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Investigating quality of care for diabetes mellitus, congestive heart failure and chronic kidney disease in Ontario's Family Health Group and Family Health Organization models

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Abstract

Background and objectives: In Ontario, primary care reform was initiated in the early 2000s with an aim to improve the quality of primary care. Hence, the provincial government restructured family physicians' remuneration package. Prior to the reform, most physicians received majority of their income through fee-for-service (FFS). In Ontario, Family Health Group (FHG) and Family Health Organization (FHO) are dominant post-reform primary care models that remunerate family physicians through blended FFS and blended capitation, respectively. In three studies, we compared physicians in FHGs and FHOs in terms of their care provision for persons with diabetes mellitus (1st study), congestive heart failure (CHF) (2nd study) and chronic kidney disease (CKD) (3rd study).

Methods: All data were obtained from the ICES (formerly known as the Institute for Clinical Evaluative Sciences). For the first and second studies, we employed propensity score-based weights and fixed effects regressions on a balanced panel of physicians spanning 10 years; all analyses were conducted at the physician level. In these two studies, the comparison was between physicians in FHG who never switched to FHO or other models (i.e., non-switchers); switchers were physicians who switched from FHG to FHO. For the third study, we performed two cross-sectional analyses at the physician level; lack of data availability for patients with CKD over time deterred us from conducting longitudinal analyses as in the first two studies.

Results: We found that switching from FHG to FHO was associated with an improvement in some aspects of diabetes care. We found that CHF care—in terms of physicians' follow-up of patients who are discharged—was not different between switchers and non-switchers. We found that some aspects of CKD care were better with physicians in FHG relative to their counterparts in FHO.

Conclusions: Compared to blended FFS, blended capitation payment is associated with a small but statistically significant improvement in some aspects of diabetes care. Our findings suggest that follow-up care for patients with CHF is similar in Ontario's blended FFS and blended capitation models. Though we found that blended FFS is associated with greater adherence to some CKD process measures, future studies could employ longitudinal regressions to account for more confounding.

Keywords: primary care reform, fee-for-service, capitation, quality of care, physician remuneration, pay-for-performance

Summary for Lay Audience

In the early 2000s, the Canadian province of Ontario embarked on reforming its system of primary care; a major aim of the reform was to improve the quality of care that family physicians provide to their patients. To achieve this aim, the government partially relied on changing family physicians' remuneration and introducing pay-for-performance (P4P) incentives.

Prior to the reform, most of Ontario's family physicians were paid through fee-for-service (FFS), a mode of remuneration where the unit of payment is the service. The post-reform primary care models are partly characterized by blended payment, which refers to a remuneration system based on multiple sources of income—of which one source predominates. For instance, in blended FFS, physicians are mainly remunerated through FFS and have secondary sources of income through bonuses, P4P incentives, and premiums. Family Health Group (FHG) and Family Health Organization (FHO) are two popular post-reform primary care models that pay physicians through blended FFS and blended capitation, respectively. In capitation, the unit of payment is a person. Over time, many physicians switched from FHG to FHO (i.e., switchers); however, some remained in FHG (i.e., non-switchers).

The evidence on physician's performance in FHGs and FHOs is limited; thus, we examined the impact of these two payment models on physicians' provision of primary care services to Ontarians with diabetes mellitus, congestive heart failure (CHF), and chronic kidney disease (CKD). We also investigated patients' health outcomes.

We found that physicians' switch from FHG to FHO was associated with moderately better care for some diabetes-related services; there was no significant difference between switchers and non-switchers in terms of the CHF care measures

we examined. We also found that adherence to some CKD-related care processes was higher for physicians in FHGs relative to their counterparts in FHOs. Collectively, our studies provide some evidence to support that family physicians' level of care can be associated with how they are paid.

Co-Authorship Statement

In the three manuscripts (i.e., Chapters 3, 4 and 5) I, Mary Aderayo Bamimore, am the first author; I developed the data creation plan in consultation with Drs. Garg and Sarma, analyzed the data at the ICES and wrote first drafts of the manuscripts under the guidance and supervision of Dr. Sarma (primary supervisor). Professor Sarma provided funding, supervision, and contributed to study design, manuscript preparation and critical revision for all thesis chapters. Professor Amit Garg (co-supervisor), Professor Gregory Zaric (member of advisory committee) and Professor Rose Anne Devlin (member of advisory committee) provided guidance and revised the manuscript drafts for exposition of the contents. Dr. Danielle Nash (co-author) also provided guidance and revisions for the third study (i.e., Chapter 5).

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Table of Contents

List of Tables

List of Appendices

List of Abbreviations

ACCORD BP	Action to Control Cardiovascular Risk in Diabetes blood pressure
ACEI	angiotensin converting enzyme inhibitor
ACR	albumin-to-creatinine ratio
ACSC	ambulatory care sensitive condition
ADG	aggregated diagnosis group
AF	atrial fibrillation
AF-CHF	Atrial Fibrillation and Congestive Heart Failure
A-HeFT	African American Heart Failure Trial
ANDROMEDA	Antiarrhythmic Trial with Dronedarone in Moderate to Severe CHF Evaluating Morbidity Decrease
ARA	aldosterone receptor antagonist
ARB	angiotensin II receptor blocker
ARNI	angiotensin neprilysin inhibitors
ATHENA	A Placebo-Controlled, Double-Blind, Parallel Arm Trial to Assess the Efficacy of Dronedarone 400 mg bid for the Prevention of Cardiovascular Hospitalization or Death from Any Cause in Patients with Atrial Fibrillation/Atrial Flutter
ATT	average treatment effect on treated
Average treatment effect on treated	ATT
BB	beta blocker
BMI	body mass index
CAPE	Client Agency Program Enrollment
CARDS	Collaborative Atorvastatin Diabetes Study
CBPS	covariate balancing propensity score
CCB	calcium channel blocker
CCM	Comprehensive Care Model
CCORT	Canadian Cardiovascular Outcomes Research Team
CCS	Canadian Cardiovascular Society
CEA	cost-effectiveness analysis
CHARM	Candesartan in Heart Failure-Assessment of Reduction in Mortality and Morbidity
CHC	Community Health Centre
CHF	congestive heart failure
CHST	Canada Health and Social Transfer
CHT	Canada Health Transfer
CI	confidence interval
CIHI	Canadian Institute for Health Information
CKD	chronic kidney disease
CME	Continuing Medical Education
CMS	Centres for Medicare and Medicaid Services
COC	cycle of care
CORR	Canadian Organ Replacement Registry

CPDB	Corporate Provider Database
CST	Canada Social Transfer
DAD	Discharge Abstract Database
DID	difference-in-differences
DIG	Digitalis Investigation Group
DMI	Diabetes Management Incentive
EB	entropy balancing
ECG	electrocardiogram
ED	emergency department
EF	ejection fraction
eGFR	estimated glomerular filtration rate
ESRD	end stage renal disease
FFS	fee-for-service
FHG	Family Health Group
FHN	Family Health Network
FHN	Family Health Network
FHO	Family Health Organization
GUIDANCE	Guideline Adherence to Enhance Care
HART	Heart Failure Adherence and Retention Randomized Behavioral Trial
$HBA1_c$	glycated hemoglobin $A1_c$
HFpEF	heart failure with preserved ejection fraction
HFrEF	heart failure with reduced ejection fraction
H-ISDN	hydralazine with isorbide dinitrate
HR	hazards ratio
HRRP	Hospital Readmissions Reduction Program
HSO	Health Service Organization
ICD	International Classification of Diseases and Related Health Problems
ICES	Institute for Clinical Evaluative Sciences
IDOCC	Improved delivery of cardiovascular care
IFAQ	Incitation financière à l'amélioration de la qualité
IKN	ICES key number
IMG	international medical graduate
IPDB	ICES Physician Database
IQR	interquartile range
JVP	jugular venous pressure
LVEF	left ventricular ejection fraction
MACH-1	Mortality Assessment in Congestive Heart Failure Trial
MOHLTC	Ministry of Health and Long-term Care
MRA	mineralocorticoid receptor antagonist
MRS	mortality risk score
NACRS	National Ambulatory Care Reporting System
NSAID	nonsteroidal anti-inflammatory drug
ODB	Ontario Drug Benefit

ODD	Ontario Diabetes Dataset
OHIP	Ontario Health Insurance Plan
OLIS	Ontario Laboratories Information System
OMA	Ontario Medical Association
OR	odds ratio
P4P	pay-for-performance
PARADIGM-HF	Prospective comparison of ARNI with ACEI to Determine Impact on Global Mortality and morbidity in Heart Failure
PCN	Primary Care Network
PCP	primary care physician
QOF	Quality and Outcomes Framework
QoL	Quality of life
RADIANCE	Randomized Assessments of [the effect of] Digoxin on Inhibitors of the Angiotensin-Converting Enzyme
RALES	Randomized Aldactone Evaluation Study
RCT	randomized controlled trial
RPDB	Registered Persons Database
RR	relative risk
SD	standard deviation
SOLVD	Studies of Left Ventricular Dysfunction
TDM	therapeutic drug monitoring
TNHI	Taiwan National Health Insurance
UK	United Kingdom
UKNAD	UK National Diabetes Audit
UKPDS	United Kingdom Prospective Diabetes Study
US	United States of America
WARCEF	Warfarin versus Aspirin in Reduced Cardiac Ejection Fraction
WASH	Warfarin/Aspirin Study in Heart Failure
WATCH	Warfarin and Antiplatelet Therapy in Chronic Heart Failure
WC	waist circumference
WESDR	Wisconsin Epidemiologic Study of Diabetic Retinopathy

Chapter 1

1 Introduction

1.1 The history of healthcare in Canada

In Canada, publicly funded healthcare is provided and financed through provincial or territorial health insurance plans. The history of Canadian healthcare system is eventful; the country came a long way to have a universal health insurance system. In this section, a brief historical context is presented to outline the Canadian government's support for universal primary care.

Prior to the late 1940's, Canada's system of healthcare was mainly privatized whereby Canadian residents' access to medical care directly depended on their affordability. Canada's shift to a system where healthcare can be accessible without out-of-pocket payments began in the province of Saskatchewan in 1947 through the introduction of a public healthcare insurance plan for hospital services (Government of Canada, 2018). The plan was called the *Saskatchewan Hospital Services Plan*, and it was the first universal health insurance plan for hospital services in North America (Lavoie, 2018). On July 1st 1962, this provincial plan was extended to cover physician services in Canada through the *Hospital Insurance and Diagnostic Services Act* passed by the federal government in 1957 (Government of Canada, 2018; Office of the Auditor General of Canada, 2002). In 1966, the federal government introduced the *Medical Care Act*, which proffered to reimburse, or cost-share, medical services provided by physicians outside the hospital setting. By 1972, each province's and territory's health insurance plan covered outpatient physician services (Government of Canada, 2018).

In 1984, both the aforementioned federal acts that were introduced in 1957 and 1966 were amalgamated through the *Canada Health Act* (or the *Act*), which ensures that the provincial and territorial governments deliver healthcare in accordance with five principles: (1) accessibility, (2) portability, (3) universality, (4) comprehensiveness and (5) public administration (Government of Canada, 1985). Accessibility ensures that each province's and territory's insurance plan enable legal residents to receive medical services without out-of-pocket payments for the insured medical services. Portability ensures that Canadians are eligible for health insurance even if they move from one province (or territory) to another. Universality ensures that the health insurance plan of each province or territory financially covers 100% of insured medical services under uniform terms and conditions. Comprehensiveness refers to the plan's coverage of services provided by hospitals, physicians, as well as emergency dental services in hospitals. Public administration essentially means that each province's and territory's insurance plan must be managed by a public jurisdiction (Conference Board, 2013; Government of Canada, 1985, 2018; Office of the Auditor General of Canada, 2002). It is important to note that the principle of public administration under the *Canada Health Act* does not preclude the delivering of health services privately because the *Act* merely dictates that the funding and/or purchasing of care be under a public authority. Consequently, the vast majority of family physicians provide their medical services in private practice settings. This is also consistent with the fact that many hospitals—as well as companies for laboratory services—are private organizations (Tindal, 1997, 2007).

The primary objective of the Canadian healthcare system is "to protect, promote and restore the physical and mental well-being of Canadian residents, and to facilitate reasonable access to medically necessary healthcare services without

financial barriers" (p. 5) (Minister of Justice, 2020). While the provincial government is mainly responsible for the delivery of healthcare, there are certain populations for whom the jurisdiction of healthcare is primarily under the federal government; these groups of people include First Nations and Inuit, and members of naval services (Conference Board, 2013).

The federal government's main involvement with Canada's decentralized healthcare system is the provision of financial support to sustain the provincial and territorial universal health insurance plans (Government of Canada, 2018). For instance, the federal government established the *Canada Health and Social Transfer* (CHST) in 1995, which was a block funding program that used federal funds and tax transfers to financially support healthcare, post-secondary education, social services and social assistance. In 2004, CHST was split into two programs, namely, *Canada Social Transfer* (CST) and the *Canada Health Transfer* (CHT). The CST program provides block funding for post-secondary education, social services and social assistance. The CHT provides block funding for healthcare to all the provinces and territories; furthermore, CHT is Canada's largest federal transfer to provinces and territories. The provinces and territories must adhere to the five principles of the *Canada Health Act* mentioned earlier to receive financial support through the CHT (Conference Board, 2013; Department of Finance-Government of Canada, 2011; Government of Canada, 1985, 2018; Martin et al., 2018; Office of the Auditor General of Canada, 2002).

1.2 **Primary care**

Primary care essentially refers to medical services individuals receive when they first contact the healthcare system; such care is comprehensive, coordinated and continuous. Primary care is comprehensive as it addresses most of an individual's

health-related issues. Primary care is coordinated because it ensures that various healthcare needs of a patient are met; for instance, if a patient is in need of mental health services, the patient's primary care physician (PCP) could refer her/him to a psychologist. Primary care is continuous because it spans a patient's lifetime (Hawk, 2002; Kroenke, 2004; Starfield, 1994). In Canada, the vast majority of primary care is provided by PCPs; these healthcare practitioners are exclusively physicians who specialize in family medicine. On the contrary, PCPs in other countries, including the United States (US), can include specialists like pediatricians and geriatricians (Canadian Medical Association, 1994). In the Canadian context, 'family physician' and 'primary care physician' are synonymous and, therefore, are used interchangeably throughout this thesis.

Though the terms 'primary care' and 'primary healthcare' are distinct, they are often used interchangeably in the health services research literature. While primary care involves a patient's first-contact interaction with a clinician, primary healthcare involves a patient's interaction with any sector of a healthcare system. For instance, water sanitation does not pertain to primary care but, rather, pertains to primary healthcare (Muldoon et al., 2006).

Fee-for-service (FFS) and capitation are the two dominant remuneration mechanisms for primary care physicians; the unit of payment in FFS and capitation is the 'service' and the 'person', respectively (Quinn, 2015).

A key advantage of FFS is that it rewards the provision of targeted and specific services. However, one disadvantage of FFS is that certain functions of primary care, such as coordination of care, are not directly rewarded under FFS; for instance, under FFS, a clinician is not incentivized to spend his/her time on coordinating non-reimbursable services such as non-face-to-face consultations via

phone or e-mail communication. Another disadvantage of FFS is that it, arguably, rewards the overprovision of care to patients, where the extra medical services may be unnecessary (Berenson & Rich, 2010; Simoens & Giuffrida, 2004).

A strength of capitation is that this remuneration mechanism incentivizes physicians to increase their patients' access to comprehensive care (Blomqvist & Busby, 2012; Brosig-Koch et al., 2017; Kralj & Kantarevic, 2013). This motivation for improving care access may not be as explicit in FFS where physicians can be indifferent towards the number of patients they have—especially since the unit of payment is the service and not a person. While physicians remunerated by FFS can bill a single patient for numerous services, their capitated counterparts receive a fixed income per patient per unit of time. Arguably, capitated physicians would be more incentivized to provide better care quality to their patients than their FFS counterparts so as to retain patients; unlike in capitation, disenrollment of a patient does not necessarily translate to financial loss in FFS (Blomqvist & Busby, 2012; Kralj & Kantarevic, 2013). A disadvantage of the capitation system is that inadequate case-mix adjustment can result in under-provision of services or over-payment. For instance, many capitated physicians with very sick patients can be underpaid for their services, which, in turn, can incentivize them to offload their care to specialists (Berenson & Rich, 2010; Sarma et al., 2018); capitation can also incentivize physicians to select low-risk (i.e., healthy) patients, a phenomenon known as 'cream-skimming'.

Primary care reform

Care gaps in the pre-reform system of primary care were noted by many including Commissioner Roy J. Romanow, and The Honourable Michael J. L. Kirby (The Standing Senate Committee on Social Affairs Science and Technology, 2002;

Romanow, 2002). In October 2002, Kirby stated that the poor management of patients' information, weak emphasis on both health promotion and preventive care can partly be attributed to the fact that primary care physicians practice in solo and under fee-for-service remuneration. Kirby recommended that primary care physicians should practice in groups rather than in solo, and that patients should be formally enrolled to physicians. Romanow emphasized the need for a focus on the evidence-based quality aspect of care ranging from the determination of quality indicators to the evaluation of care quality. Many of the recommendations of the Kirby and Romanow reports have been implemented in Ontario through the introduction of new primary care models.

In the early 2000s, most PCPs in Ontario were remunerated through FFS with the exception of a small number of family physicians who practiced in Community Health Centres (CHCs), Health Service Organizations (HSOs) and pilot Primary Care Networks (PCNs) that were experimented in 1999; physicians in HSOs and PCNs were paid through capitation, while PCPs in CHCs were remunerated through salary (Henry et al., 2012). In 1996, both the Ontario Medical Association (OMA) and the Ministry of Health and Long-term Care (MOHLTC) announced their collaboration to reform primary care.

A key feature of these reformed models is the blended payment system for primary care physicians whereby revenue is based on a composite of various forms of remuneration—with one form being dominant. For instance, in blended FFS (also known as enhanced FFS), the majority of income is through FFS, while minor sources of revenue come from financial incentives such as bonuses and premiums. The primary aim of the reform was to improve access to and quality of primary care in Ontario; reforming physicians' remuneration mechanism to blended payment was key

in the provincial government's initiative for improving access and quality (Sweetman & Buckley, 2014). The post-reform models of primary care delivery are not only characterized by physicians' reformed payment scheme but are also known for having other features including patient rostering, the formal procedure whereby a patient is officially enrolled to a physician. The main post-reform models for primary care physicians include the Family Health Network (FHN), Family Health Group (FHG), Comprehensive Care Model (CCM) and Family Health Organization (FHO) (Sweetman & Buckley, 2014).

The FHN was introduced in April 2002; this model requires at least three physicians, and the remuneration mechanism for family physicians in a FHN is blended capitation. For their enrolled patients, physicians in this model receive capitation and FFS payments for capitated and non-capitated services, respectively. While there is no enrollment limit, the per-patient capitation payments are reduced by 50% for each patient enrolled above an average of 2,400 patients per physician in the group. The annual capitation rate, which is age and sex adjusted, had an average base rate of $126.48 in 2014 (Sweetman & Buckley, 2014).

In July 2003, the provincial government introduced the FHG, whereby family physicians' remuneration mechanism is blended FFS, and this model also requires a minimum of three physicians. Under the FHG model, physicians receive 100% FFS payments, in addition to incentives and bonuses. While patient enrollment is optional in FHG, it is encouraged as physicians can be entitled to some incentives for enrolled patients; thus, formal patient enrollment encourages family physicians to meet certain targets for patients (Sweetman & Buckley, 2014).

The CCM model was introduced in October 2005 and features of this model are identical to the FHG with an exception of the minimum number of physicians

being one in a CCM. The CCM was designed for family physicians who wanted to maintain solo practice and still be a under a payment model with features of a FHG (Sweetman & Buckley, 2014).

The FHO model was introduced in November 2006 and, like the FHG model, a FHO requires a minimum of three family physicians. The remuneration scheme in a FHO is blended capitation; like in a FHN, capitation payment per patient is reduced by approximately half for each patient enrolled above an average of 2,400 patients per physician in the group . In FHOs, the capitation payments per patient are age-and-sex-adjusted, with an average base rate at $139.12 in 2014 for a slightly larger basket of services than in FHN (Sweetman & Buckley, 2014).

These four post-reform primary care models give family physicians incentives for providing after-hours care and preventive medical services; for instance, family physicians in CCM, FHG, FHN and FHO can receive the 'Colorectal Screening Bonus (Q150)' if they screen eligible enrolled patients aged between 50 and 74 years for colorectal cancer (Ontario Medical Association, 2015).

Many family physicians in Family Health Groups switched to Family Health Organizations—a major transition of PCPs between primary care models; in Ontario, majority of PCPs now practice in either a FHG or FHO (Kralj & Kantarevic, 2013; Office of the Auditor General of Ontario, 2018). The main difference between these two primary care delivery models is that FFS and capitation is the dominant mode of remuneration in FHGs and FHOs, respectively (Sweetman & Buckley, 2014). The remuneration package of these two models constitutes identical pay-for-performance (P4P) schemes; such schemes can be defined as financial rewards for physicians' provision of evidence-based care (e.g., prescription of antihypertensive medication for persons diagnosed with high blood pressure) and/or meeting of health outcomes (e.g.,

lowered blood pressure for patients with hypertension) (Milstein & Schreyoegg, 2016). More description of the FHG and FHO models are provided in Table 1 (Goldblatt et al., 2018; Government of Ontario, 2014; McLeod et al., 2016; Ministry of Health and Long-Term Care, 2007, 2011; Ministry of Health and Long-Term Care Primary Health Care Team, 2008; Ministry of Health and Long Term Care, 2013; Sweetman & Buckley, 2014).

When the FHG and FHO models were introduced, the Ontario MOHLTC designed contracts that detailed the entire remuneration structure of PCPs in the respective models. With the passage of time, the FHG and FHO remuneration schemes were slightly modified from the original contracts and information on such modifications are available in several bulletins from the Ontario MOHLTC.

1.3 **Quality of care**

As mentioned earlier, a major aim of Ontario's primary care reform was to improve the quality of first-contact care. Donabedian explained that care quality is a nonunitary concept as it can be defined from multiple perspectives (Donabedian, 1988, 2002). For example, patients' and physicians' conceptualization for quality of care can be distinct: a clinician's operationalization of care quality may correspond to adherence to evidence-based recommendation—while that of a patient may correspond to interpersonal communication (Donabedian, 1988; Haggerty, 2011). In spite of care quality being a nonunitary phenomenon, Donabedian (1988) explained that inferences about quality of care can be drawn from three metrics, namely, structure, process and outcome measures.

Structure refers to infrastructural features in which care is occurring, and such features include resources such as 'size of medical staff', and 'possession of advanced diagnostic and curative technologies'. Process represents the undertaking of a clinical

action that is expected to produce beneficial outcomes in patients' health; a classic exemplar of process is the prescription of a drug whose use has been shown to result in favourable outcomes. Finally, an outcome measure refers to an end result of care and relates to some aspect of health (e.g., 'mortality risk' and 'quality of life'). The use of the Donabedian's structure-process-outcome framework is widely used in the health services literature. According to this framework, improving structure is expected to result in better processes of care which, in turn, is expected to culminate in better health outcomes (Ameh et al., 2017; Donabedian, 1988; Moore et al., 2015).

As per Donabedian's framework, participating in a care process is ideally expected to have a significant impact on outcome. For instance, the (prophylactic) prescription of angiotensin converting enzyme inhibitors (ACEIs) or angiotensin II receptor blockers (ARBs) classes of drugs for persons with diabetes mellitus is exemplary of an ideal process measure as randomized, placebo-controlled trials have shown that use of either ACEIs or ARBs is significantly associated with a delay in nephropathy progression in persons with diabetes (Diabetes Canada Clinical Practice Guidelines Expert Committee, 2018; Lewis et al., 2001; Ravid et al., 1993).

While many studies use elements Donabedian's framework (i.e., structure, process or outcome measures) for evaluating quality of care, studies' operationalization of quality is often with limitations (Kiran et al., 2014; To et al., 2015). For example, in Kiran et al.'s (2014) comparison of diabetes care quality between various physician payment models, one of the quality indicators—as per care processes—corresponded to proportion of patients who received lipid assessment at least once annually. Under this binary definition, physicians who assessed patients' lipid profile more frequently (e.g., four or five times) are not distinguished from those who tested just twice. Though being diagnosed with diabetes was common to all

patients in Kiran et al.'s (2014) study, the specific needs of each patient is likely to vary: some patients may have an indication for lipid assessment at least four times annually (Diabetes Canada Clinical Practice Guidelines Expert Committee, 2018). Donabedian (2002) alluded to such limitations when defining of quality indicators; therefore, it is important that researchers be cognizant of such.

1.4 Overall thesis objective

The transition of Ontario's family physicians from Family Health Groups to Family Health Organizations represents a major switch of family physicians between primary care models (Kralj & Kantarevic, 2013). Therefore, Ontario's natural experiment provides a unique opportunity to understand the behaviour of physicians in FFS- and capitation-based models in terms of the provision of various processes of care and resulting health outcomes. There are theoretical and empirical explanations on how physician behaviour can be impacted by FFS or capitation. Using an experimental economics approach, Hennig-Schmidt, Selten, & Wiesen (2011) found that FFS reinforces overprovision of healthcare services, while capitation reinforces underprovision of healthcare services. Furthermore, FFS and capitation have their unique strengths with regards to improving quality of care (Hennig-Schmidt et al., 2011); it is argued that FFS leads to better access to care, while capitation leads to better continuity of care (Brosig-Koch et al., 2017; Gosden et al., 2001; Kralj & Kantarevic, 2013; Li et al., 2014). A capitation-based payment system is hypothesized to improve quality of care and population health in the context of Ontario for two important reasons. Firstly, capitation incentivizes optimal patient enrollment because in the FHO model, a PCP's capitation payment is reduced by 50% for every enrolled patient above a roster size of 2,400 per physician in the group. Furthermore, the FHO incentivizes the increase in access to care for the enrolled patient population because

PCPs in the FHO model are exclusively entitled to an "access bonus", which is a financial incentive for providing in-basket services to rostered patients. The incentive for increasing access to comprehensive care is not as pronounced in blended FFS compared to blended capitation; a FFS physician could be indifferent to the number of patients they enroll if they can still bill for many services from fewer patients (Blomqvist & Busby, 2012; Brosig-Koch et al., 2017). Secondly, capitation incentivizes the retention of enrolled patients by keeping them as healthy as possible; one way to achieve this could be adhering to the provision of preventive care services as well as process measures that are pertinent to better disease management (Blomqvist & Busby, 2012; Brosig-Koch et al., 2017).

The aforementioned reasons serve as the rationale for empirically investigating whether patients receive better care from PCPs practicing in FHOs compared to PCPs who remained in FHGs. The main objective of the thesis was to compare the impact of physician remuneration mechanisms, namely, blended FFS and blended capitation, on quality of care in chronic disease management and patients' health outcomes (estimate of mortality risk, and avoidable hospitalizations). Three separate studies were conducted to achieve this objective. The first study (Chapter 3) investigated the impact of physicians' switch from blended FFS to blended capitation on processes of care and health outcomes (estimate of mortality risk, and avoidable hospitalizations) for persons with diabetes mellitus. The second study (Chapter 4) investigated the impact of the switch from blended FFS to blended capitation on provision of post-discharge follow-up care and health outcomes for persons with CHF. The third study (Chapter 5) investigated whether blended capitation—compared to blended FFS—is associated with better CKD care quality as per CKD process measures and patients' estimate of mortality risk. For all three studies, we

hypothesized that care provision is better under blended capitation than in under blended FFS.

Relevant information regarding the pathophysiology of diabetes mellitus, congestive heart failure and chronic kidney disease are briefly provided in the Chapter 7 (Supplementary Material for Introduction Chapter). The next chapter presents findings of the literature on the association between physicians' remuneration mechanism and care quality of the three chronic conditions.

Table 1 Family Health Group and Family Health Organization models.

Model	**Family Health Group**	**Family Health Organization**
Period introduced	July 2003	November 2006
Minimum group size	3	3
Remuneration structure and features	• Income is primarily through fee-for-service. • Care is physician-led; members of a FHG can included a limited number of non-physicians (i.e., limited interprofessional involvement). • While patient enrolment is not required, certain types of payments can only be received for rostered patients. • Physicians are entitled to the 'comprehensive care premium', whereby they receive 10% premium for a repertoire of services provided to enrolled patients. • Physicians are eligible to bill new patient fee code, Q013A, for rostering up to 60 new patients. • Physicians in this payment model are eligible to claim pay-for-performance incentives such as the	• Income is primarily through capitation for capitated services provided to enrolled patients (therefore patient enrolment is required to receive income). • Care is physician-led; like in FHGs, interprofessional involvement is limited—except physicians who are part of a Family Health Team. • The capitation payments are age-and-sex-adjusted. For the 2014 fiscal year, the capitation rate, on average, was $139.12; however, this rate is reduced by 50% for every rostered patient above a roster size of 2,400 per physician in the group. • Physicians are entitled to "shadow billing premium" for capitated services provided to rostered patients. As per this premium, physicians are remunerated 15% of the fee-for-service value of the capitated services. • Fee-for-service payments are received for: non-enrolled patients and non-capitated

‘Diabetes Management Incentive (Q040A)’, ‘Heart Failure Management Incentive (Q050A)’ and ‘Smoking Cessation Counselling premium (Q042)’.

services. However, these payments are capped at a certain amount; for instance, in the 2014 fiscal year, payments were capped at $52,883.

- Physicians are entitled to “access bonus” whereby physicians are remunerated 18.59% of all capitation payment twice a year. Access bonus is slightly higher for patients in long-term care.
- Physicians are entitled to new patient fee (Q013A) just like FHGs.
- Unlike in the FHG model, physicians under this model are not eligible for the comprehensive care premium.
- Unlike in the FHG model, physicians in this model receive financial reward for completing continuing medical education (through seminars and conferences) (Q555). Hence the Q555 incentive can be said to motivate physicians to be current with the medical literature.
- Physicians are entitled to P4P incentives (such as Q040A, Q042, and Q050A) just like in FHG; see column for FHG for more details on these.

Provision of after-hours care (Each physician is required to cover one 3-hour session of after-hours care per week. Longer duration of blocks is to be covered by larger number of physicians. For example, groups of 10 to 19 physicians are to provide a total number of 7 after-hours blocks, while groups of 30 to 74 physicians are to provide a total number of 10 after-hours blocks; physicians are entitled to the after-hours premium (Q012A).)	• Mandatory.	• Mandatory.

Note: after-hours care refers to care that (1) starts any time between 5 and 7 pm on Monday to Thursday, (2) statutory holidays, and (3) weekends.

Sources: Goldblatt et al., 2018; Government of Ontario, 2014; McLeod et al., 2016; Ministry of Health and Long-Term Care, 2007, 2011; Ministry of Health and Long-Term Care Primary Health Care Team, 2008; Ministry of Health and Long-Term Care, 2013; Sweetman & Buckley, 2014

Chapter 2

2 Literature review: The relationship between physicians' payment model and care quality for diabetes mellitus, congestive heart failure and chronic kidney disease

2.1 The salience of physicians' remuneration mechanism in quality of primary care services

The objective of this thesis is to investigate the quality of care for diabetes mellitus, chronic kidney disease (CKD), and congestive heart failure (CHF) in Ontario's Family Health Group and Family Health Organization primary care models. Investigating the impact of remuneration models on care quality is a topic of great relevance for many reasons.

Firstly, the provincial government partly relied on restructuring family physicians' mode of remuneration to improve access to and quality of care for residents of Ontario. For instance, various P4P schemes in the post-reform blended payment models, including FHGs and FHOs, were designed to incentivize family physicians to meet health targets, improve preventive care services and provide care during after-hours such as on weekends, statutory holidays and after 5 PM on weekdays (Sweetman & Buckley, 2014).

Secondly, a lot of financial resources have been invested to sustain these post-reform payment models; for example, in the 2007/08 fiscal year, family physicians in the post-reform blended remuneration models received 25% more payment than their counterparts in pure FFS (Office of the Auditor General of Ontario, 2011). Furthermore,

in the 2012/13 fiscal year, $4.2 billion was paid to Ontario's PCPs, and $3.4 billion (i.e., approximately 80%) of this payment was made to family physicians in blended payment models (Office of the Auditor General of Ontario, 2013). To date, most of Ontario's primary care physicians practice either in a FHG or FHO; by September 1st 2017, 58% and 29% of family physicians in the province were in FHOs and FHGs, respectively (personal communication with Ontario Ministry of Health and Long-term Care).

Thirdly, there is mixed evidence regarding whether there is an association between physicians' payment scheme and quality of care provided (Jaakkimainen et al., 2011; Kiran et al., 2014). While some studies find that family physicians under a capitation-based scheme provide better care than their counterparts in a FFS-based system, other studies found no association or the converse. For example, a study by Jaakimainen, Barnsley, Klein-Geltink, Kopp, & Glazier, (2011) reported that physicians in blended FFS and blended capitation were not different in their adherence to process measures for diabetes, while the study by Kiran, Victor, Kopp, Shah, & Glazier, (2014) found that physicians in blended capitation adhered more to diabetes process measures compared to those in blended FFS.

Lastly, studying the relationship between physicians' remuneration mechanism and care quality for diabetes, congestive heart failure and chronic kidney disease is relevant; each of the three poses an economic burden to healthcare, and negatively impacts millions of individuals globally.

Diabetes affects at least 462 million people worldwide (Khan et al., 2020); in Canada, the number of individuals diagnosed with this metabolic disorder has increased

by more than twice since 2000 and, in 2015, 8.9% of the Canadian population (i.e., 3.34 million Canadians) was diagnosed with diabetes (Diabetes Canada, 2015, 2016; World Health Organization, 2017). The mortality and morbidity associated with diabetes mellitus is costly to healthcare systems worldwide (Zhang et al., 2010); long-term consequences of this condition include foot ulcers, vision loss, depression, myocardial infraction, end-stage renal disease, lower limb amputation, and stroke (George et al., 2014; Government of Canada, 2011; Naslafkih & Sestier, 2003). Through joint efforts with the *Centre for Spatial Economics* and *Informetrica Limited* (Diabetes Canada, 2009a), Diabetes Canada produced a report on costs (in 2009 Canadian dollars) associated with diabetes, in each of the Canadian provinces—including Ontario (Diabetes Canada, 2009b). According to this report, diabetes mellitus costed Ontario approximately 4.9 billion dollars in 2010, and the projected cost for 2020 is approximately 7 billion dollars (Diabetes Canada, 2009b); hospitalizations and long-term disability each accounted for a substantial amount of the costs; for example, the cost estimates of long-term disability for 2000, 2010 and 2020 were 463, 998 and 1,495 million dollars respectively (Diabetes Canada, 2009b).

Congestive heart failure affects approximately 26 million people worldwide (Savarese & Lund, 2017); furthermore, this condition is a leading cause of hospitalization in Canada (Yeung et al., 2012). While Ontario may have witnessed a relative decline in the rate of CHF-related hospitalizations, this chronic illness remains a major source of economic burden (Tran et al., 2016; Wijeysundera et al., 2010). Tran et al., (2016) performed a cost-analysis (in 2014 Canadian dollars) to determine the annual per patient

hospital admission cost for CHF between the 2004 and 2013 fiscal years in Canada; admission costs increased from $9,700 in 2004 to $11,000 per patient in 2013. The authors projected that the cost of a person with CHF admitted to hospital would be $14,000 per patient by 2030. Using provincial-level administrative databases, Wijeysundera et al. (2010) performed a cost-effectiveness analysis (CEA) study that compared the cost of CHF care in two settings, namely, the standard care setting (defined as care provided by a single practitioner) and the CHF clinic setting (defined as care provided with at least one physician, or nurse, with specialized training in CHF care). This CEA used the perspective of the Ontario Ministry of Health and Long-term Care, and the time horizon was 12 years. The cumulative lifetime discounted cost of CHF care in the standard care and CHF clinic settings were $53,638 and $66,532 per patient, respectively; CHF clinics costed $18,259 for each additional life-year gained; all cost estimates were in 2008 Canadian dollars.

Approximately 700 million individuals are affected by chronic kidney disease globally (Bikbov et al., 2020); in Canada, this condition affects at least 4 million individuals (Bello et al., 2019b). The economic burden posed by chronic kidney disease stems from the fact that the condition affects many persons of working age; an individual's income loss consequently translates to decreasing tax revenue. Persons diagnosed with CKD receive disability payments from the government and/or private insurers. Disability insurance costs for Canadians with advanced kidney failure is over $200 million per annum in Canada with at least 70% of the cost being incurred by private insurance (Manns et al., 2017). In 2015, $580 million was spent on kidney dialysis

services in Ontario alone (Ontario Renal Network, 2016). Chronic kidney disease can progress to end stage renal disease (ESRD) or renal failure; persons with ESRD require kidney transplant or dialysis to remain alive (Molony & Craig, 2009). Hence, management of CKD is beneficial as it can delay progression to ESRD.

In studies that investigated the relationship between physicians' mode of remuneration and quality of care metrics known as 'process measures' are often used to compare care quality. As mentioned previously, delivery of a care process is expected to result in an improvement in outcome. For example, a physician who prescribes ACEIs or ARBs to a persons with diabetes is said to provide better care quality than their counterpart who doesn't because randomized controlled trials have shown that use of ACEIs or ARBs significantly delays progression of nephropathy in this patient population (Lewis et al., 2001; Ravid et al., 1993). There are clinical actions for which the evidence to support an association with an improvement in health is absent, and Donabedian (1988) stated that such clinical undertakings can still be deemed process measures only if opinions from well-informed, authoritative entities endorse such clinical behaviours as measures of care process. While counselling persons with diabetes on self-management is considered a process measure merely on expert opinion (American Diabetes Association, 2018), a clinician who delivers this care process is said to provide better quality than their counterpart who doesn't because counselling is likely to indirectly result in better health outcomes for the patient.

Process measures relevant to the primary care management of diabetes mellitus include testing of glycated hemoglobin ($HbA1_c$), eye examination, lipid assessment,

statin prescription, measurement of blood pressure and nephropathy screening; these care processes are also congruent with clinical guidelines of Diabetes Canada. Many of the process measures relevant to the primary care management of congestive heart failure are drug-based, and these care processes are congruent with the Canadian Cardiovascular Society (CCS) clinical guidelines (Ezekowitz et al., 2017). Process measures relevant to the primary care management of chronic kidney disease include: testing of serum creatinine and urine albumin-to-creatinine ratio (ACR), and prescription of ACEIs (or ARBs) and statins (Tu et al., 2017); these quality indicators are congruent with clinical guidelines of the Canadian Society of Nephrology (Levin et al., 2008). Relevant literature on the process-outcome link for process measures related to the primary care management of diabetes, congestive heart failure and chronic kidney disease is presented in the Appendix at the end of this chapter.

The various measures for outcome of care include mortality risk and avoidable hospitalizations (Ansari, 2007; Parchman & Culler, 1994; Starfield et al., 2005). Mortality risk score (MRS) is an estimate of an individual's all-cause risk of death within one year as per an algorithm by Austin and Walraven (2011). An avoidable hospitalization refers to hospitalization due to an ambulatory care sensitive conditions which are conditions for which "timely and effective outpatient care can help to reduce the risks of hospitalization by either preventing the onset of an illness or condition, controlling an acute episodic illness or condition, or managing a chronic disease or condition"(p.163)(Billings et al., 1993).

In general, a physician's remuneration package is often defined by the mode of payment (e.g., fee-for-service, capitation or salary) and/or the presence of financial incentives such as P4P schemes (Sweetman & Buckley, 2014). Such schemes were designed to improve care in many ways; for one, it standardizes clinical practice by motivating physicians to adhere to the same evidence-based care processes (Christianson et al., 2006). For another, it aims to reduce care gaps; according to the literature, actual levels of physicians' adherence to evidence-based care processes are well below ideal (Khadilkar et al., 2014; Ornstein & Jenkins, 1999; Shah et al., 2009; Shubrook et al., 2010). For instance, a national registry in the United States found that: of the 603,014 patients with CHF who were eligible for prescription of mineralocorticoid receptor antagonists (MRA) drugs, only 36.1% of them received MRAs (Zannad et al., 2012). Similarly, results from the study by Oude Wesselink et al. (2015) support that there are care gaps in management of chronic conditions. Using data on persons diagnosed with diabetes mellitus from 18 primary care groups in Netherlands, this study found that the adherence level greatly varied for different process measures: 91% (interquartile range (IQR): 85% - 100%) of patients received annual $HbA1_c$ testing, 28% (IQR: 10% - 43%), and 33% (IQR):12% - 49%) received annual eye and foot examination, respectively (Oude Wesselink et al., 2015). The *Guideline Adherence to Enhance Care* (GUIDANCE) study by Stone et al., (2013) had similar findings as Oude Wesselink et al. (2015). Stone et al., (2013) assessed adherence levels for diabetes in primary and specialist care across eight European countries, namely, Belgium, France, Germany, Ireland, Italy, the Netherlands, Sweden and the United Kingdom and found that adherence level varied

across process indicators: the adherence level of $HbA1_c$ testing was 97.6% (95% confidence interval (CI): 97.3% - 98.0%), while that of ACR assessment was 59.4% (95% CI: 58.3% - 60.5%) (Stone et al., 2013). Likewise, Khadilkar, Whitehead, Taljaard, & Manuel (2014) evaluated the adherence level of diabetes process measures for members of the Canadian Forces and found that adherence level of annual foot examination was 15.9% (95% CI: 12.3% -19.5%), while that of $HbA1_c$ testing was 75.3% (95% CI: 71.0% - 79.5%).

The remainder of this chapter presents findings from the literature related to the relationship between physicians' remuneration and care quality insofar as management of diabetes mellitus, congestive heart failure and chronic kidney are concerned.

Pay-for-performance incentives and care quality

The existing literature has mixed evidence regarding the impact of P4P programs on care quality; while some studies found that the introduction of such incentives were associated with an improvement in care quality, others found no such association.

Ryan, Krinsky, Kontopantelis, & Doran, (2016) examined the impact of the Quality and Outcomes Framework (QOF) on mortality reduction in the United Kingdom (UK) population. The QOF is the largest primary care P4P program in the world, and was introduced to UK's primary care in 2004 (Pandya et al., 2018; Ryan et al., 2016). An aim of this P4P incentive is to improve quality of care management for specific health conditions including diabetes mellitus and chronic kidney disease. Using data between 1994 and 2010, Ryan et al. examined whether reduction in sex-adjusted and age-adjusted mortality per 100,000 ensued after the QOF was introduced—and mortality was due to a

composite of health conditions targeted by the QOF (Ryan et al., 2016). The authors created a 'synthetic control group consisting of 27 nations, which correspond to the UK population without the introduction of the QOF. The authors' post-intervention period was 2004 – 2010 inclusive (i.e., 7 years after the introduction of QOF), and 1994 – 2003 served as the pre-intervention period. Using a difference-in-differences (DID) analysis, Ryan et al. (2016) found that the reduction in mortality that was observed was not statistically significant, and therefore concluded that introduction of this P4P scheme was not associated with reduction in population mortality due to the targeted conditions.

O'Connor et al. (2020) found that improvement in diabetes care in the Republic of Ireland followed the introduction of the cycle of care (COC) program, a P4P scheme designed exclusively for the management of diabetes mellitus. Under the COC, general practitioners receive €30 for each registered patient, and are remunerated €100 per caput annually for two patient visits (O'Connor et al., 2020). This financial incentive was introduced to Ireland's primary care on October 2015; the authors used the years 2014 and 2017 as the pre-COC and post-COC periods, respectively; and data from these periods were obtained for 3,146 persons with type 2 diabetes. Results showed that rates of testing for $HbA1_c$, total cholesterol, creatinine, ACR ratio, and blood pressure increased by 45%, 40%, 71%, 32%, and 37%, respectively. Moreover, the 2017 post-COC rates of these diabetes care process were comparable to those in the 2015-2016 United Kingdom National Diabetes Audit (UKNAD) post QOF. For instance, 95% of persons with diabetes in the UK received $HbA1_c$ testing, and 98% of the patients in the study by O'Connor et al. (2020) received this process measure.

