Physician Practice Style and Healthcare Costs: Evidence from Emergency Departments.*

Gautam Gowrisankaran, Ph.D.† Keith A. Joiner, M.D. MPH‡
Pierre Thomas Léger, Ph.D.§

May 7, 2015

Abstract

We examine the impact of emergency department (ED) treatment on future healthcare costs and outcomes. We postulate that ED physicians may affect patient outcomes through acumen in diagnosis and appropriate disposition conditional on diagnosis. We make use of a unique dataset and quasi-experiment on patients who seek treatment at an ED in Montreal, Canada. Physicians there rotate across shifts between simple cases and difficult cases, implying that the assignment of patients will be quasi-random across physicians in an ED. We examine how the initial assignment of ED physician affects the use of resources during the initial ED visit and patient outcomes. We consider two serious, potentially life-threatening conditions, that present frequently in the ED, angina and transient ischemic attacks. We find that ED-costs (measured by physician-related costs and the number of procedures) and outcomes (from ED revisits to hospitalizations) vary across ED physicians practicing in the same ED. We also find a strong correlation of physician "practice style" (defined by a physician's average contribution to physician-related costs during the ED visit) across the two illness categories. Similarly, we find that physician "skills" (measured in revisits to EDs and hospitalizations), or lack there of, correlate positively across patient populations. Our results also suggest that physicians associated with costly practice styles are not associated with better outcomes. Finally, we find that variations in diagnostic skills may be quantitatively more important than variations in disposition skills.

Keywords: physician quality, emergency departments, quasi-random variation.

JEL Classification: I12

---

*Preliminary and Incomplete. Do not quote without authors' permission. We thank seminar participants at McGill University and the University of Washington. Léger acknowledges funding from HEC Montréal. Gowisankaran acknowledges funding from the Center for Management Innovations in Healthcare at the University of Arizona. The authors thank Michelle Houde and José Pérez at the Déapartement de santé publique de Montréal for data assistance and extraction and Andreas Krull, M.D. and Marie-Josée Ouimet, M.D., who provided many of institutional details about Montreal Emergency Departments.

†University of Arizona, HEC Montréal and NBER, gowrisankaran@eller.arizona.edu
‡University of Arizona, kjoiner@medadmin.arizona.edu
§HEC Montréal, CIRANO and CIRPEE, ptl@hec.ca

1 Introduction

As healthcare costs have continued to grow in the U.S. and other OECD countries, researchers and policy makers are increasingly interested in optimizing the production of healthcare, with the goal of increasing healthcare quality and access to care at the lowest possible cost. As pointed out by (10), of most importance is to increase the value of care, defined as the ratio of outcomes over costs. Overall measures of population health, using metrics such as life expectancy, mortality and morbidity amenable to medical care, infant mortality, and more indicate the value of care delivered is often less than optimal (with several studies suggesting that the US falls far below that of most developed countries). Although Hospital report cards are now commonplace, and are readily assessed through sites such as HealthGrades, Leapfrog, and Hospital Compare, they may not fully reflect the efficiency or quality of care they provide.

One of the limitations of hospital report cards is that the metrics they use do not capture the role of the individual physician in the production function for healthcare. This is important as physicians, as medical decision makers, influence patient outcomes and hospital costs (and/or profits). In many medical settings, it is infeasible to evaluate the extent of variation in physician skill and practice style. This is particularly the case when medical decisions are made in the context of management of chronic disease. As such, they do not involve random paring between physician and patient; they may involve care by a collection of healthcare providers; and they cannot be adequately adjusted for underlying patient risk. One area of medicine where rankings have been prevalent is surgery.[1] Assessment of surgeons' skills is facilitated by the fact that surgery occurs at a known time point. Determining mortality and complication rates following surgical or invasive interventions is relatively straightforward, although patient risk adjustment is still needed to make comparisons across individual physicians. Although surgeon evaluations have been valuable, they cannot measure diagnostic skill or efficient resource utilization. Moreover, the large majority of current medical care consists of chronic disease management and not surgery. For chronic disease management, provider decisions include a nuanced evaluation of patient disease status, response to therapy (including complications from pharmaceuticals and other interventions), and coordination across multiple comorbidities, such as diabetes, hypertension, heart disease, and respiratory disease. Overall, disease management and diagnosis skills by physicians are important components of the

[1] These report cards have been widely studied in the economics and public health literation; see, e.g., (4).

healthcare production function, and yet we know little about how skills and practice styles vary across physicians.

In this paper, we present a new approach to measuring physician skills (i.e., ability to yield desired outcomes) and practice styles (i.e., the use of resources) that circumvents some of the above limitations: we focus on the role of the physician in the emergency department (ED). Our study identifies the role of the ED physician by making use of a unique environment and dataset in Quebec, Canada. With respect to the latter, it contains *all* medical records for patients who visit an ED in Montreal, Quebec, Canada, during a 9 month period in 2006. For each ED encounter, we observe patient demographics, the diagnoses and procedures performed at the initial visit, and an identifier for the ED physician who is examining the patient. Importantly, our data link the ED visit with all future encounters of the patient with the health system during the 90 days following the initial visit, including office visits, outpatient visits, revisits to EDs, and hospitalizations. The linked and panel nature of the data, along with care environment we discuss below, allow us to find evidence on missed diagnoses, wrong diagnoses, inappropriate management decisions, and overuse or underuse of resources, all of which would be difficult to examine in many care environments and commonly-used data sources such as hospital discharge data.

