difficulties with scheduling.(19) In the first thesis project, we found that December holiday-discharged patients were much less likely to have outpatient physician follow-up soon after hospital discharge, and were at an increased risk of death or readmission. This finding can inform clinical decision-making around the discharge process; specifically, clinicians working over the December holiday period can now take additional steps to ensure continuity of care for patients returning home during this vulnerable time. In addition, the reduced rate of follow-up in this group provides a low benchmark for follow-up rates in times of reduced staffing. Policymakers seeking to prevent readmissions by improving continuity

of care should further examine care coordination and access to clinics during the December holiday. Our findings in thesis project #1 can also be applied beyond the December holiday period, as they provide evidence of just how low follow-up rates can go.

In the second project, we evaluated the effects of an intervention to improve timely follow-up after hospital discharge. The financial incentive introduced in 2006 was adopted by outpatient physicians seeing patients within two weeks of discharge. Despite this, there was no change in overall follow-up rates, suggesting the incentive was not effective. Incentive code uptake was greatest in physicians who were already providing the highest follow-up rates, demonstrating that the incentive was a reward, that reinforced but did not change behaviour.

Ontario policymakers could consider modifying the incentive to better align with transitional care priorities. This project informs the development of incentives for early follow-up beyond Ontario because features of this incentive (monetary value, bundling with other billing codes, lack of timeliness) may explain its lack of effect.(20) This project also documents the modest 14-day follow-up rate (66%) overall. Indeed the follow-up rate with a patient's own primary care provider was even lower at 34%. Clinicians discharging patients from hospital will need to consider the low likelihood of 14-day follow-up in making post-discharge recommendations. Additional efforts, including enhanced communication, may be needed to ensure that timely follow-up really does occur.

#### 5.5.2 Community Pharmacy Follow-Up and Readmissions

In the third thesis project, we compared the outcomes of elders receiving a MedsCheck after discharge to matched eligible controls. We found that MedCheck recipients were at lower risk of death or readmission. Our study, therefore, suggests that medication review in a community pharmacy setting may be beneficial after hospital discharge. However, interventional studies are needed to confirm our findings given the possibility of residual confounding from patient characteristics or behaviour. If confirmed, this would justify the integration of community pharmacy medication review into transitional care practices. At present, our findings suggest that community pharmacy-delivered medication review may be a useful strategy to decrease hospital readmissions.

## 5.6 Implications for Research

In this thesis, we used health administrative data to study the real-world outcomes of patients after hospital discharge. We used diverse methods to minimize bias resulting from differences in measured patient characteristics. These included interrupted time series analysis, multivariable regression, and propensity score matching. We demonstrated that measuring outpatient follow-up and community pharmacy services after discharge was feasible and informative in evaluating existing health policy.

Interrupted time series analysis (ITS) is an emerging quasi-experimental design first introduced to health services research in the 1980s.(21) Despite increasing application to drug policy and utilization research, usage and reporting guidelines have only recently become available.(22) ITS approaches such as ARIMA (auto-regressive integrated moving average) have the advantage of accounting for secular data trends and seasonality in outcomes. We found post-discharge follow-up to vary dramatically between the December holiday and the control periods. For this reason, accounting for seasonality in our second thesis project was essential. We have demonstrated that interrupted time series is a valuable tool to evaluate the effect of policy changes on health outcomes after hospital discharge.

Another methodological contribution relates to establishing outcome observation windows when control exposure time is uncertain. In the third thesis project, controls were individuals who would have been eligible to receive a MedsCheck but did not. To account for immortal time from hospital discharge to the exposure in the MedsCheck group, a similar time point was established to define the beginning of the outcome observation window in the control group. To do this, a customized matching algorithm was required. This macro (Appendix Item 1) incorporated hard matching, matching on propensity score, criteria for control eligibility, and established the beginning of the observation window for each control patient.

In addition, this thesis identified several areas for future research. These included i) the quality of transitional care during the December holiday period, ii) how to improve post-discharge follow-up rates through effective physician incentives or otherwise and iii) whether a randomized intervention of community pharmacy medication review could improve patient outcomes after discharge. Research into these areas will build the evidence base for clinical decision-making and policy, and provide direction for further lines of inquiry. In all cases, future

healthcare interventions should be comprehensively and deliberately studied. For example, the United Kingdom's Medical Research Council framework can be used to guide the development, implementation and evaluation of complex healthcare interventions.(4)

Follow-up with outpatient providers and medication safety are two of the ten domains of ideal transitional care proposed by Burke et al.(23) This thesis adds to current knowledge, yet practices in other transitional care domains are potentially important co-interventions deserving of further study. As discussed in Chapter 1, patient, provider and environmental factors all contribute to patient readmission risk, and only the avoidable proportion can be realistically reduced through better care. The development of methods estimating the probability of an avoidable readmission would facilitate the selection of patients for participation in randomized studies of transitional care interventions. Statistical modelling can also be used to integrate interventional effect sizes and the likelihood of avoidability, allowing for comparisons across populations and interventions. To prioritize the most effective interventions, such comparisons are essential.