Numerous studies have investigated the effect of the Hospital Readmissions Reduction Program (HRRP), a P4P program that was set up by the Centres for Medicare and Medicaid Services (CMS) in 2010 (Fischer et al., 2015; Wadhera et al., 2019). The CMS is under the US Department of Health and Human Services, and oversees Medicare and Medicaid—where the two are government-run programs that provide healthcare coverage for American residents (Galan, 2020). The HRRP applies financial penalties to hospitals with unexpectedly high rates of 30-day all-cause readmission after hospitalization for specific conditions such as congestive heart failure, acute myocardial infarction and pneumonia (Fischer et al., 2015; Wadhera et al., 2019). Though the HRRP was announced in March 2010, it was implemented as of October 2012 (Desai et al., 2016); a hospital is subject to the financial penalty only when its 30-day all-cause readmission rates surpasses those of the nation, on average (Boccuti & Casillas, 2015); patient demographics such as illness severity are accounted for when comparing hospital readmission rates with national average estimates.

Using interrupted time series analyses on US-wide data, Desai et al. (2016) investigated whether a reduction in the 30-day all-cause readmission rate—after discharge from CHF-related hospitalizations—ensued between April 2010 and September 2012 (i.e., the time period between HRRP announcement and its implementation). The authors compared this rate between 2,214 and 1,108 hospitals that were and were not subject to the HRRP, respectively. Desai et al. (2016) found that the rate was significantly ($p<0.001$) lower for hospitals subjected to the HRRP (Difference in annualized rate of change= -1.25 %). However, this finding contrasts with conclusions of

Mellor et al. (2017) who investigated the effect of the HRRP in hospitals across Virginia state (Mellor et al., 2017). Using data from the years 2008, 2009, 2012, 2013 and 2014, Mellor et al. (2017) found that the HRRP did not lower the risk of 30-day readmissions after CHF-related discharges. This finding is congruent with results from the study by McGarry et al. (2016) who evaluated the effect the HRRP in hospitals across New York state in two post-HRRP periods; the first period was from the 4th quarter (i.e., between October and December inclusive) of 2011 to the 4th quarter of 2012, while second period was from the 1st quarter of 2013 to November 2013. The authors used DID analyses on 2008 to 2013 data, and their main outcome of interest was 30-day readmission rates after discharges related to CHF, acute myocardial infraction and pneumonia (McGarry et al., 2016). McGarry et al. (2016) found that, compared to a pre-HRRP period, there was no change in the readmission rates in the first period, nor in the second period.

Findings from other international studies, such as the one by Lalloué et al. (2017), have also contributed to the mixed body of evidence. The authors evaluated the effect a P4P program for all acute care hospitals across France, namely, the Financial Incentive to Quality Improvement ('Incitation financière à l'amélioration de la qualité' (IFAQ)). The goal of IFAQ is to improve hospitals' management of various conditions including renal failure and acute stroke (Eckhardt et al., 2019). Under this program, only the top 20% of healthcare providers with highest care performance are financially rewarded, and the remuneration ranges between €15,000 and €500,000 (Eckhardt et al., 2019). Though IFAQ was implemented in 2016, it was experimentally introduced in 2012; the work of Lalloué et al. (2017) was a pilot study investigating the program's impact in its

experimental phase. The authors used 2009 to 2011 as the pre-intervention period; 2011 to 2013 represented the intervention period. In Lalloué et al. (2017), the treated and control groups corresponded to the 185 and 192 hospitals that did and did not receive IFAQ. The outcome was a weighted composite score of quality indicators—where higher scores indicate better quality. Using a DID analysis, the authors found that introduction of IFAQ did not impact quality (Lalloué et al., 2017).

As mentioned earlier, chronic kidney disease management is important as it delays the condition's progression to ESRD; as mentioned earlier, kidney transplantation or dialysis is essential for persons with ESRD to remain alive (Molony & Craig, 2009). The Taiwan National Health Insurance (TNHI), which is Taiwan's mandatory, single-payer health insurance system that covers 99% of the country's residents, launched the pre-ESRD P4P program in 2006 (Hsieh et al., 2017). The TNHI developed this program to reduce the incidence of ESRD by improving quality of CKD care (hence the term 'pre-ESRD'). A feature of this P4P program is that a multidisciplinary team of healthcare providers enrol persons with CKD who voluntarily chose to be enrolled for pre-ESRD care; such teams are entitled to be remunerated an equivalent of US$40 for a patient's initial enrollment visit; an equivalent of US$20 is rewarded for each follow-up visit with a patient. Furthermore, financial rewards are provided for attainment of targeted health outcomes; for instance, a bonus payment is received if enrollees' estimated glomerular filtration rate (eGFR) is lowered to below 4 mL/min/1.73 m^2 within one year after enrolment to pre-ESRD program (Lin et al., 2018). Using retrospective cohort design, Lin et al. (2018) examined the impact of the pre-ESRD P4P program on quality of CKD care

and mortality. Subjects were patients who initiated dialysis between 2007 and 2009 and eventually received dialysis for over three months; the P4P group constituted the subpopulation of subjects enrolled in the pre-ESRD P4P program, while non-enrolees corresponded to the non P4P group. Lin et al. (2018) found that the pre-ESRD P4P program improved CKD care quality. In one year prior to dialysis, the frequency of patients' eGFR measurement was significantly higher ($p<0.001$) in the P4P group (median=8, IQR: 5 – 12) than in the non-P4P group (median=5, IQR: 2 – 9). The authors also found that, enrolees had a significantly lower 3-year mortality risk post-dialysis than their counterparts who were not under the pre-ESRD program (Hazard Ratio (HR)=0.77, 95%CI: 0.73 – 0.82) (Lin et al., 2018).

While CKD was not initially among the targeted conditions of UK's QOF, this condition was included in this P4P scheme as of April 2006 (Karunaratne et al., 2013). Not only is hypertension a major risk factor of CKD, it progresses the condition; and ESRD is a consequence of this progression (Karunaratne et al., 2013). The impact of QOF renal indicators on care quality for persons with CKD was examined by Karunaratne et al. (2013). Given that hypertension is strongly related to CKD, some of the QOF renal indicators are: the measurement of blood pressure, and its control through effective management (i.e., attainment of 140/185 mmHg or less) (Karunaratne et al., 2013). In regards to the introduction of UK's QOF renal indicators, the authors' pre-intervention period spanned April 1, 2004 and March 31, 2006; the first and second post-intervention periods corresponded to April 1, 2006 to March 31, 2008, and April 1, 2008 to March 31, 2010 (Karunaratne et al., 2013). Karunaratne et al. (2013) concluded that

the renal indicators of QOF improved CKD care in the two post intervention periods. For instance, average blood pressure dropped from 143/78 mmHg in the pre-intervention period to 140/76 mmHg in the first post intervention period ($p<0.01$) (Karunaratne et al., 2013).

Richardson (2013) investigated the effect of the QOF program, on the quality of primary care for CKD using two process indicators: blood pressure measurement within 15 months and prescription of ACEI/ARBs. Using April 2004 to November 2005 as the pre-QOF period, the authors found that implementation of QOF was associated with a 2.7 percentage point increase ($p<0.001$) in practices' adherence to the CKD process indicators (Richardson, 2013).

Mode of payment and quality of care

While there is a plethora of studies on P4P schemes and care quality, far fewer ones specifically evaluate the impact of mode of payment (e.g., FFS and capitation) on physician's quality of care. Some studies found that quality of care under FFS- and capitation-based payments is different, while others found that care quality under the two is same.

A cross-sectional analyses by Kiran, Victor, Kopp, Shah, & Glazier (2014) found that the odds of an individual with diabetes receiving $HbA1_c$ testing, lipid measurement, and eye examination in Ontario was significantly higher in blended capitation than in blended fee-for-service (Odds Ratio (OR) =1.18, 95% CI :1.09 – 1.27). On the other hand, Jaakkimainen et al. (2011) in their cross-sectional study found that physicians in blended capitation and blended FFS were not significantly different in terms of their

adherence to process measures for diabetes. The varying conclusions could be due to the two studies using different time periods (Jaakkimainen et al., 2011; Kiran et al., 2014). For instance, the observation period used by Jaakkimainen et al. (2011) spanned 2004 to 2007, while Kiran et al. (2014) used 2006 to 2008 data. Furthermore, payment type was defined differently between the two studies; blended capitation constituted solely FHNs in Jaakkimainen et al. (2011), while Kiran et al. (2014) grouped FHOs and FHNs in their definition of blended capitation.

Physicians under different remuneration mechanisms can respond differently to the same financial incentive. The Diabetes Management Incentive (DMI) is a P4P scheme that financially rewards physicians for delivering care processes in accordance with Diabetes Canada's clinical guidelines. Using data from 2006 to 2010, Kantarevic & Kralj (2013) found that patients enrolled to physicians in Family Health Organizations were more likely to receive DMI services by 8.43% ($p<0.01$), compared to patients enrolled to physicians in Family Health Groups; furthermore, physicians in FHOs were more likely to participate in the DMI by 11.53% ($p<0.01$) compared to their counterparts in FHGs (Kantarevic & Kralj, 2013).

The cross-sectional study by Jaakkimainen et al. (2011) compared care processes by blended FFS and blended capitation physicians in terms of two CHF quality indicators, namely, prescription of ACEIs or ARBs, and receipt of echocardiogram within a year of CHF diagnosis. The study found that physicians under these two payment schemes were not significantly different in terms of their adherence to these two CHF process measures (Jaakkimainen et al., 2011). Using Ontario-specific data from 2005 to

2006, cross-sectional analysis by Russell et al. (2009) found that physicians under FFS- and capitation-based payment schemes were similar in terms of two CHF care processes, namely, prescription of ACEIs or ARBs, and prescription of beta-blockers (Russell et al., 2009).

Using a Cox proportional hazards regression, a study found that individuals with CHF who received higher rates (defined as 32.4% – 37.9%) of physician follow-up within 7 days of discharge, had a lower risk of all-cause 30-day readmission, compared to their counterparts who received lower rates (less than 32.4%) of 7-day physician follow-up (HR=0.85, $p<0.001$) (Hernandez et al., 2010). Physicians' follow-up visit, for persons with CHF, within four weeks post-discharge is deemed a performance indicator by the Canadian Cardiovascular Outcomes Research Team (CCORT) (Lee et al., 2003). Furthermore, physician follow-up of patients with CHF within 7 days post-discharge is also considered a performance indicator by 'Health Quality Ontario' (Health Quality Ontario, 2018).

While quality of CKD care has been described in various jurisdictions (Bello et al., 2019a; Eze, 2017; Gao, 2006; Nash et al., 2017), very few studies specifically investigated the impact of physicians' mode of remuneration on quality of CKD management (Liddy, Singh, et al., 2011; Richardson, 2013). In a secondary analysis by Liddy, Singh, et al. (2011), quality of CKD care was compared across 43, 27 and 12 Ontarian primary care practices constituted of family physicians in FFS, blended capitation and salary remuneration systems, respectively. The data for the secondary analyses came from a pragmatic trial named *Improved delivery of cardiovascular care*

(IDOCC), which is an outreach facilitation designed to improve the delivery of evidence-based care in primary care practices across the eastern part of Ontario. Outreach facilitation are educative programs for enhancing healthcare providers' care performance (Liddy, Hogg, et al., 2011). Quantification of eGFR per year was the only CKD quality indicator examined, and this study found that there was no difference in the performance of this indicator across the three payment systems. For instance, pairwise comparison of the blended capitation vs. FFS practices found that the two were statistically similar for eGFR measurement (OR=1.2, 95% CI: 0.6-2.3); nonetheless, the adherence level for this process indicator was high in all three payment systems. For example, eGFR measurement was performed for 1% (415/457), 93% (273/294), and 91% (107/117) of patients in FFS, blended capitation and salary practices, respectively (Liddy, Singh, et al., 2011).

The body of evidence pertaining to elements of physicians' remuneration—such as P4P schemes or mode of payment (e.g., FFS, and capitation)—and their quality of care is inconclusive, and reasons for this mixed literature include different: study designs, observation periods, definitions for controls, and jurisdiction of study population. Our three studies specifically compare physicians' payment mode (i.e., blended FFS and blended capitation) on several processes of care and outcomes. Given that the FHG and FHO models have the same P4P schemes (e.g., the Diabetes Management Incentive and the Heart Failure Management Incentive), we argue that our comparisons also examine whether impact of P4P schemes varies between a FFS or capitation environment. While

the FHG and FHO models have P4P programs for diabetes and CHF care, these patient enrollment models have no additional financial incentives for CKD care.

2.2 Appendix for Literature Review Chapter: Process-outcome link for care processes related to management of diabetes mellitus, congestive heart failure and chronic kidney disease

This section presents the detailed literature on the process-outcome relationship for processes of care related to the primary care management of diabetes mellitus, congestive heart failure and chronic kidney disease.

Diabetes mellitus

Glycated hemoglobin (or fructosamine) testing

Glycated hemoglobin testing has been recognized as the 'gold standard' for measuring blood glucose concentration averaged over 120 days (Bunn, 1981; Klein et al., 1987; Malik et al., 2000). While measuring plasma fructosamine is cheaper (and easier) than measuring $HbA1_c$, the former just reflects the average blood glucose concentration over the preceding two weeks. Using persons with diabetes as cases and persons without diabetes as controls, Malik et al. (2000) showed that while fructosamine testing is positively correlated with $HbA1_c$ testing (Pearson's correlation coefficient =0.6506, $p \leq 0.001$), the sensitivity of the former was 29.7% as many patients who had normal fructosamine levels, actually had abnormal levels of $HbA1_c$. Thus, Malik et al. (2000) concluded that plasma fructosamine testing is a poor substitute for $HbA1_c$ testing as it can underestimate the proportion of individuals who actually have diabetes.

A high $HbA1_c$ is a risk factor for developing complications related to diabetes (Krishnamurti & Steffes, 2001). For instance, Klein, 1995; Klein, Klein, Moss, & Cruickshanks, (1995) showed that, in type 2 diabetes, higher $HbA1_c$ levels at baseline was significantly associated with a greater increase in 10-year incidence rate of retinopathy ($p<0.005$). In addition, a high baseline level of $HbA1_c$ was also significantly associated with (1) a greater 10-year incidence rate of proteinuria ($p<0.0005$), and (2) greater risk for lower-extremity amputation ($p<0.005$) (Klein, 1995). For individuals with type 2 diabetes, one percentage point increase in $HbA1_c$ level was significantly associated with an increased risk of mortality due to ischemic heart disease (HR=1.10, 95% (CI: 1.04 - 1.1.7), and was also significantly associated with an increased risk of mortality due to stroke (HR=1.17, 95% CI: 1.05 – 1.30) (Klein, 1995).

Thus, $HbA1_c$ testing is prognostically relevant for persons with diabetes because developing very morbid conditions can be a long-term consequence of having increased levels of $HbA1_c$ (Klein, 1995). Moreover, the Diabetes Canada clinical guidelines recommend that $HbA1_c$ levels should be quantified twice and thrice annually for persons with diabetes who have, and have not, achieved glycemic control, respectively (Diabetes Canada Clinical Practice Guidelines Expert Committee, 2018).

Prescription of glucose lowering drugs

The *United Kingdom Prospective Diabetes Study* (UKPDS), a randomized controlled trial that commenced in 1977, was designed to establish whether there is an association between intensive control of blood glucose levels and the occurrence of microvascular (or macrovascular) complications in individuals with type 2 diabetes (UK

Prospective Diabetes Study (UKPDS) Group, 1998b); subjects were randomized to conventional treatment (i.e., dietary regimen) or intensive treatment (i.e., glucose-lowering medications). Results showed that the median $HbA1_c$ levels was significantly lower in the intensive treatment group (7.0%) compared to the conventional group (7.9%) ($p<0.0001$). Furthermore, in the UKPDS, a diabetes-related endpoint was defined by the occurrence of any one of the following outcomes: (1) sudden death, (2) fatal or non-fatal myocardial infraction, (3) death from hyperglycemia or hypoglycemia, (4) congestive heart failure, (5) angina, (6) vitreous hemorrhage, (7) renal failure, (8) stroke, (9) amputation, (10) retinal photocoagulation or (11) blindness in one eye or cataract extraction. The 'complication-free interval' was defined as the follow-up time to when 50% of the patients had at least one of the 11 aforementioned diabetes-related endpoints. Survival analysis in the UKPDS showed that the complication-free interval was significantly longer in the intensive treatment group (14 years) compared to the conventional group (12.7 years) ($p=0.029$). So, the UKPDS provided strong evidence to support that intensive glucose lowering, compared to dietary intervention, is associated with a lower risk of developing a diabetes-related complications in persons with this disease (UK Prospective Diabetes Study (UKPDS) Group, 1998b).

There are various glucose-lowering drugs, where metformin is the first-line therapy for individuals with type 2 diabetes (Canadian Diabetes Association, 2017; Nathan et al., 2009); results from UKPDS showed that, for persons with diabetes, the relative risk (RR) of developing any diabetes-related complication with metformin

compared to conventional therapy was 0.68 (95% CI: 0.53 - 0.87) (UK Prospective Diabetes Study (UKPDS) Group, 1998a)

Moreover, prescription of glucose-lowering drugs is also congruent with the Diabetes Canada clinical guidelines for diabetes management (Diabetes Canada Clinical Practice Guidelines Expert Committee, 2018).

Blood pressure measurement and control

Hypertension is the clinical term for the condition where an individual's blood pressure is abnormally elevated, and this condition is more common in persons with diabetes than in individuals without the disease (Arauz-Pacheco et al., 2003; Ganesh & Viswanathan, 2011). For a diagnosis of hypertension, a person must have a 'sustained' blood pressure recording of at least 140/90 mmHg; the 140 and 90 mmHg refers to systolic and diastolic pressure, respectively (Arauz-Pacheco et al., 2003; de Boer et al., 2017). Diagnosis of hypertension is always based on multiple blood pressure measurements that are each at least 140/90 mmHg, to rule out 'white coat hypertension'—which is the term for the transient hypertension that results from merely seeing a physician (hence the term 'white coat'). In 'white coat hypertension', a normotensive individual can record a measurement of 140/90 mmHg or greater—albeit only when in a clinic environment (Daskalopoulou et al., 2015; de Boer et al., 2017).

Data from the UKPDS was analyzed to evaluate the relationship between systolic blood pressure and the risk of developing any diabetes-related complication (Adler et al., 2000). In Adler et al. (2000), the risk of developing any diabetes-related complication—except for cataract extraction—significantly increased with increasing systolic blood

pressure in persons with diabetes ($p<0.0001$). On average, every 10mmHg reduction in updated mean systolic blood pressure was significantly associated with a 12% reduction in risk of any diabetes-related complication (Adler et al., 2000). So, the UKPDS established that the risk of developing any diabetes-related complication, for persons with diabetes, is greater when they have hypertension, relative to if they were normotensive.

Angiotensin converting enzyme inhibitors and angiotensin II receptor blockers are the recommended pharmacological treatment for individuals with type 2 diabetes who have hypertension; ARBs are prescribed if the person is intolerant of ACEIs (Daskalopoulou et al., 2015; Ganesh & Viswanathan, 2011). The UKPDS investigated whether tight control of blood pressure prevents macrovascular and microvascular complications in persons with diabetes who have hypertension (UKPDS 38, 1998). These subjects were randomized to 'tight control' or 'less tight control'; from an ethics perspective, the control subjects could not be randomized to no form of treatment (hence the 'less tight control'). The primary outcome was the risk of developing any diabetes-related complication. Results showed that the risk of a person with diabetes and hypertension developing any diabetes-related complication was significantly lower in the tight control group compared to the less tight control group (HR=0.76, 95% CI: 0.62 - 0.92, p=0.0046). Furthermore, Kaplan-Meier estimates showed that, compared to less tight control, tight control was associated with a 24% risk reduction in developing any diabetes-related complication (95%CI: 8% - 38%, p=0.0046).

In addition, The *Action to Control Cardiovascular Risk in Diabetes blood pressure* (ACCORD BP) study was a randomized trial that aimed to investigate whether

there is a difference in health outcome between intensive blood pressure control or standard blood pressure control in patients with type 2 diabetes; the primary outcome in this trial was a composite of (1) non-fatal myocardial infarction, (2) non-fatal stroke or (3) mortality from cardiovascular causes. Intensive and standard blood pressure control referred to using antihypertensive treatment with a target of less than 120 mmHg and 140 mmHg systolic blood pressure, respectively (ACCORD Study Group et al., 2010). The intensive and standard (i.e., control) groups achieved a mean systolic blood pressure of 119.3 mmHg (95%CI: 118.9 mmHg - 119.7 mmHg) and 133.5 mmHg (95% CI: 133.1 mmHg - 133.8 mmHg), respectively. The risk of developing the primary outcome in the intensive and standard therapy groups were not significantly different (HR=0.88, 95%CI: 0.73 - 1.06, p=0.20); nonetheless, the rate of non-fatal stroke was significantly higher in the standard therapy group (HR= 0.63, 95% CI: 0.41 - 0.96, p=0.03) (ACCORD Study Group et al., 2010).

As per the Diabetes Canada clinical guidelines for diabetes management, persons with diabetes who have hypertension should aim to have their blood pressure at 130/80 mmHg or below. The guidelines also recommend that patients who have not been diagnosed with hypertension should be tested for it once a year; the frequency of testing should be more for individuals with diabetes who are already hypertensive (Diabetes Canada Clinical Practice Guidelines Expert Committee, 2018).

Body mass index measurement

An underestimated condition of clinical and public health importance is obesity, which is defined as the condition where an individual's excess level of adiposity is

pathological. Obesity can be measured using body mass index (BMI); a person's BMI is derived by dividing their weight (in kilograms) by the squared value of his/her height (in metres^2). Obesity is defined as having a BMI of greater than 30kg/m^2 (Ofei, 2005). Although many studies on obesity use this metric to define obesity, it is important to know that this measure of adiposity is far from ideal because it does not account for an individual's body fat distribution; independent of a person's height and total body weight, fat distribution significantly impacts health. Abdominal fat (or abdominal obesity) can be measured using waist circumference. For men, abdominal obesity is defined as having a waist circumference (WC) of greater than 40 inches (or 101.6cm); for women, it is defined as having a WC of greater than 35 inches (or 88.9cm) (Krentz, 2005). Wang, Rimm, Stampfer, Willett, & Hu, (2005) compared the predictive power of BMI and WC in diagnosing type 2 diabetes mellitus in men and found that both BMI and WC were strong predictors for developing the metabolic disorder. However, WC was a relatively stronger predictor than BMI (Wang et al., 2005). There exists a strong correlation between obesity and type 2 diabetes; Kwon, Kim, Park, Park, & Cho (2017) performed a meta-analysis that quantified the association between BMI and risk of all-cause mortality, as well as risk of cardiovascular-specific mortality, in persons with diabetes. The authors also examined whether there is a dose-response effect of BMI. Using a random-effects model for their meta-analysis, Kwon et al. (2017) showed that the risk of all-cause mortality decreased with increasing BMI up to 28kg/m^2; however, the risk of all-cause mortality increased as BMI exceeded 30kg/m^2, and this significant ($p<0.001$) U-shaped relationship between all-cause mortality risk and BMI had a BMI nadir of 28kg/m^2 –

30kg/m^2. Likewise, the authors also found a significant non-linear relationship ($p<0.001$) between BMI and risk of cardiovascular-specific mortality in persons with diabetes; cardiovascular-specific mortality decreased as BMI increased from 22kg/m^2 to 29kg/m^2; however, the risk of cardiovascular-specific mortality increased as BMI exceeded 31kg/m^2 (Kwon et al., 2017). This U-shaped relationship between BMI and risk of cardiovascular mortality had a BMI nadir from 29kg/m^2 – 31kg/m^2.Thus, findings from Kwon et al. (2017) support that being underweight or overweight is associated with higher mortality risk than being normal weight; simply put, the authors showed that the risk of developing cardiovascular health problems is least when an individual's BMI falls within normal range (i.e., 18.5kg/m^2 - 24.9kg/m^2). The Diabetes Canada clinical guidelines recommend that healthcare providers work with persons with diabetes in achieving weight loss towards a normal BMI range (Diabetes Canada Clinical Practice Guidelines Expert Committee, 2018).

Smoking cessation counselling

The literature supports that smoking is an established risk factor for developing type 2 diabetes (Le Boudec et al., 2016); in addition, smoking is strongly associated with other chronic conditions such as cardiovascular disease (Iino et al., 2004). Furthermore, a systematic review and meta-analysis study showed that the risk of developing type 2 diabetes was greater in active smokers compared to persons who never smoked (Pan et al., 2015). Moreover, counselling on smoking cessation is recommended by Diabetes Canada for individuals with type 2 diabetes (Canadian Diabetes Association, 2017).

Nephropathy screening and treatment

According to expert opinion from Diabetes Canada, individuals with type 2 diabetes should annually be screened for nephropathy (i.e., the clinical term that corresponds to kidney damage) as the metabolic disorder increases a person's risk of having kidney problems (Canadian Diabetes Association, 2017). To screen for nephropathy, random urine ACR and serum creatinine can be converted to estimated glomerular filtration rate, a metric that corresponds to functioning of kidneys; a diagnosis of chronic kidney disease is made when an individual's random ACR is greater than 2.0mg/mmol and/ or eGFR less than 60mL/min/1.73m^2 in at least 2 of 3 samples over a three-month period (Canadian Diabetes Association, 2017).

Randomized, placebo-controlled trials have shown that ACEIs and ARBs are significantly associated with delayed progression of nephropathy in persons with diabetes (Lewis et al., 2001; Ravid et al., 1993). In Ravid et al. (1993), normotensive people who have diabetes were randomized to either placebo or ACEIs, and the absolute risk reduction in overt proteinuria (i.e., a condition that is indicative of an unhealthy kidney) for the ACEI group, compared to the placebo group, was 30% (95% CI: 15% - 45%); furthermore, the ACEI group had significantly better renal function than the placebo group ($p<0.05$). In Lewis et al. (2001), results from a randomized, placebo-controlled trial showed that ARB use in persons with diabetes was associated with lower risk of doubling in serum creatinine (RR= 0.71, 95% CI: 0.54 - 0.92, p=0.009), where doubling of serum creatinine is often used as marker for worsening kidney function.

Foot examination

Ulceration and amputation of the feet are one of the morbid consequences of uncontrolled type 2 diabetes (Canadian Diabetes Association, 2017). Lower-extremity amputation affects up to 15% of people who have diabetes (Scott, 2013). Using a case-control study design, Mayfield, Reiber, Nelson, & Greene (2000) investigated whether there is a preventive effect of foot examination in Pima Indians; this ethnic group is known to have the highest prevalence of diabetes mellitus compared to any other population (Baier & Hanson, 2004; Booth et al., 2017; Mayfield et al., 2000). Cases and controls were identified from January 1st, 1985 to December 31st, 1992; cases were Pima Indians who had foot amputations, while controls where their counterparts who did not have it. All subjects' information were abstracted from medical charts (Mayfield et al., 2000). Mayfield et al. (2000) hypothesized that any form of foot examination lowered the odds of having a foot amputation; however, the authors' results were not statistically significant, (OR = 0.55, 95% CI: 0.17-1.70, p=0.31). Despite an absence of evidence suggesting that foot examination significantly reduces the risk of foot amputation, expert opinion from Diabetes Canada recommends that individuals with diabetes should undergo a foot examination annually (Canadian Diabetes Association, 2017).

Eye examination

Klein, Klein, Moss, Davis, & DeMets (1989) determined the four-year incidence of retinopathy for individuals with type 2 diabetes in *The Wisconsin Epidemiologic Study of Diabetic Retinopathy* (WESDR) study. The four-year incidence (95% CI) of any form of retinopathy (or progression of retinopathy) among people with diabetes who were and weren't on insulin therapy was 47.4% (95% CI: 39.5% - 55.3%) and 34.4% (95% CI:

29.2% - 39.6%), respectively (Klein et al., 1989); these results are congruent with findings from other studies which showed that insulin use was associated with a higher occurrence of diabetic retinopathy relative to no insulin use (Zhao et al., 2014). Finding from the WESDR study has been used by various scientific associations, including Diabetes Canada, to support the practice of performing eye examinations on individuals with diabetes (Canadian Diabetes Association, 2017).

In addition, *The Liverpool Diabetic Eye Study*, which was a prospective cohort study, showed that the yearly incidence of any form of retinopathy increased from baseline for people with diabetes; the cumulative incidence in year 1 and year 4 were 5.3% (95% CI:4.6% -6.0%) and 25.2% (95% CI:23.3% -27.1%), respectively (Younis et al., 2003). According to Diabetes Canada, eye examinations should generally be performed annually in individuals with type 2 diabetes (Canadian Diabetes Association, 2017).

Lipid assessment and statin prescription

Type 2 diabetes mellitus increases an individual's risk of stroke and coronary heart disease by 2 to 4-fold (Colhoun et al., 2004). The *Collaborative Atorvastatin Diabetes Study* (CARDS) was a randomized, placebo-controlled trial that aimed to investigate the effect of statin drugs in the primary prevention of cardiovascular diseases for individuals with type 2 diabetes. In the CARDS, use of statin—compared to placebo—was associated with a significantly lower risk of developing a stroke (HR= 0.52, 95% CI: 0.31-0.89) and acute coronary events (HR= 0.64, 95% CI: 0.45-0.91) (Colhoun et al., 2004). Thus, findings from Colhoun et al. (2004) serve as evidence to

support the prophylactic use of statins for people with diabetes; furthermore, expert opinion supports that individuals with the metabolic disorder should have their lipid profile measured at least once yearly (Diabetes Canada Clinical Practice Guidelines Expert Committee, 2018).

Congestive heart failure

In the literature, congestive heart failure—or simply heart failure—can exist in two forms, namely, heart failure with reduced ejection fraction (HFrEF) or heart failure with preserved ejection fraction (HFpEF). These two forms of CHF are distinct in terms of their pathophysiology and prognosis (Borlaug, 2013). Process of care for CHF is defined more precisely for HFrEF than for HFpEF (Ponikowski et al., 2016), and the process indicators discussed herein pertain to HFrEF.

The following process measures, relevant for a primary care context, are: (1) prescription of angiotensin converting enzyme inhibitors, or angiotensin II receptor blockers, or hydralazine with isorbide dinitrate (H-ISDN), or angiotensin neprilysin inhibitors (ARNIs), (2) prescription of beta blockers (BB), (3) prescription of digoxin, (4) digoxin monitoring, (5) prescription of anticoagulants, (6) prescription of aldosterone receptor antagonists (ARAs), (7) prescription of diuretics, (8) evaluation of left ventricular ejection fraction (LVEF), (9) cardiovascular physical examination, (10) no prescription of type I antiarrhythmic drugs, (11) no prescription of calcium channel blockers, (12) no prescription of nonsteroidal anti-inflammatory drugs (NSAIDs) and (13) patient counselling. Herein, we present some evidence on the process-outcome link

for all these indicators; furthermore, these care processes are congruent with the Canadian Cardiovascular Society clinical guidelines (Ezekowitz et al., 2017).

Prescription of angiotensin converting enzyme inhibitors

The *Studies of Left Ventricular Dysfunction* (SOLVD) study, a randomized double-blind, placebo-controlled trial showed that the risk of all-cause mortality was significantly lower in the persons with CHF who used ACEIs compared to their counterparts who used placebo (Risk Reduction=17%, 95% CI: 5% – 27%) in a 48-month follow-up period. Furthermore, compared to the placebo group, the risk of hospitalization or mortality due to heart failure was significantly lower in the ACEI group (Risk Reduction= 27%, 95% CI: 18% – 34%). This study has been among the highly cited sources of high-quality evidence to support the prescription of ACEIs for people who have CHF (SOLVD investigators, 1991).

In terms of natural history of CHF, patients are characterized by two unfavourable outcomes, namely, (1) left ventricular dilation and (2) systolic dysfunction. Konstam et al. (1992) investigated the patient population in the SOLVD trial (i.e., persons with CHF) to determine the effect of chronic use of ACEIs on progression of systolic function and left ventricular dilation, and the study by Konstam et al. (1992) showed that chronic use of ACEI therapy prevents or reverses progression of CHF. In the ACEI group, LVEF was 25% ± 7% at baseline and increased to 29% ± 8% at 1 year follow-up (p=0.01); in the placebo group, LVEF was 25% ± 5% at baseline but 24% ± 8% at 1 year follow-up and the difference was statistically non-significant (Konstam et al., 1992).

The CCS clinical guidelines recommends that persons with CHF be treated with ACEI (Ezekowitz et al., 2017).

Prescription of angiotensin II receptor blockers

A substantial proportion of persons with CHF exhibit symptoms of ACEI intolerance, such as painful coughs; thus, Angiotensin II Receptor Blockers are an alternative therapy for this population of persons with CHF (Granger et al., 2003). The *Candesartan in Heart Failure-Assessment of Reduction in Mortality and Morbidity* (CHARM) study (Swedberg et al., 1999) was a program of randomized trials aimed to investigate the prognostic effects of ARB use in persons with CHF; CHARM constituted three independent, parallel, placebo-controlled randomized trials for three types of patients: (1) patients with LVEF ≤40% and who were on ACEI (the CHARM-Added trial), (2) patients with LVEF ≤40% and who were ACEI intolerant (the CHARM-Alternative trial), and (3) patients with LVEF > 40% and who were not treated with ACEI (the CHARM-Preserved trial). Patients were randomized to either placebo or ARB in all the three CHARM trials; the overarching hypothesis in these three studies was that use of ARBs is associated with a reduced risk of all-cause mortality in the three populations of CHF. The median follow-up period was 37.7 months, and findings from the overall CHARM trial (i.e., all three populations of CHF combined) demonstrated that the risk of all-cause mortality was significantly lower in ARB group compared to the placebo group (HR= 0.90, 95% CI: 0.80 – 0.99). The significantly lower risk of all-cause mortality in the ARB group was attributed to this group having a significantly lower risk of (cardiovascular disease (CVD)-specific mortality compared to placebo (HR= 0.87,

95% CI: 0.78 – 0.96). In addition, the risk of hospitalization due to CHF was also lower in the ARB group compared to placebo group (HR= 0.77, 95% CI: 0.70 – 0.84) (Pfeffer et al., 2003; Swedberg et al., 1999).

As per the CCS clinical guidelines, persons with CHF are recommended to be treated with ARB if they are ACEI intolerant (Ezekowitz et al., 2017).

Prescription of angiotensin neprilysin inhibitors

The first angiotensin neprilysin inhibitor to be tested in patients with CHF was referred to as LCZ696 in the *Prospective comparison of ARNI with ACEI to Determine Impact on Global Mortality and morbidity in Heart Failure* (PARADIGM-HF) study (McMurray et al., 2013). The PARADIGM-HF trial was a randomized, double-blind, parallel-group, active-controlled trial, that compared the effects of LCZ696 and ACEI in persons with CHF; the median follow-up period was 27 months. LCZ696 use was significantly associated with more favourable clinical outcomes than use of ACEI as the risk of cardiovascular mortality was significantly lower in the ARNI group compared to the ACEI group (HR= 0.80, 95% CI: 0.71 – 0.89); likewise, the risk of all-cause mortality was significantly lower (HR= 0.84, 95% CI: 0.76 – 0.93); the risk of hospitalization due to CHF was significantly lower as well (HR= 0.79, 95% CI: 0.71 – 0.89). The therapeutic use of ARNI for persons with CHF was approved in Canada by 2015.

Prescription of hydralazine and isorbide dinitrate

The *African American Heart Failure Trial* (A-HeFT)—the first randomized trial, for CHF, that defined its study subjects by race—investigated the effect of CHF

pharmacotherapy on persons who identified as being of Black race (Taylor et al., 2002). This study was a randomized, double-blind, placebo-controlled trial where subjects (i.e., persons of Black race) on standard therapy (i.e., ACEIs), were randomized to either placebo or the combination drug hydralazine with isorbide dinitrate**.** A strong rationale for the conduct of the A-HeFT trial was based on the literature which supports that persons of African American ancestry, on average, do not respond favourably to first-line CHF pharmacotherapy (i.e., ACEIs) the way individuals of Caucasian race—on average—would. For instance, in the SOLVD trial, there was an excess of mortality and hospitalizations in the subgroup of individuals who were of African American ancestry (Taylor et al., 2002). Another rationale for the conduct of the A-HeFT trial was the fact that persons of African American ancestry, in general, are under-represented in many randomized trials, as well as observational studies (Sankaré et al., 2015; Taylor et al., 2002).

The primary outcome in the A-HeFT trial was a composite score of weighted values for: (i) all-cause mortality, (ii) hospitalization due to CHF at 18-months of follow-up and (iii) change in Quality of Life (QoL) scores at six months of follow up; a more positive composite score indicated more favourable clinical outcomes. The A-HeFT trial was terminated early because the mortality rate was significantly higher in the placebo group compared to H-ISDN group. There was no loss to follow-up in this trial, and the mean follow-up period was 10 months. At trial termination, the composite score in the H-ISDN group was significantly more positive than the composite score in the placebo group ($p=0.01$). Furthermore, each of the three individual components of the composite

score was significantly more favourable in the H-ISDN group compared to the placebo group. Relative to the placebo group, subjects on H-ISDN had a significantly lower all-cause mortality risk (p=0.02), significantly lower risk of first hospitalization due to CHF (p= 0.001) and a significantly higher QoL score at six months (p=0.02) (Taylor et al., 2004).

The CCS clinical guidelines recommends that the combination drug H-ISDN be used for persons with CHF who are of Black race and have advanced symptoms. This guideline also recommends H-ISDN for all persons with CHF who are intolerant to ACEI, ARB or ARNI due to renal pathology or hyperkalemia (Ezekowitz et al., 2017).

Prescription of beta blockers

A randomized, double-blind, placebo-controlled trial by Packer et al. (1996) investigated the safety of beta blockers in CHF; persons with CHF on standard therapy (such as ACEIs, diuretics, etc.) were randomized either to receive either placebo or a beta blocker. Results from this trial showed that use of beta blocker was associated with significantly lower risk of all-cause mortality (Risk Reduction= 65%, 95% CI: 39% – 80%) (M Packer et al., 1996).

In addition, the CCS clinical guidelines recommends that persons with CHF be prescribed beta blockers in addition to standard therapy (e.g., on ACEIs or ARBs or ARNIs) (Ezekowitz et al., 2017).

Prescription of aldosterone receptor antagonists

Aldosterone receptor antagonists, which are also referred to as mineralocorticoid receptor antagonists, have been shown to be associated with favourable outcomes in

patients with CHF (Zannad et al., 2012). The *Randomized Aldactone Evaluation Study* (RALES) trial was the first randomized trial to investigate the effect of MRAs on morbidity and mortality in persons with CHF (Pitt et al., 1999). In this trial, subjects on standard therapy (including ACEIs), were randomized to MRA or placebo; the RALES trial was halted as favourable outcomes associated with MRA use had already been observed after a mean follow-up period of 24 months. The risk of mortality due to progressive heart failure was lower in the MRA group compared to the placebo group (Relative risk= 0.64, 95% CI: 0.51 – 0.80); similarly, the risk of hospitalization due to worsening heart failure was lower in the MRA group (RR=0.65, 95% CI: 0.54 – 0.77).

The CCS clinical guidelines recommend that persons with CHF be treated with MRAs, in addition to standard therapy (Ezekowitz et al., 2017).

Prescription of digoxin

For over 200 years, use of digoxin has been indicated for individuals with CHF who have a normal sinus rhythm, lower heart rate and increased myocardial contractility (Sebastiano et al., 2015). Over the past several decades, the safety and efficacy of Digoxin has been scrutinized especially since the advent of first-line therapies such as ACEIs (Sebastiano et al., 2015). In the *Randomized Assessments of [the effect of] Digoxin on Inhibitors of the Angiotensin-Converting Enzyme* (RADIANCE) study, a randomized trial by Packer et al. (1993), persons with CHF, who were on ACEI and diuretics, were randomized to receive either digoxin or placebo. The RADIANCE trial showed that the relative risk of worsening heart failure was higher in the placebo group

compared to the digoxin group (RR=5.9, 95% CI: 2.1 – 17.2, p<0.001) during a follow-up period of 12 weeks (Packer et al., 1993).

Like the RADIANCE study, another randomized trial by the Digitalis Investigation Group (1997) investigated the prognostic effect of digoxin during a 52-month follow-up (Digitalis Investigation Group, 1997); persons with CHF who had normal sinus rhythm were randomized to receive either digoxin or placebo. This trial found a trend where mortality due to worsening heart failure was greater in the placebo group compared to the digoxin group (p=0.06); hospitalizations due to worsening heart failure was significantly lower in the digoxin group compared to the placebo group (Digitalis Investigation Group, 1997). Using propensity score matching on retrospective data, Al-khateeb et al. (2017) found that use of digoxin—compared to no use of digoxin—is associated with unfavourable patient outcomes in a contemporary CHF cohort. Digoxin use was associated with an increase in all-cause mortality (HR= 1.74; 95% CI: 1.20 to 2.38; p<0.0001) (Al-khateeb et al., 2017). The authors argued that a lack of digoxin monitoring could be a reason for the higher mortality observed with its use (Al-khateeb et al., 2017) .

Adams et al. (2014) published a perspective regarding digoxin use and concluded that the decline in digoxin use in over the past 20 years could be a result of the Digitalis Investigation Group (DIG) trial demonstrating neutral effects on mortality and some studies pointing towards possible harm from digoxin use in persons with CHF. Adams et al. (2014) emphasized that digoxin use be considered given that it is inexpensive and possibly being more therapeutic at lower doses (Adams et al., 2014).

Kongkaew, Sakunrag, & Jianmongkol (2012) performed a systematic review of observational studies, on the prevalence of Digoxin compliance in persons with only CHF, only AF, and the two conditions; the authors reported that the prevalence of Digoxin non-compliance is quiet substantial in patients with CHF and/or AF. The pooled mean non-compliance prevalence rate was 25.10% (95% CI: 12.20% - 37.90%). Thus, non-compliance for digoxin could partly explain the conflicting findings regarding its use in the literature (Kongkaew et al., 2012).

As per the CCS clinical guidelines, digoxin can be considered for persons with CHF with sinus rhythm and whose symptoms range between moderate and severe (Ezekowitz et al., 2017).

Digoxin monitoring

In general, the aim of therapeutic drug monitoring (TDM) is to avoid drug toxicity and increase drug efficiency in patients (Matzuk et al., 1991). Digoxin is a therapeutic agent that has a narrow therapeutic range of 0.5-0.8 ng/ml (Rosenberg & Federiuk, 2003); as a result, digoxin is supposed to be frequently monitored for both inpatients and outpatients (Matzuk et al., 1991). It is also important to note that the serum concentration of 0.5-0.8 ng/ml is a general therapeutic range because the therapeutic range varies from patient to patient; simply put, a concentration that is toxic for one patient may fall within the ‘therapeutic range’ of another. In addition, Matzuk et al. (1991) suggested that TDM of digoxin could be cost-efficient to a health care system as regular monitoring can reduce hospitalizations due to unfavourable outcomes from drug toxicity (Matzuk et al., 1991).

The CCS clinical guidelines for CHF recommends that patients be monitored regularly for toxicity of digoxin (Ezekowitz et al., 2017).

Prescription of anticoagulants

Congestive heart failure is associated with (1) being in a hypercoagulable state and (2) higher mortality due to atherothrombotic events, and, therefore, use of anticoagulants has been indicated for persons with CHF (Homma et al., 2012). Use of anticoagulants (such as warfarin) in CHF has been a subject of investigation for at least a half a century (Bhatia et al., 2009).