At most EDs in Montreal, ED physicians typically see patients with a full range of diagnoses and levels of complication. This procedure (discussed in detail below) leads to a quasi-random assignment of physicians to patients conditional on treatment at a particular ED. We exploit this quasi-random assignment to examine how the initial assignment of ED physician can contribute to the care received during the ED visit as well as the future pattern of health outcomes, healthcare consumption and healthcare costs.

We focus on emergency departments (EDs) both because of the quasi-random assignment of patients but also because it is of significant interest to understand the role of ED physician practice style. EDs are a primary point of entry to the healthcare system for many patients, particularly patients who are underserved by primary care physicians. Furthermore, EDs are often seen as a particularly wasteful entry point to healthcare access, with researchers focusing on the (presumably negative) consequences that increased insurance can have on increasing ED usage ((13)). Also, ED care is particularly complex given the acute and time-sensitive nature of the diagnostic and therapeutic process and thus EDs are among the most common sites for misdiagnosis ((11; 9; 8)). Finally, EDs are a prominent place of treatment for a number of widely-prevalent diseases such as ischemic heart disease and cerebrovascular disease, which may be difficult to diagnose and where appropriate and timely care is particularly important.

We propose a simple conceptual model to highlight the role of the ED physician. In our model, the central role of the ED physician is the appropriate diagnosis and disposition of the patient. There are four possibilities to describe the consequences of the initial interaction between patients and providers in the ED. The physician either makes the correct diagnosis or does not. At that point, the physician either institutes appropriate treatment or does not. At both of these steps, decisions are made about resource utilization (laboratory tests, imaging studies, medications, specialty consultation, hospitalization, and more). In the optimal circumstance, the correct diagnosis is made, the disposition is appropriate, and only necessary resources are used. In contrast, overuse or underuse of resources, coupled with and sometimes connected to an incorrect diagnosis or inappropriate disposition, can result in worse outcomes and additional costs. Our model contains both potential vertical and horizontal dimensions to physician skill. On the vertical dimension, a physician who is better at diagnosis and the implementation of the appropriate treatment will be the best. On the horizontal dimension, some physicians may over-treat, leading to too high costs, while others may under-treat, leading to potential adverse health outcomes and costly future care.

The main empirical focus of our paper is to estimate an empirical counterpart to this conceptual model. More specifically, we estimate the impact of treatment by different physicians on healthcare resource use during the initial ED visit. This allows us to examine the extent of variation in ED care patterns across ED physicians - what we call the physician's "practice style". We also estimate the impact of treatment by different physicians on a series of outcomes measured as the use (and costs) of future medical services (from the number of ED revisits to the number and costs of hospitalizations). This allows us to examine the extent of variation in future care patterns across ED physicians - what we call the physician's "skill(s)". Also, because we observe multiple dimensions of outcomes, including the presence and costs of inpatient hospitalizations, external hospital clinic visits, physician office visits, and ED revisits, we can estimate the extent to which physicians' practice styles vary and correlate across different dimensions/outcomes. Thus, we can uncover, for instance, whether physicians who spend more in the ED have more or less future costs of hospitalizations. It also allows us to uncover whether physicians who achieve good outcomes, do so across outcome measures and patient populations. Finally, by examining different subsets of the population within a particular illness category, we can identify whether and to what extent variations in outcomes are driven by variations in diagnostic skills or disposition skills.

Our analysis considers particular illnesses in separate sets of regressions: angina and transient ischemic attacks (TIAs). Angina is a precursor to myocardial infarction (heart attack). It reflects partial blockage of one or more coronary arteries, which supply blood to the heart muscle. The initial presentation of angina is typically associated with exertion, which puts an increased load on the heart muscle. The classic symptom of angina is chest pressure or pain ("an elephant is sitting on my chest") but other presentations such as jaw or shoulder pain, indigestion, or nausea also occur. Diagnosis is considered more difficult in women, in which up to 50% may present without chest pressure/pain ((McSweeney et al.)). Anginal symptoms usually resolve quickly, with cessation of exertion, because the relative limitation of blood flow to the heart is relieved. Confirmation of coronary artery disease depends upon prompt assessment using stress echocardiogram, coronary angiography, and/or nuclear medicine scans. The consequences of failing to consider or appropriately manage angina include myocardial infarction and sudden death.

TIAs are precursors to strokes, and are sometimes called mini-strokes. They result from a transient occlusion of a blood vessel in the brain. Unlike strokes, the signs and symptoms resolve quickly (usually within minutes), because the occlusion partially or fully resolves. The symptoms and signs, which vary enormously depending upon the part of the brain that is affected, include visual or speech changes, weakness, and numbness. Confirmation of a TIA depends upon additional tests, often done after discharge from the ED (carotid ultrasound, MRI or CT, echocardiogram). The consequences of failing to consider or appropriately manage a TIA include a nearly 5-fold increase in the incidence of stroke over the subsequent 90 days (12).

We consider these illness categories in our analysis for two reasons. First, these conditions require a relatively high level of diagnostic acumen from the physician's perspective and as such are likely to capture physician diagnostic differences. That is, they are illnesses that can easily be misdiagnosed, and, misdiagnosis can lead to dramatic consequences. Second, encouraging the appropriate disposition of patients conditional on diagnosis may also be challenging.