## 5.7 Knowledge Translation

## 5.7.1 Goals and Target Audiences

The primary goal of this thesis was to build the evidence base for decision- and policy-making relating to transitional care. The target audiences were clinicians, policymakers, other researchers, and the public.

## 5.7.2 Activities

Planned knowledge translation activities included presentations to policymakers, clinicians and researchers at conferences, publication in high impact journals, and dissemination through the media.

Several activities have already been undertaken. Early in the planning process, several meetings were held with the Ontario Ministry of Health and Long-Term Care policy leads for primary care and pharmacy services. This was done to better understand the original goals of the policies studied in projects # 2 and # 3, and to obtain related documentation.

Project # 1 was presented to the Canadian Association of Health Services and Policy Research (CAHSPR) Annual Meeting, as well as the University of Toronto Department of Medicine Annual Day at the University of Toronto. The study was published in the *BMJ*, and received widespread coverage in local and international news media (Toronto Star, CNN, Fox, CBS, Reuters, Medscape, MSN, and WebMD among others).(183)

Project # 2 was presented to the Canadian Society of Internal Medicine (CSIM) Annual Meeting and in poster form at the University of Toronto Department of Medicine Annual Day. In addition, Dr Lapointe-Shaw gave an invited presentation at the Institute for Health Policy, Management and Evaluation's (IHPME) Health Policy Rounds on the methods and results of Project # 2. This study was published in *CMAJ*, with an accompanying editorial.(184, 185) The related press release was published in several health and science news outlets.

Project # 3 has already been presented to the Director of Drug Programs for the Ontario Ministry of Health and Long-Term Care. It will be submitted for presentation to the Society of General Internal Medicine Annual Meeting, and presented to OPEN (Ontario Pharmacy Evidence Network). The manuscript is in preparation for submission to peer reviewed journals.

## 5.8 Summary

The primary goal of this thesis was to build the evidence base for decision- and policy-making relating to the transition home after hospital discharge. This aim, as well as the three specific project objectives, have been met. Diverse analytic methods were used to minimize bias in all three studies, providing an example of a range of approaches to policy-shaping healthcare research. The thesis findings will guide decision-making for clinicians at the point of care, as they prepare their patient for hospital discharge and a smooth transition home. They will also inform the development and refinement of healthcare policies relating to improved transitional care processes and outcomes in Ontario and beyond.

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## Appendix

```
1. Macro for matching algorithm using in Project #3
   /*
Note: in a previous coding step, we defined the following terms:
outcome_time=min(edhospdthdate,02_adr1st_index)-indexdate+1;
if outcome_time=. then outcome_time=5000
medscheck_time=medscheck_date-indexdate
*/
%macro do_list(howmany);
%do x=1 %to &howmany;
%let n=%eval(&x+1);
%let k=%eval(&x);
data cases;
set lauren.unmatched&x;
if medscheck=1;
time=medscheck_time;
run;
data controls;
set lauren.unmatched&x;
if medscheck=0;
time=outcome_time;
run;
 %match(case=cases,control=controls,idca=ikn,idco=ikn,
 mvars=logit_ps copd chf nnewmeds_highrisk_cat circ sxnos,wts=1
1 1 1 1 1, dmaxk=0.257395 0 0 0 0,
 time=time,
 method=greedy,
 ncontls=1, seedca=12548, seedco=13568, maxiter=100000,
 out=_out,outnmca=_nmca,outnmco=_nmco,print=no, summary=y);
data lauren.matched&k;
set _out;
run;
```

```
data lauren.leftover case&k;
set _nmca;
run;
data lauren.leftover_control&k;
set _nmco;
run;
/*for controls, need to pick up fill_time and check that this is
not after the matched
case's _catime*/
/*get the source dataset*/
data psdataset; /*880,149observations and 106 variables*/
set lauren.unmatched&x;
run;
/*sort dataset by ikn*/
proc sort data=psdataset out=sortedsource;
by ikn;
run;
/*sort by control ikn now*/
proc sort data=_out out=sortedmatched;
by __idco;
run;
/*then proc sql merge*/
proc sql;
  create table matched_time as
    select a.*, b.fill_time
       from sortedmatched a,
           sortedsource b
        where a.___idco = b.ikn
          ;
quit;
data lauren.good_match&k;
set matched_time;
where fill_time<=__catime;</pre>
```

```
run;
/*now we need to take the already matched people out of the
source dataset and start again*/
/*first remove the good match cases*/
proc sql;
  create table ps_sourcea as
    select a.*
       from sortedsource a
        where a.ikn not in (select __idca from
lauren.good_match&k)
          ;
quit;
/*now remove the good match controls*/
proc sql;
  create table ps_sourceb as
    select a.*
       from ps_sourcea a
        where a.ikn not in (select __idco from
lauren.good_match&k)
          ;
quit;
data lauren.unmatched&n;
set ps_sourceb;
run;
%end;
%mend do_list;
%do_list(15)
```