Bhatia et al. (2009) reported how clinical suggestions regarding anticoagulant use were inconsistent across various clinical expert groups—such as those affiliated with the American Heart Association, Heart Failure Society of America, and American College of Chest Physicians. Bhatia et al. (2009) reviewed the literature on whether the use of anticoagulants for CHF is associated with favourable or unfavourable patient outcomes, and the authors found that some studies support use of it, while others show no benefit of persons with CHF using it. In the literature, use of anticoagulants is associated with reduced rates of embolic events and reduced rates of mortality; however in many of those studies, subjects had atrial fibrillation and clinically significant valvular disease (Homma et al., 2012).

Aspirin is a pharmacological agent with anticoagulant properties, and its use in CHF has also been controversial in the literature (Bermingham et al., 2014; Massie, 2005). In the *Warfarin versus Aspirin in Reduced Cardiac Ejection Fraction* (WARCEF) study, a randomized, multi-centre, double-blind trial, the efficacy of Warfarin was

investigated in persons with CHF who had sinus rhythm; the trial excluded CHF patients with atrial fibrillation (Homma et al., 2012). This trial showed that the risk of ischemic stroke was significantly lower in the warfarin group compared to the aspirin group (HR= 0.52, 95% CI: 0.33 – 0.82). For other patient outcomes such as risk of all-cause mortality and risk of hospitalization, the WARCEF trial showed that there were no significant differences between the two groups for these two treatments (Homma et al., 2012).

Two other randomized trials also investigated and compared the effect of aspirin and warfarin on health outcome for persons with CHF and who have sinus rhythm, namely the *Warfarin/Aspirin Study in Heart Failure* (WASH) and *Warfarin and Antiplatelet Therapy in Chronic Heart Failure* (WATCH) trials (Bermingham et al., 2014). Bermingham et al. (2014) reported how the WASH and WATCH trials reported excess of hospitalization with aspirin use (Cleland et al., 2004; Massie et al., 2009); the authors used propensity score methods to investigate the effect of low dose aspirin on risk of mortality, as well as risk of hospitalization in persons with CHF; patients were categorized as low-dose aspirin users (75mg aspirin daily), high-dose aspirin users (greater than 75mg aspirin daily) and non-aspirin users. Multivariable analyses in the study by Bermingham et al. (2014) showed that the risk of mortality was lower in the low-dose aspirin group compared to high-dose group (HR=0.57, 95% CI: 0.35 – 0.92); furthermore, the risk of mortality in the low dose aspirin group was lower than in the non-aspirin use group (HR=0.58, 95% CI: 0.46 -0.74) (Bermingham et al., 2014). Multivariable analyses showed that the risk of mortality was not statistically different between the high-dose and no aspirin group (HR=0.98, 95% CI: 0.59 -1.63). The risk of

hospitalization due to CHF was lower in the low-dose aspirin users compared to no aspirin use (HR= 0.70, 95% CI: 0.54 – 0.90). The risk of hospitalization due to CHF was lower in the high-dose aspirin users compared to no aspirin users (HR=0.50, 95% CI: 0.27 – 0.92). The risk of hospitalization when comparing low dose aspirin use with high dose aspirin use was not statistically different (HR= 1.27, 95% CI: 0.70 – 2.30). Thus, findings from Bermingham et al. (2014) support that use of aspirin at low-doses is beneficial, and that the prognostic impact of aspirin is dependent on its dose—as would any pharmacological agent.

The CCS clinical guidelines recommend that low dose of aspirin be used for persons with CHF who have a clear indication for the prevention of secondary atherosclerotic cardiovascular events; the guideline recommends against the use of aspirin in persons with CHF with sinus rhythm (Ezekowitz et al., 2017).

Prescription of diuretics

Diuretics reduce pulmonary congestion and, therefore, using them provides symptomatic relief for persons with CHF (Faris et al., 2002). A meta-analysis of four randomized trials showed that the odds of worsening heart failure was lower for persons with CHF taking diuretics compared to their counterparts on placebo (pooled OR= 0.31, 95% CI: 0.15 – 0.62) (Faris et al., 2002).

However, findings from Pellicori et al. (2016) contradicted findings from Faris et al. (2002); while findings from the former supported the use of diuretics for persons with CHF is beneficial, results from the latter showed that using diuretics is associated with unfavourable outcomes in this patient population. Pellicori et al. (2016) performed a

prospective cohort study to investigate the effect of diuretic use on the (1) risk of all-cause mortality or (2) hospitalization due to CHF in persons with CHF. The authors defined an adverse event to be the occurrence of either of these two outcomes (Pellicori et al., 2016). Using a follow–up period of 5 years, survival analyses showed that use of diuretics, at any dose (i.e., at least 10 mg), was associated with a higher risk of adverse events compared to not using diuretics (HR=2.18, 95% CI:1.62 – 2.95); higher doses of diuretics (i.e., greater than 40mg vs. no diuretic) further increased the risk of an adverse event (HR= 2.95, 95% CI: 2.13 – 4.10) (Pellicori et al., 2016).

Furthermore, clinical guidelines for heart failure also allude to the cautious use of diuretics (Ponikowski et al., 2016); as per the CCS clinical guidelines, diuretics are recommended for persons with CHF if there is a need to control peripheral edema and/or congestion (Ezekowitz et al., 2017).

Evaluation of left ventricular ejection fraction

When managing CHF, it is important to evaluate physiological measurements, such as left ventricular ejection fraction (Edvardsen et al., 2006). Using a cohort study design, Niebauer, Clark, Anker, & Coats, (1999) investigated the prognostic value of LVEF in persons with CHF who have very low ejection fraction (EF) (i.e., EF≤20%); the study was censored at 3 years of follow-up to mimic a clinically relevant time span. The subjects were divided into 2 groups of EF where individuals in one group had an EF that ranged between 11% and 20%, while members of the other group had EF≤10% (Niebauer et al., 1999). These two groups were similar in baseline characteristics. The study showed that, within each year, the risk of mortality was not significantly different among the two

groups, and Niebauer et al. (1999) concluded that LVEF was a not a predictor of mortality.

Curtis et al. (2003) analyzed data from the DIG trial, which was a randomized trial that investigated the effect of digitalis (a pharmacological agent) on hospitalization and mortality in persons with CHF who have stable sinus rhythm. This trial enrolled subjects with varying EF and thus Curtis et al. (2003) was able to investigate the prognostic value of evaluating LVEF in persons with CHF. Curtis et al. (2003) divided the subjects according to six clinically meaningful ranges of EF: (1) EF≤ 15%, (2) EF= 16% - 25%, (3) EF= 26% - 35%, (4) EF=36% - 45%, (5) EF= 46% - 55% and (6) EF > 55%. All-cause mortality and death due to worsening HF were the outcomes and the median follow-up period was 37 months. The study showed that mortality rates increased, linearly, among patients whose EF value were within the first four ranges; e.g., the mortality rate in the LVEF ≤ 15% group and LVEF= 36% - 45% group, were 51.7% and 25.6%, respectively, ($p<0.001$). However, mortality rates were not statistically different for patients in the EF groups above 45% (Curtis et al., 2003). Thus, findings from this study supports that evaluation of LVEF is of prognostic value as this physiological measurement can predict health outcome.

Curtis et al. (2003) stated that prognostic value of LVEF in CHF declines once EF falls below 25%, and this statement is congruent with the findings from Niebauer et al. (1999)—where the previous study showed that there is no difference in mortality rates between persons with CHF who have LVEF of 11% - 20% or LVEF ≤ 10%.

The CCS clinical guidelines suggest that LVEF be measured once to thrice a year in persons with CHF to monitor if ventricular function is improving or worsening (Ezekowitz et al., 2017).

Cardiovascular physical examination

In a cardiovascular physical examination, cardinal signs of heart failure, such as elevated jugular venous pressure (JVP) and an S_3 gallop (which is also referred to as a third heartbeat sound), can be identified. Rame, Dries, & Drazner, (2003) discussed how physicians nowadays, in general, are not performing cardiac physical examination. The authors explained that the replacement of such examinations with newer technologies resulted in fewer educators who can teach medical students how to conduct a cardiovascular physical examination (Rame et al., 2003).

To identify whether S_3 gallop or elevated JVP (i.e., two measures derived from a cardiovascular physical examination) have a prognostic value in CHF, Rame et al. (2003) performed a *post hoc* analysis on data from the SOLVD trial (Rame et al., 2003), a randomized, placebo-controlled study that compared the effect of ACEI vs. placebo in persons with CHF. The SOLVD trial had data on whether its subjects had both elevated JVP and S_3 gallop. *Post hoc* analysis showed that patients with an S_3 gallop or elevated JVP were significantly at a higher risk for unfavourable patient outcomes than patients without these physical examination signs. For instance, the risk of all-cause mortality was higher in patients with an elevated JVP (relative risk= 1.52, 95% CI: 1.27 – 1.82, $p<0.001$) and an S_3 gallop (relative risk= 1.35, 95% CI: 1.47 – 2.17, $p<0.001$). The risk of heart failure-related hospitalization was higher in subjects with an elevated JVP (relative

risk= 1.78, 95% CI: 1.47–2.17, p<0.001); likewise, the risk of heart failure-related hospitalization was higher in those with an S_3 gallop (relative risk= 1.70, 95% CI= 1.46–1.97, p<0.001). Thus cardiovascular physical examination can enhance risk stratification for persons with CHF (Rame et al., 2003).

Like Rame et al. (2003), Caldentey et al. (2014) investigated the prognostic value of cardiovascular physical examination in a contemporary cohort of persons with CHF who had a history of atrial fibrillation. The authors conducted a *post hoc* analysis on data from a randomized study, namely the *Atrial Fibrillation and Congestive Heart Failure* (AF-CHF) trial (Caldentey et al., 2014). Univariate analysis showed that an S_3 gallop was significantly associated with an increased risk of (1) all-cause mortality, (2) cardiovascular mortality and (3) hospitalization due to CHF; upon multivariate analyses, the statistical significance for all these three outcomes was lost—though a non-significant trend of increased risk was maintained (Caldentey et al., 2014). The loss in statistical significance could be due to a reduction in statistical power—where multivariate analyses requires a greater sample size to maintain the same level of Type II error. Nonetheless, multivariate analyses from this study showed that pulmonary rales (another cardiovascular physical examination sign) was significantly associated with an increased risk of (1) cardiovascular mortality (HR=1.43, 95%CI: 1.09 – 1.88, p=0.0097), (2) all-cause mortality (HR= 1.32, 95% CI: 1.03 – 1.69, p=0.0286) and (3) hospitalization due to CHF (HR=1.42, 95%CI: 1.05 – 1.90, p=0.0211) (Caldentey et al., 2014).

Notwithstanding the emerging technologies used for the diagnosis and prognosis of cardiovascular ailments, Suh, Wong, & Krishnan, (2008) support that the practice of

cardiovascular physical examination and documentation of medical history should not be undermined. Furthermore, the authors produced a case report where interpretation of 12-lead electrocardiogram (ECG), from an 80-yeard old male diagnosed with CHF, led to accurate diagnosis; through the 'older technology', physicians were able to identify a specific cardiomyopathy known as pacemaker syndrome, and this diagnosis led to identifying a suitable therapeutic intervention (Suh et al., 2008).

The CCS clinical guidelines strongly endorses that persons with CHF undergo cardiac physical examination (Ezekowitz et al., 2017).

No prescription of type 1 antiarrhythmic drugs

Arrhythmia, the irregular rhythm of heart beat, is common in individuals diagnosed with CHF, and it can lead to sudden mortality in persons with CHF (Køber et al., 2008). Several types of antiarrhythmic drugs can be used to manage arrhythmia.

For instance, type 3 antiarrhythmic drugs have been associated with favourable patient outcomes in persons diagnosed with CHF; for example, a multi-center, prospective, randomized trial investigated the prophylactic effect of a low dose type 3 antiarrhythmic drug on mortality risk in patients who have no symptom of arrhythmia (Doval et al., 1994). In the trial, patients with severe CHF were randomized to receive either (1) standard therapy (i.e., ACEI) or (2) type 3 antiarrhythmic drug in low dose in addition to standard therapy. The total mortality and hospitalization due to CHF was significantly less for the group on the type 3 drug compared to the standard therapy group (Doval et al., 1994).

On the contrary, type 1 antiarrhythmic drugs have been associated with unfavourable patient outcomes in CHF; evidence regarding the management of CHF with type 1 antiarrhythmic drugs is mixed as the literature is filled with conflicting findings.

The *Antiarrhythmic Trial with Dronedarone in Moderate to Severe CHF Evaluating Morbidity Decrease* (ANDROMEDA) study, a randomized, double-blind, placebo-controlled trial, compared the effect of type 1 antiarrhythmic drug vs. placebo on morbidity and mortality in persons with CHF. This trial showed that use of type 1 antiarrhythmic drug was significantly associated with all-cause mortality (HR= 2.19, 95% CI: 1.06 to 4.52, p=0.03), within a time period of 210 days (Køber et al., 2008).

While the findings from the ANDROMEDA study showed that use of type 1 antiarrhythmic drug is significantly associated with an higher risk of mortality, a *post hoc* analyses of *A Placebo-Controlled, Double-Blind, Parallel Arm Trial to Assess the Efficacy of Dronedarone 400 mg bid for the Prevention of Cardiovascular Hospitalization or Death from Any Cause in Patients with Atrial Fibrillation/Atrial Flutter* (ATHENA) study showed that use of type 1 antiarrhythmic drug is not associated with an increased risk of mortality in patients with atrial fibrillation (AF) and CHF (Hohnloser et al., 2009).

Such discrepancies in literature can be reconciled by understanding that, in many studies pertaining to CHF, the study population may differ (e.g., CHF only vs. CHF with AF). So, the nuances in how the trials defined their patient population, along with varying inclusion and exclusion criteria, may partly account for these discrepant findings.

Chatterjee, Ghosh, Lichstein, Aikat, & Mukherjee, (2012) performed a systematic review and meta-analysis on the cardiovascular effects of type 1 antiarrhythmic drug in CHF or atrial fibrillation; data from the ATHENA (Hohnloser et al., 2009) and ANDROMEDA (Køber et al., 2008) trials were included in this meta-analysis. The meta-analysis showed that type 1 antiarrhythmic drug use was non-significantly associated with higher risk of all-cause and cardiovascular-specific mortality in patients with CHF or AF. However, when Chatterjee et al. (2012) removed data from the ATHENA study, type 1 antiarrhythmic use became significantly associated with higher risk of all-cause mortality and cardiovascular specific mortality in persons with CHF or AF (Chatterjee et al., 2012).

The only drug that the CCS clinical guidelines recommend for persons with CHF who have arrhythmia is "Amiodarone", which is a type 3 antiarrhythmic drug (Ezekowitz et al., 2017).

No prescription of calcium channel blockers

According to an evidence-based review of CHF pharmacotherapies (Raj & Adhyaru, 2016), calcium channel blockers should not be recommended for persons with CHF because the evidence shows that use of them are either non-significantly associated with slight benefits, or associated with unfavourable health outcomes.

The *Mortality Assessment in Congestive Heart Failure Trial* (MACH-1) (Levine et al., 2000) was a randomized, multicenter, double-blind, placebo-controlled trial that aimed to investigate the effect of using calcium channel blockers (CCBs) vs. placebo on the risk of mortality and heart failure-related hospitalization in persons with CHF. The

trial showed that there was no significant difference between CCB and placebo use for these outcomes. However, in the first three months, there was a trend where the risk of all-cause mortality was higher in the CCB group compared to placebo (Levine et al., 2000).

Cleophas & van Marum, (2001) performed a meta-analysis of randomized trials that compared the effect of placebo and second generation CCBs on mortality and morbidity for persons with CHF. The authors showed that there was a non-significant trend where use of the second generation calcium channel blockers was associated with more favourable outcome, such as lower mortality risk and increased exercise tolerance (Cleophas & van Marum, 2001).

The CCS clinical guidelines strongly recommend against persons with CHF using CCBs (Ezekowitz et al., 2017).

No prescription of nonsteroidal anti-inflammatory drugs

Evidence to support that the use of NSAIDs is associated with an increased risk of being diagnosed with CHF had existed since the late 1980's (Vandenouweland et al., 1988). In Vandenouweland et al. (1988), use of NSAID medication shortly preceded a diagnosis of CHF in elderly patients with locomotor diseases. The risk of developing such diseases increases with age; oftentimes, the elderly were prescribed NSAIDs (for symptoms of pain), and a common side effect is fluid retention (Vandenouweland et al., 1988).

In 2002, Feenstra, Heerdink, Grobbee, & Stricker, (2002) reported relevant findings from the Rotterdam Study, a population-based prospective cohort study on the

prevalence, incidence and determinants of various diseases in the elderly. The authors investigated whether (1) use of NSAIDs is significantly associated with first occurrence of CHF and (2) whether use of NSAIDs is significantly associated with worsening of already existing CHF (Feenstra et al., 2002). The cohort study showed that the relative risk of first occurrence of CHF with NSAIDs use is 1.1 (95% CI: 0.7-1.7) within a mean (± standard deviation (SD)) follow-up period of 6 years (±1.6 years); however, the relative risk for hospitalization due to heart failure in patients already diagnosed with CHF was 9.9 (95% CI: 1.7-57.8) within a mean (± SD) follow-up period of 6 years (±1.6 years) (Feenstra et al., 2002). This finding from the Rotterdam Study supports that use of NSAIDs is not significantly associated with a diagnosis of CHF, but is significantly associated with hospitalization due to heart failure for persons who already have CHF (Feenstra et al., 2002). Similarly, findings from Gislason et al. (2009) support that use of NSAIDs is significantly associated with an increased risk of heart failure-related hospitalization for persons with CHF (Feenstra et al., 2002; Gislason et al., 2009).

The CCS clinical guidelines strongly recommends against persons with CHF using NSAIDs (Ezekowitz et al., 2017).

Patient counselling for healthy lifestyle choices

Optimal management of CHF includes patient counselling; persons with CHF can learn about self-care when counselled by a healthcare professional (Koelling et al., 2005). Through counselling, patients can understand the significance of self-care practices like medication adherence, daily monitoring of sodium intake, and so on. Moreover, a substantial proportion of hospitalizations that occur in this patient population is attributed

to medication non-adherence—where the noncompliant behaviour may result from a lack of knowledge (Annema et al., 2009; Koelling et al., 2005).

Vinluan, Wittman, & Morisky, (2015) used a randomized, prospective, open trial to investigate whether persons with CHF aged 65 years and above had better medication adherence when they received either pharmacist counselling (i.e., intervention group) or regular care (i.e., control group), at discharge. In the intervention group, counselling was much more comprehensive and engaging than in the control group. This open trial showed that medication adherence was higher in the intervention group at day 30 (100% vs. 86%) and day 60 (100% vs. 83%). By day 90, the two groups were similar in terms of compliance (50% vs. 50%). The study showed that, at day 30, more patients were readmitted to hospital in the control group relative to the intervention group (0% vs. 11%); however, at day 60, more patients were readmitted in the intervention group, relative to the control group (29% vs. 11 %). At day 90, the readmission rates were the same in both groups (0% vs. 0%).

Vinluan et al. (2015) also reported information on mortality. At day 30, the mortality rate in intervention and control groups were 0% and 22% respectively. The mortality rate was 0% in both arms at day 60 and day 90 (Vinluan et al., 2015). Given that mortality was observed only in the control at Day 30, the higher hospitalization rate seen in the intervention group (i.e., the 29% vs. 11%) at day 60, could be due to the fact that the two comparison groups were not completely equal in terms of observable and unobservable prognostic factors after the control group (which is already small to start with) was short of two of subjects (due to death).

Findings from Vinluan et al. (2015) are congruent with previous findings from the study by Koelling et al. (2005) where persons with CHF were randomized to either standard discharge education (i.e., control group) or patient-targeted HF counselling in addition to the standard education (i.e., the intervention group). The relative risk of death or hospitalization in the intervention group was 0.66 (95% CI: 0.46 to 0.95, p=0.025) (Koelling et al., 2005).

The *Heart Failure Adherence and Retention Randomized Behavioral Trial* (HART) was another trial that also investigated effect of counselling on mortality or hospitalization rate at follow-up (Powell et al., 2010). Unlike Vinluan et al. (2015) and Koelling et al. (2005), findings from the HART trial showed that counselling had no significant effect. This discrepancy could be explained by the different trials having different times to follow-up.

Notwithstanding the mixed evidence for patient counselling, healthcare providers are advised to provide counselling to persons with CHF. The CCS clinical guidelines strongly endorses that persons with CHF receive counselling for lifestyle choices ranging from smoking cessation to preconception counselling for women with CHF (Ezekowitz et al., 2017).

Chronic kidney disease

Process of care indicators for chronic kidney disease in the primary care setting were recently established by Tu et al. (2017). The authors argued that, in Canadian primary care, CKD was receiving less attention than other health conditions (Tu et al., 2017). Seventeen quality indicators were developed by Tu et al. (2017), and we

investigated four of these, namely, testing of (1) creatinine and (2) albumin-to-creatinine ratio; prescription of (3) ACEIs (or ARBs) and (4) statins. Many—if not most—cases of chronic kidney disease are secondary to diabetes mellitus (Arora et al., 2013) and, therefore, many of the process measures for diabetes care are synonymous with CKD management. Herein, we present some evidence on the process-outcome link for CKD process measures; and these quality indicators are congruent with clinical guidelines of professional associations such as the Canadian Society of Nephrology (Levin et al., 2008).

Testing of creatinine and albumin-to-creatinine ratio

The quantification of an individual's eGFR (i.e., a measure of renal functioning) requires, among other things, measurement of their serum creatinine level (Lewis, 2012; National Kidney Foundation, 2019a). A person's albumin-to-creatinine ratio is a measure of the protein content in their urine, and ACR can be used to detect proteinuria, a condition characterized by abnormally high urinary protein; proteinuria is suggestive of nephropathy (National Kidney Foundation, 2019b). Thus creatinine testing and ACR quantification are care processes for monitoring CKD (Qaseem et al., 2013). Qaseem, Hopkins, Sweet, Starkey, & Shekelle (2013) stated that no RCT had been conducted to compare the prognostic effects of routinely monitoring CKD. Nonetheless, the Canadian Society of Nephrology recommends that individuals with CKD should be monitored for proteinuria (Levin et al., 2008).

Prescription of angiotensin converting enzyme inhibitors or angiotensin II receptor blockers

Evidence from randomized controlled trials (RCTs) have shown that use of ACEIs or ARBs by persons with CKD results in favourable health outcomes (Lewis et al., 2001; Maschio et al., 1996). For instance, Maschio et al. (1996) investigated the effect of ACEIs on progression of renal insufficiency in persons with CKD, and the primary outcome of this RCT was time to 'doubling of serum creatinine', an indicator of decreasing eGFR, which, in turn, is suggestive of worsening kidney functioning (Lambers Heerspink et al., 2011). Kaplan-Meier estimates showed that, 26 of 180 (i.e., 14%), and 42 of 176 (i.e., 24%) of subjects with moderate renal insufficiency, attained the primary outcome in the ACEI and placebo groups, respectively, within three years ($p=0.01$).

Lewis et al. (2001) investigated the effect of ARBs on the progression of renal damage in persons who have type 2 diabetes, hypertension, and some form of nephropathy. Results showed that, in this study population, use ARBs—compared to placebo—was associated with a significantly ($p=0.009$) lower risk of doubling of serum creatinine (Relative risk=0.71, 95% CI: 0.54 - 0.92); the mean duration of follow-up was approximately 2.6 years (E. Lewis et al., 2001). Moreover, the Canadian Society of Nephrology recommends that persons with CKD—with or without diabetes—should be placed on ACEIs; if intolerance for ACEIs is evident, then ARBs should be recommended (Levin et al., 2008).

Prescription of statins

Fassett, Ball, Robertson, Geraghty, & Coombes (2008) investigated the effect of statins on the progression of renal disease for persons with CKD. The authors' primary

outcome was rate of decline in eGFR (Fassett et al., 2008). Results from this RCT showed a trend where the statin drug was non-significantly associated with a slower rate of decline in eGFR (Fassett et al., 2010). However, a post-hoc analysis study found that, compared to dietary intervention alone, use of statins in addition to the nutritional control was significantly ($p<0.01$) associated with a lower risk of CVD development in persons with Stage 3 CKD and of Japanese ethnicity (HR=0.45, 95% CI: 0.30 – 0.69) (Nakamura et al., 2009). In addition, the Canadian Society of Nephrology recommends that persons with CKD be placed on statin therapy (Levin et al., 2008).

No prescription of nonsteroidal anti-inflammatory drugs

Nonsteroidal anti-inflammatory class of drugs are commonly used by the elderly population for pain relief (Chang et al., 2015; Gooch et al., 2007). Evidence on the association between NSAID use and decline in renal function is mixed as some studies support that the use of NSAIDs is harmful to renal health (Chang et al., 2015; Gooch et al., 2007), while other studies show that using NSAIDs is neither beneficial nor harmful to renal health (Curhan et al., 2004; Rexrode et al., 2001). In spite of the mixed evidence, expert opinion supports that the use of NSAIDs should be avoided for persons with CKD (Tu et al., 2017).

Chapter 3

3 Quality of diabetes care in blended fee-for-service and blended capitation payment systems: evidence from Ontario, Canada

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3.1 Introduction

One goal of primary care reform in many developed countries is to improve the delivery of high quality patient care (Roland & Campbell, 2014). In Canada, the province of Ontario witnessed primary care reform in the early 2000's, rolling out primary care models with various remuneration schemes for family physicians. Among such models are the blended FFS Family Health Group and the blended capitation Family Health Organization, introduced in 2003 and 2006, respectively (Sweetman & Buckley, 2014). Prior to the reform, over 90 per cent of family physicians in Ontario were paid through pure FFS (Sweetman & Buckley, 2014); today, most are paid either by blended FFS or by blended capitation. These new models are characterized by formal patient enrollment, the mandatory provision of after-hours care, and a variety of P4P schemes including the DMI. The DMI rewards physicians $60 per patient per annum for organizing, rendering and documenting care processes that meet the clinical guidelines of Diabetes Canada. Essential care services of the DMI include testing glycated hemoglobin, measuring lipid profile, screening for nephropathy, retinopathy, and prescribing statins (Diabetes Canada Clinical Practice Guidelines Expert Committee, 2018; Kantarevic & Kralj, 2013).

The evidence on the relationship between physicians' remuneration and quality of diabetes care is mixed. The effect of P4P incentives on physicians' provision of diabetes care is, by and large, inconclusive as some studies failed to find any effect (Chien et al., 2012; Dimitrovová et al., 2020; Gupta & Ayles, 2019; Jaakkimainen et al., 2011; Lavergne et al., 2018; Pawaskar et al., 2010), while others found increases in diabetes-

related services under P4P schemes (Chen et al., 2010; Kiran et al., 2014, 2015; A. Scott et al., 2009).

Scott et al. (2009) used an Australian panel data set spanning 2002 to 2007, and found that general practitioners in the 'Practice Incentive Program' P4P scheme were 20% more likely to order an $HbA1_c$ test for their patients with diabetes compared to physicians who are not in the program. In a similar vein, Chen et al. (2010) used a Hawaiian panel data set from 1999 to 2006, and found that persons with diabetes cared by P4P participating physicians were more likely to receive at least two $HbA1_c$ tests and one lipid assessment per year relative to non-P4P participating physicians. O'Connor et al. (2020) found P4P schemes improved quality of diabetes care in Ireland. A review by Gupta and Ayles (2019) found that, in Taiwan, P4P incentives increased physicians' care continuity for persons with diabetes. This review also reported that P4P incentives were associated with a reduction in 5-year risk of all-cause mortality (Gupta & Ayles, 2019). A more recent paper again using Taiwanese data corroborated these findings (Kung et al., 2020).

Kontopantelis et al. (2013), using a pre-post analyses on patient-level data from 148 UK primary care practices between 2000 and 2006, found that the quality of diabetes management improved after introduction of the Quality and Outcomes Framework (i.e., a P4P program) in 2004. In this study, care quality for diabetes was a composite score of 17 indicators related to the management of diabetes; they found that the quality of care improved by 14.2% in the year this P4P was introduced; however, three years after, the magnitude of this improvement fell (Kontopantelis et al., 2013).

Not all of the literature has concluded that diabetes P4P measures improved care. Ryan, Krinsky, Kontopantelis, & Doran, (2016) found that P4P schemes did not impact mortality risk. Difference-in-differences analyses by Chien et al. (2012) found no improvement in diabetes care processes, including $HbA1_c$ testing and eye examination, after the introduction of the Hudson Health Plan, a P4P plan serving a region of New York (United States). A similar study from Colorado (United States) also found that the P4P scheme did not improve lipid testing or dilated eye exams (Rosenthal et al., 2016). Using 2000 to 2015 data from Portugal, Dimitrovová, Perelman and Serrano-Alarcón (2020) concluded that the addition of a P4P incentive for diabetes care did not reduce diabetes-related avoidable hospitalizations. Pawaskar et al. (2010) found that persons with diabetes under pure capitation payment plans were more likely to be hospitalized relative to those under pure FFS payment plans in the United States.

Three studies using data in Ontario are particularly relevant for our paper. Jaakkimainen et al. (2011) using administrative data from 2004 to 2007 reported no difference in the annual eye examination and prescription of statins between family physicians remunerated through blended FFS and blended capitation. By contrast, a cross-sectional study by Kiran et al. (2014) found that the likelihood of individuals with diabetes receiving eye examination, $HbA1_c$ testing and lipid measurement altogether was greater in blended capitation than in blended FFS. Kiran et al. (2015) found that patients with blended capitation physicians were more likely to get recommended tests for diabetes care.

The goal of our paper is to examine whether physicians switching from FHGs to FHOs behave differently when it comes to diabetes management. By using a longer follow-up, more outcome variables and sophisticated empirical methods, we contribute to the literature on the impact of physician remuneration on diabetes care. It is important, however, to understand why the FHG and FHO models may affect quality of care differently. Because capitated physicians receive a fixed payment per patient per time, they arguably have the financial flexibility to coordinate care and ensure continuity of care, leading us to hypothesize that physicians switching from the FHG to the FHO model would increase adherence to diabetes care. The health economics literature further suggests that blended capitation provides better incentives for primary care physicians than pure FFS for the efficient supply of health services (Christianson & Conrad, 2012; Eggleston, 2005; McGuire, 2011). In Ontario's FHO, capitation adjusts for the age and sex of enrolled patients, but not comorbidity – meaning that 'sicker' individuals may be eschewed by capitated physicians (the 'cream skimming' phenomenon), which would mitigate against the positive incentive effects of capitation. Our empirical strategy controls the average health of patients in order to deal with this potential issue. Moreover, various P4P incentives and access bonus (incentive to ensure that enrolled patients do not seek in-basket services from physicians outside of the practice) are designed to attenuate cream-skimming behavior in FHOs.

3.2 Methods

Study design

We used a retrospective cohort study design, with observations between April 1st, 2006 and March 31st, 2016. Our sample is comprised of physicians practicing in FHGs and FHOs, and their patients diagnosed with diabetes mellitus. At the baseline (April 1st, 2006), all physicians were in FHGs; we defined a 'switcher' as a FHG physician who switched to a FHO at any point within the study period and remained in the FHO after switching. A 'non-switcher' is a FHG physician who remained in this model throughout the study period. We examined whether switching from FHG to FHO affected physicians' behaviour in terms of six processes of care for diabetes management: $HbA1_c$ testing, lipid profile testing, nephropathy screening, eye examination, prescription of angiotensin converting enzyme inhibitors or angiotensin II receptor blockers, and prescription of statins. These indicators are consistent with Diabetes Canada clinical practice guidelines (Diabetes Canada Clinical Practice Guidelines Expert Committee, 2018). We also investigated the impact of switching on patients' mortality risk score, and their risk of hospitalization for an ambulatory care sensitive condition (ACSC) related to diabetes; by definition, ACSCs are avoidable in persons aged below 75 years if ambulatory care is efficient (Canadian Institute for Health Information, 2020a).

Data Sources

All data were obtained from the ICES which houses numerous Ontario health administrative databases. Persons with diabetes mellitus were identified through the Ontario Diabetes Dataset (ODD), a validated database with a sensitivity and specificity of 86.1% and 97.1%, respectively (Hux et al., 2002; Lipscombe & Hux, 2007). Although ODD excludes gestational diabetes, it does not distinguish between the type 1 and type 2

forms; most individuals identified in ODD would be type 2 since we included patients whose diagnosis of diabetes mellitus occurred at age 30 years or above (Kiran et al., 2014). Patients enrolled to physicians in FHGs and FHOs were identified through the client agency program enrollment database. The ICES physician database and corporate provider database provided physician characteristics and their practice model. The registered persons database provided patient characteristics. The income quintile was based on the census dissemination area-level data (Statistics Canada, 2015). Laboratory testing and prescription services were identified using the Ontario Health Insurance Plan (OHIP) database and Ontario Drug Benefit claims database.

Outcome Variables

Outcome variables were defined for each year. Each of the six processes of care was quantified as a proportion using OHIP billing codes (Appendix Table A1.2). For the laboratory-based indicators (HbA1c testing, lipid assessment and nephropathy screening) and eye examination, the denominator value represented the total number of a physician's patients with diabetes who were alive in the given year, and the numerator is a subset of the denominator population that received the respective process care at least once in that year. For the two drug-based indicators (ACEI/ARB, and statin prescription), the denominator was the total number of a physician's patients who were alive and aged at least 65 years in the given year; the numerator represented the subset of the denominator population who filled the prescription at least once in the respective year.

An individual's mortality risk score corresponds to his/her one-year risk of all-cause mortality based on the algorithm of Austin and Walraven. An ACSC

hospitalization due to diabetes refers to a hospital admission that occurs in persons aged below 75 years and is associated with a diabetes-related hospitalization (codes in Appendix Table A1.3). Appendix A contains detailed information on data sources and variable definitions.

Statistical analyses

All analyses were conducted at the physician-level, hence, all patient-level information were aggregated to the physician-level. We excluded physicians who were not present every year (e.g., retirees and new graduates were excluded), yielding a balanced panel of 2,120 physicians. Following previous research, physicians with fewer than 20 patients with diabetes were excluded to focus on physicians with a stable practice of patients with diabetes who are likely to be up to date with the best practices for diabetes management (Daneman et al., 2013).

Since the choice to remain in a FHG, or switch to a FHO, was voluntary, switchers may be different from non-switchers leading to a selection bias that could influence the outcomes. We employed a two-stage estimation procedure to deal with selection bias. The first stage accounts for the differences between switchers and non-switchers using an inverse-probability-weighted technique based on estimated propensity scores. This approach ensures that the two groups of physicians were similar in terms of their observable characteristics at baseline (i.e., before switching to FHO). The second stage estimates the impact of switching from FHG to FHO on processes of care for diabetes and related outcomes using inverse-probability-weighted fixed-effects regressions. This two-stage estimation approach has been employed in recent

publications to study the impact of reform on other outcomes (Kralj & Kantarevic, 2013; Sarma et al., 2018; Somé et al., 2019).

Propensity score model

We begin with estimating a propensity score model using a logistic regression. A general guideline is to include covariates in a propensity score model that are likely to be associated with both the outcome and exposure variable (Guo & Fraser, 2015; Rosenbaum & Rubin, 1983). Following the literature, we include: physicians' expected income gain by switching from FHG to FHO and its squared term, age, international medical graduate status (graduates outside of Canada and the United States), group size, number of enrolled patients, physician sex, average age of patients in the physician's practice, proportion of female patients in the practice, patients' average comorbidity score based on the Johns Hopkins Aggregated Diagnosis Groups (ADG), proportion of patients from low income area, proportion of patients living in rural areas, and the outcome variables in the baseline year (Kantarevic et al., 2011; Kralj & Kantarevic, 2013; Sarma et al., 2018).

The estimated value of a FHG physician's income after joining a FHO is the expected gain in income from switching. To assist FHG physicians in deciding whether to join a FHO, the Ministry of Health and Long-term Care provided them with an estimate of their potential gain in income (Kralj & Kantarevic, 2013; Sarma et al., 2018). The estimated income gain is based on the services a FHG physician provided to their enrolled and non-enrolled patients in the 12 months preceding April 1st, 2006. The estimated potential income in an FHO used the following: (i) income from capitation rate

of $144.08 multiplied by the age-sex modifier for enrolled patients as of April 1st 2006, (ii) income from shadow billing, which was 10% of FFS value for in-basket services in 2006, (iii) income from providing out-of-basket services to both enrolled and non-enrolled patients based on 100% of FFS value, (iv) income from the "hard cap" based on 100% of FFS value for in-basket services to non-enrolled patients up to $47,500, and (v) special payments for providing hospital services, obstetrical care, home visits and prenatal care (Kralj & Kantarevic, 2013; Sarma et al., 2018). Out-of-basket services refer to services that are not under the capitation basket. Inclusion of the expected gain in income is a crucial variable in the propensity score model as this variable influences a FHG physician's decision on whether or not switch to FHO.

Once the propensity score model was estimated, we used the estimated propensity scores ("predicted probabilities") to construct weights based on kernel matching. Since our objective is to estimate the effect of switching to a FHO, every switcher physician was given a weight of one and the non-switcher physicians were weighted based on the distance between their propensity scores and that of a switcher physician within a bandwidth of 0.06 (Garrido et al., 2014; Guo & Fraser, 2015). Physicians who did not fall within these criteria (i.e., outside the range of common support) were excluded. We used t-tests and the standardized bias to assess the balance of covariates (Harder et al., 2010). Finally, given that the misspecification of a propensity score model and covariate imbalance can result in biased estimates, we used two alternative weighting procedures as robustness checks: the covariate balancing propensity score (CBPS) (Imai & Ratkovic, 2014) and entropy balancing (EB) weights (Hainmueller, 2012).

Fixed-effects regressions

Fixed-effects regressions account for unmeasured time-invariant confounding by controlling for variations by physicians not captured by included covariates (Allison, 2009; Wooldridge, 2010). For each of the eight quality indicators, we ran both unweighted and inverse-probability-weighted pooled and fixed-effects regressions; the weights were derived from kernel, CBPS and EB weighting. The process indicators were analysed using a random-effects model with group means, equivalent to a fixed-effects regression (Papke, 1996); mortality risk score, a continuous variable, was analyzed using a linear weighted fixed-effects regression (Sarma et al., 2018); and diabetes-related ACSC hospitalizations were analysed using a weighted fixed-effects Poisson regression. The equation below describes the linear fixed-effects regression:

$$Y_{it} = \alpha_i + \delta FHO_{it} + \beta X_{it} + \varepsilon_{it}.$$

Here Y_{it} represents the outcome variable of physician *i* in time period *t*, FHO is a dummy variable that takes a value of one if physician *i* switched to FHO at time *t* and zero if remained in FHG; δ is the estimated coefficient of interest capturing the effect of a physician's switch to FHO on Y; X_{it} is the vector of covariates previously listed; α_i captures unmeasured time-invariant physician-specific factors and ε_{it} is the error term. We use fractional years to account for the duration a switcher was in the FHO model during the first year of switch.

Sub-group analyses were undertaken separately by sex of the physician, their age (below 55 and 55+ years at the baseline), and by four switching cohorts (2008-2009; 2010-2011; 2012-2013; 2014-2015). The purpose of these subgroup analyses was to

identify whether the effect of switching to FHO was different across various sub-populations of physicians. All analyses employed the statistical software *Stata* version 15.1 (StataCorp, 2017).

Ethics

The use of data in this project was authorized under section 45 of Ontario's Personal Health Information Protection Act, which does not require review by a Research Ethics Board.

3.3 Results

We observed 2,120 physicians over 10 years (21,200 physician-year observations): 1,291 switchers and 829 non-switchers; a simple flow chart for the derivation of the final sample size of physicians is depicted in Appendix B Figure B.0. Table B1.0 in Appendix B presents the mean values of explanatory and outcome variables for switchers and non-switchers across all years. Prior to kernel weighting, all covariates were significantly different between switchers and non-switchers except physician's sex. Non-significant *p*-values, and a standardized bias of no greater than 7% were revealed for all covariates after weighting (Table 3.1). The robustness of these results was confirmed with CBPS and EB weights (Tables B1.1 and B1.2 in Appendix B). In addition, graphs of propensity scores as well as standardized difference in means and variance ratios confirmed reasonable covariate balance between the switchers and non-switchers after weighting (Figures B.1 and B.2 in Appendix B).

Our inverse-probability-weighted fixed-effects estimates found that the marginal effects of switching to FHO increased a physician's $HbA1_c$ testing, lipid assessment,

nephropathy screening and statin prescription, at least once a year, by 2.75% (95% CI: 1.89%, 3.60%), 2.57% (CI: 1.72%, 3.44%), 2.76% (CI: 1.86%, 3.49%) and 1.08% (CI: 0.56%, 1.69%), respectively. These results reveal substantially more patients receiving care from switchers: based on 2,131,830 total diabetes patient-year observations in FHOs in our data with 1,081,528 of them over 65 years, switching from FHG to FHO resulted in 58,625 (CI: 40,291, 76,745) more patients receiving $HbA1_c$ testing, 54,788 (CI: 36,667, 73,121) more patients receiving lipid assessment, 58,838 (CI: 41,570, 76,106) more patients receiving nephropathy screening and 11,680 (CI: 5,515, 17,953) more patients receiving statin prescription over 10 years. On average, switchers' patients had a 0.197 lower mortality risk score (CI: -0.33, -0.060) (Table 3.2), suggesting that the risk of dying within one-year was reduced by approximately 0.0124% (CI: 0.0123%, 0.0126%) or 265 (CI: 262, 268) fewer total deaths in switchers' patients. The risk of ACSC hospitalizations was not different between switchers' and non-switchers' patients (Table 3.2). The corresponding results based on CBPS and EB weighted results were qualitatively similar.

For physicians who were male, female, younger (aged below 55 in 2006), and older (aged 55+ years in 2006), switching to FHO was associated with more $HbA1_c$ testing, lipid assessments, nephropathy screening and statin prescriptions (Table 3.3, Tables B1.3-B1.6 in Appendix B). While the effect of switching to FHO was slightly higher in male physicians (3.0%) relative to females (1.7%) for $HbA1_c$ testing, lipid assessments (2.6% vs. 2.4%) and nephropathy screenings (2.9% vs. 2.4%), the respective confidence intervals overlapped (Table 3.3). Similarly, the effect of switching on statin

prescription was higher for females compared to males (1.4% vs. 1.0%), but the respective confidence intervals overlapped (Table 3.3). In the four subgroups of physicians (male, female, young and old), we found no difference for eye examinations and ACEI/ARB prescriptions (Table 3.3); except for female physicians, we found no difference in patients' risk of ACSC hospitalizations. For female physicians, switching to FHO was associated with a decreased risk of ACSC hospitalizations (relative risk=0.610, CI: 0.403, 0.912) (Table 3.3), and this finding was corroborated by both CBPS and EB results (Table B1.4 in Appendix B). The effect of switching to FHO was associated with a statistically significant decrease in the mean mortality risk score of patients of male physicians and older physicians; the impact of switching to FHO on mortality risk score was non-significant for physicians who were female or younger (Table 3.3).

Switching to FHO was associated with an increase in $HbA1_c$ testing, lipid assessment and nephropathy screening for both early and late switchers compared to non-switchers. Though the effect on these three care processes was slightly greater for the early switchers, there was considerable overlap in the respective confidence intervals (Table 3.4, Table B1.7 in Appendix B). The impact of switching to the blended capitation model on statin prescription was associated with a significant increase only for early switchers; no effect was observed for late switchers, and these two groups of switchers were statistically similar for ACEI/ARB prescriptions and ACSC hospitalizations. The impact of switching to FHO was associated with a slight decrease in eye examinations only for late switchers between 2012 and 2013. Significantly lower mortality risk scores

for patients were found for early switchers and switchers between 2010 and 2011 (Table 3.4, Table B1.7 in Appendix B).