In order to understand the skill of diagnosis and disposition for angina patients, our main analysis considers all patients who are diagnosed during an ED visit with either angina or an illness that could be indicative of a misdiagnosed angina. We refer to this broader sample as angina+. Our unit of observation is one ED visit for one patient. Our main dependent variables include the patient's consumption of ED-physician related care during the initial ED visit as well as her consumption of medical services within 90 days following this visit. We separate consumption by type of facility, i.e., inpatient hospital, external clinic, physician office, and ED.

We believe that assignment to physicians is quasi-random within an ED due to the variation in shift assignments. However, there may still be small variations in assignment patterns. Accordingly, we evaluate the randomness of physician assignment within an ED by regressing patient age or gender on physician indicators within an ED. We then discard from our sample: (i) a very small number of outlying physicians within EDs that exhibited randomness in general, and (ii) EDs where the randomness is questioned in general. We test the robustness of our results to including these physicians (and EDs).

Our paper relates to several studies. A recent literature has considered the quasi-random assignment of hospitals (3; 2). Our study builds on this literature by examining in more depth the role of physicians as inputs into the healthcare production function. Other studies have evaluated misdiagnosis in the ED. These studies have typically restricted the sample to those subsequently identified to have an adverse event (e.g., complication, death, or hospitalization, sometimes associated with a medical liability suit) (5; 6; 1). In our case, our unique data allows us to track all patient interactions with the health system for 90 days after the initial ED visit. Thus in turn allows us to measure costs and a variety of other well-defined outcomes.

Our results suggest that physicians vary both in their "practice style" (i.e., average contribution to physician-related costs and number of procedures during the initial ED visit) and "skills"(i.e., average contribution to future use of healthcare such as ED revisits and hospitalization). We also find that physician "practice style" correlate across different illness categories. We do not find that those who are associated with a costly "practice style" yield better outcomes. We do find some positive correlation in "skills" across illness categories. Finally, we find that variations in diagnostic skills may be more important than variations in disposition skills.

[Insert some policy implications]

The remainder of the paper is organized as follows. Section 2 discusses the data and sample construction, Section 3 the model and estimation, and Section 4 the results. Finally, Section 5 concludes.

2 Data and Sample Construction

2.1 Data

Our study uses administrative data from *la Régie de l'assurance maladie du Québec* (RAMQ). The RAMQ data track all publicly-funded healthcare expenditures from the Canadian province of Quebec. More specifically, their database tracks all patients through time and across four types of care environments: EDs, private office, hospital external clinics, and inpatient-hospitals. The RAMQ provides first-dollar coverage to all enrollees, which includes almost all residents of Quebec.[2]

We study residents of the Island of Montreal with an initial ED visit during the period April 1, 2006 to December 31, 2006. The Island of Montreal includes the city of Montreal and some suburban municipalities. Henceforth, we refer to this area simply as Montreal. Our study area includes about 1.9 million residents. We observe the entire universe of patients residing and ED physicians working in Montreal. Access to the data is provided through Montreal's public health department (*le Département de santé publique de Montréal*). Although we use the residents of Montreal and their ED visits as the initial point of interest, we track *all* future healthcare consumption that occurs within the provincial boundaries (not just those in Montreal). That is, we observe each patient's subsequent consumption of care (across ED, office, hospital external clinic and inpatient care) as long as it is within the provincial boundaries and covered by the provincial health insurance program.

In Quebec (especially in ED settings during the study period), physicians across locations are paid on a fee-for-service basis. Our data include the billed physician cost (i.e., the total fee-for-service payment) for office, outpatient and ED visits. Inpatient care cost data is recorded differently where a proxy for the total cost of each inpatient stay is called *Niveau d'intensité relative des resources utilisées* (NIRRU). We observe the NIRRU and use it as our measure of hospital costs.[3]

One limitation of our data is that certain procedures are provided by hospitals and hence not directly billed to (associated with) the patient. These include complex imaging services, for instance.[4] Another limitation of our data is that the NIRRU is only a proxy for costs, rather than

[2]Although a privately funded sector exists in Quebec, it is very small and generally deals with non-covered services such as cosmetic surgery. This market remains insignificant as physicians who bill for any services privately must completely opt out of the public sector. An exception to the opt out rule is for imaging facilities.

[3]They do so because all non-physician related expenditures are covered by a "Global Budget" and thus not directly "billed" (associated with) to the patient.

[4]Additionally, imaging services are one market for which there exists a robust private market that will not be included in our data.

reflecting an actual payment.

For each patient/ED observation, our data include the patient's gender, age group (one of 18), 3-digit postal code as well as two measures of socio-economic status, as constructed for us by the public health department. The first of these measures, known as the *Indice de défavorisation matérielle* (material deprivation index), is a score of 1 to 5 which seeks to reflect the individual's material (i.e., economic) wellbeing. It reflects mostly variations in education, employment and income. The second known as the *Indice de d'éfavorisation social* (social deprivation index) seeks to reflect the individual's social and family support and wellbeing (also a score from 1 to 5). It reflects mostly variations in family structure and marital status. Both of these are constructed using a variety of sources and are based in large part on geographical (i.e., postal code) location.[5]

Our data contain all visits to a Montreal ED by a Montreal resident from April 1, 2006 through December 31, 2006. Each ED visit constitutes one observation. For each observation, the data also include the ED's unique identifier, the date of service, the physician's unique identifier, 4 digit ICD-9 diagnosis codes, procedure codes as well as an aggregate of the fees paid to physicians for services provided.[6] The data also link the initial ED visit with future visits for 90 days (which may be in the same or another ED or hospital, or in an office or external hospital clinic setting). Thus our data terminate on March 31, 2007. For each future visit, the data track all subsequent healthcare consumption, irrespective of location of consumption as long as it is within the provincial boundaries.