3.4 Discussion

In Ontario, relative to those who remained in a FHG, family physicians who switched to the FHO model had an increase in $HbA1_c$ testing, lipid assessment, nephropathy screening, and statin prescription for individuals with diabetes. Patients of these switchers had a lower mortality risk compared to patients of physicians who remained in FHG. However, switchers and non-switchers were not different in terms of annual eye examinations, ACEI/ARB prescription and patients' risk of ACSC hospitalizations. Patients of physicians who switched to FHO between 2012 and 2013 had slightly fewer eye examinations than non-switchers' patients; patients of female switchers, on average, had marginally lower ACSC hospitalizations relative to non-switchers' patients. We also implemented a before-and-after analysis using only the switchers' data, and these results were in the similar direction with relatively higher effects compared to our main analysis (Table B1.8 in Appendix B).

Our study has various strengths. Compared to previous literature, our identification strategy allows for stronger conclusions. For instance, the studies by Kiran et al. (2014) and Jaakkimainen et al. (2011) compared care quality in different payment models using cross-sectional regressions and did not account for time-invariant physician-specific confounding; nor did these studies address potential selection into physician practice models. Our two groups of practice models were based on similar observed characteristics and outcomes at the baseline; in our study, blended capitation

and blended FFS each constituted only one practice model, unlike Kiran et al. (2014) where, blended capitation included FHOs and Family Health Networks. Our longer follow-up period allowed physicians time to adjust to the new remuneration scheme, arguably capturing a more accurate measure of physicians' behaviour in these models.

Our study has some limitations. Given that we conducted binary analyses for care processes (i.e., 'no' vs. 'at least one' $HbA1_c$ testing), our notion of quality—for the process measures investigated—essentially corresponded to the provision vs. non provision of care. Although laboratory services identified through OHIP include services provided in hospitals, it may not be captured completely. It is possible that some patients were given a laboratory requisition, but they did not follow through. For the prescription-based process indicators, the information in the Ontario Drug Benefit database captures patients' records of prescriptions filled by patients who are aged 65 years or older. It is possible, therefore, that a physician prescribed medications which the patient did not fill; moreover, we could not capture the prescriptions of those under 65 years of age (Cheung et al., 2017). A proportion of FHO physicians are also part of the family health team and the effects found in our study can be interpreted as the combined effect of blended capitation and team-based primary care. While process and outcome indicators are established metrics for measuring care quality (Ameh et al., 2017; Donabedian, 1988; Moore et al., 2015), they have limitations: more testing and prescriptions are not always synonymous with better care, and health outcomes such as risk of mortality and hospitalization can be influenced by factors beyond physician (life style choices and economic circumstances). Our identification strategy that combines propensity-score

based weights with fixed-effects regression cannot definitively confirm a causal effect of remuneration on quality of care because of the potential for residual confounding. Nonetheless, including the expected income gain of switching to FHO and its squared term along with a rich set of physician- and patient-characteristics in the propensity score model combined with the inverse-probability-weighted fixed-effects regressions arguably minimize the influence of residual confounding.

Our work suggests important positive influences of P4P incentives for diabetes management in a blended capitation payment system, consistent with some of the findings of previous work. We can explain some of the discrepancies between our paper and those of other papers. For instance, our conclusions for eye examinations are inconsistent with Kiran et al. (2014); their study was based on data over two years (2006-2008), while ours used a decade of data. Our inverse-probability-weighted strategy accounts for potential differences between the two groups before switching to FHO. Finally, policy-level factors can reconcile the discrepancy between Kiran et al. (2014) and our study. Prior to November 1st, 2004, retinal examinations were covered by the OHIP for Ontario residents of any age, but, after that date it was delisted with the exception of individuals with diabetes. The delisting of eye examination for non-diabetes patients was associated with unintended consequences of decline in eye examination for persons with diabetes (Kiran et al., 2013).

In the absence of randomization, propensity score-based inverse-probability-weighted fixed-effects regressions is a reasonable approach to identify associations that are closer to causal. With this identification strategy on a balanced panel of family

physicians spanning over a decade, our study provides stronger empirical evidence that the switching of Ontario's family physicians from Family Health Groups to Family Health Organizations increased physicians' adherence to many process measures for diabetes management. Future studies can use Ontario's natural experiment setting to investigate the effect of physicians' switching from a blended FFS to a blended capitation model on quality of care indicators for other patient populations.

Table 3.1 Means and standardized bias results before and after kernel weighting

Covariate	Means and standardized bias prior to kernel weighting					Means and standardized bias after kernel weighting				
	FHO	**FHG**	**Bias**	**t-statistic**	**p-value**	**FHO**	**FHG**	**Bias**	**t-statistic**	**p-value**
Physicians' characteristics										
Expected income gain (in thousand $)	137.13	108.15	34.3	24.74	0	137.13	137.21	-0.1	-0.02	0.98
(Expected income gain)^2	25022	19737	17.1	12.19	0	25022	25294	-0.9	-0.23	0.82
Age (years)	54.43	56.55	-23.2	-16.56	0	49.93	50.43	-5.5	-1.5	0.14
Age^2	3041.9	3283.5	-23.8	-17.01	0	2564.1	2614.2	-4.9	-1.49	0.14
Female (proportion)	0.27	0.26	1.2	0.84	0.4	0.27	0.26	0.8	0.2	0.85
IMG (proportion)	0.13	0.22	-24.6	-17.92	0	0.13	0.13	-0.2	-0.05	0.97
Group size	31.65	54.04	-35.1	-25.7	0	39.33	41.31	-3.1	-0.89	0.38
Number of enrolled patients	1744.6	1856.3	-14.7	-10.7	0	1811.5	1802.1	1.2	0.33	0.75
Patients' characteristics										
Female (proportion)	0.52	0.51	4.8	3.44	0.01	0.52	0.52	0.8	0.19	0.85
Rural areas (proportion)	0.11	0.06	28	19.26	0	0.11	0.11	-1.1	-0.22	0.83
Average age (in years)	42.56	41.67	15.3	10.93	0	40.25	40.38	-2.2	-0.6	0.55
Low income quintile (proportion)	0.36	0.4	-26.6	-19.08	0	0.37	0.38	-2.9	-0.77	0.44
Average ADG	3.23	3.39	-38.7	-27.74	0	3.34	3.34	-0.8	-0.2	0.85
Outcome variables										
$HbA1_c$ testing (proportion)	0.61	0.59	15	10.68	0	0.57	0.56	5.7	1.37	0.17

Lipid assessment (proportion)	0.57	0.57	0.3	0.18	0.86	0.55	0.54	6.8	1.65	0.1
Nephropathy screening (proportion)	0.66	0.64	13.4	9.5	0	0.64	0.63	4.5	1.05	0.3
Eye examination (proportion)	0.05	0.05	-12.7	-9.11	0	0.05	0.05	1.4	0.37	0.72
ACEI or ARB prescription (proportion)	0.65	0.63	16	11.4	0	0.69	0.69	0.2	0.06	0.96
Statin prescription (proportion)	0.71	0.7	10.2	7.32	0	0.66	0.65	4.8	1.08	0.28
Mortality risk score	51.03	49.98	23.6	17.15	0	49.72	49.84	-2.9	-0.74	0.47
ACSC hospitalization	0.162	0.173	-2.3	-1.68	0.094	0.192	0.189	0.8	0.17	0.86

Abbreviations: FHG: Family Health Group, FHO: Family Health Organization, IMG: International Medical Graduate, ADG: Aggregated Diagnosis Groups (Johns Hopkins), $HbA1_c$: glycated hemoglobin, ACEI: Angiotensin converting enzyme inhibitors, ARB: Angiotensin II receptor blocker, ACSC: ambulatory care sensitive condition due to diabetes.

FHO represents physicians who switched from FHG to FHO at any point within the observation period; FHG represents physicians who remained in a FHG model throughout the study period.

Table 3.2 Effect of switching to FHO on process of care and health outcomes for persons with diabetes mellitus

Outcome variable[a]	Pooled		Fixed-effects	
	Unweighted	**Kernel**	**Unweighted**	**Kernel**
$HbA1_c$ testing (%)	3.86***	4.00***	2.62***	2.75***
	(2.58 - 5.15)	(2.23 - 5.77)	(1.95 - 3.29)	(1.89 - 3.60)
Lipid assessment (%)	3.09***	4.25***	2.67***	2.57***
	(1.85 - 4.32)	(2.58 - 5.93)	(2.00 - 3.34)	(1.72 -3.43)
Nephropathy screening (%)	3.85***	4.07***	2.73***	2.76***
	(2.65 - 5.06)	(2.36 - 5.78)	(2.09 - 3.37)	(1.95 - 3.57)
Eye examination (%)	-0.0912	0.412**	0.0196	-0.0622
	(-0.429 - 0.247)	(0.0901 - 0.734)	(-0.162 - 0.201)	(-0.240 - 0.115)
ACEI or ARB prescription (%)	0.757**	0.251	-0.221	0.403
	(9.87e-03 - 1.50)	(-0.635 - 1.14)	(-0.730 - 0.288)	(-0.199 - 1.01)
Statin prescription (%)	2.09***	1.38***	0.926***	1.08***
	(1.28 - 2.90)	(0.397 - 2.36)	(0.441 - 1.41)	(0.508 - 1.66)
Mean mortality risk score	0.0628	-0.207	-0.384***	-0.197***
	(-0.161 - 0.287)	(-0.495 - 0.0806)	(-0.497 - -0.270)	(-0.334 - -0.0597)
Risk ACSC hospitalization	1.069	1.008	0.998	1.004
	(0.960 - 1.192)	(0.883 - 1.151)	(0.865 - 1.152)	(0.850 - 1.186)

Abbreviations: OLS: ordinary least squares, $HbA1_c$: glycated hemoglobin, ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker, FHO: Family Health Organization; ACSC: ambulatory care sensitive condition, FHO: Family Health Organization

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses.

[a]This table reports the average marginal effects of a physician's switch from FHG to FHO on processes of care. For example, results show that switching from FHG to FHO increases a physician's ordering at least one $HbA1_c$ test by 2.75% per physician per year. This table also reports patients' risk of diabetes-related ACSC hospitalization and patients' mean mortality risk score of those who switched from FHG to FHO.

Table 3.3 Effect of switching to FHO on process of diabetes care and patients' health outcomes for various subgroups of physicians

Outcome variable[a]	Subgroup			
	Male	**Female**	**Younger**	**Older**
$HbA1_c$ testing (%)	3.03***	1.68**	2.08***	3.67***
	(2.01 - 4.06)	(0.287 - 3.07)	(0.983 - 3.19)	(2.12 - 5.22)
Lipid assessment (%)	2.59***	2.38***	2.26***	3.00***
	(1.58 - 3.60)	(0.859 - 3.90)	(1.14 - 3.37)	(1.44 - 4.55)
Nephropathy screening (%)	2.91***	2.43***	2.36***	3.29***
	(1.85 - 3.96)	(1.02 - 3.84)	(1.32 - 3.41)	(1.80 - 4.78)
Eye examination (%)	-0..118	0.104	-0.142	0.0515
	(-0.323 - 0.0865)	(-0.238 - 0.446)	(-0.354 - 0.0702)	(-0.260 - 0.363)
ACEI or ARB prescription (%)	0.285	0.612	0.491	0.135
	(-0.382 - 0.951)	(-0.742 - 1.97)	(-0.273 - 1.26)	(-0.823 - 1.09)
Statin prescription (%)	0.942***	1.40**	0.822**	1.41***
	(0.311 - 1.57)	(0.166 - 2.64)	(0.0936 - 1.55)	(0.516 - 2.31)
Mean mortality risk score	-0.252***	-0.069	-0.134	-0.321***
	(-0.412 - -0.0920)	(-0.331 - 0.193)	(-0.306 - 0.0386)	(-0.537 - -0.104)
Risk of ACSC hospitalization	1.089	0.610**	0.991	1.055
	(0.910 - 1.304)	(0.403 - 0.921)	(0.799 - 1.229)	(0.811 - 1.373)
n	15,660	5,540	13,510	7,690

Abbreviations: HbA1c: glycated hemoglobin, ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker, FHO: Family Health Organization, ACSC: ambulatory care sensitive condition due to diabetes, n: physician-year observations.

Notes:

Only results from kernel weighted fixed effects regression are reported in this table

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses.

[a] For the four subgroups of physicians, this table reports the average marginal effects of a physician's switch from FHG to FHO on processes of care. This table also reports patients' risk of diabetes-related ACSC hospitalization and patients' mean mortality risk score under the four subgroups of switchers and non-switchers.

Table 3.4 Effect of switching to FHO on process of diabetes care and patients' health outcomes for different cohorts of switchers

Outcome variable[a]	**switched between 2008 and 2009**	**switched between 2010 and 2011**	**switched between 2012 and 2013**	**switched between 2014 and 2015**
$HbA1_c$ testing (%)	2.70***	1.30***	2.07***	0.552
	(1.98 - 3.41)	(0.472 - 2.13)	(0.857 - 3.29)	(-1.68 - 2.78)
Lipid assessment (%)	2.88***	1.20***	1.18*	0.314
	(2.13 - 3.63)	(0.339 - 2.07)	(-0.129 - 2.49)	(-2.06 - 2.69)
Nephropathy screening (%)[b]	2.60***	1.51***		
	(1.89 - 3.30)	(0.727 - 2.29)		
Eye examination (%)	-0.081	-0.242	-0.455***	0.313
	(-0.269 - 0.107)	(-0.536 - 0.0509)	(-0.748 - -0.162)	(-0.0869 - 0.713)
ACEI or ARB prescription (%)	-0.0265	0.11	0.106	0.791
	(-0.561 - 0.508)	(-0.535 - 0.755)	(-0.719 - 0.932)	(-0.352 - 1.93)
Statin prescription (%)	1.51***	0.336	-0.683	-0.403
	(1.03 - 1.99)	(-0.261 - 0.934)	(-1.50 - 0.132)	(-1.35 - 0.545)
Mean mortality risk score	-0.375***	-0.364***	-0.159	0.0853
	(-0.503 - -0.247)	(-0.514 - -0.214)	(-0.373 - 0.0542)	(-0.179 - 0.350)
Risk of ACSC hospitalization	1.089	0.923	1.158	0.977
	(0.910 - 1.302)	(0.699 - 1.218)	(0.700 - 1.917)	(0.369 - 2.588)
n	19,071	11,410	5,840	2,991

Abbreviations: $HbA1_c$: glycated hemoglobin, ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker, FHO: Family Health Organization, ACSC: ambulatory care sensitive condition, n: sample size

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in Xit, 95% confidence interval in parentheses.

-Only results from kernel weighted fixed effects regression are reported in this table.

[a] This table reports the average marginal effects of a physician switching from FHG to FHO in each cohort of switchers on processes of care relative to non-switchers. This table also reports patients' risk of diabetes-related ACSC hospitalizations and patients' mean mortality risk of each cohort of switchers relative to non-switchers.

[b] Estimates for nephropathy screening could not be computed for physicians who switched as of 2012 because the main independent variable predicted outcome perfectly.

Appendix A (for Chapter 3)

A1.1 Schematic for creation of study population

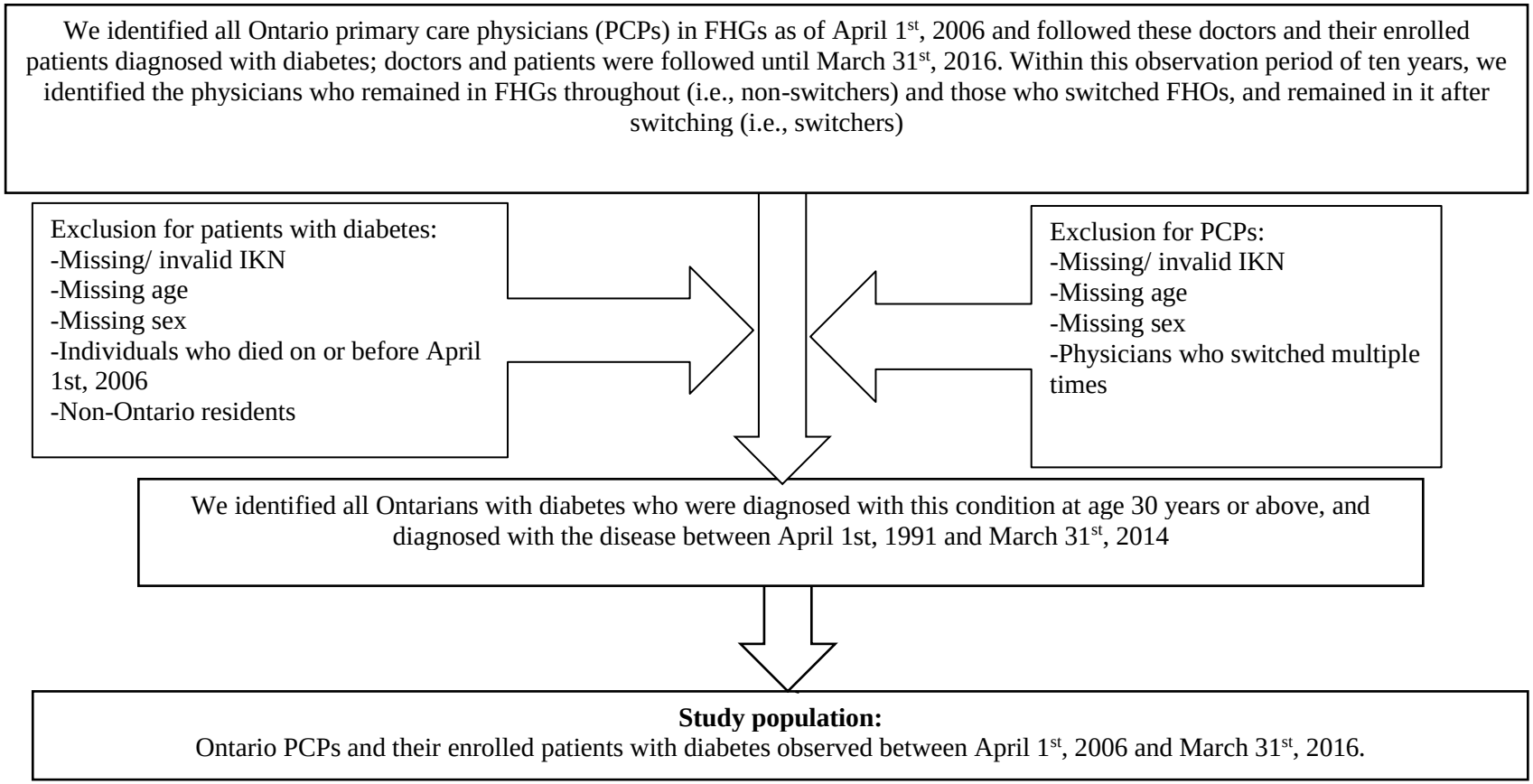


Figure A1.1 Schematic for creation of study population.

A1.2 Data sources for variables

The Client Agency Program Enrollment (CAPE) database records patients registered with a physician who practices in any of the patient enrolment models (Glazier et al., 2012); we used CAPE to identify patients who are either enrolled with a FHG or FHO physician. We used the Ontario Diabetes Dataset to identify individuals diagnosed with diabetes mellitus; ODD is a registry of Ontarians diagnosed with diabetes mellitus since 1991. The algorithm for identifying individuals with diabetes in the ODD is the occurrence of the following within two years: at least one hospital discharge with a diabetes diagnosis or at least two physician service claims with a diabetes diagnosis. ODD had been validated and has a sensitivity of 86.1%, a specificity of 97.1% and a positive predictive value of 80% (Hux et al., 2002; Lipscombe & Hux, 2007). While ODD excludes individuals with gestational diabetes, ODD does not distinguish between type 1 and type 2 diabetes mellitus; nevertheless, the vast majority of individuals identified in ODD would be persons with type 2 diabetes (Kiran et al., 2014). Demographic information, such as sex, date of birth, and payment model type for primary care physicians are obtained from the Corporate Provider Database (CPDB) (Lofters et al., 2013; Ontario Ministry of Health and Long Term Care, 2017). The Canadian Institute for Health Information - Hospital Discharge Abstract Database (CIHI-DAD or simply DAD) contains clinical and administrative inpatient information for individuals who are discharged from hospitals. As of 2002, DAD uses the 10th revision of the International Classification of Diseases (ICD-10) (Gandhi, 2016; Glazier et al., 2012). We used DAD for identifying ACSC hospitalizations due to diabetes mellitus. The ICES Physician Database (IPDB) contains encrypted physician numbers, yearly demographic information, and some practice characteristics on all physicians in Ontario. We used IPDB to identify physicians' characteristics, including age, sex, year of graduation, and country of medical education (i.e., international

medical graduate or Canadian medical graduate). The Canadian Institutes for Health Information-National Ambulatory Care Reporting System (CIHI-NACRS or simply NACRS) contains information on outpatient visits to hospital and community-based ambulatory care facilities such as emergency departments (Gandhi, 2016; Glazier et al., 2012). We used information from OHIP, DAD and NACRS for mortality risk score. The Ontario Drug Benefit Claims Database (ODB) contains claims data for prescription medications covered by the Ontario Drug Benefit Program, which is a provincial program that provides coverage for various prescription medications to Ontarians aged 65 years and above, as well as to social assistance recipients (Gandhi, 2016). We used ODB for identifying prescription-based process measures (i.e., ACEI/ARB and statin prescriptions). The Ontario Health Insurance Plan Database contains claims data of all insured services provided by licensed healthcare providers (including primary care physicians) to Ontario residents eligible for the provincial healthcare coverage. Information recorded under OHIP includes the type of service provided, the person who provided the service, the person who received the service, the date the service was provided, and the fee code(s) associated with the service (Gandhi, 2016; Glazier et al., 2012). We used OHIP to identify laboratory-based process measures (i.e., $HbA1_c$ testing, lipid assessment, nephropathy screening and eye examination). The Registered Persons Database (RPDB) is a registry that houses demographic information for Ontarians with provincial healthcare coverage; the information includes individuals' sex, date of birth, and date of death (Gandhi, 2016; Glazier et al., 2012). We used RPDB to identify patients' characteristics, including age and sex. Postal codes from the RPDB is used to obtain census dissemination area level income quantile.

Table A1.1 Eligible patient population and outcome for quality indicators

Quality indicator	Eligible patient population (i.e., denominator)	Outcome (i.e., numerator)
$HbA1_c$ testing	For each year, only include patients diagnosed with diabetes and who are alive in that year	For each year, include patients who received $HbA1_c$ testing at least once
	Data sources: ODD, RPDB, OHIP	
Lipid assessment	For each year, only include patients diagnosed with diabetes and who are alive in that year	For each year, include patients who received testing for lipid profile at least once
	Data sources: ODD, RPDB, OHIP	
Nephropathy screening	For each year, only include patients diagnosed with diabetes and who are alive in that year	For each year, include patients who received ACR testing and creatinine testing at least once
	Data sources: ODD, OHIP, RPDB	
Eye examination	For each year, only include patients diagnosed with diabetes and who are alive in that year	For each year, include patients who had retinal eye examination done at least once
	Data sources: ODD, OHIP,RPDB	
Prescription of ACEI or ARBs	For each year, only include patients diagnosed with diabetes and who are alive in that year. Also, only include patients who are aged 65 years or older	For each year, include patients who received a prescription for ACEI or ARB at least once
	Data sources: ODD, ODB, RPDB	

Prescription of statins	For each year, only include patients diagnosed with diabetes and who are alive in that year. Also, only include patients who are aged 65 years or older	For each year, include patients who received a statin prescription at least once
	Data sources: ODB, ODD, RPDB	
Risk of hospitalization for diabetes mellitus as an ambulatory care sensitive condition (ACSC)	For each year: -identify inpatients records from acute care hospitals with diabetes as the most responsible diagnosis -only include diabetes patients who are below 75 years of age -only include diabetes patients who are alive within that year	
	Data sources: DAD, NACRS, ODD	
Mortality risk score	For each year, calculate patients' mortality risk score as per the algorithm by Austin and Walraven (2011) (Austin & Walraven, 2011)	
	Data Sources: RPDB, OHIP, DAD, NACRS	

Abbreviations: CAPE: Client Agency Program Enrollment Registry, CPDB: Corporate Provider Database, DAD: Canadian Institute for Health Information - Hospital Discharge Abstract Database, ICES: Institute for Clinical Evaluative Sciences, IPDB: ICES Physician Database, NACRS: National Ambulatory Care Reporting System, ODB: Ontario Drug Benefit Claims Database, ODD: Ontario Diabetes Dataset, OHIP: Ontario Health Insurance Plan Database, RPDB: Registered Persons Database, ACSC: ambulatory care sensitive condition, $HbA1_c$: glycated haemoglobin, ACR: albumin-to-creatinine ratio, ACEI: Angiotensin converting enzyme inhibitor, ARB: Angiotensin II receptor blockers

Notes:

The first six outcomes were quantified as proportions; avoidable diabetes-related hospitalizations (i.e., the seventh outcome variable) were quantified as counts, and mortality risk score (i.e., the eighth outcome variable) were quantified as means.

Table A1.2 Codes for identifying diabetes process measures

Variable	**Code(s)***
$HbA1_c$ testing	L093
Lipid testing	L055, L117, L243
Nephropathy screening: creatinine testing	L065,L067,L068
Nephropathy screening: ACR testing	G009, G010, L253, L254
Eye examination	V406, A234, A233, V409, A235, V404, A112, A115, A239, A236, G460, A110, A252, A254, A230, A237, G461, A250, A111, A114

Note:
*The code(s) correspond to fee codes in the Ontario Health Insurance Plan (OHIP) database
Abbreviation: ACR: Albumin-to-Creatinine Ratio, $HbA1_c$: glycated hemoglobin

Table A1.3 ICD-10-CA codes for ACSC hospitalization due to diabetes mellitus

Codes	E10.0, E10.1^, E.10.9, E11.9, E13.0, E13.9, E14.0, E14.63, E14.9, E11.0^, E11.1^, E13.0^, E13.1^, E14.0^, E14.1^, E10.2^, E10.3^, E10.4^, E10.5^, E10.6^, E10.7^, E11.2^, E11.3^, E11.4^, E11.5^, E11.6^, E11.7^, E13.2^, E13.3^, E13.4^, E13.5^, E13.6^, E13.7^, E14.2^, E14.3^, E14.4^, E14.5^, E14.6^, E14.7^

Abbreviation: ICD-10-CA: International Classification of Diseases and Related Health Problems (10th edition), Canada, ACSC: ambulatory care sensitive condition.

References: https://www150.statcan.gc.ca/n1/pub/82-622-x/2011007/definition-eng.htm , http://cmajopen.ca/content/suppl/2017/10/06/5.4.E746.DC1/2017-0007-2-at.pdf

Appendix B (for Chapter 3)

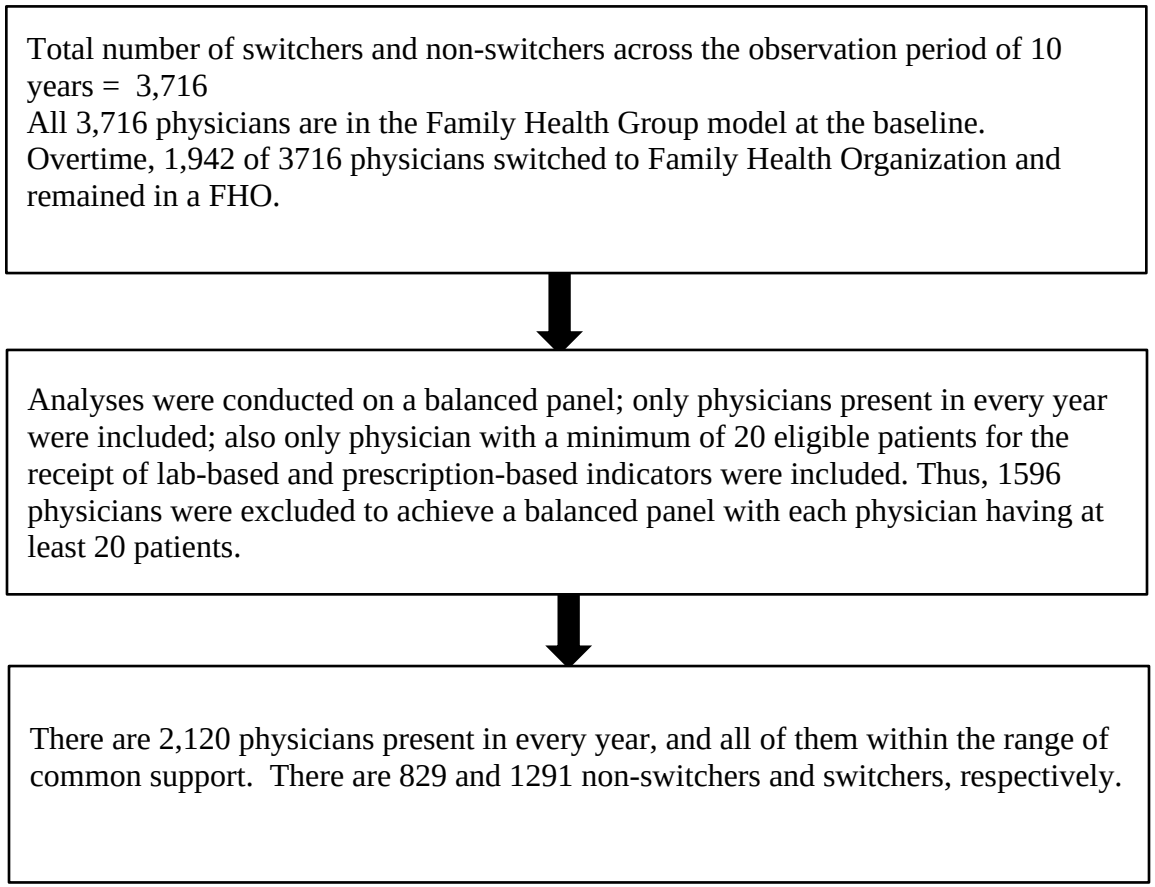


Figure B.0 Simple schematic for derivation of final sample size

Table B1.0 Mean values of outcome and explanatory variables for the switchers (n= 1,291) and non-switchers (n= 829)

Variable	Switcher	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Outcome variables											
$HbA1_c$ testing	0	0.548	0.555	0.579	0.585	0.593	0.596	0.578	0.593	0.596	0.59
	1	0.563	0.57	0.592	0.603	0.617	0.621	0.606	0.625	0.634	0.63
Lipid assessment	0	0.557	0.563	0.57	0.571	0.58	0.576	0.546	0.557	0.556	0.542
	1	0.545	0.553	0.563	0.571	0.583	0.583	0.551	0.563	0.563	0.548
Nephropathy screening	0	0.627	0.629	0.64	0.642	0.647	0.648	0.627	0.637	0.634	0.627
	1	0.631	0.637	0.647	0.658	0.67	0.676	0.655	0.666	0.667	0.663
Eye examination	0	0.059	0.054	0.051	0.048	0.049	0.046	0.043	0.043	0.042	0.043
	1	0.049	0.045	0.045	0.043	0.043	0.041	0.038	0.039	0.037	0.038
ACEI or ARB prescription	0	0.66	0.66	0.652	0.641	0.641	0.621	0.607	0.6	0.591	0.585
	1	0.682	0.68	0.67	0.656	0.653	0.636	0.622	0.616	0.607	0.604
Statin prescription	0	0.636	0.66	0.679	0.695	0.708	0.712	0.712	0.717	0.718	0.722
	1	0.654	0.681	0.696	0.712	0.72	0.723	0.721	0.721	0.722	0.724
Mortality risk score	0	48.39	48.59	48.91	49.27	49.63	50	50.37	50.86	51.47	52.3
	1	49.72	49.83	50.09	50.44	50.67	51.08	51.4	51.77	52.26	53.09
ACSC hospitalization	0	0	0.179	0.174	0.141	0.195	0.189	0.193	0.187	0.162	0.141
	1	1	0.192	0.160	0.136	0.182	0.161	0.175	0.139	0.143	0.177
Physician characteristics [a]											
Age (in years)	0	52.042	53.042	54.042	55.042	56.042	57.042	58.042	59.042	60.042	61.042
	1	49.925	50.925	51.925	52.925	53.925	54.925	55.925	56.925	57.925	58.925
Female (proportion)	0	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259
	1	0.264	0.264	0.264	0.264	0.264	0.264	0.264	0.264	0.264	0.264
Group size	0	50.057	50.016	62.162	64.868	62.956	56.536	52.222	50.489	46.602	44.441

	1	39.323	39.313	49.644	47.059	39.138	25.316	21.216	20.8	17.88	16.808
IMG (proportion)	0	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
	1	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128
Number of enrolled patients	0	1858	1930	1938	1932	1895	1870	1843	1800	1772	1731
	1	1812	1864	1861	1811	1772	1739	1703	1665	1634	1591
Patients' characteristics											
Female (proportion)	0	0.514	0.512	0.51	0.508	0.506	0.505	0.504	0.504	0.503	0.501
	1	0.516	0.514	0.513	0.513	0.512	0.511	0.511	0.51	0.509	0.507
Rural (proportion)	0	0.052	0.051	0.051	0.051	0.051	0.051	0.052	0.052	0.052	0.053
	1	0.103	0.102	0.102	0.102	0.101	0.101	0.101	0.101	0.101	0.101
Mean age (in years)	0	39.317	39.795	40.301	40.769	41.276	41.829	42.406	43.056	43.645	44.228
	1	40.25	40.677	41.129	41.69	42.213	42.777	43.358	43.953	44.504	45.036
Low income quintile (proportion)	0	0.41	0.403	0.398	0.394	0.391	0.389	0.387	0.386	0.383	0.377
	1	0.366	0.362	0.357	0.354	0.35	0.349	0.348	0.347	0.345	0.339
ADG	0	3.411	3.38	3.315	3.382	3.418	3.407	3.451	3.394	3.354	3.388
	1	3.337	3.295	3.23	3.279	3.268	3.232	3.243	3.149	3.103	3.121

Abbreviations: IMG: International Medical Graduate, ADG: Aggregated Diagnosis Groups (Johns Hopkins), ACSC: ambulatory care sensitive condition, $HbA1_c$: glycated haemoglobin, ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker

Notes:

0=non-switchers, 1=switchers

[a] Expected income gain for switchers and non-switchers, in 2006, were 137,133 and 108,148 dollars, respectively

Table B1.1 Results from Covariate Balancing Propensity Score weighting

Means and standardized bias after CBPS weighting					
	FHO	FHG	Bias reduction	t-statistic	p-value
Physician's characteristics					
Expected income gain (in thousand $)	137.13	137.13	100	0	1
(Expected income gain)^2	25022	25022	100	0	1
Age (years)	49.924	49.924	100	0	1
Age^2	2564.1	2564.1	100	0	1
Female (%)	0.26336	0.26336	100	0	1
IMG (%)	39.322	39.322	100	0	1
Group size	0.12703	0.12703	100	0	1
Number of enrolled patients	1811.5	1811.5	100	0	1
Patients' characteristics					
Female (%)	0.51563	0.51563	100	0	1
Rural areas (%)	0.10259	0.10259	100	0	1
Average age (in years)	40.249	40.249	100	0	1
Low income quintile (%)	0.36592	0.36593	100	0	1
Average ADG	3.3363	3.3363	100	0	1
Outcome variables					
HbA1c testing	0.56204	0.56204	100	0	1
Lipid assessment	0.54453	0.54453	100	0	1
Nephropathy screening	0.63066	0.63066	100	0	1
Eye examination	0.04893	0.04893	100	0	1
ACEI or ARB prescription	0.68157	0.68157	100	0	1
Statin prescription	0.65352	0.65352	100	0	1
Mortality risk score	49.711	49.711	100	0	1
ACSC hospitalization due to diabetes	0.192	0.192	100	0	1

Abbreviations: FHG: Family Health Group, FHO: Family Health Organization, IMG: International Medical Graduate, ADG: Aggregated Diagnosis Groups (Johns Hopkins), ACSC: ambulatory care sensitive condition, CBPS: covariate balancing propensity score, $HbA1_c$: glycated haemoglobin, ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker

FHO represents physicians who switched from FHG to FHO at any point within the observation period; FHG represents physicians who remained in a FHG model throughout the observation period.

Table B1.2 Results from Entropy Balancing weighting

	Means and standardized bias after EB weighting				
	FHO	FHG	Bias reduction	t-statistic	p-value
Physician's characteristics					
Expected income gain (in thousand $)	137.13	137.14	100	0	0.997
(Expected income gain)^2	25022	25022	100	0	1
Age (years)	49.924	49.925	100	0	0.998
Age^2	2564.1	2564.2	100	0	0.998
Female (%)	0.26336	0.26323	97.5	0.01	0.994
IMG (%)	39.322	39.323	100	0	1
Group size	0.12703	0.12696	99.9	0.01	0.995
Number of enrolled patients	1811.5	1811.6	99.9	0	0.999
Patients' characteristics					
Female (%)	0.51563	0.51564	99.6	0	0.998
Rural areas (%)	0.10259	0.10259	100	0	1
Average age (in years)	40.249	40.25	99.9	0	0.997
Low income quintile (%)	0.36592	0.36593	100	0	0.999
Average AGD	3.3363	3.3364	99.9	0	0.997
Outcome variables					
HbA1c testing	0.56204	0.56205	99.9	0	0.999
Lipid assessment	0.54453	0.54454	99.9	0	0.999
Nephropathy screening	0.63066	0.63067	99.7	0	0.999
Eye examination	0.04893	0.04893	100	0	1
ACEI or ARB prescription	0.68157	0.68158	99.9	0	0.997

Statin prescription	0.65352	0.65354	99.9	0	0.998
Mortality risk score	49.711	49.712	99.9	-0.01	0.995
ACSC hospitalization due to diabetes	0.192	0.192	100	0	1

Abbreviations: FHG: Family Health Group, FHO: Family Health Organization, IMG: International Medical Graduate, ADG: Aggregated Diagnosis Groups (Johns Hopkins), EB: entropy balancing, $HbA1_c$: glycated haemoglobin, ACEI: Angiotensin converting enzyme inhibitor, ARB: Angiotensin II receptor blockers

FHO represents physicians who switched from FHG to FHO at any point within the observation period; FHG represents physicians who remained in a FHG throughout the observation period.

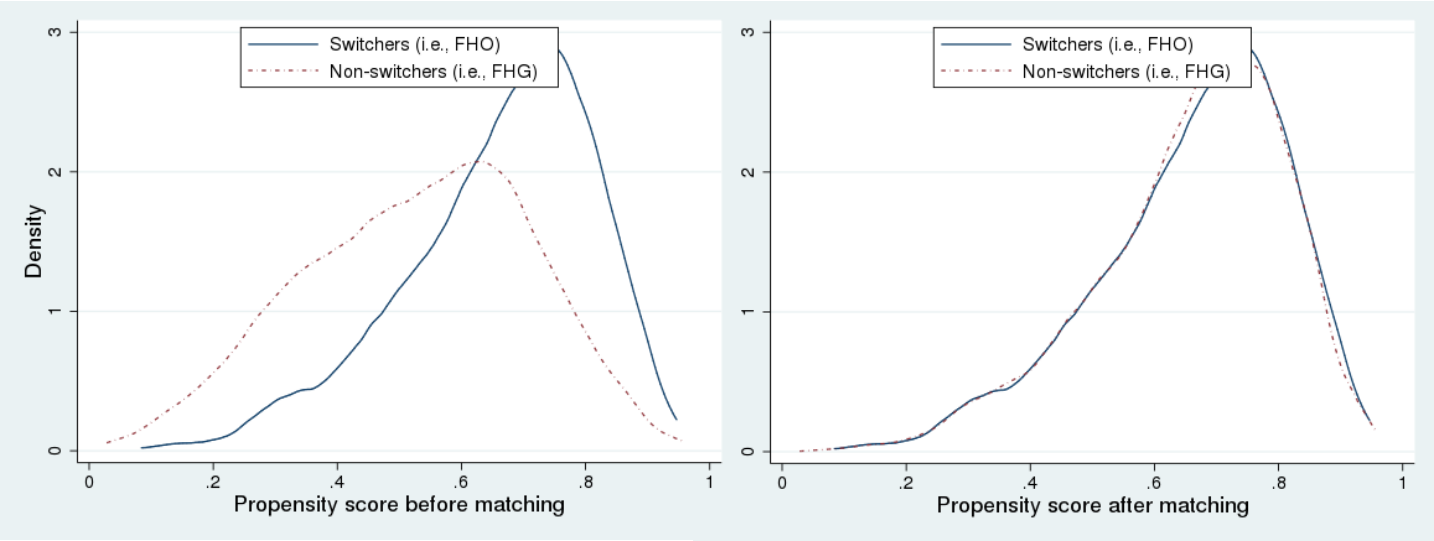


Figure B.1 Distribution of propensity scores before and after kernel weighting.