2.2 Sample Construction

From this universe of patients in Montreal, we exclude initial visits at 3 of the 20 EDs: two EDs serve less than 1000 patients per year, and one serves only children. We also exclude all ED physicians who are not present in all months studied as well as those who saw less than 200 cases during the 9-month period, as these physicians are less likely to have an equitable mix of cases. Our base sample includes 280 ED physicians who practice in 17 Emergency Departments. We observe 321,256 ED visits, each of which constitutes one observation. These visits are made by 199,442 distinct patients. 26% of the observations occur on the weekend.

Our analysis uses different sets of patients which are differentiated by the patient's diagnosis.

[5] These are known as the *Pampalon* indices.

[6] An ED visit can include consultation with several MDs as well as several diagnoses and acts. The data include unique MD identifiers for each diagnosis provided and act administered to the patient.

We define a patient as having suffered from an "angina+" type illness if they were diagnosed with angina itself or any related diagnoses which might be confounded with angina in an ED setting. Our goal is to choose a set that is sufficiently broad that all ED physicians would diagnose angina patients with one of these diagnoses. But, we also would like the set to be sufficiently narrow that dimensions of physician practice style are similar for all patients within these classes. Similarly, we define a patient as having suffered from a "TIA+" type illness if they were diagnosed with TIA or any related diagnoses which might be confounded with TIA in an ED setting.

Table 1: ICD-9 diagnosis codes for angina+, TIA+ and PE+

Angina+		TIA+	
Code	Description	Code	Description
413	Angina	435.9	Transient ischemic attack (TIA)
786	Chest pain	346	Migraine
789.6, 530.8	Gastro-esophageal reflux	345	Epilepsy
530.5	Esophageal dysmotility	780.2	Syncope
530.1	Esophagitis	432.1	Subdural hematoma
535.5	Gastritis	431	Intra-cerebral hemmorage
733.6	Costochondrititis	721.1	Compressive myelopathy
307.8	Psychosematic/psychogenic		
420	Pericarditis		
422	Myocarditis		
441	Acute aortic syndroms		
415.1	Pulmonary embolism		
486	Pneumonia		
489	Asthma		

Table 1 indicates the ICD-9 diagnosis codes that we use for each of these diagnoses. The diagnoses for angina+ include the most common non-cardiac causes for chest pain (786), including gastro-esophageal reflux (789.6, 530.8) , esophageal dysmotility (530.5), esophagitis (530.1) gastritis (535.5), costochondritis (733.6) and psycosomatic/psychogenic (307.8). This diagnosis for TIA+ includes the most common diagnoses which present with symptoms that overlap with TIA, including migraine (346), epilepsy (345) and syncope (780.2).

We now discuss assignment of patients to physicians in the ED. EDs in Montreal are staffed with 1 or more physicians. When 2 or more ED physicians are present, physicians are assigned to either the heavy cases (most often patients who arrive by ambulance) or the light cases (most often patients who enter through the front door) for the duration of their shift. If two physicians are assigned to the same shift type, then the allocation of patients to physicians is random in the sense that it is based uniquely on the triage order (which provides how much time the patient can wait before seeing a physician, or equivalently, who should be seen next). The triage order is done by a triage nurse. Finally, shift allocations (i.e., defined by its time and shift type) are done several months in advance in an equitable manner. As ED physicians are paid fee-for-service, where payments are invariant to any physician characteristics such as experience or tenure, most ED physicians are expected to work all shift types in similar proportions. Exceptions may nonetheless exist, especially among older physicians who may only work part-time or may be given only one type of patients (generally milder cases).

Although in a given shift the allocation of patients to physicians is conditionally deterministic, the quasi-random allocation of ED physicians to shift-types over time should lead all ED physicians to see very similar pools of patients over the long run. There is at least one exception to this assignment rule: in at least one ED, physicians were not assigned to heavy or mild cases but rather the allocation of patients was based uniquely on the triage order (and therefore, purely random in nature from the onset).[7]

Table 2: F-tests for randomness

	Gender	Age	Gender(restricted)	Age(restricted)
1	1.87*	21.34	1.50***	1.88*
2	2.17*	25.54	2.63*	10.25
3	2.18	85.36	2.28	3.69
4	1.43***	0.29***		
5	1.91	2.63	1.72*	2.38
6	4.66	6.02	5.04	3.83
7	12.70	2.34*	2.86*	2.18*
8	2.35	7.62	1.86**	2.41*
9	1.48***	1.14***		
10	6.39	3.12	2.25*	1.64**
11	6.81	19.38	7.78	3.67
12	1.80**	7.14	2.00*	5.34
13	2.34	41.54	1.81*	3.54
14	2.20*	9.51	2.39*	8.28
15	1.96*	4.50	1.80**	1.91*
16	4.54	6.73	2.30	4.41
17	1.03***	2.15	1.06***	1.73*

[7] There is no way, however, for us to identify which ED in our data does this as the unique ED identifiers are numerical in nature and anonymous because of privacy issues.

In order to test and deal with the possibility of non-random assignment of patients, no matter how small, we examine whether physicians within an ED treat patients with observably different patient characteristics. We use two observable patient characteristics here: age group and gender. Although patient pools could still differ in unobservable manners, we believe that this test is informative in identifying the non-random assignment of patients.[8] We proceed by regressing the patient characteristic of interest (gender or age group) on physician dummies, separately for each ED. We then test whether the MD dummy variables are statistically different from each other.[9]

We present results from F-tests for gender and age group in the first two columns of Table 2. Of the seventeen EDs, we find evidence that 9 do not assign their patients in a purely random matter with respect to their gender (EDs 3, 5, 6, 7, 8, 10, 11, 13, 16) while we find evidence against random assignment with respect to the patient age group for most hospitals (except for EDs 4, 7 and 9). In order to get a sense of whether differences uncovered above are meaningful, we examine the differences between gender-mean and age-mean patient assignments for an individual physician and the ED averages at the ED at which the physician works. These distributions (omitted for compactness) suggest that F-test results may be driven in part by a few atypical physicians. The presence of apparent outliers is consistent with the fact that certain older physicians (especially those without advanced emergency-medicine training) may be assigned, on average, less-severely ill patients (where illness severity may be correlated with a patient's gender and/or age).

In light of this possibility, we eliminate ED physicians whose mean-gender or mean-age are significantly different than their own ED peers (for all EDs except 4 and 9 as these EDs satisfied the random assignment condition with all physicians included). More specifically, we drop physicians whose mean-gender is more than 5% from the mean for their ED, and whose age group mean is more than 0.5 of an age group around the mean for their ED. Once we exclude these outliers we rerun the same two F-tests as before. Results from these F-tests, on the more "restrictive" sample of ED physicians, are presented in the last two columns of Table 2.

The F-test results from the restrictive samples suggest that a total of 8 EDs (i.e., EDs 1, 4, 7, 8, 9, 10, 15, 17) do not violate the randomness assumption on both observable patient characteristics. However, because a relatively large number of physicians were dropped between samples for ED

[8]Other patient characteristics, such as the probability of a certain diagnosis, may be assigned in different ways by different ED physicians and thus inappropriate for the purposes of testing random assignment of patients to ED physicians.

[9]In the above F-tests we control for the month and whether or not the care was provided on a weekend.

number 10 (i.e., a relatively large number of physicians in ED number 10 had patient populations that were atypical relative to their peers in terms of mean-age and mean-sex), we omit ED 10 altogether. In light of these results, our analysis henceforth uses seven EDs (i.e., 1, 4, 7,8, 9, 15 and 17).

Table 3 presents summary statistics on the initial sample of EDs and physicians, while Table 4 presents summary statistics on our estimation (i.e., restrictive) samples. In both of these tables, the data is split into four different samples: (i) the angina sample: the set of patients who were diagnosed with angina during the ED visit, (ii) the angina+ sample: the set of patients who were diagnosed with angina or any other of the confounding illnesses during the initial ED visit, (iii) the TIA sample: the set of patients who were diagnosed with TIA during the initial ED visit, and (iv) the TIA+ sample: the set of patients who were diagnosed with TIA or any other of the confounding illnesses during the initial ED visit.

Table 3: Summary statistics for all EDs and ED physicians in Montreal

Statistic	Angina	Angina+	TIA	TIA+
Number of EDs	17	17	17	17
Number of ED physicians	217	280	132	280
Mean age	14.73	12.26	15.43	12.86
Mean male	.50	.46	.44	.42
Number of distinct patients	1637	29430	393	7408
Spending during ED visit	66.30	56.28	60.12	69.03
Number of Procedures during ED visit	2.00	2.05	1.58	2.38
Number of ED revisits 0-5 days	.32	.30	.36	.37
Number of ED revisits 6-90 days	.83	.74	.47	.82
Number of office visits 0-30 days	.72	.63	.83	.61
Number of external clinic visits 0-30 days	1.06	.86	1.61	.99
Number of hospitalizations 0-5 days	.34	.40	.27	.23
Number of hospitalizations 6-90 days	.20	.16	.18	.18
Costs of hospitalization 0-5 days ($)	5068.41	2662.93	3192.13	3786.46
Costs of hospitalizations 6-90 days ($)	2806.74	2086.77	2026.87	2261.83

Note: patient statistics treat each patient/ED encounter as a unique observation.

By comparing these tables, one can see that we retain 91 ED physicians out of a total of 280 when moving from an initial 17 hospitals to the final 7 and dropping ED physicians whose patient population are deemed atypical relative to the ED-peers with respect to mean patient age and gender.