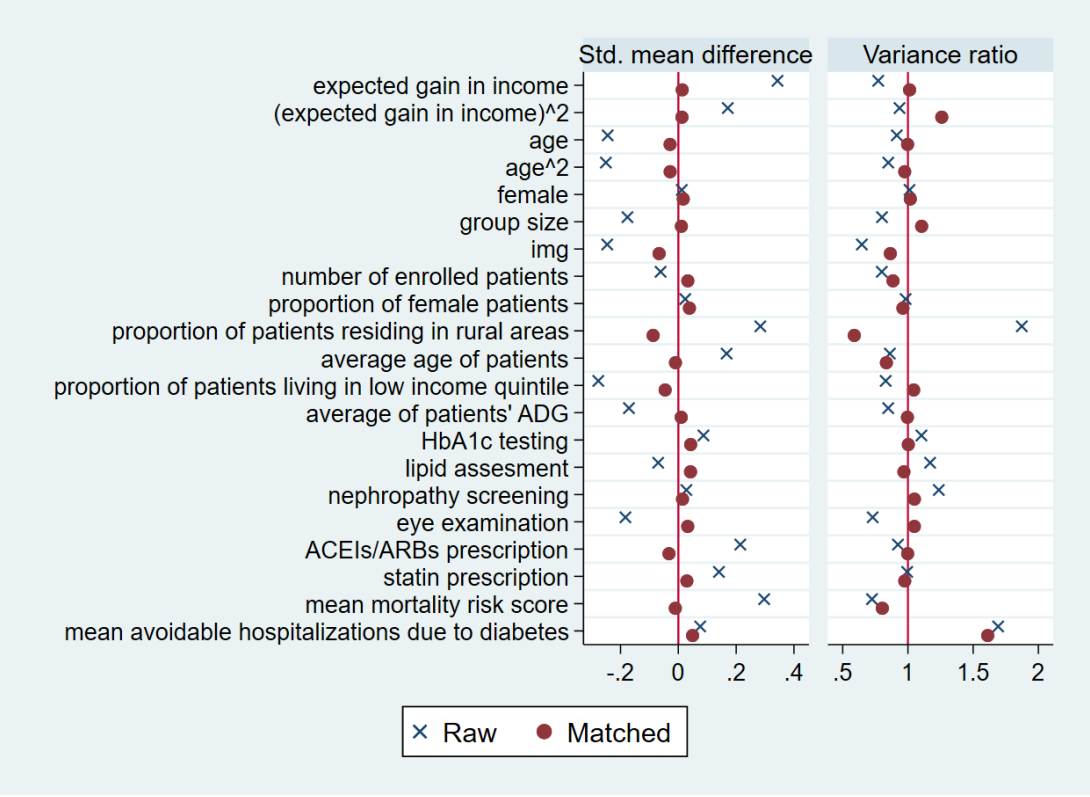


Figure B.2 Standardized mean difference and variance ratio for covariates from the unmatched (i.e., raw) and matched samples.
Abbreviations: IMG: International Medical Graduate, ADG: Aggregated Diagnosis Groups (Johns Hopkins), $HbA1_c$: glycated hemoglobin, ACEI: Angiotensin converting enzyme inhibitors, ARB: Angiotensin II receptor blocker, ACSC: ambulatory care sensitive condition

Table B1.3 Effect of switching to FHO on process of diabetes care and patients' health outcomes, for male physicians

Outcome Variable	Unweighted	Kernel	CBPS	EB
$HbA1_c$ testing	0.0248***	0.0259***	0.0261***	0.0256***
	(0.0168 - 0.0327)	(0.0158 - 0.0360)	(0.0159 - 0.0363)	(0.0140 - 0.0373)
Lipid assessment	0.0248***	0.0259***	0.0261***	0.0256***
	(0.0168 - 0.0327)	(0.0158 - 0.0360)	(0.0159 - 0.0363)	(0.0140 - 0.0373)
Nephropathy screening	0.0266***	0.0291***	0.0284***	0.0305***
	(0.0184 - 0.0348)	(0.0185 - 0.0396)	(0.0179 - 0.0389)	(0.0180 - 0.0430)
Eye examination	-0.000222	-0.00118	-0.000974	-0.000351
	(-0.00227 - 0.00183)	(-0.00323 - 0.000865)	(-0.00301 - 0.00107)	(-0.00265 - 0.00195)
ACEI or ARB prescription	-0.00439	0.00285	0.0037	0.00688*
	(-0.0101 - 0.00131)	(-0.00382 - 0.00951)	(-0.00300 - 0.0104)	(-0.000370 - 0.0141)
Statin prescription	0.00815***	0.00942***	0.00994***	0.0114***
	(0.00279 - 0.0135)	(0.00311 - 0.0157)	(0.00377 - 0.0161)	(0.00400 - 0.0188)
Mortality risk score	-0.425***	-0.252***	-0.211**	-0.346***
	(-0.556 - -0.293)	(-0.412 - -0.0920)	(-0.403 - -0.0199)	(-0.510 - -0.182)
ACSC hospitalization due to diabetes	1.081 (0.926 - 1.262)	1.089 (0.910 - 1.304)	1.115 (0.931 - 1.336)	1.098 (0.884 - 1.365)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses; effects and corresponding 95% CI are reported as proportions.
Abbreviations: OLS: ordinary least squares, FE: fixed effects, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; ACSC: ambulatory care sensitive condition, FHO: Family Health Organization, $HbA1_c$: glycated haemoglobin, ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker

Table B1.4 Effect of switching to FHO on process of diabetes care and patients' health outcome, for female physicians

Outcome variable	Unweighted	Kernel	CBPS	EB
$HbA1_c$ testing	0.0190***	0.0168**	0.0160**	0.0223***
	(0.00650 - 0.0316)	(0.00287 - 0.0307)	(0.00213 - 0.0299)	(0.00736 - 0.0372)
Lipid assessment	0.0307***	0.0238***	0.0238***	0.0277***
	(0.0188 - 0.0426)	(0.00859 - 0.0390)	(0.00914 - 0.0385)	(0.0139 - 0.0416)
Nephropathy screening	0.0297***	0.0243***	0.0239***	0.0289***
	(0.0181 - 0.0413)	(0.0102 - 0.0384)	(0.0102 - 0.0376)	(0.0159 - 0.0420)
Eye examination	0.00169	0.00104	0.00129	-0.00105
	(-0.00195 - 0.00533)	(-0.00238 - 0.00446)	(-0.00220 - 0.00478)	(-0.00615 - 0.00404)
ACEI or ARB prescription	0.00347	0.00612	0.0059	-0.00322
	(-0.00745 - 0.0144)	(-0.00742 - 0.0197)	(-0.00764 - 0.0194)	(-0.0303 - 0.0238)
Statin prescription	0.0115**	0.0140**	0.0145**	0.0166**
	(0.000954 - 0.0221)	(0.00166 - 0.0264)	(0.00218 - 0.0268)	(0.00382 - 0.0294)
Mortality risk score	-0.285**	-0.069	-0.108	0.0685
	(-0.515 - -0.0540)	(-0.331 - 0.193)	(-0.367 - 0.151)	(-0.357 - 0.494)
ACSC hospitalization due to diabetes	0.612** (0.417 - 0.897)	0.610** (0.403 - 0.921)	0.621** (0.413 - 0.932)	0.608** (0.406 - 0.910)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses; effects and corresponding 95% CI are reported as proportions. Abbreviations: OLS: ordinary least squares, FE: fixed effects, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; ACSC: ambulatory care sensitive condition, FHO: Family Health Organization, $HbA1_c$: glycated haemoglobin, ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker

Table B1.5 Effect of switching to FHO on process of diabetes care and patients' health outcome, for physicians aged below 55 years

Outcome variable	**Unweighted**	**Kernel**	**CBPS**	**EB**
$HbA1_c$ testing	0.0184***	0.0208***	0.0196***	0.0235***
	(0.00988 - 0.0268)	(0.00983 - 0.0319)	(0.00860 - 0.0306)	(0.0129 - 0.0342)
Lipid assessment	0.0225***	0.0226***	0.0217***	0.0237***
	(0.0138 - 0.0311)	(0.0114 - 0.0337)	(0.0103 - 0.0332)	(0.0126 - 0.0349)
Nephropathy screening	0.0222***	0.0236***	0.0222***	0.0278***
	(0.0140 - 0.0304)	(0.0132 - 0.0341)	(0.0116 - 0.0329)	(0.0173 - 0.0382)
Eye examination	-0.00111	-0.00142	-0.00132	-0.00162
	(-0.00321 - 0.000997)	(-0.00354 - 0.000702)	(-0.00346 - 0.000821)	(-0.00432 - 0.00108)
ACEI or ARB prescription	-0.00245	0.00491	0.00464	0.00272
	(-0.00867 - 0.00377)	(-0.00273 - 0.0126)	(-0.00300 - 0.0123)	(-0.00958 - 0.0150)
Statin prescription	0.00569*	0.00822**	0.00820**	0.0115***
	(-0.000380 - 0.0118)	(0.000936 - 0.0155)	(0.00103 - 0.0154)	(0.00350 - 0.0194)
Mortality risk score	-0.314***	-0.134	-0.0885	-0.116
	(-0.453 - -0.175)	(-0.306 - 0.0386)	(-0.287 - 0.110)	(-0.331 - 0.0998)
ACSC hospitalization due to diabetes	0.952	0.991	1.038	1.043
	(0.793 - 1.143)	(0.799 - 1.229)	(0.836 - 1.290)	(0.810 - 1.343)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses ; effects and corresponding 95% CI are reported as proportions.Abbreviations: OLS: ordinary least squares, FE: fixed effects, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; ACSC: ambulatory care sensitive condition, FHO: Family Health Organization, $HbA1_c$: glycated haemoglobin, ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker

Table B1.6 Effect of switching to FHO on process of diabetes care and patients' health outcome, for physicians aged 55 years and above

Outcome variable	Unweighted	Kernel	CBPS	EB
$HbA1_c$ testing	0.0376***	0.0367***	0.0384***	0.0433***
	(0.0255 - 0.0498)	(0.0212 - 0.0522)	(0.0233 - 0.0536)	(0.0229 - 0.0637)
Lipid assessment	0.0340***	0.0300***	0.0320***	0.0328***
	(0.0218 - 0.0462)	(0.0144 - 0.0455)	(0.0168 - 0.0471)	(0.0136 - 0.0520)
Nephropathy screening	0.0342***	0.0329***	0.0331***	0.0338***
	(0.0226 - 0.0459)	(0.0180 - 0.0478)	(0.0185 - 0.0477)	(0.0141 - 0.0535)
Eye examination	0.00205	0.000515	0.000774	0.00193
	(-0.00125 - 0.00536)	(-0.00260 - 0.00363)	(-0.00236 - 0.00391)	(-0.00154 - 0.00541)
ACEI or ARB prescription	-0.00239	0.00135	0.00319	0.00776
	(-0.0113 - 0.00649)	(-0.00823 - 0.0109)	(-0.00617 - 0.0126)	(-0.00162 - 0.0171
Statin prescription	0.0150***	0.0141***	0.0158***	0.0150***
	(0.00690 - 0.0230)	(0.00516 - 0.0231)	(0.00702 - 0.0245)	(0.00422 - 0.0259)
Mortality risk score	-0.518***	-0.321***	-0.381***	-0.463***
	(-0.711 - -0.324)	(-0.537 - -0.104)	(-0.591 - -0.172)	(-0.702 - -0.224)
ACSC hospitalization due to diabetes	1.091	1.055	1.051	1.016
	(0.863 - 1.380)	(0.811 - 1.373)	(0.809 - 1.365)	(0.751 - 1.375)

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses; effects and corresponding 95% CI are reported as proportions.

Abbreviations: OLS: ordinary least squares, FE: fixed effects, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; ACSC: ambulatory care sensitive condition, FHO: Family Health Organization, $HbA1_c$: glycated haemoglobin, ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker

Table B1.7 Effect of switching to FHO on process of diabetes care and patients' health outcome, for physicians who switched in between 2008 & 2009, 2010 & 2011, 2012 & 2013 and 2014 &2015

Outcome variable	**Unweighted**	**Kernel**	**CBPS**	**EB**
switched in between 2008 & 2009 (N=19,071)				
$HbA1_c$ testing	0.0252***	0.0270***	0.0275***	0.0358***
	(0.0186 - 0.0318)	(0.0198 - 0.0341)	(0.0204 - 0.0347)	(0.0243 - 0.0472)
Lipid assessment	0.0244***	0.0288***	0.0284***	0.0353***
	(0.0177 - 0.0311)	(0.0213 - 0.0363)	(0.0209 - 0.0360)	(0.0236 - 0.0471)
Nephropathy screening	0.0247***	0.0260***	0.0260***	0.0324***
	(0.0183 - 0.0310)	(0.0189 - 0.0330)	(0.0190 - 0.0331)	(0.0209 - 0.0439)
Eye examination	-0.000189	-0.00081	-0.000777	0.0004
	(-0.00201 - 0.00163)	(-0.00269 - 0.00107)	(-0.00265 - 0.00110)	(-0.00166 - 0.00246)
ACEI or ARB prescription	-0.00225	-0.000265	-0.000294	-0.000617
	(-0.00719 - 0.00270)	(-0.00561 - 0.00508)	(-0.00557 - 0.00499)	(-0.00694 - 0.00570)
Statin prescription	0.00748***	0.0151***	0.0148***	0.0140***
	(0.00294 - 0.0120)	(0.0103 - 0.0199)	(0.01000 - 0.0196)	(0.00882 - 0.0192)
Mortality risk score	-0.374***	-0.375***	-0.367***	-0.416***
	(-0.487 - -0.261)	(-0.503 - -0.247)	(-0.494 - -0.241)	(-0.571 - -0.262)
ACSC hospitalization due to diabetes	1.046	1.089	1.103	1.071
	(0.895 - 1.222)	(0.910 - 1.302)	(0.920 - 1.323)	(0.875 - 1.311)
switched between 2010 & 2011 (N=11,410)				
$HbA1_c$ testing	0.0162***	0.0130***	0.0131***	0.0123***

	(0.00832 - 0.0240)	(0.00472 - 0.0213)	(0.00471 - 0.0214)	(0.00393 - 0.0206)
Lipid assessment	0.0126***	0.0120***	0.0122***	0.0115**
	(0.00445 - 0.0208)	(0.00339 - 0.0207)	(0.00346 - 0.0208)	(0.00269 - 0.0203)
Nephropathy screening	0.0147***	0.0151***	0.0153***	0.0145***
	(0.00730 - 0.0222)	(0.00727 - 0.0229)	(0.00742 - 0.0231)	(0.00668 - 0.0224)
Eye examination	-0.00146	-0.00242	-0.00228	-0.00225
	(-0.00380 - 0.000874)	(-0.00536 - 0.000509)	(-0.00525 - 0.000687)	(-0.00518 - 0.000680)
ACEI or ARB prescription	0.00158	0.0011	0.00125	0.00112
	(-0.00431 - 0.00747)	(-0.00535 - 0.00755)	(-0.00527 - 0.00777)	(-0.00549 - 0.00773)
Statin prescription	-0.00136	0.00336	0.00336	0.00172
	(-0.00686 - 0.00414)	(-0.00261 - 0.00934)	(-0.00263 - 0.00936)	(-0.00430 - 0.00774)
Mortality risk score	-0.299***	-0.364***	-0.362***	-0.343***
	(-0.441 - -0.157)	(-0.514 - -0.214)	(-0.512 - -0.211)	(-0.495 - -0.190)
ACSC hospitalization due to diabetes	1.03	0.923	0.929	0.925
	(0.808 - 1.314)	(0.699 - 1.218)	(0.702 - 1.229)	(0.700 - 1.223)
switched between 2012 & 2013 (N=5,840)				
$HbA1_c$ testing	0.0227***	0.0207***	0.0223***	0.0178***
	(0.0119 - 0.0335)	(0.00857 - 0.0329)	(0.0101 - 0.0345)	(0.00490 - 0.0307)
Lipid assessment	0.0136**	0.0118*	0.0136**	0.0134*
	(0.00190 - 0.0252)	(-0.00129 - 0.0249)	(0.000430 - 0.0267)	(-0.000146 - 0.0270)

Nephropathy screening				
Eye examination	-0.00206	-0.00455***	-0.00473***	-0.00448***
	(-0.00500 - 0.000874)	(-0.00748 - -0.00162)	(-0.00767 - -0.00179)	(-0.00768 - -0.00127)
ACEI or ARB prescription	-0.000438	0.00106	0.00203	0.00445
	(-0.00798 - 0.00710)	(-0.00719 - 0.00932)	(-0.00636 - 0.0104)	(-0.00480 - 0.0137)
Statin prescription	-0.00696*	-0.00683	-0.00683	-0.00346
	(-0.0140 - 5.33e-05)	(-0.0150 - 0.00132)	(-0.0150 - 0.00132)	(-0.0123 - 0.00535)
Mortality risk score	-0.147	-0.159	-0.136	-0.124
	(-0.337 - 0.0422)	(-0.373 - 0.0542)	(-0.352 - 0.0796)	(-0.353 - 0.105)
ACSC hospitalization due to diabetes	1.262	1.158	1.191	1.004
	(0.814 - 1.957)	(0.700 - 1.917)	(0.718 - 1.976)	(0.596 - 1.690)
switched between 2014 & 2015 (N=2,991)				
$HbA1_c$ testing	0.0162*	0.00552	0.00705	0.00776
	(-0.00289 - 0.0354)	(-0.0168 - 0.0278)	(-0.0154 - 0.0295)	(-0.0156 - 0.0311)
Lipid assessment	0.0193*	0.00314	0.00397	0.00385
	(-0.000835 - 0.0394)	(-0.0206 - 0.0269)	(-0.0199 - 0.0278)	(-0.0205 - 0.0282)
Nephropathy screening				
Eye examination	0.00357	0.00313	0.00264	0.0028
	(-0.000764 - 0.00790)	(-0.000869 - 0.00713)	(-0.00134 - 0.00662)	(-0.00113 - 0.00673)
ACEI or ARB prescription	0.00649	0.00791	0.00827	0.00681
	(-0.00325 - 0.0162)	(-0.00352 - 0.0193)		(-0.00452 - 0.0181)

			(-0.00297 - 0.0195)	
Statin prescription	-0.00843* (-0.0174 - 0.000573)	-0.00403 (-0.0135 - 0.00545)	-0.00431 (-0.0137 - 0.00510)	-0.00526 (-0.0151 - 0.00455)
Mortality risk score	0.0473 (-0.213 - 0.307)	0.0853 (-0.179 - 0.350)	0.0777 (-0.190 - 0.346)	0.155 (-0.120 - 0.430)
ACSC hospitalization due to diabetes	1.073 (0.484 - 2.378)	0.977 (0.369 - 2.588)	0.958 (0.361 - 2.540)	0.929 (0.351 - 2.460)

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses; effects and corresponding 95% CI are reported as proportions.

Abbreviations: OLS: ordinary least squares, FE: fixed effects, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; ACSC: ambulatory care sensitive condition, FHO: Family Health Organization, $HbA1_c$: glycated haemoglobin, ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker

N=total number of observations

Estimates for nephropathy screening could not be computed for physicians who switched as of 2012 because the main independent variable predicted outcome perfectly.

Table B1.8 Effect of switching to FHO on process of care and health outcomes for persons with diabetes mellitus: Results of before-and-after analyses

Outcome variable (n=12,910)	**Pooled**	**Fixed effects**
$HbA1_c$ testing (%)	3.43***	2.27***
	(1.94 - 4.93)	(1.57 - 2.96)
Lipid assessment (%)	4.18***	3.09***
	(2.71 - 5.64)	(2.36 - 3.82)
Nephropathy screening (%)	3.67***	2.29***
	(2.23 - 5.10)	(1.60 - 2.98)
Eye examination (%)	0.233	-0.125
	(-0.171 - 0.637)	(-0.321 - 0.0709)
ACEI or ARB prescription (%)	-0.615	-0.0567
	(-1.57 - 0.336)	(-0.563 - 0.450)
Statin prescription (%)	1.39***	2.19***
	(0.366 - 2.42)	(1.71 - 2.66)
Mean mortality risk score	-0.153	-0.368***

	(-0.407 - 0.101)	(-0.478 - -0.259)
Risk ACSC hospitalization due to diabetes	1.191**	0.988
	(1.011 - 1.402)	(0.825 - 1.183)

Abbreviations: $HbA1_c$: glycated hemoglobin, ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker, FHO: Family Health Organization; ACSC: ambulatory care sensitive condition, n: sample size.

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses

This table reports the effect of switching from FHG to FHO on processes of care and patients' health outcomes.

Chapter 4

4 Impact of family physician payment schemes on follow-up care, mortality risk and avoidable hospitalizations in patients with congestive heart failure

A version of this chapter has been submitted for publication as: Bamimore MA, Devlin RA, Zaric GS, Garg AX and Sarma S. Impact of family physician payment schemes on follow-up care, mortality risk and avoidable hospitalizations in patients with congestive heart failure.

4.1 Introduction

In the past two decades, many developed countries have reformed primary care in order to improve access to primary care services, (OECD, 2016) especially better management of chronic diseases (Li et al., 2014; OECD, 2016; Roland & Campbell, 2014). Many of the reform proposals involved changes in physician remuneration from pure payment systems of FFS, capitation or salary to blended remuneration (Gosden et al., 2001; Newhouse, 1996; Robinson, 2001). Blended remuneration schemes combine elements of pure payment systems with pay-for-performance incentives to address weaknesses in pure payment systems.

The province of Ontario introduced primary care reforms in the early 2000s that restructured how family physicians were paid and to provide better chronic disease management and preventive care to the targeted populations (Hutchison & Glazier, 2013; Sweetman & Buckley, 2014). Prior to the reform, over 90 per cent of Ontario's family physicians received most of their income through FFS payments (Sweetman & Buckley, 2014), now over two-thirds are remunerated through blended payment schemes.

Family Health Groups and Family Health Organizations are the two dominant post-reform blended payment models available to primary care physicians in Ontario. The FHG, introduced in July 2003, is a blended FFS scheme and the FHO, introduced in November 2006, is a blended capitation scheme (Sweetman & Buckley, 2014). In FHO, physicians receive capitation payments adjusted for age and sex to provide a core basket of services to enrolled patients. They also receive 15% of the FFS payment for each in-basket service provided to these patients, and 100% of the FFS payment for services

provided outside of the basket and for all services to non-enrolled patients up to an annual limit. FHG physicians are primarily paid by FFS plus a small capitation payment. Physicians in both models are eligible to claim the same pay-for-performance incentives in the areas of illness prevention and chronic disease management (diabetes and congestive heart failure), and are required to provide a minimum of 3-hours/week after-hours care (Sweetman & Buckley, 2014).

Both FHGs and FHOs include a pay-for-performance program known as the 'Heart Failure Management Incentive' which rewards physicians $125 per enrolled patient per annum for providing congestive heart failure care in accordance with the practice guidelines of the Canadian Cardiovascular Society (Ezekowitz et al., 2017). The Heart Failure Management Incentive requires that physicians provide patient counselling, conduct physical examinations, and prescribe the following first-line pharmacological therapy for patients whose ejection fraction is 40% or below: angiotensin converting enzyme inhibitors (or angiotensin II receptor blockers for those who are ACEI intolerant), and beta blockers; loop diuretics, mineralocorticoid receptor antagonists, and digoxin are recommended for symptom relief. Furthermore, it suggests the prophylactic use of acetylsalicylic acid, and recommends the prescription of appropriate anticoagulants for those diagnosed with atrial fibrillation (Ministry of Health and Long-Term Care Primary Health Care Team, 2008). These care elements of the Heart Failure Management Incentive have been linked to better patient outcomes (Granger et al., 2003; Milton Packer et al., 1996; Pitt et al., 1999).

The main question addressed in this paper is whether the outcome of the Heart Failure Management Incentive program is affected by whether it is grafted onto a blended FFS (FHG) or a blended capitation (FHO) environment. Health economics theory suggests that capitation provides better incentives for the efficient delivery of health services than pure FFS (Christianson & Conrad, 2012; Eggleston, 2005; McGuire, 2011). The empirical literature suggests a relationship between physician remuneration and quality of patient care (Kiran et al., 2014; Kralj & Kantarevic, 2013); some studies found that P4P programs result in decreased hospital readmissions (Desai et al., 2016; Lalloué et al., 2017), while studies by Mellor et al. (2017) and McGarry et al. (2016) found that such outcomes are not affected by P4P schemes. Capitation payments have been found to improve continuity of care (like follow-ups post hospitalization) and preventative care, relative to FFS (Blomqvist & Busby, 2012; Brosig-Koch et al., 2017; Kralj & Kantarevic, 2013). This result arises partly because capitated physicians rely on a stable roster of patients for most of their income, fostering strong physician-patient relationships. A priori, one might think that CHF patients would be better served by the Heart Failure Management Incentive program under blended capitation (FHO) relative to those in blended FFS (FHG).

Two studies to date have examined some elements of this problem (Jaakkimainen et al., 2011; Russell et al., 2009). Russell et al. (2009) employed a cross-sectional analysis and found no difference in specific prescription behaviour between family physicians in FFS- and capitation-based schemes; the same result was echoed by Jaakkimainen et al. (2011) also with cross-sectional data. But the Heart Failure

Management Incentive involves much more than prescription behaviour. The availability of more and better data allows for a more rigorous investigation into this question – which is the main contribution of this paper. We push the empirical investigation in two directions. First, a broader array of performance indicators than the previous literature are examined: follow-up care after hospitalization within seven days and 30 days, avoidable hospitalizations due to CHF, and mortality risk. These four indicators present a better picture of the impact of the physician remuneration on patient outcomes in the area of CHF. Second, we employ a longitudinal data set which is able detect changes in physician behaviour over time, while accounting for potential biases present in previous cross-sectional study designs.

4.2 Methods

Study design

We used a retrospective cohort design with an observation period spanning April 1st, 2006 and March 31st, 2016. Our sample consisted of physicians in FHOs and FHGs, and their patients diagnosed with CHF; a schematic of the creation of our study population is presented in Supplementary Appendix S1. FHG physicians who switched to a FHO and remained in this model throughout the observation period were defined as 'switchers'; 'non-switchers' were those physicians who remained in the FHG model throughout our study period. All physicians were in the FHG model in the 1st year of our study.

Data sources and ethics

All our data were obtained from ICES (formerly known as the Institute for Clinical Evaluative Sciences), which houses numerous healthcare administrative databases for Ontario. Persons with CHF were identified using the ICES CHF database, which contains all patients diagnosed with CHF since 1991 with high sensitivity and specificity (Schultz et al., 2013). The client agency program enrollment database identified patients enrolled to physicians in the FHG and FHO models. Physician characteristics were obtained from the corporate provider database and ICES physician database. Patient characteristics were obtained from the Registered Persons Database and area-level census. These databases were linked using a unique anonymized patient identifier.

The data for this study were used in accordance with section 45 of Ontario's Personal Health Information Protection Act: hence, a Research Ethics Board approval was not required.

Outcome Variables

We investigated discharges due to CHF that were followed up with a physician within seven days and 30 days, patients' estimated mortality risk score, and avoidable hospitalizations due to CHF. An avoidable hospitalization due to CHF is defined as a hospital admission in persons aged below 75 years with the most responsible ICD-10-CA (International Classification of Diseases and Disorders, 10th Revision Canadian Modification codes) diagnosis codes being I50 (heart failure) and J81 (pulmonary edema), excluding cardiac procedures (the details are provided in Table 2 in Supplementary Appendix S1); such events are termed 'avoidable' because CHF-related

admissions in persons aged below 75 years are potentially preventable if ambulatory care is adequate and efficient (Canadian Institute for Health Information, 2020a). The follow-up care outcomes were proportions: for each physician, the denominator was the total number of physician's patients discharged from a CHF hospitalization in the given year and the numerator is those discharged patients with a follow-up with the physician within seven or 30 days. MRS is an estimate of a person's risk of all-cause death within one year based on an algorithm by Austin and Walraven (2011). Using the patient-level MRS, we constructed the average of CHF patients' MRS in a physician's practice. Avoidable CHF-related hospitalization was a count variable: for each physician in a given year, we counted the total number of CHF-related avoidable hospitalizations experienced by a physician's patients. More details on variable definitions are provided in Supplementary Appendix S1.

Statistical analyses

We conducted all analyses at the physician-level; physicians not present in each year were excluded, yielding a balanced panel-data for 10 years. For longitudinal analyses, two models were initially considered: (1) single-group before-after, and (2) before-and-after analysis with a control group. Model 1 comprises only physicians who switched to FHO; however, a major drawback is the absence of a contemporaneous control group. Model 2 entails switchers and non-switchers, allowing for difference-in-differences analyses; but model 2 does not account for potential systematic differences between switchers and non-switchers (or selection bias). Thus, we implemented a propensity score model and used the estimated propensity scores to construct inverse

probability weights (Guo & Fraser, 2015) to ensure that both groups of physicians were similar in terms of all covariates and outcomes at the baseline. Thus, any change in outcomes over the baseline is most likely due to the effect of remuneration, after adjusting for potential confounders.

One further issue could be the presence of physician-specific time-invariant confounding (essentially an omitted variable bias arising due to this type of confounding). To account for such bias, we performed an inverse probability weighted fixed-effects regression analysis, detailed in Supplementary Appendix S2A. A fractional weighted fixed-effects regression model was used for the follow-up indicators (Papke, 1996), a linear weighted fixed-effects regression model was used for mortality risk scores (Sarma et al., 2018) and a weighted fixed-effects Poisson regression model was used for avoidable CHF-related hospitalization.

Propensity score model

A physician's propensity score is their probability of being in the exposed group or control group, given a set of explanatory variables (Faries et al., 2010). Propensity scores are estimated using a logistic regression that regresses the probability of exposure assignment on covariates (Faries et al., 2010; Rosenbaum & Rubin, 1983). The general guideline is to include variables in the propensity score model that can plausibly affect outcome and exposure (Faries et al., 2010; Rosenbaum & Rubin, 1983). Following the previous literature, we include physician characteristics (age, country of medical education (Canada/US or international), group size and number of patients enrolled, patient characteristics in physicians' practice (proportion of females, average age of

patients in the physician's practice, proportion of female patients in the practice, patients' average comorbidity score based on the Johns Hopkins Aggregated Diagnosis Groups, proportion of patients from low income quintile (based on census dissemination area-level income) and the proportion of patients living in rural areas), and expected income gain from switching from FHG to FHO at the baseline in our propensity score model (Kralj & Kantarevic, 2013; Sarma et al., 2018; Somé et al., 2019). We excluded physicians from the switcher and non-switcher groups if the range of their propensity scores did not overlap (were outside the range of common support), which is necessary in order to make inferences about treatment (here switching) effects. We then derived inverse probability weights for physicians from their estimated propensity scores using kernel matching (i.e. kernel weighting). Regressions that are weighted by the inverse probability weights allow for the estimation of the average effect of switching to FHOs on outcomes in switchers (our point estimate of interest). Here, a weight of one was assigned to FHO physicians (switchers); non switchers were given a weight that corresponded to the distance between the non-switcher's and switcher's propensity scores within a bandwidth of 0.06 (Garrido et al., 2014; Guo & Fraser, 2015).

Balance in the covariate distribution between switcher and non-switcher physicians at baseline was assessed using t-tests and standardized bias tests (Guo & Fraser, 2015; Harder et al., 2010). We also used two alternatives to kernel weighting procedure to address bias due to covariate imbalance: the covariate balancing propensity score(Imai & Ratkovic, 2014) and entropy balancing weights (Hainmueller, 2012). Given differences in patients' eligibility criteria for indicators of follow-up care and health outcomes, the

propensity score model was run on two separate samples: one for follow-up care, and the other for health outcomes.

To see whether the impact of switching to FHO varied across subgroups, separate analyses were conducted on: (1) males, (2) females, (3) those aged 55 years or higher at the baseline, (4) those aged below 55 years at the baseline, and (5) by timing of switch to FHO as previous research found that switchers in the 2006-2009 period and 2010 onwards were different with regards to referrals to specialists (Kralj & Kantarevic, 2013; Sarma et al., 2018). The statistical software Stata version 15.1 (StataCorp, 2017) was used for all analyses.

4.3 **Results**

We observed a total of 749 physicians for follow-up care analysis, comprising 7,490 physician-year observations: 478 switchers and 271 non-switchers. In the sample for the MRS and CHF-related avoidable hospitalizations, we observed 2,639 physicians (26,390 physician-year observations): 1,596 switchers and 1,043 non-switchers. Mean values for follow-up care and health-related outcomes are provided in Appendix S2B. A simple schematic for derivation of the final sample size of physicians is provided in Supplemental Figure S0.

Before applying propensity score weights, all the covariates in the follow-up care sample were significantly different between switchers and non-switchers except for sex; non-significant p-values were reported for all covariates after applying inverse probability weighting (Supplementary Table S1). Likewise, our alternative weighting procedures also produced non-significant p-values for all covariates after weighting

(Supplementary Tables S2 and S3). For the other two indicators (i.e., MRS and avoidable hospitalization), there was no significant difference between the covariates after applying CBPS and entropy balancing weights (Supplementary Tables S4 – S6). In both groups of performance indicators, non-significant *p*-values, and standardized bias of no greater than 7% were reported for all variables after applying inverse probability weighting. Furthermore, visual representation for the distribution of propensity scores, and the standardized difference in means and variance ratios confirmed that there was reasonable balance in the distribution of covariates between switchers and non-switchers after weighting (Supplemental Figures S1 – S4).

Regression results

We reported estimates from unweighted and weighted pooled and fixed-effects regressions; fixed-effects estimates account for unobservable time-invariant physician factors, while pooled estimates do not. Unweighted estimates are from regressions that did not incorporate inverse probability weights (model 2 described in the methods section), while weighted regressions incorporated such weights. Model 1 results are reported in the Supplementary Appendix S6. The inverse probability weighted regressions are reported here. We found that switching to FHO had no significant impact on all four performance indicators.

Switching was non-significantly associated with a reduction in physicians' post-discharge follow-up visit within seven days by 0.57% (95% CI: -3.38%, 2.24%); similarly, a non-significant reduction by 0.31% (95% CI: -3.7%, 3.1%) was observed for physician' post-discharge follow-up visit within 30 days (Table 4.1). Switchers' patients,

on average, had non-significantly lower MRS by 0.143 (95% CI: -0.412, 0.127), and non-significantly lower risk of avoidable CHF-related hospitalizations (relative risk = 0.76, 95% CI: 0.42 – 1.38) (Table 4.1). These findings were corroborated using CBPS and EB weights (Supplementary Appendix S4). Similarly, switching did not have any differential impact for physicians who were male, female, aged below 55 years and aged at least 55 years (Table 4.2); the robustness of these subgroup analyses was corroborated with CBPS and EB weights (Supplementary Appendix S4). The impact of switching to FHO was not significantly different across physicians who switched to the FHO model in any of the four timeframes (Table 4.3), and the robustness of this finding was confirmed with CBPS and EB weights (Supplementary Appendix S5).

4.4 Discussion

We found that family physicians who switched from FHGs to FHOs were not significantly different in terms of following up with their patients with CHF within seven and 30 days post-discharge from avoidable hospitalization compared to their counterparts who remained in the FHG. We also found that switchers' and non-switchers' patients with CHF, on average, were not different in terms of their estimated mortality risk scores and risk of avoidable hospitalizations due to CHF. For all four outcomes, results from one-group before-and-after analysis produced similar conclusions (Supplementary Appendix S6).

Our study has several strengths. Our statistical approach, which used inverse probability weighted fixed-effects regressions with longitudinal data over ten years leads to robust conclusions and improves upon the two existing cross-sectional studies

(Jaakkimainen et al., 2011; Russell et al., 2009). Employing a long follow-up period after the introduction of the FHO model adds to the credibility of our results. One limitation of our study is that we cannot rule out hidden bias arising from the fact that the switchers and non-switchers were not randomized. Nonetheless, the repertoire of covariates included in our propensity score model (including physicians' expected income gain) and inverse probability weighted fixed-effects regressions should limit the influence of hidden bias. The drug-prescribing, evidence-based, care processes required by the Heart Failure Management Incentive are exclusive to persons with CHF who have a reduced ejection fraction. Given that information on ejection fraction is currently unavailable through the ICES databases, we could not examine prescription-based indicators. Like our study, a previous study (Esse et al., 2013) also pointed out that quality of physicians' care practices in CHF management is not necessarily affected by remuneration schemes in the United States.

Continuity and coordination of care are major hallmarks of primary care—a process whereby family physicians, specialists and patients work collaboratively to ensure effective management of patients' health condition (Jaakkimainen et al., 2011; Russell et al., 2009). Post-discharge follow-up care by family physicians is a relevant performance indicator for the management of CHF as up to 57% of persons with CHF discharged from a hospitalization are often readmitted within 90 days (Sezgin et al., 2017). Receiving appropriate care during a transition (e.g., between seven to 30 days after a hospital discharge) is prognostically relevant because the timing of care can intercept adverse events. According to the World Health Organization, only 50% of

persons with chronic diseases adhere to their medication (Eduardo Sabaté (WHO/NMH/CCH), 2001). Thus, patient counselling on the importance of following first-line pharmacological therapies can result in an increased likelihood of medication adherence, and counselling can be provided during post-discharge follow-up.

Conclusions

There seems to be no effect arising from the physician's mode of remuneration on our four CHF performance indicators. Interestingly and importantly, our conclusions basically echo those of these two previous papers (Jaakkimainen et al., 2011; Russell et al., 2009).

Table 4.1. Effect of switching to FHO on performance indicators for persons with congestive heart failure

Outcome Variable	Pooled		Fixed effects	
	Unweighted	**Kernel**	**Unweighted**	**Kernel**
Follow-up visit within 7 days of discharge (n=7,490)	-0.0243** (-0.0445 – -0.0041)	-0.0043 (-0.0267 - 0.0181)	-0.0142 (-0.0396 - 0.0111)	-0.0057 (-0.0338 - 0.0224)
Follow-up visit within 30 days of discharge (n=7,490)	-0.0258** (-0.0492 - -0.00247)	-0.0153 (-0.0423 - 0.0117)	-0.0010 (-0.0390 - 0.0210)	-0.0031 (-0.0371 - 0.0309)
Mean mortality risk score (n=26,390)	-0.167 (-0.466 - 0.132)	-0.222 (-0.572 - 0.128)	-0.126 (-0.371 - 0.119)	-0.143 (-0.412 - 0.127)
Avoidable hospitalizations (n=26,390)	0.941 (0.629 - 1.409)	0.965 (0.614 - 1.516)	0.766 (0.425 - 1.381)	0.755 (0.417 - 1.367)

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in Supplementary Appendix S2A, 95% confidence interval in parentheses; n: number of physician-year observations

Table 4.2. Effect of switching to FHO on performance indicators: Subgroup Analysis by Age and Sex

Outcome variable	Overall	Male	Female	Younger	Older
Follow-up visit within 7 days of discharge	-0.00571	-0.0176	⁑	-0.0224	0.0172
	(-0.0338 - 0.0224)	(-0.0458 - 0.0105)	⁑	(-0.0631 - 0.0183)	(-0.0196 - 0.0540)
n	7,490	6,640	850	4,100	3,390
Follow-up visit within 30 days of discharge	-0.00308	-0.00939	⁑	-0.026	0.0257
	(-0.0371 - 0.0309)	(-0.0448 - 0.0261)	⁑	(-0.0731 - 0.0211)	(-0.0222 - 0.0737)
n	7,490	6,640	850	4,100	3,390
Mean mortality risk score	-0.143	-0.261*	0.0779	-0.106	-0.186
	(-0.412 - 0.127)	(-0.541 - 0.0199)	(-0.479 - 0.635)	(-0.448 - 0.235)	(-0.565 - 0.193)
n	26,390	17,140	9,250	18,050	8,340
Avoidable hospitalizations	0.755	0.773	0.75	0.506*	1.471
	(0.417 - 1.367)	(0.433 - 1.379)	(0.146 - 3.857)	(0.227 - 1.124)	(0.651 - 3.327)
n	26,390	17,140	9,250	18,050	8,340

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in Supplementary Appendix S2A, 95% confidence interval in parentheses; n: number of physician-year observations; ⁑ Insufficient sample size

Table 4.3. Effect of switching to Family Health Organization on performance indicators: Subgroup Analysis by timing of switching

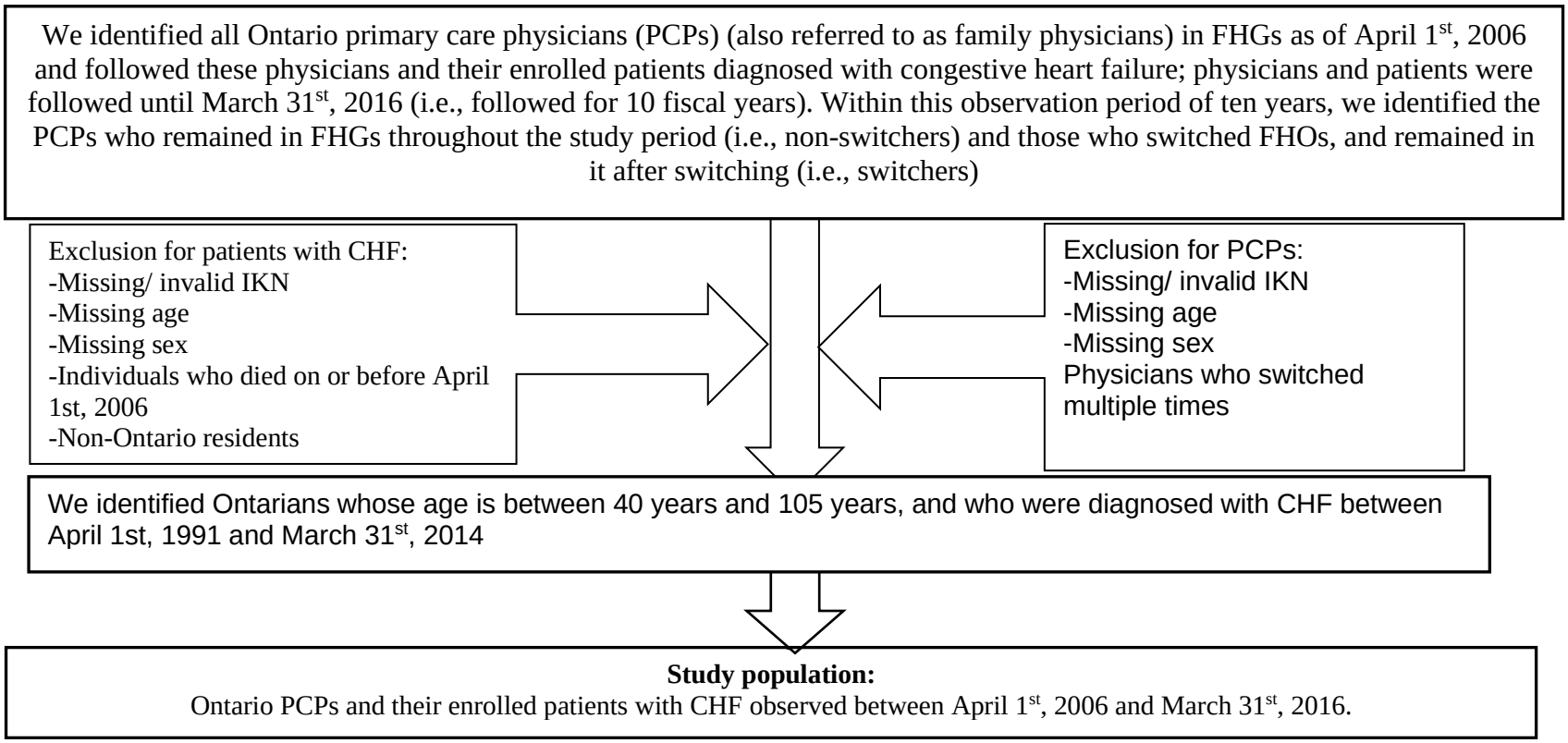
Outcome variable	switched between 2008 & 2009	switched between 2010 & 2011	switched between 2012 & 2013	switched in 2014 &2015
Follow-up visit within 7 days of discharge	-0.00127	-0.0162	-0.0534	-0.0346
	(-0.0309 - 0.0283)	(-0.0613 - 0.0289)	(-0.175 - 0.0687)	(-0.206 - 0.137)
n	6,174	3,878	1,950	966
Follow-up visit within 30 days of discharge	0.0216	-0.0133	-0.0909	-0.0405
	(-0.0140 - 0.0572)	(-0.0732 - 0.0466)	(-0.219 - 0.0372)	(-0.226 - 0.145)
n	6,174	3,878	1,950	966
Mortality risk score	-0.116	-0.269	0.0604	0.0667
	(-0.360 - 0.129)	(-0.605 - 0.0680)	(-0.489 - 0.609)	(-0.701 - 0.835)
n	23,832	14,161	7,300	3,759
Avoidable hospitalizations	0.946	0.755	1.914	1.696
	(0.471 - 1.902)	(0.225 - 2.533)	(0.308 - 11.90)	(0.0128 - 224.0)
n	23,832	14,161	7,300	3,759

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in Supplementary Appendix S2A, 95% confidence interval in parentheses; n: number of physician-year observations

Appendix (for Chapter 4)

Supplementary Appendix S1

Schematic for creation of study population



Data sources for variables

The Client Agency Program Enrollment is a centralized database that contains information on patients enrolled to a physician practicing under any of the patient enrolment models (Glazier, Zagorski, & Rayner, 2012). The Ontario CHF database contains Ontarians diagnosed with congestive heart failure since1991. The algorithm used for identifying patients with CHF in this database was validated by Schultz, Rothwell, Chen, & Tu (2013), where the algorithm is based on any of the following within one year: at least one hospitalization record with CHF diagnosis (or at least one ambulatory record with a CHF diagnosis) in addition to at least one record of CHF diagnosis from any source. This algorithm has a sensitivity of 84.4%, a specificity of 97.0% and positive predictive value of 55.6% (Schultz, Rothwell, Chen, & Tu, 2013). We used the CHF database to identify patients with CHF. CAPE combined with CHF database were used to identify persons diagnosed with CHF who are either enrolled with a FHG or FHO physician in each year. The Corporate Provider Database provides information on healthcare providers (Lofters, Gozdyra, & Lobb, 2013; Ontario Ministry of Health and Long Term Care, 2017), and this database was used to identify a family physician's payment model type. Information on inpatients are available in the Canadian Institute for Health Information - Hospital Discharge Abstract Database; this database uses ICD-10 as of 2002 (Gandhi, 2016; Glazier et al., 2012), was used to identifying avoidable hospitalizations due to CHF. The ICES Physician Database entails demographic information on physicians including data on physicians' practice; this database was used to identify doctors' sex, age, and country of medical education (i.e., international or Canadian/ United States medical graduate). The Canadian Institutes for Health Information-National Ambulatory Care Reporting System holds information for outpatients in hospital and ambulatory care settings (Gandhi, 2016; Glazier et al., 2012);

NACRS, DAD and OHIP were used for mortality risk score using the Algorithm of Austin and Walraven (2011). In the Ontario Health Insurance Plan Database, claims data for services that are insured—and delivered by licenced health professionals (such as family physicians)—are provided. This database includes information pertaining to the service rendered and the associated fee codes (Gandhi, 2016; Glazier et al., 2012); we used OHIP to identify physician visits. Demographic information for Ontario residents who are eligible for provincial healthcare coverage are contained in the Registered Persons Database (Gandhi, 2016; Glazier et al., 2012). We used RPDB to identify patients' age, sex, dates of birth and death; in addition, information on income quintile was obtained using RPDB and census dissemination area-level data.

Table 1 Indicator definitions

Quality indicator	Eligible patient population (i.e., denominator)	Outcome (i.e., numerator)
Physician visit within 7 days after patients' discharge from an acute care hospital due to CHF	For each year: - include CHF patients who were alive within that year - include CHF patients who were discharged from an acute care hospital stay with a most responsible diagnosis of CHF	For each year, identify proportion of discharges that were followed up with patients' enrolled physicians within 7 days
	Data sources: CHF, RPDB, DAD, OHIP, IPDB	
Physician visit within 30 days after patients' discharge from an acute care hospital due to CHF	For each year: -include CHF patients who were alive within that year -include CHF patients who were discharged from an acute care hospital stay with a most responsible diagnosis of CHF	For each year, identify proportion of discharges that were followed up with patients' enrolled physicians within 30 days
	Data sources: CHF, RPDB, DAD, OHIP, IPDB	
Risk of hospitalization for CHF as an ambulatory care sensitive condition (i.e., risk of avoidable hospitalization)	For each year: -identify inpatients records from acute care hospitals with CHF as the most responsible diagnosis; patients must be alive and aged below 75 years	
	Data sources: CHF, RPDB, DAD	
Mortality risk score	For each year, calculate CHF patients' mortality risk score as per the algorithm developed by Austin and Walraven (2011)(Austin & Walraven, 2011)	
	Data sources: RPDB, OHIP, DAD, NACRS	

Abbreviations: CAPE: Client Agency Program Enrollment Registry, CPDB: Corporate Provider Database, DAD: Canadian Institute for Health Information - Hospital Discharge Abstract Database, IPDB: ICES Physician Database, NACRS: National Ambulatory Care Reporting System, OHIP: Ontario Health Insurance Plan Database, RPDB: Registered Persons Database, ACSC: ambulatory care sensitive condition,

Note: CHF (under column 'Quality indicator'): congestive heart failure; CHF (under 'Data sources'): Ontario congestive heart failure database.

Table 2 ICD-10-CA codes for avoidable CHF-related hospitalization

Codes*	I50, J81

Abbreviation: ICD-10-CA: Canadian modification for International Classification of Diseases and Related Health Problems (10th Revision Canadian Modification codes). CHF: congestive heart failure
*We excluded cases with cardiac procedures.
The following are the list of cardiac procedure codes (in CCP, ICD-9-CM and CCI) for exclusion:
CCP:47^^, 480^-483^, 489.1, 489.9, 492^-495^, 497^ ,498^
ICD-9-CM: 336, 35^^,36^^,373^,375^,377^,378^,379.4-379.8
CCI: 1.HA.58.^^, 1.HA.80.^^, 1.HA.87.^^, 1.HB.53.^^, 1.HB.54.^^, 1.HB.55.^^, 1.HB.87.^^, 1.HD.53.^^, 1.HD.54.^^, 1.HD.55.^^, 1.HH.59.^^, 1.HH.71.^^, 1.HJ.76.^^, 1.HJ.82.^^, 1.HM.57.^^, 1.HM.78.^^, 1.HM.80.^^, 1.HN.71.^^, 1.HN.80.^^, 1.HN.87.^^, 1.HP.76.^^, 1.HP.78.^^, 1.HP.80.^^, 1.HP.82.^^, 1.HP.83.^^, 1.HP.87.^^, 1.HR.71.^^, 1.HR.80.^^, 1.HR.84.^^, 1.HR.87.^^, 1.HS.80.^^, 1.HS.90.^^, 1.HT.80.^^, 1.HT.89.^^, 1.HT.90.^^, 1.HU.80.^^, 1.HU.90.^^, 1.HV.80.^^, 1.HV.90.^^, 1.HW.78.^^, 1.HW.79.^^, 1.HX.71.^^, 1.HX.78.^^, 1.HX.79.^^, 1.HX.80.^^, 1.HX.83.^^, 1.HX.86.^^, 1.HX.87.^^, 1.HY.85.^^, 1.HZ.53 rubric (except 1.HZ.53.LA-KP), 1.HZ.54.^^, 1.HZ.55 rubric (except 1.HZ.55.LA-KP), 1.HZ.56.^^, 1.HZ.57.^^, 1.HZ.59.^^, 1.HZ.80.^^, 1.HZ.85.^^, 1.HZ.87.^^, 1.IF.83.^^, 1.IJ.50.^^, 1.IJ.54.GQ-AZ, 1.IJ.55.^^, 1.IJ.57.^^, 1.IJ.76.^^, 1.IJ.80.^^, 1.IJ.86.^^, 1.IK.50.^^, 1.IK.57.^^, 1.IK.80.^^, 1.IK.87.^^, 1.IN.84.^^, 1.LA.84.^^, 1.LC.84.^^, 1.LD.84.^^, 1.YY.54.LA-NJ, 1.YY.54.LA-FS, 1.YY.54.LA-NM

Source: Canadian Institute for Health Information. Ambulatory Care Sensitive Conditions. Indicator Library(Canadian Institute for Health Information, 2018)

Supplementary Appendix S2A: Detailed information on statistical analyses

Inverse probability weighting, balancing diagnostics after propensity score based weighting, and robustness checks

In inverse probability weighting for estimation of average effect of intervention on the exposed group is used. Here, a weight of one is assigned to FHO physicians (i.e., switchers); non switchers were given a weight that corresponded to the distance between the non-switcher's and switcher's propensity scores within a bandwidth of 0.06 (Garrido et al., 2014; Guo & Fraser, 2015).

Balance in covariate distribution between switcher and non-switcher physicians was assessed using t-tests and standardized bias tests (Guo & Fraser, 2015; Harder et al., 2010); the literature suggests that a standardized bias of 10% or less after applying inverse probability weighting is indicative of reasonable balance (Austin, 2009; Garrido et al., 2014).

We also used inverse probability weights from two other alternative techniques that are robust to covariate imbalance, namely, covariate balancing propensity score (Imai & Ratkovic, 2014) and entropy balancing weights (Hainmueller, 2012). Model misspecification—which results in biased estimates—occurs when the estimated propensity score is different from the true propensity score (Drake, 1993), and misspecification can occur even when there is balance in covariate distribution using kernel weighting. However, CBPS and EB weighting are demonstrated to be doubly robust (Imai & Ratkovic, 2014; Q. Zhao & Percival, 2015), meaning that if either the propensity score model or the outcome model is correctly specified the estimated results are reliable. Obtaining similar results from all three weighting would support

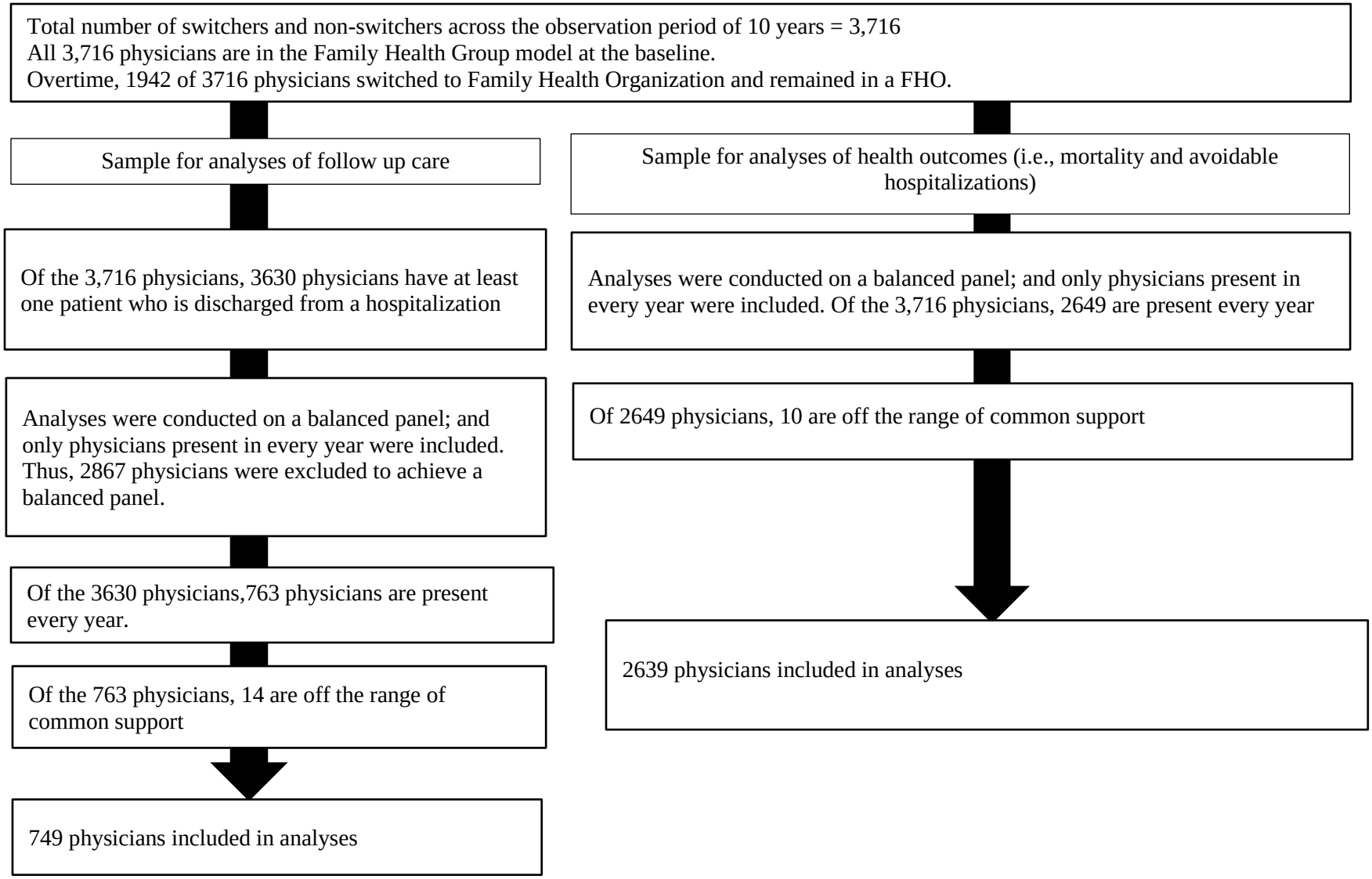
that our conclusions are robust to either model misspecification. Moreover, recent studies have used CBPS and EB as robustness checks (Sarma et al., 2018; Somé et al., 2019).

Regression equation

Fractional correlated random effects models (equivalent to the weighted fixed-effects regressions in the context of fractional outcomes) were used for outcomes that were proportions (Papke, 1996); linear weighted fixed-effects regression was used for mortality risk scores (Sarma et al., 2018); and weighted Poisson fixed-effects regression was used for avoidable CHF-related hospitalization. The equation below represents the statistical model for our fixed-effects regression:

$$Y_{it} = \alpha_i + \delta FHO_{it} + \beta X_{it} + \varepsilon_{it}$$

Here, the outcome variable of interest in time *t* is represented by Y_{it}; α_i captures physician-specific time-invariant factors; FHO represents the switcher vs. non-switcher dichotomous variable; δ is the point estimate of interest (i.e., effect of switching to FHO on outcome). The vector X_{it} included age, age squared, international medical graduate status, physicians' group size, number of enrolled patients, proportion of female patients, average age of patients in physicians' practice, proportion of patients living in rural areas, proportion of patients in low income quintile and average ADG score of patients; ε_{it} is the error term. To account for the fraction of time a switcher was in a FHO during the first year of switching, we used fractional year.



Supplemental Figure S0. A simple flow chart depicting derivation of the final sample sizes of physicians.

Supplementary Appendix S2B Descriptive statistics for follow up care, avoidable hospitalizations and mortality risk scores

Table 1 Mean values of outcomes and covariates for switchers (n=478) and non-switchers (n=271) in the sample for follow-up care

	Switcher/Non	**Fiscal year**									
	-switcher [a]	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Outcome variable											
7-day follow up											
(proportion)	0	0.271	0.269	0.291	0.286	0.294	0.304	0.247	0.293	0.286	0.268
	1	0.304	0.27	0.274	0.274	0.277	0.254	0.244	0.257	0.231	0.221
30-day follow up											
(proportion)	0	0.561	0.549	0.577	0.614	0.592	0.615	0.56	0.594	0.562	0.558
	1	0.595	0.586	0.589	0.581	0.567	0.548	0.554	0.561	0.529	0.52
Physicians' characteristics [b]											
Age (years)	0	53.691	54.691	55.691	56.691	57.691	58.691	59.691	60.691	61.691	62.691
	1	51.917	52.917	53.917	54.917	55.917	56.917	57.917	58.917	59.917	60.917
Female (proportion)	0	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137
	1	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101
Group size	0	45.953	46.056	56.181	58.377	57.34	51.137	47.052	45.724	41.823	40.388
	1	39.827	37.118	48.402	44.641	37.153	24.442	18.622	18.814	17.383	16.164
IMG	0	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174
	1	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126

Number of enrollees	0	1946.6	2024.62	2044.1	2045.3	2007.83	1979.27	1951.07	1903.80	1875.72	1832.9
	1	1995.3	2055.18	2051.64	1991.1	1953.48	1913.33	1872.2	1830.46	1787.78	1740.715
Patients' characteristics											
Female (proportion)	0	0.487	0.486	0.484	0.483	0.481	0.48	0.48	0.481	0.48	0.478
	1	0.484	0.483	0.481	0.482	0.48	0.48	0.48	0.48	0.479	0.477
Rural areas (proportion)	0	0.066	0.064	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
	1	0.107	0.105	0.105	0.104	0.102	0.102	0.101	0.101	0.101	0.101
Average age (in years)	0	41.892	42.385	42.934	43.413	43.91	44.444	44.987	45.653	46.202	46.757
	1	42.73	43.16	43.595	44.191	44.725	45.304	45.89	46.456	47.017	47.543
Low income quintile (proportion)	0	0.408	0.403	0.398	0.395	0.393	0.39	0.39	0.388	0.387	0.384
	1	0.387	0.383	0.379	0.376	0.373	0.372	0.371	0.37	0.368	0.364
Average ADG	0	3.458	3.442	3.383	3.446	3.483	3.478	3.527	3.479	3.449	3.481
	1	3.402	3.361	3.297	3.356	3.337	3.304	3.319	3.229	3.195	3.214

Abbreviations: Aggregated Diagnosis Group (Johns Hopkins), IMG: International Medical Graduate

[a] 0=non-switchers, 1=switchers

[b] Switchers' and non-switchers' expected income gain in the baseline year were $155,490 and $124,425 respectively

Percentages are expressed as proportions

Table 2 Mean values of outcomes and covariates for the switchers (n=1,596) and non-switchers (n=1,043) in the sample for mortality risk scores, and avoidable CHF-related hospitalizations.

		Fiscal year									
	Switcher [a]	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Outcome Variables											
mortality risk score	0	66.645	66.28	66.502	66.619	66.679	66.926	67.045	67.162	67.467	66.966
	1	67.066	67.068	66.858	67.245	67.062	67.272	67.325	67.406	67.752	67.211
Avoidable CHF	0	0.009	0.0077	0.0096	0.014	0.0124	0.0029	0.0086	0.0048	0.0058	0.0086
	1	0.014	0.0088	0.0081	0.0088	0.0050	0.0056	0.0087	0.0069	0.0069	0.0056
Physicians' characteristics [b]											
Age (years)	0	50.87	51.87	52.87	53.87	54.87	55.87	56.87	57.87	58.87	59.87
	1	48.743	49.743	50.743	51.743	52.743	53.743	54.743	55.743	56.743	57.743
Female (proportion)	0	0.331	0.331	0.331	0.331	0.331	0.331	0.331	0.331	0.331	0.331
	1	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364
Group size	0	48.393	48.678	60.548	62.813	61	55.024	50.878	49.25	45.257	43.039
	1	37.15	36.443	46.99	44.576	37.368	24.852	20.815	20.558	18.19	17.053
IMG (proportion)	0	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219
	1	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117
Number of enrolled patients	0	1689.948	1770.188	1784.469	1785.185	1755.718	1738.964	1718.32	1683.034	1659.118	1621.94
	1	1656.992	1716.416	1720.539	1681.295	1651.425	1625.038	1596.587	1563.706	1538.805	1501.079
Patients' characteristics											

Female (proportion)	0	0.528	0.526	0.524	0.522	0.52	0.518	0.517	0.517	0.515	0.513
	1	0.539	0.538	0.536	0.535	0.534	0.533	0.533	0.532	0.53	0.528
Rural areas (proportion)	0	0.055	0.053	0.053	0.053	0.053	0.053	0.054	0.054	0.054	0.054
	1	0.099	0.099	0.099	0.098	0.098	0.098	0.098	0.098	0.098	0.097
Average age (in years)	0	38.292	38.741	39.234	39.701	40.179	40.732	41.285	41.902	42.487	43.033
	1	39.153	39.586	40.04	40.586	41.102	41.659	42.238	42.842	43.408	43.937
Low income quintile (proportion)	0	0.398	0.392	0.386	0.382	0.379	0.377	0.375	0.374	0.372	0.366
	1	0.355	0.35	0.346	0.342	0.339	0.337	0.336	0.335	0.333	0.327
Average ADG	0	3.377	3.352	3.283	3.348	3.384	3.372	3.415	3.35	3.311	3.34
	1	3.322	3.282	3.217	3.264	3.251	3.211	3.222	3.126	3.078	3.092

Abbreviations: Aggregated Diagnosis Group (Johns Hopkins), IMG: International Medical Graduate, CHF: congestive heart failure

[a] 0=non-switchers, 1=switchers

[b] Switchers' and non-switchers' expected income gain in the baseline year were $125,041 and $ 94,658 respectively

Percentages are expressed as proportions

Supplementary Appendix S3. Balancing diagnostics

Results of propensity score-based weighting are presented in Tables S1 to S6; a standardized bias of no greater than 7% were reported for all variables after applying inverse probability weighting. Furthermore, visual representation of the distribution of propensity scores, and the standardized difference in means and variance ratios confirmed that there was reasonable balance in the distribution of covariates between switchers and non-switchers after weighting (Figures S1 – S4).

Supplementary Table S1. Results from kernel weighting for follow-up care

	Mean and standardized bias prior to kernel weighting					Mean and standardized bias after kernel weighting				
Covariate	**Switcher**	**Non-switcher**	**Bias[a]**	**t-statistic**	**p-value**	**Switcher**	**Non-switcher**	**Bias[a]**	**t-statistic**	**p-value**
Physicians' characteristics										
Expected income gain (in thousand $)	155.49	124.42	33.2	14.11	0	155.49	154.33	1.2	0.21	0.836
Expected income gain squared	31641	25483	15.8	6.71	0	31641	31177	1.2	0.2	0.84
Age (years)	56.416	58.19	-19.7	-8.28	0	51.916	52.149	-2.6	-0.44	0.663
Age squared	3258.8	3471.4	-20.8	-8.78	0	2763.1	2788.2	-2.5	-0.46	0.648
Female (proportion)	0.10042	0.13653	-11.2	-4.74	0	0.10042	0.09994	0.1	0.02	0.98
IMG (proportion)	0.12552	0.17343	-13.5	-5.71	0	0.12552	0.12643	-0.3	-0.04	0.966
Group size	30.256	49.003	-31.4	-13.57	0	39.826	41.057	-2.1	-0.33	0.74
Number of enrolled patients	1919.1	1961.1	-5.4	-2.33	0.02	1995.3	1982.5	1.7	0.26	0.792
Patients' characteristics										
Female (proportion)	0.48001	0.48144	-1.9	-0.8	0.423	0.48331	0.48455	-1.7	-0.27	0.788
Rural areas (proportion)	0.10247	0.06426	20.8	8.49	0	0.10609	0.10975	-2	-0.26	0.799
Average age (in years)	45.061	44.257	14	5.81	0	42.729	42.72	0.2	0.03	0.979
Low income quintile (proportion)	0.37383	0.3931	-14.2	-5.97	0	0.38674	0.38747	-0.5	-0.08	0.933
Average ADG	3.3009	3.4621	-36.4	-15.23	0	3.4016	3.4143	-2.9	-0.44	0.661
Outcome Variables										
Proportion of discharges that were followed up within 7 days	0.2601	0.28052	-7.3	-3.04	0.002	0.30359	0.29489	3.1	0.48	0.631
Proportion of discharges that were followed up within 30 days	0.56243	0.57772	-4.7	-1.94	0.052	0.59468	0.58626	2.6	0.41	0.682

Abbreviations: IMG: International Medical Graduate, ADG: Aggregated Diagnosis Groups (Johns Hopkins), CHF: congestive heart failure, [a]Standardized bias

Supplementary Table S2. Results from CBPS weighting for CHF follow-up care.

Covariate	Means and standardized bias after CBPS weighting				
	Switcher	**Non-switcher**	**Bias[a]**	**t-statistic**	**p-value**
Expected income gain (in thousand $)	155.49	155.49	0	0	1
Expected income gain squared	31641	31641	0	0	1
Age (years)	51.916	51.916	0	0	1
Age squared	2763.1	2763.1	0	0	1
Female (proportion)	0.10042	0.10042	0		1
Group size	39.826	39.826	0	0	1
IMG (proportion)	0.12552	0.12552	0	0	1
Number of enrolled patients	1995.3	1995.3	0	0	1
Female (proportion)	0.48331	0.48331	0	0	1
Rural areas (proportion)	0.10609	0.1061	0	0	1
Average age (in years)	42.729	42.729	0	0	1
Low income quintile (proportion)	0.38674	0.38675	0	0	0.999
Average ADG	3.4016	3.4016	0	0	1
Proportion of discharges that were followed up within 7 days	0.30359	0.30359	0	0	1
Proportion of discharges that were followed up within 30 days	0.59468	0.59468	0	0	1

Supplementary Table S3. Results from EB weighting for follow-up care.

Covariate	Means and standardized bias after EB weighting				
	Switcher	**Non-switcher**	**Bias[a]**	**t-statistic**	**p-value**
Expected income gain (in thousand $)	155.49	155.53	0	-0.01	0.994
Expected income gain squared	31641	31643	0	0	1
Age (years)	51.916	51.92	0	-0.01	0.995
Age squared	2763.1	2763.3	0	0	0.996
Female (proportion)	0.10042	0.10022	0.1	0.01	0.992
Group size	39.826	39.829	0	0	0.999
IMG (proportion)	0.12552	0.12525	0.1	0.01	0.99
Number of enrolled patients	1995.3	1995.4	0	0	0.997
Female (proportion)	0.48331	0.48335	0	-0.01	0.993
Rural areas (proportion)	0.10609	0.1061	0	0	1
Average age (in years)	42.729	42.732	-0.1	-0.01	0.992
Low income quintile (proportion)	0.38674	0.38677	0	0	0.997
Average ADG	3.4016	3.4019	-0.1	-0.01	0.992
Proportion of discharges that were followed up within 7 days	0.30359	0.30361	0	0	0.999
Proportion of discharges that were followed up with within 30 days	0.59468	0.59472	0	0	0.998

Supplementary Table S4. Results from kernel weighting for mortality and avoidable hospitalizations.

Covariate	Means and standardized bias prior to kernel weighting					Means and standardized bias after kernel weighting				
	Switcher	**Non-switcher**	**Bias[a]**	**t-statistic**	**p-value**	**Switcher**	**Non-switcher**	**Bias[a]**	**t-statistic**	**p-value**
Physicians' characteristics										
Expected income gain (in thousand $)	125.04	94.657	34.8	28.13	0	125.04	124.96	0.1	0.03	0.977
Expected income gain squared	22028	17792	14.7	11.73	0	22028	22564	-1.9	-0.52	0.601
Age (years)	53.242	55.37	-22.8	-18.2	0	48.742	48.944	-2.2	-0.66	0.512
Age squared	2917.6	3157	-23.4	-18.73	0	2450.5	2470.9	-2	-0.67	0.502
Female (proportion)	0.36341	0.33078	6.9	5.43	0	0.36341	0.3543	1.9	0.54	0.592
IMG (proportion)	0.11654	0.2186	-27.6	-22.5	0	0.11654	0.11668	0	-0.01	0.991
Group size	30.399	52.487	-36.1	-29.63	0	37.15	38.813	-2.7	-0.88	0.376
Number of enrolled patients	1625.2	1720.7	-12.4	-10.03	0	1657	1648.1	1.1	0.33	0.743
Patients' characteristics										
Female (proportion)	0.53334	0.5195	12.1	9.55	0	0.53882	0.53623	2.3	0.61	0.545
Rural areas (proportion)	0.09767	0.05305	25.3	19.6	0	0.09871	0.09908	-0.2	-0.05	0.962
Average age (in years)	41.455	40.558	14.4	11.55	0	39.153	39.204	-0.8	-0.25	0.806
Low income quintile (proportion)	0.33948	0.3797	-26.1	-20.99	0	0.35443	0.35826	-2.5	-0.72	0.473
Average ADG	3.206	3.3527	-34.1	-27.36	0	3.322	3.3238	-0.4	-0.12	0.906
Outcome variable										
Mean mortality risk score	67.226	66.829	7.2	5.76	0	67.066	67.173	-1.9	-0.53	0.597

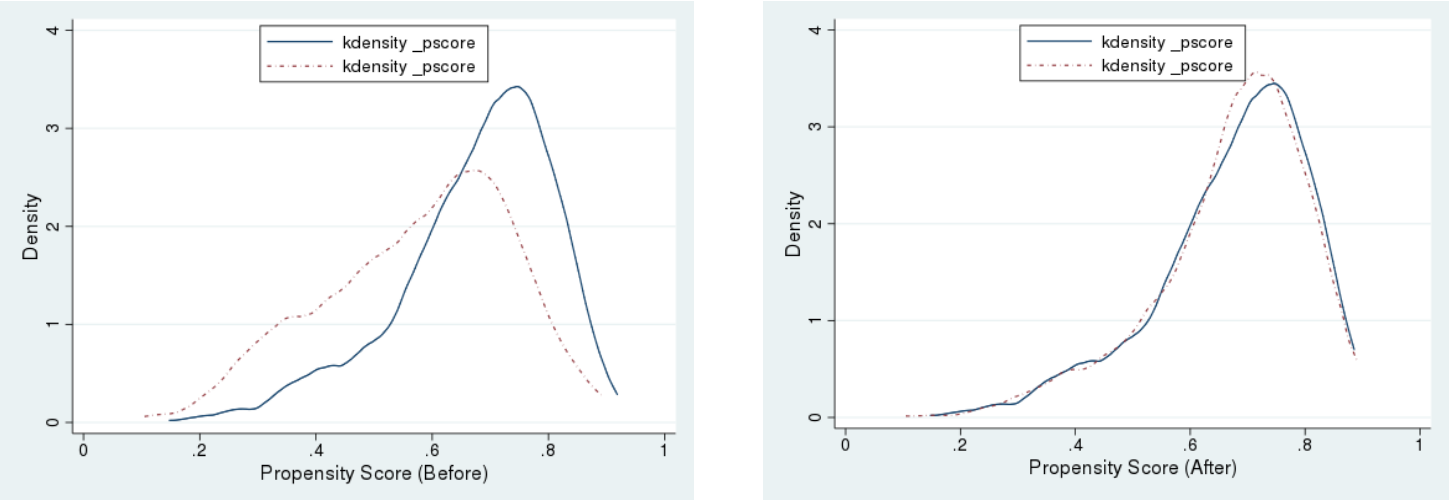
Abbreviations: IMG: International Medical Graduate, ADG: Aggregated Diagnosis Groups (Johns Hopkins), CHF: congestive heart failure, [a]Standardized bias

Supplementary Table S5. Results from CBPS weighting for mortality risk scores and avoidable hospitalizations.

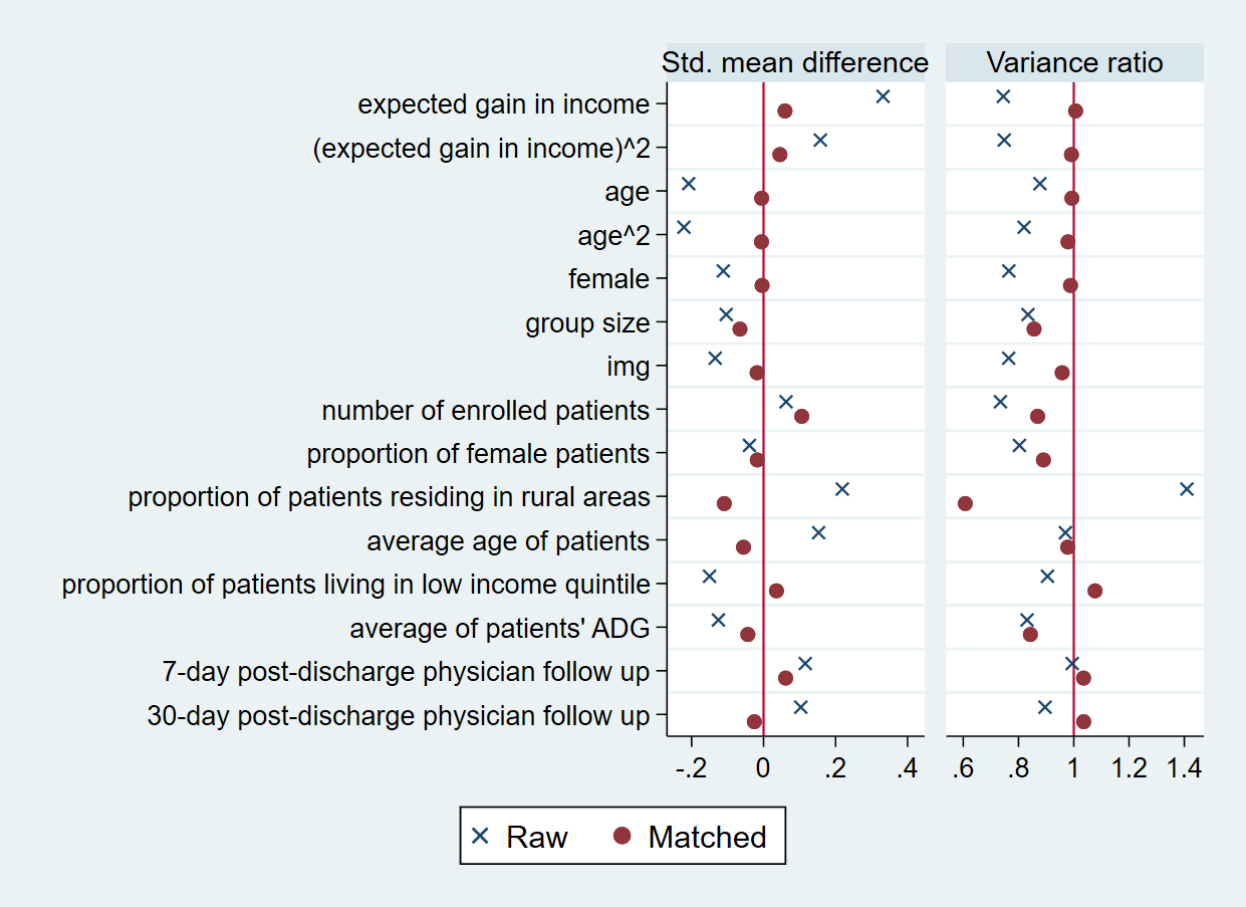
Covariate	Means and standardized bias after CBPS weighting				
	Switcher	**Non-switcher**	**Bias[a]**	**t-statistic**	**p-value**
Expected income gain (in thousand $)	125.04	125.04	0	0	1
Expected income gain squared	22028	22028	0	0	1
Age (years)	48.742	48.742	0	0	1
Age squared	2450.5	2450.5	0	0	1
Female (proportion)	0.36341	0.36341	0	0	1
Group size	37.15	37.15	0	0	1
IMG (proportion)	0.11654	0.11654	0	0	1
Number of enrolled patients	1657	1657	0	0	1
Female (proportion)	0.53882	0.53882	0	0	1
Rural areas (proportion)	0.09871	0.09872	0	0	1
Average age (in years)	39.153	39.153	0	0	1
Low income quintile (proportion)	0.35443	0.35443	0	0	1
Average ADG	3.322	3.322	0	0	1
Mean mortality risk score	67.066	67.066	0	0	1

Supplementary Table S6. Results from EB weighting for CHF avoidable hospitalizations.

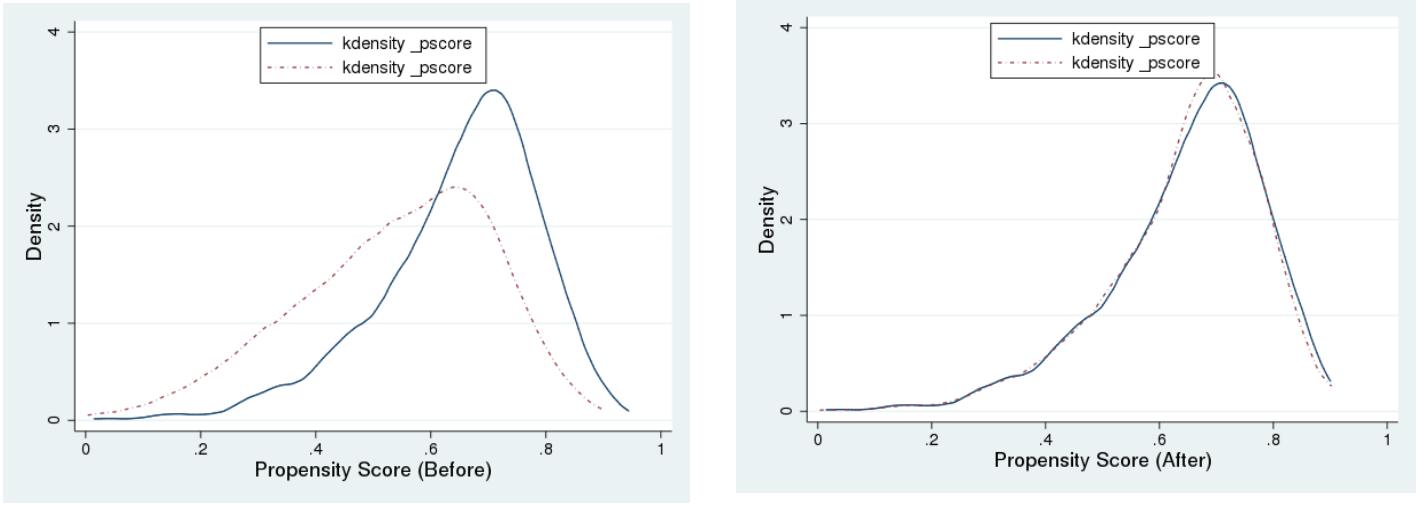
Covariate	Means and standardized bias after EB weighting				
	Switcher	**Non-switcher**	**Bias[a]**	**t-statistic**	**p-value**
Expected income gain (in thousand $)	125.04	125.04	0	0	0.999
Expected income gain squared	22028	22029	0	0	0.999
Age (years)	48.742	48.743	0	0	0.998
Age squared	2450.5	2450.5	0	0	0.999
Female (proportion)	0.36341	0.36331	0	0.01	0.996
Group size	37.15	37.15	0	0	1
IMG (proportion)	0.11654	0.1165	0	0	0.997
Number of enrolled patients	1657	1657	0	0	1
Female (proportion)	0.53882	0.53883	0	0	0.999
Rural areas (proportion)	0.09871	0.09872	0	0	1
Average age (in years)	39.153	39.153	0	0	0.998
Low income quintile (proportion)	0.35443	0.35444	0	0	0.998
Average ADG	3.322	3.322	0	0	0.997
Mean mortality risk score	67.066	67.067	0	0	0.996



Supplemental Figure S1. Distribution of propensity scores before and after kernel weighting for follow-up care.



Supplemental Figure S2. Standardized mean difference and variance ratio for covariates from the unweighted (i.e., raw) and weighted (i.e., matched) samples for follow-up care.



Supplemental Figure S3. Distribution of propensity scores before and after kernel weighting, for mortality and avoidable hospitalizations.

Supplemental Figure S4. Standardized mean difference and variance ratio for covariates from the unweighted (i.e., raw) and weighted (i.e. matched) samples for mortality and avoidable hospitalizations.

Supplementary Appendix S4

Table 1. Effect of switching to FHO on CHF performance indicators.

Variables	Pooled				Fixed			
	Unweighted	**Kernel**	**CBPS**	**EB**	**Unweighted**	**Kernel**	**CBPS**	**EB**
Proportion of discharges that were followed up with a physician visit within 7 days	-0.0243** (-0.0445 - -0.00411)	-0.00429 (-0.0267 - 0.0181)	-0.00628 (-0.0287 - 0.0161)	-0.012 (-0.0357 - 0.0116)	-0.0142 (-0.0396 - 0.0111)	-0.00571 (-0.0338 - 0.0224)	-0.00565 (-0.0333 - 0.0220)	-0.0127 (-0.0410 - 0.0156)
Proportion of discharges that were followed up with a physician visit within 30 days	-0.0258** (-0.0492 - -0.00247)	-0.0153 (-0.0423 - 0.0117)	-0.017 (-0.0433 - 0.00924)	-0.0165 (-0.0463 - 0.0133)	-0.00896 (-0.0390 - 0.0210)	-0.00308 (-0.0371 - 0.0309)	-0.00204 (-0.0362 - 0.0321)	-0.014 (-0.0491 - 0.0210)
Mean mortality risk score	-0.167 (-0.466 - 0.132)	-0.222 (-0.572 - 0.128)	-0.156 (-0.504 - 0.191)	-0.0744 (-0.450 - 0.301)	-0.126 (-0.371 - 0.119)	-0.143 (-0.412 - 0.127)	-0.142 (-0.423 - 0.139)	-0.0973 (-0.396 - 0.201)
Avoidable hospitalizations due to CHF	0.941 (0.629 - 1.409)	0.965 (0.614 - 1.516)	0.973 (0.621 - 1.526)	1.014 (0.668 - 1.540)	0.766 (0.425 - 1.381)	0.755 (0.417 - 1.367)	0.754 (0.411 - 1.384)	0.792 (0.439 - 1.429)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses
Abbreviations: CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; FHO: Family Health Organization, CHF: congestive heart failure.
Number of observations for follow up care and health outcome indicators were 7,490 and 26,390, respectively.

Table 1. Effect of switching to FHO on CHF performance indicators, for male physicians.

Variables	Pooled				Fixed			
	Unweighted	**Kernel**	**CBPS**	**EB**	**Unweighted**	**Kernel**	**CBPS**	**EB**
Proportion of discharges that were followed up with a physician visit within 7 days	-0.0286***	-0.00939	-0.0114	-0.0173	-0.0205	-0.0176	-0.0158	-0.0205
	(-0.0503 - -0.00699)	(-0.0333 - 0.0146)	(-0.0354 - 0.0126)	(-0.0427 - 0.00813)	(-0.0469 - 0.00585)	(-0.0458 - 0.0105)	(-0.0442 - 0.0127)	(-0.0497 - 0.00862)
Proportion of discharges that were followed up with a physician visit within 30 days	-0.0279**	-0.0168	-0.0189	-0.0185	-0.0121	-0.00939	-0.00681	-0.0163
	(-0.0523 - -0.00354)	(-0.0453 - 0.0116)	(-0.0466 - 0.00881)	(-0.0499 - 0.0129)	(-0.0432 - 0.0189)	(-0.0448 - 0.0261)	(-0.0426 - 0.0290)	(-0.0532 - 0.0206)
Mean mortality risk score	-0.183	-0.156	-0.0885	-0.0267	-0.251**	-0.261*	-0.241	-0.199
	(-0.506 - 0.140)	(-0.534 - 0.222)	(-0.468 - 0.292)	(-0.452 - 0.399)	(-0.496 - -0.00591)	(-0.541 - 0.0199)	(-0.545 - 0.0630)	(-0.527 - 0.129)
Avoidable hospitalizations due to CHF	0.916	1.004	1.012	0.977	0.72	0.773	0.786	0.781
	(0.611 - 1.371)	(0.664 - 1.520)	(0.668 - 1.533)	(0.629 - 1.519)	(0.390 - 1.331)	(0.433 - 1.379)	(0.438 - 1.413)	(0.431 - 1.414)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses
Abbreviations: OLS: ordinary least squares, FE: fixed effects, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; FHO: Family Health Organization, CHF: congestive heart failure
Number of observations for follow up care and health outcome indicators were 6,640 and 17,140, respectively.

Table 2. Effect of switching to FHO on CHF performance indicators for female physicians.

Variables	Pooled				Fixed			
	Unweighted	**Kernel**	**CBPS**	**EB**	**Unweighted**	**Kernel**	**CBPS**	**EB**
Proportion of discharges that were followed up with a physician visit within 7 days	‡	‡	‡	‡	‡	‡	‡	‡
Proportion of discharges that were followed up with a physician visit within 30 days	‡	‡	‡	‡	‡	‡	‡	‡
Mean mortality risk score	-0.339 (-0.941 - 0.263)	-0.564 (-1.275 - 0.147)	-0.465 (-1.170 - 0.239)	-0.338 (-1.058 - 0.382)	0.0823 (-0.440 - 0.605)	0.0779 (-0.479 - 0.635)	0.0386 (-0.518 - 0.595)	0.0696 (-0.502 - 0.641)
Avoidable hospitalizations due to CHF	1.079 (0.326 - 3.571)	0.945 (0.246 - 3.634)	0.952 (0.252 - 3.596)	1.27 (0.410 - 3.931)	1.004 (0.213 - 4.743)	0.75 (0.146 - 3.857)	0.713 (0.134 - 3.794)	0.866 (0.170 - 4.407)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses
Abbreviations: OLS: ordinary least squares, FE: fixed effects, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; FHO: Family Health Organization, CHF: congestive heart failure
Number of observations for follow up care and health outcome indicators were 850 and 9,250, respectively.
‡ Insufficient sample size

Table 3. Effect of switching to FHO on CHF performance indicators for physicians aged below 55 years

Variables	Pooled				Fixed			
	Unweighted	**Kernel**	**CBPS**	**EB**	**Unweighted**	**Kernel**	**CBPS**	**EB**
Proportion of discharges that were followed up within 7 days	-0.0308** (-0.0581 - -0.0034)	-0.0102 (-0.0405 - 0.0201)	-0.0121 (-0.0428 - 0.0187)	-0.0223 (-0.0536 - 0.00903)	-0.0341* (-0.0692 - 0.000935)	-0.0224 (-0.0631 - 0.0183)	-0.0242 (-0.0638 - 0.0155)	-0.0329 (-0.0733 - 0.0075)
Proportion of discharges that were followed up within 30 days	-0.0255 (-0.0568 - 0.00577)	-0.0187 (-0.0533 - 0.0160)	-0.0186 (-0.0532 - 0.0160)	-0.029 (-0.0644 - 0.00639)	-0.0302 (-0.0719 - 0.0114)	-0.026 (-0.0731 - 0.0211)	-0.0279 (-0.0751 - 0.0193)	-0.0443* (-0.0920 - 0.00348)
Mean mortality risk score	-0.136 (-0.511 - 0.239)	-0.236 (-0.678 - 0.205)	-0.156 (-0.593 - 0.282)	-0.128 (-0.601 - 0.344)	-0.0963 (-0.410 - 0.217)	-0.106 (-0.448 - 0.235)	-0.0936 (-0.446 - 0.259)	-0.0644 (-0.444 - 0.315)
Avoidable hospitalizations due to CHF	0.78 (0.450 - 1.352)	0.874 (0.473 - 1.615)	0.887 (0.480 - 1.638)	0.898 (0.518 - 1.555)	0.542 (0.249 - 1.180)	0.506* (0.227 - 1.124)	0.495* (0.218 - 1.124)	0.542 (0.249 - 1.182)

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses Abbreviations: OLS: ordinary least squares, FE: fixed effects, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; FHO: Family Health Organization, CHF: congestive heart failure

Number of observations for follow up care and health outcome indicators were 4,100 and 18,050, respectively.