In our final samples, mean spending on physician services during the initial ED visit is about $53 for the angina+ sample and $69 for the TIA+ sample. Furthermore, the mean number of procedures performed during the initial ED visit are 2.00 and 2.47 for the same samples, respectively. The mean number of ED revisits over a 90-day period is high. For example, the number of ED revisits within 5 days from an initial ED visit are .30 and .36 for the angina+ and TIA+ samples, respectively. Furthermore, the number of revisits within 6 to 90 days from an initial ED visit are .74, and .82 for the angina+ and TIA+ samples, respectively. Similarly, a considerable number of individuals seek care in office and external clinic settings. For example, the number of office visits within the first 30 days of an initial ED visit are .63 and .61 for the angina+ and TIA+ samples, respectively. Finally, the number of hospital external clinic visits are .85 and .93 for the angina+ and TIA+ samples, respectively. Although these may be important in terms of revisits, hospitalizations and their costs stand out. For example, the number of hospitalizations with 90 days of the initial visit are .56 and .41 for the angina+ and TIA+ samples, respectively.[10] Furthermore, the total cost associated with hospitalizations within 90 days of the initial visit are $4,749.70 and $6,048.29 for the angina+, and TIA+ samples, respectively.[11]

3 Model and Estimation

3.1 Model

In this section, we postulate a simple model of ED patient treatment, health outcomes, and health-care expenditures. The basic premise of our model is that the most important function of the ED is the appropriate disposition of the patient. An ED that does not adequately recognize signs and symptoms characteristic of life-threatening diseases will send patients home without adequate follow-up treatment, with the risk of further complications. An ED that is overly aggressive in its treatments will result in extra resources being used without delivering any health benefit. Appropriate disposition of the patient depends on the ability to accurately diagnose signs and symptoms and the knowledge of appropriate treatments. Since many diagnostic and therapeutic interventions occur only after discharge from the ED, disposition also depends on the ability to convince patients to obtain the appropriate treatments.

[10]These numbers are obtained by simply adding the 0-5 and 6-90 day windows for each variable of interest.

[11]The number of physicians for angina and TIA is fewer than for angina+ and TIA+ because the sample sizes are relatively small and we drop physicians who do not examine many patients within a diagnosis, as noted above.

Table 4: Summary statistics for estimation sample

Statistic	Angina	Angina+	TIA	TIA+
Number of EDs	7	7	7	7
Number of ED physicians	75	91	47	91
Mean age	14.73	12.59	15.31	12.71
Mean male	.49	.46	.50	.40
Number of patients	559	9121	109	2136
Spending during ED visit	60.79	53.13	59.85	68.85
Number of procedures during ED visit	2.04	2.00	1.80	2.47
Number of ED revisits 0-5 days	.38	.28	.45	.35
Number of ED revisits 6-90 days	.82	.71	.43	.77
Number of office visits 0-30 days	.73	.62	.64	.61
Number of external clinic visits 0-30 days	1.12	.85	1.5	.93
Number of hospitalizations 0-5 days	.33	.17	.29	.22
Number of hospitalizations 6-90 days	.21	.16	.20	.18
Costs of hospitalization 0-5 days ($)	4966.39	2465.27	2983.73	3868.76
Costs of hospitalizations 6-90 days ($)	3062.38	2059.58	2793.23	1931.43

Note: patient statistics treat each patient/ED encounter as a unique observation.

Our model is meant to be fairly general, and can apply to any case where appropriate diagnosis and disposition of the patient are difficult skills. As discussed in the introduction, our empirical work considers three potentially life-threatening conditions, angina and TIA. For these conditions, diagnosis might be challenging and confirmation of the diagnosis depends on tests that are often done after release from the ED. This section illustrates the model for TIA, but the same model applies equally well to angina.

Consider a patient i who experiences an illness shock θ_i and then presents at the ED with symptoms that may or may not be indicative of a TIA (such as visual or speech changes, weakness, or numbness). We assume that there are two possible varieties of illness shocks: $\theta = \theta^{TIA}$ if the patient has experienced TIA, or $\theta{=}\theta^N$ if the patient has experienced the null disease, which is the absence of a TIA, but may exhibit similar symptoms.[12]

We do not directly specify the information that the ED physician observes, regarding the probability that patient i has θ^{TIA} or θ^N. We allow the possibility that these shocks are fully or partially observable to the ED physician. In our model, the physician, and not the patient, make all decisions, and hence the information known to the patient is not relevant.

[12]As noted in Section 2, disease θ^N groups together all conditions which are in TIA+ but not in TIA. Importantly, we assume that the follow-up care that is useful for a TIA is not useful for these other conditions.

We further assume that there are two treatments T. The appropriate treatment for a TIA is given by T^{TIA} and the appropriate treatment for illness θ^N is given by T^N. T^{TIA} is more expensive than T^N, involving referrals for scans for instance.

We now exposit the patient's health production function. The health stock is a latent value H_i^* which we assume is additive in the patient's baseline health endowment, illness shock, and treatment.

The baseline health endowment $\overline{H}_i$ is the endowment prior to the onset of the illness shock. The illness shock θ_i is given by $\overline{v}(\theta) + \varepsilon_i$ (or more specifically, θ_i^{TIA}=$\overline{v}(\theta^{TIA}) + \varepsilon_i$ and θ_i^N=$\overline{v}(\theta^N) + \varepsilon_i$). The mean component of the health shock is $\overline{v}(\theta) < 0$ and $\overline{v}(\theta^{TIA}) < \overline{v}(\theta^N)$ so that TIA confers a worse health shock on average than the null illness. The ε_i is the deviation of the health shock from the mean level.