Table 4. Effect of switching to FHO on CHF performance indicators, for physicians aged 55 years and above

Variables	Pooled				Fixed			
	Unweighted	**Kernel**	**CBPS**	**EB**	**Unweighted**	**Kernel**	**CBPS**	**EB**
Proportion of discharges that were followed up with a physician visit within 7 days	-0.0169 (-0.0462 - 0.0125)	0.000282 (-0.0315 - 0.0321)	-0.00155 (-0.0331 - 0.0300)	-0.000156 (-0.0342 - 0.0339)	0.0112 (-0.0255 - 0.0479)	0.0172 (-0.0196 - 0.0540)	0.0197 (-0.0172 - 0.0566)	0.0172 (-0.0210 - 0.0554)
Proportion of discharges that were followed up with a physician visit within 30 days	-0.0275 (-0.0618 - 0.00684)	-0.0151 (-0.0544 - 0.0243)	-0.0186 (-0.0566 - 0.0194)	-0.00464 (-0.0506 - 0.0413)	0.017 (-0.0268 - 0.0608)	0.0257 (-0.0222 - 0.0737)	0.0307 (-0.0177 - 0.0791)	0.0252 (-0.0253 - 0.0757)
Mean mortality risk score	-0.135 (-0.614 - 0.345)	-0.153 (-0.696 - 0.390)	-0.115 (-0.653 - 0.423)	0.116 (-0.427 - 0.658)	-0.156 (-0.507 - 0.195)	-0.186 (-0.565 - 0.193)	-0.239 (-0.614 - 0.136)	-0.144 (-0.559 - 0.271)
Avoidable hospitalizations due to CHF	1.29 (0.736 - 2.261)	1.289 (0.744 - 2.235)	1.266 (0.730 - 2.194)	1.421 (0.822 - 2.456)	1.335 (0.553 - 3.218)	1.471 (0.651 - 3.327)	1.505 (0.662 - 3.419)	1.691 (0.732 - 3.907)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses
Abbreviations: OLS: ordinary least squares, FE: fixed effects, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; FHO: Family Health Organization, CHF: congestive heart failure
Number of observations for follow up care and health outcome indicators were 3,390 and 8,340, respectively.

Supplementary Appendix S5

Table 1. Effect of switching to FHO on CHF performance indicators, for physicians who switched in 2007, 2009, 2011 and 2013

Variables	Fixed effects			
	Unweighted	**Kernel**	**CBPS**	**EB**
2007				
Proportion of discharges that were followed up with a physician visit within 7 days	-0.00547 (-0.0331 - 0.0222)	-0.00127 (-0.0309 - 0.0283)	-0.00719 (-0.0374 - 0.0231)	0.00107 (-0.0283 - 0.0304)
Proportion of discharges that were followed up with a physician visit within 30 days	-0.00301 (-0.0357 - 0.0297)	0.0216 (-0.0140 - 0.0572)	0.0106 (-0.0257 - 0.0469)	0.0102 (-0.0275 - 0.0480)
Mean mortality risk score	-0.145 (-0.389 - 0.0996)	-0.116 (-0.360 - 0.129)	-0.127 (-0.370 - 0.116)	-0.151 (-0.405 - 0.104)
Avoidable hospitalizations due to CHF	0.819 (0.420 - 1.596)	0.946 (0.471 - 1.902)	0.878 (0.431 - 1.787)	0.985 (0.472 - 2.056)
2009				
Proportion of discharges that were followed up with a physician visit within 7 days	-0.0202 (-0.0633 - 0.0230)	-0.0162 (-0.0613 - 0.0289)	-0.0185 (-0.0636 - 0.0267)	-0.00904 (-0.0548 - 0.0367)
Proportion of discharges that were followed up with a physician visit within 30 days	-0.0139 (-0.0670 - 0.0391)	-0.0133 (-0.0732 - 0.0466)	-0.0162 (-0.0762 - 0.0438)	-0.00734 (-0.0677 - 0.0531)
Mean mortality risk score	-0.156 (-0.475 - 0.162)	-0.269 (-0.605 - 0.0680)	-0.269 (-0.610 - 0.0718)	-0.286* (-0.626 - 0.0542)
Avoidable hospitalizations due to CHF	0.757 (0.263 - 2.184)	0.755 (0.225 - 2.533)	0.752 (0.224 - 2.524)	0.792 (0.233 - 2.694)
2011				
Proportion of discharges that were followed up with a physician visit within 7 days	-0.0128 (-0.0975 - 0.0719)	-0.0534 (-0.175 - 0.0687)	-0.061 (-0.183 - 0.0610)	-0.0599 (-0.182 - 0.0624)
Proportion of discharges that were followed up with a physician visit within 30 days	-0.0299 (-0.124 - 0.0640)	-0.0909 (-0.219 - 0.0372)	-0.0838 (-0.212 - 0.0444)	-0.0838 (-0.212 - 0.0447)
Mean mortality risk score	-0.14 (-0.623 - 0.343)	0.0604 (-0.489 - 0.609)	0.149 (-0.410 - 0.708)	0.0515 (-0.509 - 0.612)
Avoidable hospitalizations due to CHF	0.957 (0.194 - 4.722)	1.914 (0.308 - 11.90)	2.011 (0.317 - 12.76)	1.808 (0.281 - 11.64)

2013				
Proportion of discharges that were followed up with a physician visit within 7 days	-0.0442 (-0.194 - 0.106)	-0.0346 (-0.206 - 0.137)	-0.0604 (-0.225 - 0.105)	-0.0699 (-0.240 - 0.100)
Proportion of discharges that were followed up with a physician visit within 30 days	-0.0497 (-0.209 - 0.110)	-0.0405 (-0.226 - 0.145)	-0.0715 (-0.252 - 0.109)	-0.0742 (-0.261 - 0.113)
Mean mortality risk score	0.426 (-0.275 - 1.126)	0.0667 (-0.701 - 0.835)	0.0217 (-0.746 - 0.789)	0.0803 (-0.718 - 0.879)
Avoidable hospitalizations due to CHF	0.231 (0.000656 - 81.44)	1.696 (0.0128 - 224.0)	1.7 (0.0120 - 240.9)	1.935 (0.00768 - 487.5)

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses

Abbreviations: CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; FHO: Family Health Organization, CHF: congestive heart failure

Number of observations for follow-up care indicators were 6174, 3878, 1950, 966 for physicians who switched between 2008 & 2009, switched between 2010 & 2011, switched between 2012 & 2013, and switched in 2014 &2015 respectively.

Number of observations for health outcome indicators were 23832, 14161, 7300 and 3759 for physicians who switched between 2008 & 2009, switched between 2010 & 2011, switched between 2012 & 2013, and switched in 2014 &2015 respectively.

Supplementary Appendix S6

Table 1. Results from simple before and after analysis

Outcome variable	Pooled	Fixed effects
Follow-up visit within 7 days of discharge (n=4,920)	-0.0144 (-0.0441 - 0.0153)	0.00627 (-0.0244 - 0.0369)
Follow-up visit within 30 days of discharge (n=4,920)	-0.00481 (-0.0380 - 0.0284)	0.0162 (-0.0163 - 0.0487)
Mean mortality risk score (n=16,060)	-0.0943 (-0.484 - 0.295)	-0.0857 (-0.341 - 0.170)
Avoidable hospitalizations (n=16,060)	0.751 (0.428 - 1.317)	0.723 (0.341 - 1.534)

Notes:
-all regressions include all the covariates defined in X_{it}, 95% confidence interval in parentheses; n: number of observations
-The before-after analyses are based on only switchers. In our main analyses (i.e., inverse probability weighted fixed effects regression), there were 478 and 1,596 switchers for follow-up care and health outcomes, respectively. However, in our simple before-after analysis, there were 492 and 1,606 switchers for follow-up care and health outcomes, respectively. Fewer physicians in the main analyses were due to the exclusion of physicians outside the range of common support.

Chapter 5

5 The relationship between family physicians' remuneration mechanism and quality of care for persons with chronic kidney disease

5.1 Introduction

Healthcare systems in many developed nations have been endeavoring to improve the quality of care provided to patients with chronic diseases (Li et al., 2014). Like in many jurisdictions, the government of Ontario introduced primary care reform in the early 2000s (Sweetman & Buckley, 2014). To improve quality of primary care, the provincial government's plan of action included restructuring the compensation mechanism of primary care physicians in Ontario and introducing pay-for-performance incentives (Marchildon & Hutchison, 2016). A reason for employing this tactic was the realization of a link between physicians' behaviour and their remuneration mechanism; findings from various studies support a correlation between the two (Chami & Sweetman, 2019; Kantarevic & Kralj, 2013; Kiran et al., 2014; Kralj & Kantarevic, 2013; Liddy, Singh, et al., 2011), but some studies do not find any association (Jaakkimainen et al., 2011; Russell et al., 2009). Furthermore, P4P programs have been found to improve the quality of CKD care (Karunaratne et al., 2013; Lin et al., 2018; Richardson, 2013).

Though many studies have investigated some aspects of the relationship between physicians' compensation and the quality of care, there is a paucity of research on the relationship between primary care physicians' mode of remuneration and quality of CKD management with the exception of one study by Liddy, Singh, et al. (2011).

Prior to Ontario's primary care reform, 90 per cent of the province's primary care physicians received the vast majority of their income through pure FFS (Sweetman & Buckley, 2014), a payment mechanism where the unit of payment is a service (Quinn, 2015). The reform introduced blended payment systems where physicians obtain their income from multiple modes of payment (Marchildon & Hutchison, 2016). Family Health Group and Family Health Organization are the two dominant post-reform primary care models that remunerate family physicians through blended FFS (introduced July 2003) and blended capitation (introduced November 2006), respectively (Sweetman & Buckley, 2014). Physicians in these two models are entitled to the same P4P incentives for the management of diabetes ($60 per enrolled patient per annum) and congestive heart failure ($125 per enrolled patient per annum) (Sweetman & Buckley, 2014), but no such incentives for chronic kidney disease currently exist.

We used Ontario's FHG and FHO models to investigate the relationship between physicians' remuneration mechanism and quality of CKD management using four process indicators and mortality risk score. These care processes were identified through a literature search, and are relevant to the primary care setting; they were: testing of (1) serum creatinine and (2) urine ACR, (3) prescriptions for angiotensin converting enzyme inhibitors or angiotensin II receptor blockers, and (4) prescriptions for statins (Tu et al., 2017). A person's mortality risk score is an estimate of their 1-year risk of all-cause mortality according to the algorithm of Austin & Walraven (2011).

The aim of our study was to determine whether patients received different quality of CKD management across FHO and FHG physicians. We hypothesized that persons

with CKD receive better management for their condition if their family physician is remunerated through blended capitation relative to blended FFS. Compared to a FFS-based scheme, patients are more likely to receive better health management under a capitation-based system because capitation incentivizes physicians to retain their enrollees—which can be achieved by keeping them as healthy as possible (Blomqvist & Busby, 2012; Brosig-Koch et al., 2017; Kralj & Kantarevic, 2013). Some empirical evidence suggests that capitation payment is associated with better care quality than FFS in the management of chronic conditions such as diabetes mellitus and asthma (Kiran et al., 2014; Kralj & Kantarevic, 2013; To et al., 2015).

Our study found that patients in FHG received slightly more care than their counterparts in FHO; furthermore, our findings showed that patients in the blended FFS model had slightly higher mortality risk scores. These findings could be explained by the fact that patients in one model, on average, may be more (or less) healthy than patients under the other model. Due to data limitations, our findings were based on two years of observations and analyses were cross-sectional. Our study is the first to compare quality of CKD management in capitation- and FFS-based remuneration schemes for a primary care context.

5.2 Methods

Study design

All data were obtained through ICES (formerly known as the Institute for Clinical Evaluative Sciences), a not-for-profit organization that holds various administrative healthcare databases in Ontario. The use of data in this project was authorized under

section 45 of Ontario's Personal Health Information Protection Act, which does not require review by a Research Ethics Board. We used a cross-sectional study design for two observation periods, namely, the 2014 and 2015 fiscal years (April to March). We observed FHG and FHO physicians and their enrolled patients diagnosed with CKD (diagnosis confirmed by two eGFR laboratory test results of below 60mL/min/1.73m^2 separated by at least 3 months but fewer than 18 months); the schematic for our cohort creation is presented in Appendix A for Chapter 5. Patients who were receiving dialysis or had a kidney transplant were excluded.

For each observation period, five quality indicators were investigated: (1) serum creatinine testing, (2) urine ACR measurement, prescription of (3) ACEIs/ARBs and (4) statins, and (5) mortality risk sore—which are used to estimate a person's risk of all-cause mortality within a year. Estimation is through a logistic regression model where explanatory variables include the individual's age, sex and comorbidity (the Johns Hopkins Aggregated Diagnoses Group (ADG) was used to quantify comorbidity) (Austin & Walraven, 2011; The Johns Hopkins University Bloomberg School of Public Health, 2011).

We examined patients' receipt of the process indicators (1-4 above) at least once in each year, and information on data sources and variable definitions are provided in the Appendix (Sections A3.2 and A3.3 of Appendix A for Chapter 5).

Statistical analyses

Inverse probability weighted multivariable regressions

Analyses were conducted at the physician level; all patient-level information were aggregated to the level of the physician. The main explanatory variable was the primary care model (i.e., FHG or FHO). Given that a physician's choice to be in either payment model is voluntary, there would be systematic differences between physicians in the two models. Such differences result in selection bias, which we addressed by employing multivariable regressions with inverse probability weights derived from propensity scores;

Our inverse probability weights were derived from the propensity scores estimated through kernel matching—as it is a matching technique that is widely used in the health economics literature (Bamimore et al., 2020; Sarma et al., 2018; Somé et al., 2019; Vu et al., 2020).In addition to using weights derived from kernel matching, we also used two alternative weighting procedures as robustness checks, namely, covariate balancing propensity scores (Imai & Ratkovic, 2014) and entropy balancing weighting (Hainmueller, 2012); these two alternative methods are virtually robust to model misspecification in simulation studies.

A physician's propensity score refers to their probability of being in either of two groups, given a set of observable explanatory variables. Such scores are estimated from logistic regressions whereby the probability of group assignment is regressed on a set of independent variables (Faries et al., 2010; Rosenbaum & Rubin, 1983). The general guideline is to include independent variables in a propensity score model that are likely to be related to both the outcome of interest and group assignment. Furthermore, a propensity score model is said to be covariate-balanced when the distribution of each

independent variable is balanced between the two groups after matching on the propensity score (Garrido et al., 2014); absolute value of the standardized difference is a common metric to quantify imbalance. If such value is 0% for a given covariate, the distribution of that covariate is said to be completely balanced; an imbalance between 10% and 25% is acceptable (Garrido et al., 2014). The explanatory variables of our propensity score model included physician's characteristics (age, sex, group size, number of enrolled patients, and country of medical education (United States/Canada or international)). We also included characteristics of patients in physicians' practice such as the proportion of patients' who are female, proportion of patients who live in rural areas, the average age of patients, and the proportion of patients in high income quintile.

Physicians outside the range of common support were excluded. For our analyses, we refer to the FHO group as the treated, and the FHG group as the control or the untreated. When using inverse probability weighting to estimate the average treatment effect on the treated (ATT), the treated are given a weight of one; control subjects are given a weight that corresponds to the distance between them and treated subjects' propensity scores within a bandwidth of 0.06 (Garrido et al., 2014). In ATT estimation, the treated correspond to the FHO physicians and the inverse probability weights for the FHG group creates a synthetic sample where distribution of the observable covariates is similar to the FHO physicians (Austin & Stuart, 2015).

The comparison of CKD care quality between the FHG and FHO models was also conducted for four subgroups: physicians who were male, female, aged 55 years and above, and aged below 55 years. We conducted these subgroup analyses to observe

whether CKD care quality under FHG and FHO is similar—or different—in various subgroups of physicians. The literature is filled with inconsistent evidence on the impact of gender on care delivery (Berthold et al., 2008; Henderson & Weisman, 2001; Kim et al., 2005; Schmittdiel et al., 2000). While some studies found no relationship between physicians' gender and care quality (Schmittdiel et al., 2000), others concluded that care provision varies according to gender; for example, Kim et al. (2005) found that female primary care physicians were more likely to provide lipid assessment for their patients with diabetes compared to their male counterparts. Some have explained that female physicians involve more positive talk, information-giving and question-asking in their practice style relative to their male peers (Bertakis et al., 1995). There literature is inconclusive about the relationship between a physician's and their care quality (Tsugawa et al., 2017). Some argue that older physicians may provide better care than their younger peers as the older ones, on average, have practiced medicine longer; others propound that care delivery of younger physicians could be better than that of their older counterparts because the junior clinicians' knowledge would be based on more current medical literature (Tsugawa et al., 2017). As the medical literature expands over time, older physicians' knowledge may become outdated; furthemore, physicians may find it burdensome to update clinical practice with current the clinical literature (Tsugawa et al., 2017). Moreover, the effect of continuing medical education (CME) is—according to literature—mixed: some studies found that CME impacts performance, while other s found that it is ineffective at improving physicians' care practices (Cervero & Gaines, 2015).

The equation below describes the multivariable regression:

$$Y_i = \delta FHO_i + \beta X_i + \varepsilon_{it}.$$

Y_i corresponds to the outcome of interest for physician *i*, FHO is a dummy variable which takes a value of one if physician *i* is in FHO and zero if in a FHG; δ is the estimated coefficient of interest capturing the association between a physician being in FHO (relative to being in a FHG) and Y; X_i is the vector of explanatory variables previously listed; ε_i is the error term. Fractional regressions were used for outcomes that were proportions (i.e., the four care processes) (Papke, 1996); linear regression was used for mortality risk score (as it is a continuous variable) (Sarma et al., 2018).

All analyses were conducted with the statistical software *Stata* version 15.1 (StataCorp, 2017).

5.3 Results

For 2014, we identified 4,008 physicians—1,085 in FHGs and 2,923 in FHOs; in 2015, we identified 4,572 physicians, 1,195 in FHGs and 3,377 in FHOs. Figure 1 of Appendix B for Chapter 5 provides a flow chart depicting the derivation of the final sample sizes of physicians for our two observation periods.

Covariate balance and descriptive statistics

For the observation periods, all three weighting techniques (i.e., kernel, CBPS and EB weighting) yielded balance in distribution of observable covariates. Balancing diagnostics for kernel weighting are provided in Figure 5.1 and Tables 5.1 and 5.2; absolute standardized mean difference was under 15% for all covariates in both years.

Balancing diagnostics for the two alternative weighting procedures are provided in Appendix B (Tables 1 and 2 of Appendix B).

In both observation periods, more physicians were in FHOs, and were mostly males (Tables 5.3 and 5.4). Mean values for the four process indicators show that, by and large, care was slightly higher for patients in FHGs compared to those in FHOs.

Association between FHO and CKD care quality for 2014

Our inverse probability weighted regression results revealed that FHO compared to FHG was associated with 1.98% (95% CI: -2.81%,-1.16%) less serum creatinine testing at least once each year, and 7.18% (95% CI: -8.78%,-5.57%) less urine ACR testing at least once a year (Table 5.5). We also found that FHO model was associated with patients, on average, having lower mortality risk scores by 0.905 (95% CI: -1.103, -0.706). Our results showed no difference between the two models for prescription of ACEI/ARB and statins. Our results support that fewer patients were receiving care from FHO physicians in 2014: based on 170,494 total CKD patient-year observations in FHOs in our 2014 data (where 153,246 of the patients over 65 years), there were 3,376 (CI: 4,791, 1,978) less patients receiving testing for serum creatinine, and 12,241 (CI:14,969, 9,497) less patients receiving urine ACR measurement. Our results also suggest that risk of all-cause mortality within one year was reduced by approximately 0.0131% (CI: 0.0129%, 0.0133%). All results under CBPS and EB weighting were qualitatively similar (Table 5.5).

For physicians who were male, female, younger (aged below 55 years), and older (55 years and above), being in a FHO (vs. FHG) was associated with less urine ACR

measurement at least once a year (Table 5.6). Of these four subgroups, point estimate of the absolute difference between FHO vs. FHG was highest in younger physicians (-9.89%), and most attenuated in older physicians (-4.72%). In all subgroups excepts older physicians, FHO (vs. FHG) was associated with less serum creatinine testing at least once annually (Table 5.6). On average, patients' mortality risk score was lower under FHO physicians of all four subgroups (Table 5.6). Results of subgroup analyses were mostly corroborated by CBPS and EB weights (Tables 3 to 7 in Appendix B).

Association between FHO and CKD care quality for 2015

Our inverse probability weighted regression results showed that FHO was associated with 2.40% (95% CI: -3.17%,-1.63%) less serum less serum creatinine testing at least once each year and 6.59% (95% CI: -8.08, -5.09%) less urine ACR measurements at least once a year (Table 5.7). On average, patients under FHO physicians had 0.809 lower mortality risk score (95% CI: -1.009, -0.608). All results under CBPS and EB weighting were qualitatively similar (Table 5.7). Unlike for 2014, we found a significant difference for ACEI/ARB prescription: FHO was associated with more prescription of ACEIs/ARBs by 1.19% (95% CI: 0.402%, 1.98%); this finding was corroborated by only CBPS weights (Table 5.7). Our results support that fewer patients were receiving care from FHO physicians in 2015: based on 206,535 total CKD patient-year observations in FHOs in our 2015 data (where 185,270 of the patients are over 65 years), there are 4,957 (CI: 6,547, 3,367) less patients receiving testing for serum creatinine, and 13,611 (CI: 16,688, 10,513) less patients receiving urine ACR measurement. Our results also suggest that risk of all-cause mortality within one year was reduced by approximately 0.0130%

(CI: 0.0128%, 0.0132%); our results also suggest that 2,205 (CI: 745, 3,668) more patients receive ACEI/ARB prescription in FHO (vs. FHG).

For physicians who were male, female, younger, and older, being in a FHO (vs. FHG) was associated with less serum creatinine testing, and less urine ACR measurement, at least once a year (Table 5.8). On average, patients' mortality risk score was lower under FHO physicians of all four subgroups (Table 5.8). The FHO model was associated with increased ACEI/ARB prescription only for the subpopulation of physicians who were female and older (Table 5.8). Results of subgroup analyses were mostly corroborated by CBPS and EB weights (Tables 8 to 12 in Appendix B).

5.4 **Discussion**

We examined the association between primary care physicians' payment mechanisms and the quality of primary care for persons with chronic kidney disease using four process indicators and a mortality risk score for 2014 and 2015. For 2014 and 2015, inverse probability weighted regressions showed that persons with CKD are less likely to receive serum creatinine testing and urine ACR measurements in a FHO than in a FHG. However, we found that patients' mortality risk scores were, on average, lower under FHO, and this finding could result from FHO physicians rostering healthier patients; this finding could also be explained by the possibility that patients under FHO are being kept healthier. Statin prescription did not differ under FHG and FHO for both years. For only 2015, our results revealed that patients in FHO are slightly more likely to receive ACEI or ARB prescriptions.

Our findings are at odds with our original hypothesis, namely that patients with CKD would receive better management for their condition if their family physician were remunerated through blended capitation relative to blended FFS. However, we need to be cautious in interpreting our results because they are based on only two years of cross-sectional data. Data unavailability at the time of our analyses deterred us from employing statistical techniques that address some of the potential bias that is present. Fixed-effects regressions would permit stronger conclusions.

Another limitation of our study pertains to our binary analyses of CKD process measures (e.g., 'no' vs. 'at least one' ACR measurement): in our study, quality of care process pertained to the provision vs. non provision of care. Given that the Ontario Drug Benefit program covers Ontarians aged 65 years and over (Cheung et al., 2017; Government of Ontario, 2020), we could not study individuals below this age group. The Ontario Laboratories Information System (OLIS) database was used to identify persons with CKD, as well as the laboratory-based process indicators (i.e., serum creatinine testing and urine ACR measurement). The OLIS database holds information from various laboratories across Ontario, including hospital laboratories, community laboratories and public health laboratories (eHealth Ontario, 2018a). The goal of OLIS is to have a 100 per cent coverage for laboratory records in Ontario; the coverage has been increasing annually since 2006 (eHealth Ontario, 2012, 2016). The inconsistency in percent coverage across years deterred us from conducting longitudinal analysis to control for unobservable time-invariant confounding.

In the existing literature, there is limited research on the relationship between primary care physicians' remuneration mechanism and quality of care for CKD patients. Our result pertaining to serum creatinine testing is different from that of the study by Liddy, Singh, et al. (2011); the previous study found that blended capitation and FFS were similar in terms of measuring estimated glomerular filtration rate. This discrepancy could be due to the previous study using data from the Eastern part of Ontario only; moreover, the authors' comparison was between a mixed and pure payment models (i.e., blended capitation vs. FFS)—unlike ours that compared two mixed payment models (i.e., blended capitation vs. blended FFS).

While our study did not specifically investigate the impact of physicians' switch from FHG to FHO, our conclusion for urine ACR measurement resonates with findings from Chami & Sweetman (2019) who found that switching physicians from FHGs to FHOs was associated with a reduction in laboratory requisitions. Moreover, the FHG and FHO models do not have financial incentives specifically for CKD care (Ontario Medical Association, 2015).

Our study was the first to examine whether quality of CKD care varies between FFS-based and capitation-based schemes in the primary care setting. While we found that blended FFS can be associated with some better care processes for CKD, future studies could investigate the complexities of the relationship between physicians' mode of remuneration and care quality for persons with this health condition using longitudinal analyses that accounts for more bias than cross-sectional approaches. Nonetheless,

findings from our study have contributed to the knowledge base on payment scheme and quality of primary care for persons with chronic kidney disease.

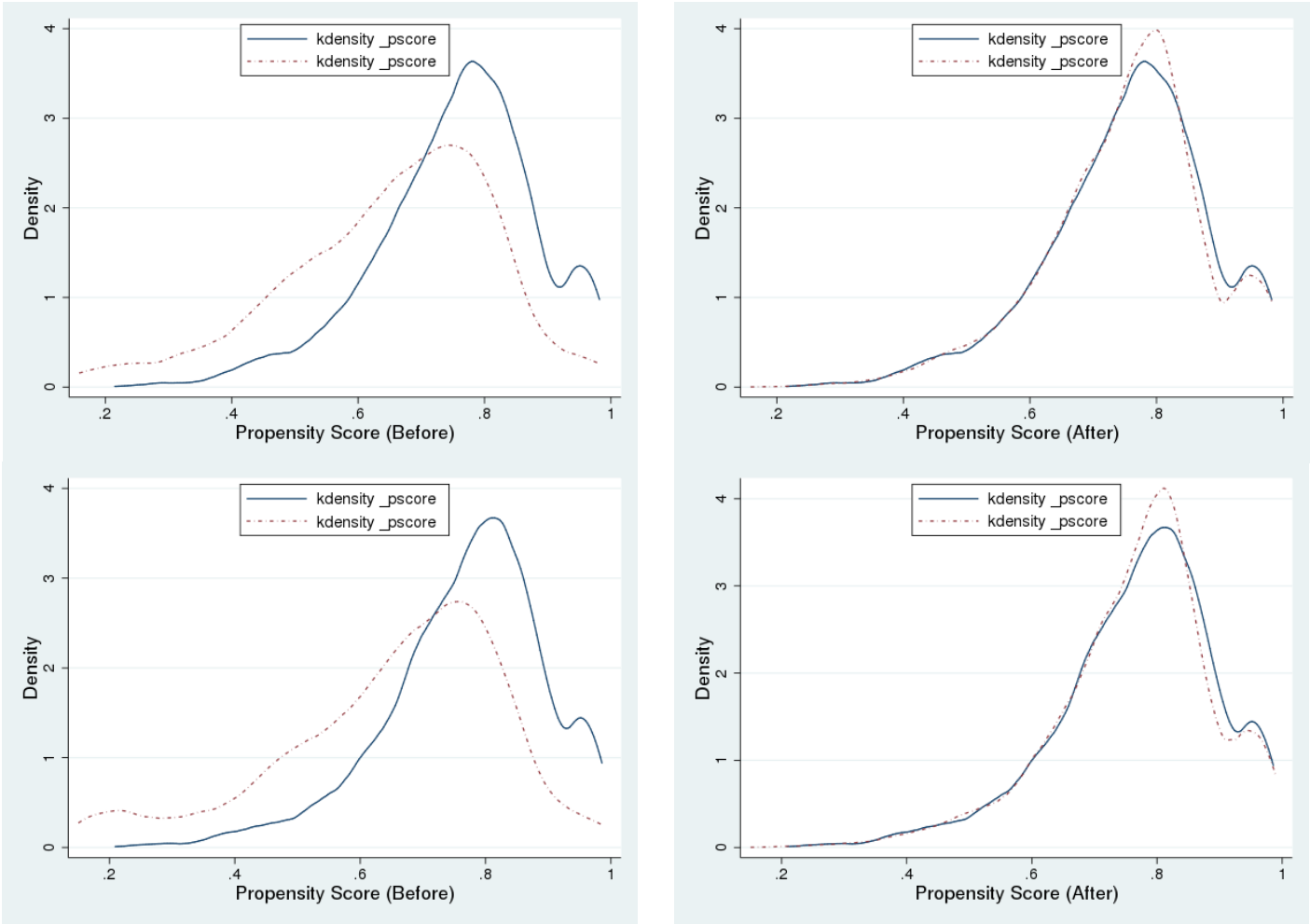


Figure 5.1 Distribution of propensity scores before and after kernel weighting for 2014 (top) and 2015 (bottom)

Table 5.1 Means and standardized bias before and after kernel weighting for 2014

Covariate	Means and standardized bias prior to kernel weighting			Means and standardized bias after kernel weighting		
	FHO	**FHG**	**Bias**	**FHO**	**FHG**	**Bias**
Physicians' characteristics						
Age (years)	53.923	56.6	-26.1	53.923	54.874	-9.3
Female (proportion)	0.35888	0.33548	4.9	0.35888	0.32427	7.3
Group size	18.043	23.672	-29.7	18.043	15.563	13.1
Number of enrolled patients	1513.4	1687.6	-25.1	1513.4	1495.2	2.6
IMG (proportion)	0.15327	0.28848	-33.0	0.15327	0.1575	-1.0
Patients' characteristics						
Age, (years)	77.078	76.484	20.7	77.078	77.221	-5.0
Female (proportion)	0.58417	0.57175	9.6	0.58417	0.58251	1.3
Rural area (proportion)	0.14039	0.04745	42.4	0.14039	0.10928	14.2
High income quintile (proportion)	0.3879	0.39853	-6.6	0.3879	0.39762	-6.0

Abbreviations: FHG: Family Health Group, FHO: Family Health Organization, IMG: International Medical Graduate
Note: FHO represents all physicians in the FHO model in 2014; FHG represents all physicians in the FHG model in 2014

Table 5.2 Means and standardized bias before and after kernel weighting for 2015

Covariate	Means and standardized bias prior to kernel weighting			Means and standardized bias after kernel weighting		
	FHO	**FHG**	**Bias**	**FHO**	**FHG**	**Bias**
Physicians' characteristics						
Age (years)	53.534	56.635	-29.4	53.534	54.422	-8.4
Female (proportion)	0.39147	0.35146	8.3	0.39147	0.35947	6.6
Group size	17.834	26.18	-38.2	17.834	15.582	10.3
Number of enrolled patients	1462.9	1639.1	-25.4	1462.9	1441.1	3.2
IMG (proportion)	0.16908	0.30377	-32.1	0.16908	0.173	-0.9
Patients' characteristics						
Age (years)	76.938	76.442	17.4	76.938	77.083	-5.1
Female (proportion)	0.58373	0.57307	8.2	0.58373	0.58403	-0.2
Rural area (proportion)	0.13669	0.0456	42.1	0.13669	0.10636	14
High income quintile (proportion)	0.38514	0.39868	-8.1	0.38514	0.39443	-5.6

Abbreviations: FHG: Family Health Group, FHO: Family Health Organization, IMG: International Medical Graduate
FHO represents all physicians in the FHO model in 2015; FHG represents all physicians in the FHG model in 2015

Table 5.3 Mean values of outcome and explanatory variables for 2014

Variables	Model	
	FHG (n=1,085)	**FHO (n=2,923)**
Physicians' characteristics		
Age, in years (mean ± SD)	56.6 ± 10.2	53.9 ± 10.3
Female (proportion)	0.34	0.36
Group size (mean ± SD)	24 ± 23	18 ±14
Number of enrolled patients (mean ± SD)	1687 ± 807	1413 ± 559
IMG (proportion)	0.29	0.15
Patients' characteristics		
Age, in years (mean ± SD)	76.5 ± 3.1	77.1 ± 2.6
Female (proportion)	0.57	0.58
Rural area (proportion)	0.047	0.14
High income quintile (proportion)	0.40	0.39
Outcome		
Serum creatinine testing (proportion)	0.85	0.83
Urine ACR measurement (proportion)	0.51	0.40
ACEI/ARB prescription (proportion)	0.58	0.58
Statin prescription (proportion)	0.65	0.63
Mortality risk score (mean)	67.1 ± 4.4	67.0 ± 3.6

Abbreviation: FHG: Family Health Group, FHO: Family Health Organization, ACR: albumin-to-creatinine ratio, ACEIs: angiotensin-converting enzyme inhibitors, ARBs: and angiotensin II receptor blockers, IMG: international medical graduate

Table 5.4 Mean values of outcome and explanatory variables for 2015

Variables	Model	
	FHG (n=1,195)	**FHO (n=3,377)**
Physicians' characteristics		
Age, in years (mean ± SD)	56.6 ± 10.5	53.5 ± 10.6
Female (proportion)	0.35	0.39
Group size (mean ± SD)	26 ± 27	18 ± 14
Number of enrolled patients (mean ± SD)	1639 ± 799	1463 ± 566
IMG (proportion)	0.30	0.17
Patients' characteristics		
Age, in years (mean ± SD)	76.4 ± 3.1	76.9 ± 2.6
Female (proportion)	0.57	0.58
Rural area (proportion)	0.05	0.14
High income quintile (proportion)	0.40	0.39
Outcome		
Serum creatinine testing (proportion)	0.85	0.83
Urine ACR measurement (proportion)	0.50	0.39
ACEI/ARB prescription (proportion)	0.56	0.57
Statin prescription (proportion)	0.65	0.62
Mortality risk score (mean)	67.3 ± 4.3	67.1 ± 3.6

Abbreviation: FHG: Family Health Group, FHO: Family Health Organization, ACR: albumin-to-creatinine ratio, ACEIs: angiotensin-converting enzyme inhibitors, ARBs: and angiotensin II receptor blockers, IMG: international medical graduate

Table 5.5 Effect of FHO on quality of chronic kidney disease care for 2014

Outcome variable[a]	Unweighted	Kernel	CBPS	EB
Serum creatinine testing	-0.0168***	-0.0198***	-0.0220***	-0.0141**
	(-0.0234 - -0.0101)	(-0.0281 - -0.0116)	(-0.0303 - -0.0136)	(-0.0250 - -0.00320)
Urine ACR measurement	-0.0715***	-0.0718***	-0.0742***	-0.0666***
	(-0.0858 - -0.0572)	(-0.0878 - -0.0557)	(-0.0911 - -0.0574)	(-0.0880 - -0.0452)
ACEI/ARB prescription	0.00153	0.00178	0.00315	0.00133
	(-0.00587 - 0.00894)	(-0.00636 - 0.00992)	(-0.00490 - 0.0112)	(-0.00943 - 0.0121)
Statin prescription	-0.00409	-0.00386	-0.00618	-0.00611
	(-0.0126 - 0.00447)	(-0.0134 - 0.00567)	(-0.0158 - 0.00344)	(-0.0177 - 0.00549)
Mortality risk score	-0.822***	-0.905***	-0.841***	-0.740***
	(-1.000 - -0.643)	(-1.103 - -0.706)	(-1.042 - -0.639)	(-0.960 - -0.521)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses
Abbreviations: ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; FHG: Family Health Group
Total number of observations = 4,008
[a]This table reports the average marginal effects of FHO on physicians' care quality for chronic kidney disease. For example, physicians in FHO, relative to their counterparts in FHG, are less likely to provide serum creatinine testing by 1.98% in 2014. This table also reports patients' mean mortality risk score of under FHO—relative to FHG.

Table 5.6 Effect of FHO on quality of chronic kidney disease care across various subgroups of physicians for 2014

Outcome variable[a]	All (n=4,008)	Male (n=2,595)	Female (n=1,413)	Young (n=1,923)	Old (n=2,085)
Serum creatinine testing	-0.0198***	-0.0189***	-0.0208***	-0.0284***	-0.0119*
	(-0.0281 - -0.0116)	(-0.0290 - -0.00879)	(-0.0347 - -0.00702)	(-0.0383 - -0.0184)	(-0.0239 - 6.35e-05)
Urine ACR measurement	-0.0718***	-0.0715***	-0.0718***	-0.0989***	-0.0472***
	(-0.0878 - -0.0557)	(-0.0910 - -0.0520)	(-0.1000 - -0.0437)	(-0.123 - -0.0746)	(-0.0684 - -0.0261)
ACEI/ARB prescription	0.00178	-0.00341	0.0102	-0.00369	0.0056
	(-0.00636 - 0.00992)	(-0.0133 - 0.00644)	(-0.00418 - 0.0245)	(-0.0158 - 0.00840)	(-0.00521 - 0.0164)
Statin prescription	-0.00386	-0.00192	-0.0113	-0.00942	-0.00091
	(-0.0134 - 0.00567)	(-0.0133 - 0.00946)	(-0.0287 - 0.00616)	(-0.0231 - 0.00431)	(-0.0140 - 0.0122)
Mortality risk score	-0.905***	-1.082***	-0.653***	-0.971***	-0.797***
	(-1.103 - -0.706)	(-1.319 - -0.845)	(-1.024 - -0.282)	(-1.285 - -0.658)	(-1.047 - -0.547)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses
Abbreviations: ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization
[a]This table reports the average marginal effects of FHO on physicians' care quality for chronic kidney disease for various subgroup of physicians. For example, male physicians in FHO, relative to their counterparts in FHG, are less likely to provide serum creatinine testing by 1.89% in 2014. This table also reports patients' mean mortality risk score of under FHO—relative to FHG—for various subgroup of physicians.

Table 5.7 Effect of FHO on quality of chronic kidney disease care for 2015

Outcome variable[a]	Unweighted	Kernel	CBPS	EB
Serum creatinine testing	-0.0194***	-0.0240***	-0.0266***	-0.0215***
	(-0.0258 - -0.0130)	(-0.0317 - -0.0163)	(-0.0345 - -0.0187)	(-0.0316 - -0.0114)
Urine ACR measurement	-0.0718***	-0.0659***	-0.0674***	-0.0592***
	(-0.0853 - -0.0583)	(-0.0808 - -0.0509)	(-0.0818 - -0.0529)	(-0.0796 - -0.0388)
ACEI/ARB prescription	0.00824**	0.0119***	0.0130***	0.0063
	(0.00121 - 0.0153)	(0.00402 - 0.0198)	(0.00515 - 0.0208)	(-0.00400 - 0.0166)
Statin prescription	-0.00661*	-0.00488	-0.00668	-0.0101*
	(-0.0145 - 0.00125)	(-0.0141 - 0.00436)	(-0.0156 - 0.00228)	(-0.0217 - 0.00158)
Mortality risk score	-0.732***	-0.809***	-0.776***	-0.809***
	(-0.899 - -0.565)	(-1.009 - -0.608)	(-0.973 - -0.578)	(-1.062 - -0.556)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses
Abbreviations: ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization
Total number of observations = 4,572
[a]This table reports the average marginal effects of FHO on physicians' care quality for chronic kidney disease. For example, physicians in FHO, relative to their counterparts in FHG, are less likely to provide serum creatinine testing by 2.40% in 2015. This table also reports patients' mean mortality risk score of under FHO—relative to FHG.

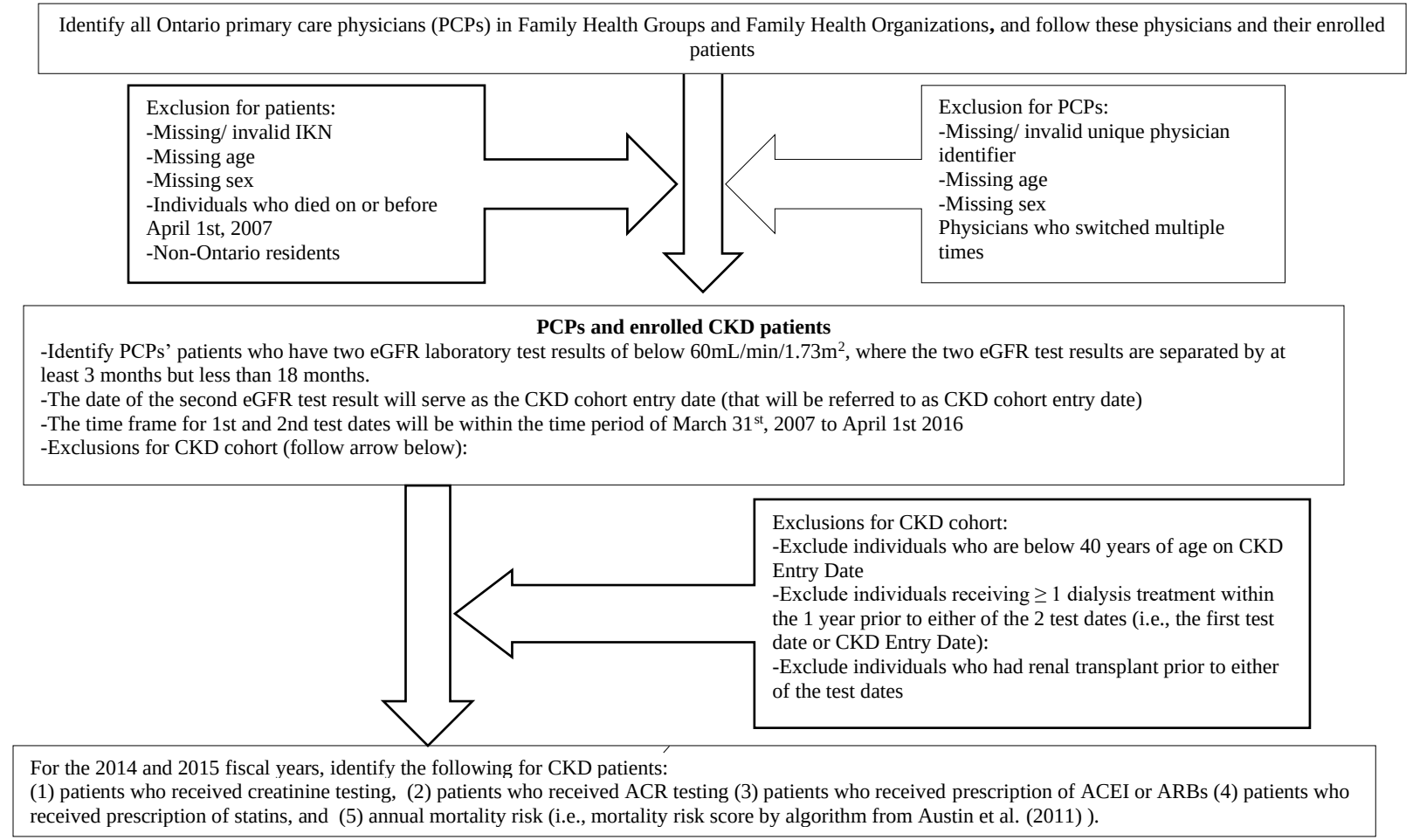
Table 5.8 Effect of FHO on quality of chronic kidney disease care across various subgroups of physicians for 2015

Outcome variable	All (n=4,572)	Male (n=2,830)	Female (n=1,742)	Young (n=2,222)	Old (n=2,350)
Serum creatinine testing	-0.0240***	-0.0205***	-0.0318***	-0.0301***	-0.0169***
	(-0.0317 - -0.0163)	(-0.0305 - -0.0104)	(-0.0433 - -0.0203)	(-0.0407 - -0.0195)	(-0.0279 - -0.00596)
Urine ACR measurement	-0.0659***	-0.0616***	-0.0754***	-0.0861***	-0.0442***
	(-0.0808 - -0.0509)	(-0.0801 - -0.0431)	(-0.101 - -0.0496)	(-0.109 - -0.0636)	(-0.0636 - -0.0249)
ACEI/ARB prescription	0.0119***	0.00674	0.0197***	0.00884	0.0134**
	(0.00402 - 0.0198)	(-0.00277 - 0.0163)	(0.00566 - 0.0337)	(-0.00272 - 0.0204)	(0.00292 - 0.0239)
Statin prescription	-0.00488	-0.00211	-0.00976	-0.0109	0.00193
	(-0.0141 - 0.00436)	(-0.0136 - 0.00939)	(-0.0254 - 0.00592)	(-0.0243 - 0.00245)	(-0.0106 - 0.0145)
Mortality risk score	-0.809***	-0.920***	-0.684***	-0.774***	-0.821***
	(-1.009 - -0.608)	(-1.161 - -0.679)	(-1.034	(-1.074 - -0.475)	(-1.084 - -0.558)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses
Abbreviations: ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker, CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization
[a]This table reports the average marginal effects of FHO on physicians' care quality for chronic kidney disease for various subgroup of physicians. For example, male physicians in FHO, relative to their counterparts in FHG, are less likely to provide serum creatinine testing by 2.05% in 2015.This table also reports patients' mean mortality risk score of under FHO—relative to FHG—for various subgroup of physicians.