Denote the mean value of a particular treatment, which is assumed to be illness-dependent, as $v(\theta_i, T)$. We assume that: (i) $v(\theta^N, T^{TIA}) = v(\theta^N, T^N)$, so that there is no extra expected value in receiving the intensive treatment for the null illness θ^N, and (ii) $v(\theta^{TIA}, T^{TIA}) > v(\theta^{TIA}, T^N)$, so that there is a positive value in getting an intensive treatment given TIA.

Taken together, the expression for the latent (i.e., unobservable) post-treatment health stock is given by:

$$H_i^* = \overline{H}_i + \overline{v}(\theta) + v(\theta_i, T) + \varepsilon_i, \tag{1}$$

where θ is either θ^{TIA} or θ^N and T is either T^{TIA} or T^N.

Although the health stock is unobservable to the econometrician, the consumption of medical services is observable. More specifically, denote H_i as an observable healthcare event, occurring after the initial illness shock and care at the ED, for example a hospitalization. In such an example, the observable hospitalization occurs if $H_i = 1\{H_i^* < 0\}$, that is, the patient is hospitalized if his or her (latent) health falls below a given threshold (normalized at zero). Although in this example, the outcome variable is binary in nature (i.e., hospitalized or not), it can be a count variable (i.e., the number of hospitalizations) or a continuous variable (i.e., the costs associated with hospitalizations) as well.

Corresponding to our health production function, we also define a dollar expenditure function.

Expenditures for patient i are a function of the illness shock, treatment, and a residual term:

$$D_i = e(\theta_i, T) + u_i, \tag{2}$$

where: (i) u_i denotes a person-specific cost shock, (ii) the e function provides the deterministic part in the relationship between the illness-treatment pair at the ED, and costs at the ED, and (iii) D is measured in dollars, and hence observable (unlike the health stock). Also, unlike with health shocks, we take no stand as to the costs resulting from the different treatments. While T^{TIA} will cost more than T^N in the current ED visit, it is possible that T^N will cost more in the long-run, due to adverse outcomes such as strokes.

Considering the implications of our model, there are three things that can occur to patient i from a health point of view. She might have had the null disease, in which case the treatment does not affect her health status. Or, she might have had a TIA, in which case the T^{TIA} treatment will result in a higher expected final latent health and a lower probability of a stroke (the potentially avoidable adverse outcome) than would an inappropriately low treatment T^N. From an expenditure point of view, her medical expenditures will be higher if she gets T^{TIA} regardless of her underlying health status.

We seek to use our framework and data to evaluate each ED physician's average contribution to ED resource use during the initial ED visit (what we loosely refer to as the physician's practice style) as well as to desired outcomes (what we loosely refer to as the physician's skills).

In our model, the practice style (i.e., contribution to ED costs) and "skill" (i.e., contribution to desired outcomes) of an ED physician will depend on (1) her ability to distinguish θ^{TIA} from θ^N; and (2) her ability to get patients to receive the appropriate follow-up care, T^{TIA} and T^N respectively. While this statement suggests a vertical dimension to skills, skills will also be partly horizontal. In particular, some physicians may over-treat patients with the null disease, resulting in too many procedures and high expenditures, but good health outcomes, while other physicians may under-treat patients with TIA, resulting in low expenditures in the ED but potentially adverse health outcomes down the road.

To understand the role of physician skill, define $P_j(T|\theta)$ to be the probability that physician j picks treatment T when faced with health state θ, and define $P_i(\theta)$ to be patient i's probability of having illness θ. Let $c(i)$ denote the assignment of patient to some physician j.[13]

Patient i's expected (latent) health-stock will then be equal to:

$$E[H_i^*] = \overline{H}_i + P_i(\theta^N)(v(\theta^N, T^N) + \overline{v}(\theta^N)) + P_i(\theta^{TIA})(v(\theta^{TIA}, T^N) + \overline{v}(\theta^{TIA})) + \varepsilon_i$$
$$+ P_i(\theta^{TIA})P_{c(i)}(T^{TIA}|\theta^{TIA})(v(\theta^{TIA}, T^{TIA}) - v(\theta^{TIA}, T^N)) \quad (3)$$

where the expectation here is over the probability of TIA and the physician's treatment action. In (3), the first line is the underlying health status of patient i (which is invariant to the physician allocation) and the second line is the impact of being treated by physician j (i.e., which in turn depends on his or her skill). Note that physician skill here only matters to the extent that the patient has TIA, as treatments do not affect health outcomes given that the patient has the null disease.

Define $S_{ij}^H \equiv P_i(\theta^{TIA})P_{c(i)}(T^{TIA}|\theta^{TIA})\left(v(\theta^{TIA}, T^{TIA}) - v(\theta^{TIA}, T^N)\right)$. S_{ij}^H is the treatment effect, in terms of expected incremental health benefit, from being treated by physician j. Hence, it is a measure of the impact of the skill of physician j on i's health. Using this definition, we can rewrite (3) as:

$$E[H_i^*] = S_{ij}^H + \overline{H}_i + P_i(\theta^N)\left(v(\theta^N, T^N) + \overline{v}(\theta^N)\right) + P_i(\theta^{TIA})\left(v(\theta^{TIA}, T^N) + \overline{v}(\theta^{TIA})\right) + \varepsilon_i. \quad (4)$$

We can also exposit the expectation of D_i, in a similar fashion to $E[H_i^*]$.

$$E[D_i] = S_{ij}^D + P_i(\theta^N)e(\theta^N, T^N) + P_i(\theta^{TIA})e(\theta^{TIA}, T^N) + u_i. \quad (5)$$

Note that the equation underlying S_{ij}^D in (5) is different from S_{ij}^H in (4) because expenditures can be affected by the treatment regardless of the underlying health state. S_{ij}^D is the treatment effect of physician j in terms of lowering expenditures to patient i.