Appendix A (for Chapter 5)

A3.1 Schematic of Cohort Creation



Abbreviations: eGFR: estimated glomerular filtration rate; CKD: chronic kidney disease, IKN: ICES Key number; ACR: albumin-to-creatinine ratio; ACEI: angiotensin-converting enzyme inhibitors; ARB: angiotensin II receptor blockers

A3.2 Data sources for variables

We used data from the following nine ICES databases: Client Agency Program Enrollment Registry, Canadian Institute for Health Information-Hospital Discharge Abstract Database, National Ambulatory Care Reporting System (NACRS), Ontario Laboratories Information System, Canadian Organ Replacement Registry (CORR), Ontario Health Insurance Plan Database, Registered Persons Database, and Ontario Drug Benefit Claims; these databases were linked using a unique patient identifier known as the ICES key number (IKN).

CAPE is a registry which constitutes centralized information on individuals registered with doctors practicing in any of the patient enrolment models including Family Health Groups and Family Health Organizations (Glazier et al., 2012); this registry was used to identify patients in FHGs and FHOs. CAPE was also used to identify physicians' information such as their date of birth, sex, and primary care model (i.e., FHG or FHO) (Lofters et al., 2013; Ontario Ministry of Health and Long Term Care, 2017). Information on persons undergoing organ transplant in Canada can be obtained through CORR (Canadian Institute for Health Information, 2020b; Nash et al., 2017); hence we used this database to exclude persons with end-stage kidney disease as per exclusion criteria in Section A3.1. Inpatient information (including diagnosis, length of stay, and patient's sex) as from 1988 is obtainable through CIHI-DAD (or simply DAD) (Canadian Institute for Health Information, 2020c). Persons with chronic kidney disease were identified using OLIS, a centralized information system containing data

pertaining to laboratory test orders (such as patient's serum creatinine level, white blood count, etc.) from laboratories all across Ontario (eHealth Ontario, 2018b; ICES, 2016). We used OLIS to identify some of the process indicators for CKD care Information pertaining to outpatient care in facilities like kidney dialysis clinics and emergency departments are obtainable through NACRS (Canadian Institute for Health Information, 2020d; Gandhi, 2016; Glazier et al., 2012). Both NACRS and DAD were used for identifying CKD process indicators (more details in Section A3.3). Information on claims for prescription drugs financially covered by the Ontario Drug Benefit Program are available in ODB (Gandhi, 2016), and this database was used for the identification of prescription process indicators; ODB has coverage for individuals aged 65 years and above and special populations (e.g., persons on government-funded disability support). Information on medical services insured by Ontario's single-payer healthcare insurance plan are available in the OHIP database (Gandhi, 2016; Glazier et al., 2012). Demographic information of Ontarians including sex, date of birth and death, and postal code are recorded in RPDB (Gandhi, 2016; Glazier et al., 2012); we used RPDB to obtain patients' demographic information. Computation of mortality risk score was based on information from NACRS, DAD and OHIP.

A3.3 Definition of outcome variables

Table A3.1 Definition of outcome for each quality indicator

Quality indicator	Eligibility criteria for patients	Outcome definition
Receipt of at least one serum creatinine testing	For each year: -persons who are confirmed to have CKD before start of fiscal year[a] -only identify patients who are alive within that year	For each year: -receipt of at least one serum creatinine testing, and • exclude if date of serum creatinine tests = date of a hospital (or an emergency department) admission, • exclude patients whose date of serum creatinine test = date of a hospital (or an emergency department) discharge, • exclude patients whose date of serum creatinine test falls between a hospital (or ED) admission and a hospital (or ED) discharge
	Data sources: OLIS, RPDB, CORR, DAD, NACRS	
Receipt of at least one urine ACR measurement	For each year: -persons who are confirmed to have CKD before start of fiscal year[a] -only identify patients who are alive within that year	For each year: -receipt of at least one ACR tests, and • exclude patients whose date of ACR tests = date of a hospital (or an emergency department) admission, • exclude patients whose date of serum creatinine test = date of a

		hospital (or an emergency department) discharge, • exclude patients whose date of serum creatinine test falls between a hospital (or ED) admission and a hospital (or ED) discharge
	Date sources: OLIS, RPDB, CORR, DAD, NACRS	
Prescription of ACEI or ARBs	For each year: -persons who are confirmed to have CKD before start of fiscal year[a] -only identify patients who are alive within that year -only include patients who are aged 65 years or older	For each year: -identify patients who received a prescription for ACEI or ARB
	Data sources: ODB, RPDB, CORR	
Prescription of statins	For each year: -persons who are confirmed to have CKD before start of fiscal year[a] -only include patients who are alive within that year -only include patients who are aged 65 years or older	For each year: -identify patients who received a prescription for statin
	Data sources: ODB, RPDB, CORR	
Mortality risk	Patients' mortality risk score as per the algorithm by Austin et al. (2011)	
	Data sources: RPDB, OHIP, DAD, NACRS	

[a]Refer to Section A3.1 for schematic of cohort creation for more explanation on CKD cohort

Appendix B (for Chapter 5)

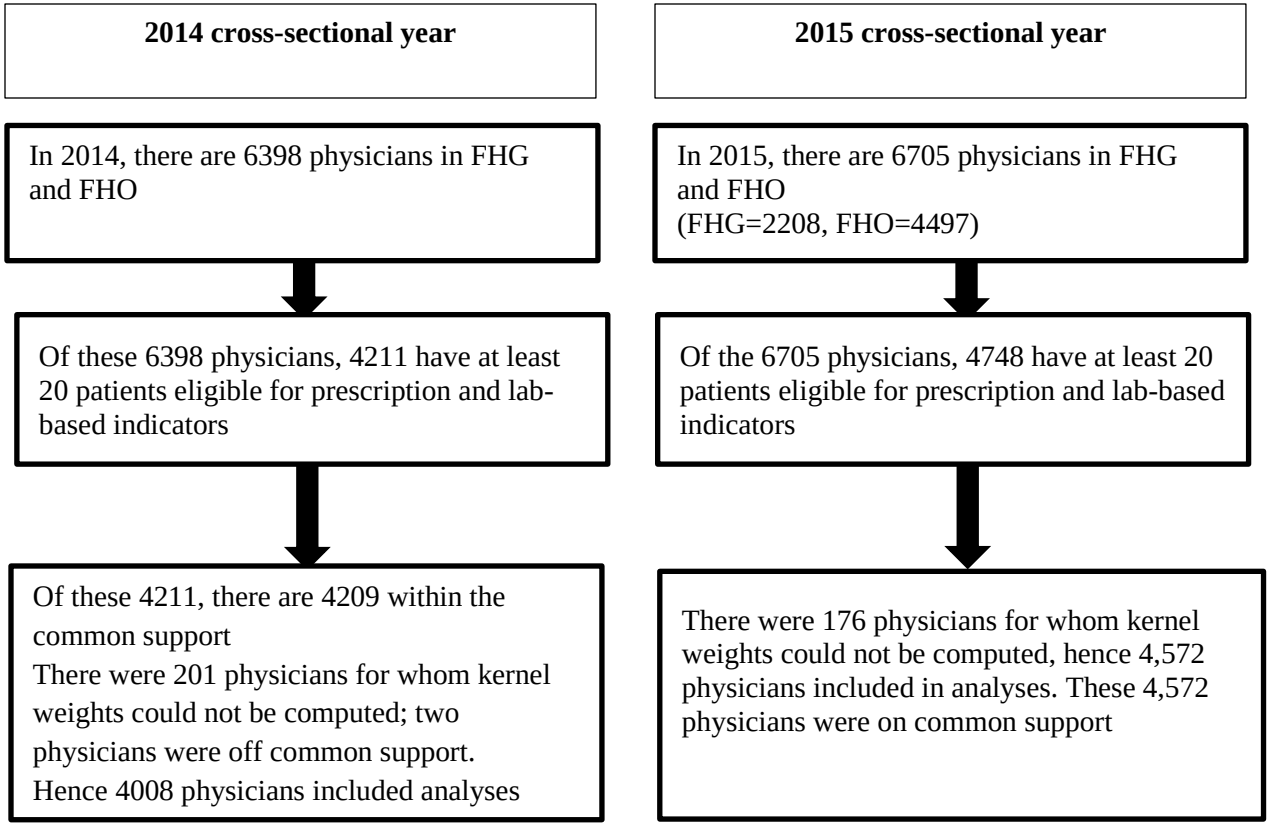


Figure 1 Simple schematic for derivation of final sample size

Table 1. Results from Covariate Balancing Propensity Score weighting and Entropy Balancing weighting for 2014

Covariate	Means and standardized bias after CBPS weighting			Means and standardized bias after EB weighting		
	FHO	**FHG**	**Bias**	**FHO**	**FHG**	**Bias**
Physicians' characteristics						
Age (years)	53.923	53.923	0	53.923	53.923	0
Female (proportion)	0.35888	0.35887	0	0.35888	0.35871	0
Group size	18.043	18.043	0	18.043	18.043	0
Number of enrolled patients	1513.4	1513.4	0	1513.4	1513.4	0
IMG (proportion)	0.15327	0.15326	0	0.15327	0.15314	0
Patients' characteristics						
Age (years)	77.078	77.078	0	77.078	77.077	0
Female (proportion)	0.58417	0.58417	0	0.58417	0.58417	0
Rural area (proportion)	0.14039	0.1404	0	0.14039	0.14039	0
High income quintile (proportion)	0.3879	0.3879	0	0.3879	0.38789	0

Abbreviations: FHG: Family Health Group, FHO: Family Health Organization, IMG: International Medical Graduate
FHO represents all physicians in the FHO model in 2014; FHG represents all physicians in the FHG model in 2014

Table 2. Results from Covariate Balancing Propensity Score weighting and Entropy Balancing weighting for 2015

Covariate	Means and standardized bias after CBPS weighting			Means and standardized bias after EB weighting		
	FHO	**FHG**	**Bias**	**FHO**	**FHG**	**Bias**
Physicians' characteristics						
Age (years)	53.534	53.534	0	53.534	53.533	0
Female (proportion)	0.39147	0.39148	0	0.39147	0.39134	0
Group size	17.834	17.834	0	17.834	17.834	0
Number of enrolled patients	1462.9	1462.9	0	1462.9	1462.9	0
IMG (proportion)	0.16908	0.16909	0	0.16908	0.16896	0
Patients' characteristics						
Age (years)	76.938	76.938	0	76.938	76.937	0
Female (proportion)	0.58373	0.58373	0	0.58373	0.58372	0
Rural area (proportion)	0.13669	0.1367	0	0.13669	0.13669	0
High income quintile (proportion)	0.38514	0.38514	0	0.38514	0.38514	0

Abbreviations: FHG: Family Health Group, FHO: Family Health Organization, IMG: International Medical Graduate
FHO represents all physicians in the FHO model in 2015; FHG represents all physicians in the FHG model in 2015

Table 3. Effect of FHO on serum creatinine testing at least once a year, across various physician subgroups for 2014

Subgroup	Unweighted	Kernel	CBPS	EB
Male	-0.0143***	-0.0189***	-0.0207***	-0.0118*
	(-0.0225 - -0.00612)	(-0.0290 - -0.00879)	(-0.0314 - -0.00994)	(-0.0257 - 0.00218)
Female	-0.0235***	-0.0208***	-0.0236***	-0.0189**
	(-0.0357 - -0.0114)	(-0.0347 - -0.00702)	(-0.0362 - -0.0109)	(-0.0337 - -0.00408)
Younger	-0.0199***	-0.0284***	-0.0304***	-0.0200**
	(-0.0296 - -0.0103)	(-0.0383 - -0.0184)	(-0.0409 - -0.0200)	(-0.0353 - -0.00470)
Older	-0.0142***	-0.0119*	-0.0138**	-0.00887
	(-0.0234 - -0.00512)	(-0.0239 - 6.35e-05)	(-0.0263 - -0.00130)	(-0.0229 - 0.00514)

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses

This table reports the average marginal effects of FHO on physicians' care quality for chronic kidney disease—as per serum creatinine testing—for various subgroup of physicians.

Abbreviations: CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization

Table 4. Effect of FHO on urine albumin-to-creatinine ratio testing at least once a year, across various physician subgroups for 2014

Subgroup	Unweighted	Kernel	CBPS	EB
Male	-0.0706***	-0.0715***	-0.0732***	-0.0657***
	(-0.0881 - -0.0531)	(-0.0910 - -0.0520)	(-0.0937 - -0.0527)	(-0.0914 - -0.0400)
Female	-0.0726***	-0.0718***	-0.0760***	-0.0683***
	(-0.0979 - -0.0473)	(-0.1000 - -0.0437)	(-0.104 - -0.0479)	(-0.103 - -0.0338)
Younger	-0.0946***	-0.0989***	-0.101***	-0.0879***
	(-0.116 - -0.0732)	(-0.123 - -0.0746)	(-0.128 - -0.0753)	(-0.120 - -0.0561)
Older	-0.0536***	-0.0472***	-0.0467***	-0.0471***
	(-0.0728 - -0.0344)	(-0.0684 - -0.0261)	(-0.0674 - -0.0261)	(-0.0750 - -0.0191)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses
This table reports the average marginal effects of FHO on physicians' care quality for chronic kidney disease—as per urine albumin-to-creatinine ratio testing—for various subgroup of physicians
Abbreviations: CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization

Table 5. Effect of FHO on ACEI/ARB prescription at least once a year, across various physician subgroups for 2014

Subgroup	Unweighted	Kernel	CBPS	EB
Male	-0.00156	-0.00341	-0.00215	0.00125
	(-0.0105 - 0.00736)	(-0.0133 - 0.00644)	(-0.0119 - 0.00763)	(-0.0121 - 0.0146)
Female	0.00622	0.0102	0.0118*	-0.00034
	(-0.00737 - 0.0198)	(-0.00418 - 0.0245)	(-0.00218 - 0.0258)	(-0.0161 - 0.0155)
Younger	-0.00508	-0.00369	-0.00063	-0.00538
	(-0.0164 - 0.00621)	(-0.0158 - 0.00840)	(-0.0123 - 0.0110)	(-0.0232 - 0.0124)
Older	0.00578	0.0056	0.00564	0.00779
	(-0.00405 - 0.0156)	(-0.00521 - 0.0164)	(-0.00536 - 0.0166)	(-0.00443 - 0.0200)

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses

This table reports the average marginal effects of FHO on physicians' care quality for chronic kidney disease—as per ACEI/ARB prescription—for various subgroup of physicians

Abbreviations: ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker; CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization

Table 6. Effect of FHO on statin prescription at least once a year, across various physician subgroups for 2014

Subgroup	Unweighted	Kernel	CBPS	EB
Male	-0.00332	-0.00192	-0.00436	-0.00152
	(-0.0133 - 0.00671)	(-0.0133 - 0.00946)	(-0.0158 - 0.00705)	(-0.0161 - 0.0131)
Female	-0.00927	-0.0113	-0.0132	-0.0170*
	(-0.0256 - 0.00707)	(-0.0287 - 0.00616)	(-0.0309 - 0.00451)	(-0.0351 - 0.00113)
Younger	-0.00731	-0.00942	-0.0119*	-0.0177**
	(-0.0200 - 0.00533)	(-0.0231 - 0.00431)	(-0.0258 - 0.00190)	(-0.0341 - -0.00131)
Older	-0.00149	-0.00091	-0.0022	0.00463
	(-0.0133 - 0.0103)	(-0.0140 - 0.0122)	(-0.0154 - 0.0110)	(-0.0118 - 0.0210)

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses

This table reports the average marginal effects of FHO on physicians' care quality for chronic kidney disease—as per statin prescription—for various subgroup of physicians

Abbreviations: CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization

Table 7. Effect of FHO on patients' mortality risk score across various physician subgroups for 2014

Subgroup	Unweighted	Kernel	CBPS	EB
Male	-0.931***	-1.082***	-1.017***	-0.988***
	(-1.144 - -0.717)	(-1.319 - -0.845)	(-1.250 - -0.784)	(-1.249 - -0.726)
Female	-0.676***	-0.653***	-0.605***	-0.330*
	(-1.006 - -0.346)	(-1.024 - -0.282)	(-0.983 - -0.227)	(-0.704 - 0.0436)
Younger	-0.976***	-0.971***	-0.871***	-0.765***
	(-1.261 - -0.691)	(-1.285 - -0.658)	(-1.191 - -0.551)	(-1.097 - -0.433)
Older	-0.675***	-0.797***	-0.776***	-0.683***
	(-0.905 - -0.445)	(-1.047 - -0.547)	(-1.019 - -0.533)	(-0.955 - -0.410)

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses

This table reports patients' mean mortality risk score of under FHO—relative to FHG—for various subgroup of physicians

Abbreviations: CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization

Table 8. Effect of FHO on serum creatinine testing at least once a year, across various physician subgroups for 2015

Subgroup	Unweighted	Kernel	CBPS	EB
Male	-0.0147***	-0.0205***	-0.0213***	-0.0133*
	(-0.0228 - -0.00669)	(-0.0305 - -0.0104)	(-0.0316 - -0.0110)	(-0.0274 - 0.000845)
Female	-0.0298***	-0.0318***	-0.0362***	-0.0352***
	(-0.0410 - -0.0187)	(-0.0433 - -0.0203)	(-0.0480 - -0.0244)	(-0.0470 - -0.0234)
Younger	-0.0257***	-0.0301***	-0.0340***	-0.0293***
	(-0.0356 - -0.0158)	(-0.0407 - -0.0195)	(-0.0448 - -0.0232)	(-0.0432 - -0.0154)
Older	-0.0138***	-0.0169***	-0.0174***	-0.0137**
	(-0.0222 - -0.00531)	(-0.0279 - -0.00596)	(-0.0290 - -0.00578)	(-0.0265 - -0.000957)

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses

This table reports the average marginal effects of FHO on physicians' care quality for chronic kidney disease—as per serum creatinine testing—for various subgroup of physicians

Abbreviations: CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization

Table 9. Effect of FHO on urine albumin-to-creatinine ratio testing at least once a year, across various physician subgroups for 2015

Subgroup	Unweighted	Kernel	CBPS	EB
Male	-0.0681***	-0.0616***	-0.0636***	-0.0519***
	(-0.0848 - -0.0513)	(-0.0801 - -0.0431)	(-0.0815 - -0.0457)	(-0.0762 - -0.0276)
Female	-0.0800***	-0.0754***	-0.0748***	-0.0705***
	(-0.103 - -0.0568)	(-0.101 - -0.0496)	(-0.0996 - -0.0500)	(-0.104 - -0.0365)
Younger	-0.0906***	-0.0861***	-0.0832***	-0.0889***
	(-0.111 - -0.0704)	(-0.109 - -0.0636)	(-0.105 - -0.0617)	(-0.118 - -0.0599)
Older	-0.0552***	-0.0442***	-0.0473***	-0.0286**
	(-0.0734 - -0.0370)	(-0.0636 - -0.0249)	(-0.0662 - -0.0285)	(-0.0547 - -0.00256)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses
This table reports the average marginal effects of FHO on physicians' care quality for chronic kidney disease—as per urine albumin-to-creatinine ratio testing—for various subgroup of physicians
Abbreviations: CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization

Table 10. Effect of FHO on ACEI/ARB prescription at least once a year, across various physician subgroups for 2015

Subgroup	Unweighted	Kernel	CBPS	EB
Male	0.00429	0.00674	0.00801	0.00246
	(-0.00425 - 0.0128)	(-0.00277 - 0.0163)	(-0.00166 - 0.0177)	(-0.00984 - 0.0148)
Female	0.0144**	0.0197***	0.0206***	0.0114
	(0.00184 - 0.0270)	(0.00566 - 0.0337)	(0.00703 - 0.0341)	(-0.00502 - 0.0278)
Younger	0.00339	0.00884	0.0106*	0.00453
	(-0.00735 - 0.0141)	(-0.00272 - 0.0204)	(-0.000737 - 0.0220)	(-0.0109 - 0.0200)
Older	0.0112**	0.0134**	0.0129**	0.00748
	(0.00191 - 0.0205)	(0.00292 - 0.0239)	(0.00211 - 0.0236)	(-0.00457 - 0.0195)

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses

This table reports the average marginal effects of FHO on physicians' care quality for chronic kidney disease—as per ACEI/ARB prescription—for various subgroup of physicians

Abbreviations: CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker

Table 11. Effect of FHO on statin prescription at least once a year, across various physician subgroups for 2015

Subgroup	Unweighted	Kernel	CBPS	EB
Male	-0.00495	-0.00211	-0.00451	-0.00394
	(-0.0146 - 0.00470)	(-0.0136 - 0.00939)	(-0.0157 - 0.00670)	(-0.0186 - 0.0107)
Female	-0.00995	-0.00976	-0.0105	-0.0209**
	(-0.0237 - 0.00375)	(-0.0254 - 0.00592)	(-0.0257 - 0.00474)	(-0.0382 - -0.00360)
Younger	-0.0084	-0.0109	-0.0108	-0.0219**
	(-0.0203 - 0.00354)	(-0.0243 - 0.00245)	(-0.0238 - 0.00227)	(-0.0387 - -0.00520)
Older	-0.00425	0.00193	-0.00115	0.00238
	(-0.0148 - 0.00627)	(-0.0106 - 0.0145)	(-0.0137 - 0.0114)	(-0.0125 - 0.0173)

Notes:

*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses

This table reports the average marginal effects of FHO on physicians' care quality for chronic kidney disease—as per statin prescription—for various subgroup of physicians

Abbreviations: CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker

Table 12. Effect of FHO on patients' mortality risk score across various physician subgroups for 2015

Subgroup	Unweighted	Kernel	CBPS	EB
Male	-0.795***	-0.920***	-0.858***	-0.901***
	(-0.997 - -0.593)	(-1.161 - -0.679)	(-1.101 - -0.615)	(-1.207 - -0.595)
Female	-0.653***	-0.684***	-0.689***	-0.663***
	(-0.949 - -0.358)	(-1.034 - -0.334)	(-1.024 - -0.354)	(-1.083 - -0.244)
Younger	-0.738***	-0.774***	-0.728***	-0.894***
	(-0.999 - -0.477)	(-1.074 - -0.475)	(-1.018 - -0.438)	(-1.266 - -0.522)
Older	-0.708***	-0.821***	-0.795***	-0.719***
	(-0.926 - -0.490)	(-1.084 - -0.558)	(-1.066 - -0.524)	(-1.038 - -0.399)

Notes:
*** p<0.01; ** p<0.05; * p<0.1, all regressions include all the covariates defined in X_i for the respective year; 95% confidence interval in parentheses
This table reports patients' mean mortality risk score of under FHO—relative to FHG—for various subgroup of physicians
Abbreviations: CBPS: covariate balancing propensity score, EB: entropy balancing, FHO: Family Health Organization; ACEI: angiotensin converting enzyme inhibitor, ARB: angiotensin II receptor blocker

Chapter 6

6 Conclusions

6.1 Summary of findings

The literature suggests that physicians' mode of remuneration can be associated with their behaviour; through three studies, we made some extension to this literature. While there exists a substantial body of literature for the impact of pay-for-performance incentives on physicians' performance, far fewer studies have specifically examined the effect of physicians' mode of remuneration on the delivery of care quality. Our studies on the effect of physicians' switch from blended FFS to blended capitation on several aspects of care quality—as per the management of major chronic conditions—are novel contributions to the existing literature.

Family physicians in Ontario's Family Health Group and Family Health Organization models are eligible for the same P4P incentives for diabetes and congestive heart failure management; the main difference between the two models is that the base remuneration is FFS in a FHG and capitation in a FHO. Over time, many family physicians in Ontario switched from the FHG to FHO model (Sweetman & Buckley, 2014), we referred to these physicians as 'switchers'; 'non-switchers' corresponded to those who remained in the FHG model. The vast majority the province's primary care physicians currently practice in either of these two (Office of the Auditor General of Ontario, 2018).

In our first study, we investigated the impact of this switch on family physicians' quality of care for diabetes management. The effect of switching on follow-up care and health outcomes for persons with congestive heart failure were examined in our second

study. In these two studies, we employed a two-stage estimation approach of propensity score-based weighting methods (that balances observable covariates at baseline) and fixed-effects regression (that accounts for physician-specific time-invariant unobservable factors). Ontario-wide data with an observation period spanning a decade was used for the first two studies. For our third study, we compared family physicians' quality of care for the management of chronic kidney disease. Given some data limitations, this study did not use fixed-effects estimation approach like the first two studies. Our last study conducted cross-sectional analyses on two recent time periods: the 2014 and 2015 fiscal years. As mentioned earlier, binary analyses were conducted for the care processes investigated in the first and third studies (i.e., 'provision' vs. 'non-provision' of care (e.g., $HbA1_c$ testing)); we acknowledged this limitation in our definition of care quality as per process measures.

Our findings reveal that physicians under blended capitation provide better quality of diabetes management than their counterparts under blended FFS; family physicians' switch from blended FFS to blended capitation moderately increased physicians' testing for $HbA1_c$, lipid profile, and nephropathy screening; switchers were more likely to prescribe statins than non-switchers. While the risk of avoidable hospitalization due to diabetes mellitus did not differ between patients of switchers' and non-switchers', patients under blended capitation had moderately lower mortality risk scores. Physicians in blended capitation and blended FFS were not different in terms of eye examination and prescription of ACEIs or ARB. Our two-stage estimation results showed that primary care physicians' switch from the FFS- to capitation-based payment scheme did not impact follow-up care for persons with CHF. The risk of avoidable hospitalization due to CHF was not different

between switchers' and non-switchers' patients; mortality risk scores did not differ as well. Our last study found that quality of CKD care received by patients under the FHG and FHO model differed; patients in blended capitation were less likely to receive testing for serum creatinine and albumin-to-creatinine ratio in the two observation periods; however, in 2015, patients in blended capitation were more likely to receive ACE/ARB prescription; for the two observation periods, patients under FHO had slightly lower mortality risk scores.

6.2 **Discussion**

Ontario's natural experiment permitted us to examine the impact of family physicians' switch from a blended FFS to blended capitation model on several dimensions of care for persons with diabetes mellitus, congestive heart failure, and chronic kidney disease. The observation period of our first two studies was the longest ever used to investigate the impact of family physicians' switch from FHG to FHO on outcomes compared to previous studies (Jaakkimainen et al., 2011; Kiran et al., 2014; Kralj & Kantarevic, 2013). By virtue of using a longer panel, we argue that our conclusions have high internal validity and hence relatively stronger than that of previous studies based on cross-sectional design or shorter follow-up periods. The benefit of using longer timeframes is evident throughout the literature; for example, when Campbell and colleagues (2007, 2009) investigated the impact of the QOF using an observation period of one vs. three years, the conclusions varied. The authors found greater improvement in care quality in the short term than in the longer term (Campbell et al., 2007, 2009).

Our measures of care were chiefly process measures. Compared to outcome measures, process indicators are more sensitive to differences in care quality that result from differential use of evidence-based interventions (Mant, 2001). For instance, if mortality is used to determine whether quality of care varies between two hospitals or jurisdictions, it would take longer time and larger sample size to detect minimum difference with 20% probability of a Type II error. However, with process measures, it would take less time and require smaller sample size to detect an effect (Kyeremanteng, 2015; Mant, 2001; Smith et al., 2008). Furthermore, compared to outcome measures, process indicators are better measures of quality as they are under a clinician's direct control (Mant, 2001; Shekelle et al., 2001) and process measures are amendable through direct action for quality improvement initiatives.

As mentioned earlier, the secondary sources of income in the FHG and FHO models are by and large similar (e.g., physicians in both models are entitled to the same financial incentives, such as the Diabetes Management Incentive); base payment is the main difference between the FHG (i.e., FFS) and FHO (i.e., capitation). Differences in outcome observed between these two payment models can be driven by factors other than pay-for-performance incentives. For example, physicians in FHG and FHO could systematically differ in their level of involvement with specialists when providing care to patients—and such differences can influence care processes and health outcomes. Moreover, various studies support that primary care with specialist involvement—compared to a lack thereof—can be associated with an improvement in physicians' care delivery and patients' health outcomes (Datto et al., 2003; Katon et al., 2002). For instance, a randomized study

by Datto et al. (2003) found that patients with depression were more likely to receive guideline-adherent care when their management regimen involved both primary and specialist care—relative to when they received care solely from primary care clinicians. Furthermore, this specialist involvement—vs. a lack thereof—was associated with improvement in depression symptoms (Datto et al., 2003). Similarly, factors other than P4P schemes can also influence transitional care (such as post-discharge follow up). Using 2016 to 2019 data from Southwestern Ontario, Lien et al. (2020) investigated factors associated with family physicians' follow up of patients within 30 days after being discharged from an emergency department (ED) visit; patients were rostered to physicians in Family Health Networks. The authors' retrospective chart review found that patients were more likely to be followed up when ED physicians provided discharge instructions—compared to if such were not provided (Lien et al., 2020). Hence system-level factors (e.g., hospital's administrative system) can influence primary care delivery to patients—and, consequently, health outcomes.

6.3 **Directions for Future Research**

Our results provide some evidence that care quality varies under blended capitation and blended FFS linked to financial incentives. Future work could investigate the effect of primary care reform on healthcare costs, especially since diabetes mellitus, CHF and CKD are costly to the healthcare systems. At a population level, the improved health of patients due to better provision of care may lead to reduced healthcare expenditures. As with quality, identifying whether healthcare costs vary under different payment models would be relevant to policymakers.

Our findings from Ontario's natural experiment highlight the importance of studies that aim to determine whether remuneration models help improve outcomes in the management of chronic conditions. Future studies investigating the impact of physician payment on the quality of primary care for conditions, such as chronic respiratory diseases, could have important policy implications for directing healthcare resources in the management of such costly diseases. Extensions of our work can also include examining whether long-term outcome of care measures, such as 5-year mortality risk, varies under different payment schemes. And relatedly, whether patients under the care of FHO and FHG physicians vary in quality of life, an important endpoint in medicine and health services research (Haraldstad et al., 2019).

7 Supplementary Material for the Introduction Chapter: Pathophysiology of diabetes mellitus, chronic kidney disease and congestive heart failure

Herein, brief, and relevant, information on the pathophysiology of diabetes mellitus, chronic kidney disease and congestive heart failure are provided.

7.1 Diabetes mellitus

Diabetes mellitus (or simply ‘diabetes’) is a very common chronic disease that is characterized by hyperglycemia, which is the clinical term for a condition where an individual’s blood glucose level is pathologically high. According to Diabetes Canada, an individual can be diagnosed with diabetes if their level of $HbA1_c$ is least 6.5%. This disease is generally asymptomatic in its early stages and, therefore, individuals are often undiagnosed when they are in the early stage of diabetes. Furthermore, the hyperglycemia-induced damage to various body tissues occurs during this symptomless phase—albeit at a level not severe enough to be noticed (Naslafkih & Sestier, 2003).

This chronic condition is of three types, namely, type 1, type 2 and gestational. In type 1 diabetes mellitus, hyperglycemia occurs because the body produces no (or very little) insulin, and this form of the disease usually occurs in childhood or adolescence; the age distribution for developing type 1 is typically known to be bimodal, wherein the first and second peaks are between 4 to 6 years and 10 to 14 years, respectively (Al-Fifi, 2010). In type 2 of this disease, the pathologically elevated blood glucose level is a consequence of the body either (1) not producing enough insulin, or (2) not being able to utilize the insulin it produces (Diabetes Canada, 2015). Type 2 diabetes is typically known to develop around middle age as individuals are likely to be diagnosed with the

disease at age 45 years or above (National Institute of Diabetes and Digestive and Kidney Diseases, 2017). A transient form of diabetes that occurs in a woman who is pregnant and has no history of the disease is referred to as gestational diabetes; this form of the disease usually commences in late second trimester, and immediately disappears after delivery (Alfadhli, 2015). While type 1 and type 2 diabetes have traditionally been known to occur within a specific age range, it is important to note that such age conventions have recently been inexact because pre-teen children are now being diagnosed with type 2 diabetes and some individuals develop the type 1 form of the metabolic disorder in their adulthood (American Diabetes Association, 2019). Notwithstanding the dissolution of the age conventions in recent times, age is still a risk factor for developing type 2 diabetes mellitus (Mayo Clinic, 2019). Furthermore, type 2 is the most common form of diabetes as it accounts for 90% to 95% of all cases (Wu et al., 2014).

7.2 **Congestive heart failure**

The human heart is a hollow organ that is divided into four chambers. The pumping of blood by the heart can be said to resemble the forcing of fluid from a bulb syringe when it is compressed. The two top chambers are the right atrium and left atrium; the two bottom chambers are the right ventricle and left ventricle. Because the ventricles do the real work of pumping the blood, the walls of the ventricles are thicker than the walls of the atria. The right atrium and right ventricle are sometimes referred to as the right heart; likewise, the left atrium and left ventricle are sometimes referred to as the left heart (Phibbs, 2007).

Blood completes its course when it travels from the heart and back to the heart. Blood enters the right heart through the superior vena cava and inferior vena cava; it flows from the right atrium into the right ventricles. The right ventricle pumps blood to the lungs through the pulmonary artery, which carries deoxygenated blood to the lungs. Gaseous exchange occurs in the lungs, where deoxygenated blood becomes oxygenated; the fresh blood is delivered to the left atrium through the pulmonary veins. Oxygenated blood flows from the left atrium to the left ventricles. Blood is pumped from the left ventricles, which pumps blood to the rest of the body. When any of the heart chambers contracts to pump blood, the contraction is called a systole; diastole occurs when any of the chambers relaxes to be filled with blood. A reliable measure of ventricular function is the ejection fraction, which is defined as the percentage of blood in the ventricles pumped out of the heart in each heart beat (Phibbs, 2007). The following equation is a simple way of computing ejection fraction:

$$100\% \text{ x } \left(\frac{\text{Volume at the end of diastole} - \text{Volume at the end of systole}}{\text{Volume at the end of diastole}}\right)$$

Congestive heart failure is a chronic progressive condition where the pumping ability of the heart is pathologically diminished; CHF is syndromic because the decreased ability is polyetiological. The reduced contractibility ability of the heart consequently leads to fluid build-up due to pulmonary and/or systemic congestion. The ejection fraction, which is a measure of the heart's pumping ability, is used to distinguish heart failure with reduced ejection fraction and heart failure with preserved ejection fraction—

where EF is at most and at least 40%, respectively. Though the signs, symptoms, and risk profiles are somewhat different for the two, both fall under the term congestive heart failure (Borlaug, 2013; Katz, 2011; Phibbs, 2007; Ponikowski et al., 2016; van Heerebeek & Paulus, 2016).

7.3 **Chronic kidney disease**

Like congestive heart failure, chronic kidney disease is essentially a syndrome because it is polyetiological. A clinical definition for chronic kidney disease is the persistence of abnormal kidney function for at least three months, where an individual's kidney function is quantified by their estimated glomerular filtration rate. The estimate of an individual's glomerular filtration rate is a measure of the filtering capacity of their kidney; in general, the higher an individual's estimated glomerular filtration rate, the better functioning are their kidneys. Chronic kidney disease is categorized into five stages where higher stages correspond to worsening renal function (i.e., lower eGFR values). As shown in the table below, the range of an individual's eGFR value determines the stage of their syndrome. The eGFR values in Stages 1 and 2 are above 90, and between 60 and 90 mL/min/1.73m^2, respectively; in addition to the low eGFR values, the presence of structural abnormality (e.g., overt proteinuria) is essential for a diagnosis of these two stages. Stages 3 to 5 are defined by the occurrence of an estimated glomerular filtration rate of less than 60mL/min/1.73m^2; furthermore, the presence of a structural abnormality is not necessary for a diagnosis of these three stages (Molony & Craig, 2009). Stage 5 includes end-stage renal disease, which is also known as kidney failure. Progression to ESRD can be delayed with proper management of the syndrome.

Stages of CKD according to severity

Stage	eGFR value (mL/min/1.73m^2)
1	>90 (with structural abnormalities)
2	60-90 (with structural abnormalities)
3	30-59
4	15-29
5	<15

Abbreviations: CKD=chronic kidney disease, eGFR=estimated glomerular filtration rate Information to make this table was taken from (Molony & Craig, 2009)

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Zhao, C., Wang, W., Xu, D., Li, H., Li, M., & Wang, F. (2014). Insulin and risk of diabetic retinopathy in patients with type 2 diabetes mellitus: Data from a meta-analysis of seven cohort studies. *Diagnostic Pathology*. https://doi.org/10.1186/1746-1596-9-130

Zhao, Q., & Percival, D. (2015). Entropy balancing is doubly robust. *Journal of Causal Inference*, *5*(1), 1–23. https://doi.org/10.1515/jci-2016-0010

9 Curriculum Vitae (CV)

Post-secondary qualifications

2015-present	Doctor of Philosophy (PhD) candidate in Epidemiology and Biostatistics, The University of Western Ontario, Canada
2011-2013	Master of Science (MSc) in Biochemistry, The University of Western Ontario, Canada
2012	Western Certificate in University Teaching and Learning, The University of Western Ontario, Canada
2008-2011	Bachelor of Medical Sciences (BMSc) (Western Scholars) *with Distinction,* in Clinical Biochemistry, The University of Western Ontario, Canada

Conferences/Presentations/Programs/Workshops

1.	(Conference) **Oral presentation** title: *Quality of Diabetes care in blended capitation and blended fee-for-service payment models* Conference name, location, and date: Canadian Association for Health Services and Policy Research (CAHSPR) Halifax Convention Center, Halifax Nova Scotia, Canada May 28th to 31st, 2019	2019
2.	(Conference) **Oral presentation** title: *Investigating quality of care received by patients with diabetes mellitus, congestive heart failure and chronic kidney disease in Ontario's family health groups and family health organizations* Conference name, location, and date: *Research Day: University at Buffalo, McMaster University, Western University* University of Buffalo, Buffalo, New York, United States of America May 25th, 2018	2018
3.	(Workshop)Workshop title: Personalizing Healthcare Under Uncertainty by Professor Charles Manski Location and Date: McMaster University, Hamilton, Ontario, Canada April 11th to April 12th, 2018	2018
4.	(Program) *2017 International Summer Program for Medical &*	2017

Healthcare Students: An Introduction to Global Health:
Location and Duration:
Schulich School of Medicine and Dentistry, Western University, London, Ontario, Canada.
Duration: July 3rd to July 14th, 2017

5. (Conference) **Oral presentation** title: *Cost-Effectiveness of treating Heart Failure patients with 'Angiotensin Neprilysin Inhibitors' compared to treatment with 'Angiotensin Converting Enzyme Inhibitors'.* — 2017
Conference name, location, and date:
London Health Research Day,
London, Ontario, Canada
March 28th, 2017

6. (Presentation) **Oral presentation** title: *Writing Academic Papers*. — 2014
Location and Date: Department of Orthopedic Surgery Grand Rounds at the King Faisal Specialist Hospital and Research Center (KFSHRC), Riyadh, Kingdom of Saudi Arabia
Date: May 22nd, 2014

7. (Conference) Poster presentation title: *Identifying genetic determinants of hypercholesterolemia in Familial Combined Hyperlipidemia*. — 2013
Conference name, location, and date:
Arteriosclerosis, Thrombosis and Vascular Biology (ATVB) 2013 Scientific Sessions
Location: Orlando, Florida, United States of America
May 1st to May 3rd, 2013

8. (Presentation) **Oral presentation** title: *Identifying genetic determinants of hypercholesterolemia in Familial Combined Hyperlipidemia*. — 2013
Location, and date:
Graduate Student Seminar, Department of Biochemistry, Western University, London, Ontario, Canada
February 23rd, 2013

Academic Honors, Awards and Achievements

1. Western Graduate Research (WGRS) Scholarship — 2015-2019

2. Canadian Institutes of Health Research (CIHR) Strategic Training Program in Vascular Research Fellowship ($24,000) 2011-2013
3. Western Graduate Research Scholarship (WGRS) 2011-2013
4. Inaugural 3-Minte Thesis (3MT) (Elevator Speech) Competition Finalist Award ($500) 2012
5. Dean's Honor List every academic year of Bachelor's program 2008-2011
6. International Student Bursary ($600) 2009
7. Inaugural 'Igal Holtzer and Family International Bursary'($1,500) 2008

Peer-reviewed publications

Bamimore, M. A., Devlin, R. A., Zaric, G. S., Garg, A. X., & Sarma, S. (2020). Quality of diabetes care in blended fee-for-service and blended capitation payment systems. *Canadian Journal of Diabetes*. https://doi.org/https://doi.org/10.1016/j.jcjd.2020.09.002

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Awan, Z., Choi, H. Y., Stitziel, N., Ruel, I., **Bamimore, M. A**., Husa, R., Gagnon, M.-H., Wang, R.-H. L., Peloso, G. M., Hegele, R. A., Seidah, N. G., Kathiresan, S., & Genest, J. (2013). APOE p.Leu167del mutation in familial hypercholesterolemia. ***Atherosclerosis***, *231*(2), 218–222. https://doi.org/10.1016/j.atherosclerosis.2013.09.007

Futema, M., Shah, S., Cooper, J. A., Li, K., Whittall, R. A., Sharifi, M., Goldberg, O., Drogari, E., Mollaki, V., Wiegman, A., Defesche, J., D'Agostino, M. N., D'Angelo, A., Rubba, P., Fortunato, G., Waluś-Miarka, M., Hegele, R. A., **Bamimore, M**.**A**., Durst, R., … Humphries, S. E. (2015). Refinement of variant selection for the LDL cholesterol genetic risk score in the diagnosis of the polygenic form of clinical familial hypercholesterolemia and replication in samples from 6 countries. ***Clinical Chemistry***, *61*(1), 231–238. https://doi.org/10.1373/clinchem.2014.231365