3.2 Estimation

Using our conceptual model as a basis, we seek to estimate the ED-physician component of different outcome measures. Our idea is to uncover the physician treatment effects across different dimen-

[13]So $P_{c(i)}(T^N|\theta^{TIA})$=$1 - P_{c(i)}(T^{TIA}|\theta^{TIA})$.

sions, notably costs and health outcomes. We then examine the extent to which these different treatment effects for a given physician correlate with each other. We estimate the fixed effects as empirical counterparts to versions of (3) and (5).

We now discuss our basic regression analyses. Focusing on health status, we parametrize the expected value of the part of health status that is not a function of assignment to ED physician as:

$$\overline{H}_i + P_i(\theta^N)(v(\theta^N, T^N) + \overline{v}(\theta^N)) + P_i(\theta^{TIA})(v(\theta^{TIA}, T^N) + \overline{v}(\theta^{TIA})) = x_i\beta^H, \tag{6}$$

where x_i are observables and β^H is a vector of parameters to estimate. In our data, we observe information on the socio-economic status of the patient, gender, and age, as well as the patient's choice of hospital. These variables all enter into x_i.

We further assume that the physician effects are homogenous across a set of patients $\mathcal{I}$, so that $S^H_{ic(i)} = S^H_{ic(i')}$ for all patients i and i' in $\mathcal{I}$. The interpretation of $\overline{S}^H_j$ is the physician's j contribution or "skill" in producing health outcome H^*_i (across patients), where "skills" is in quotes because many health outcomes are "bad".

Substituting (6) into (3), replacing $\overline{S}^H_j$ for S^H_{ij}, and solving for the realization H^*_i instead of the expectation, we obtain:

$$H^*_i = \overline{S}^H_j + x_i\beta^H + \mu_i, \tag{7}$$

where μ_i captures the random component of health outcomes. Analogously, we can obtain an estimating equation for costs

$$C^*_i = \overline{S}^C_j + x_i\beta^C + \psi_i \tag{8}$$

, which has a similar derivation and identical form to (7).

Equation (7) forms the basis of our main estimating equation. The first specification expresses the physician's skills as inputs into the patient's health production function. Similarly, the second specification expresses the physician's practice-style as an input into the costs (during the initial ED visit). We will focus on the physician fixed effects $\overline{S}^H_j$ and $\overline{S}^C_j$ that stem from these regressions.

In general, there is a central complication that makes estimating the role of ED physicians difficult: the underlying health status of the patient may vary and may be systematically correlated with the assignment to ED physician, $c(i)$. Patients who present at the ED with symptoms of a particular disease may be assigned to a physician with more expertise in that disease, for instance.

If patients are even partially informed regarding their illness, this will then create an endogeneity bias in evaluating the impact of physician quality. We address this endogeneity concern using the fact that the assignment to patients at many EDs in Montreal is quasi-random. The quasi-random nature of the assignment implies that the assignment of physician *within an ED* will not be systematically related to unobserved factors (i.e., implies that $\overline{S}_j^H$ will not be correlated with μ_i and $\overline{S}_j^C$ is not correlated with ψ_i).

We now discuss specifics of our empirical implementation. All our analysis is based on linear regressions. All specifications include fixed effects for each ED physician and the same patient demographics in x_i. Focusing on TIA, our model considers patients who present at the ED with symptoms that could plausibly be indicative of TIA. As in Section 2, denote this set of patients as TIA+. Accordingly, most of our TIA regressions define the sample $\mathcal{I}$ to be the set of TIA+ patients. The underlying assumption is that the set of diagnoses in TIA+ (and equivalently for angina+) is sufficiently broad that a diagnosis of TIA+ would be similar across all ED physicians in a given ED. We estimate several versions of (7) and (8). The dependent variables in (8) include the costs of during the initial ED visit and the number of procedures performed. These allow us to identify each physician's average contribution to resource use during the initial ED visit, or, their "practice style". The dependent variable in (7) include the number of revisits to the ED; the number of physician office visits and external clinic visits; and the costs of hospitalization; all within different specified time intervals. These allow us to identify each physician's average contribution to outcomes, or, their "skills".

Note that patients may self-select into different EDs based on unobservable attributes of health status, needs and demands. Different areas of the region may also have people with differential likelihoods of TIA given similar symptoms, implying that even if patients select the ED closest to their home, we might see differences across EDs in μ_i and in ψ_i. Thus, our data only contain quasi-random assignment of patients conditional on admission to a given ED. Thus, we can only identify the level of the skill relative to the mean level at that ED: the interpretation of $\overline{S}_j^H$ is of the skill level relative to other physicians at the same ED. Similarly, the interpretation of $\overline{S}_j^C$ is of the practice style relative to other physicians at the same ED.

Using the TIA+ sample for $\mathcal{I}$, the interpretation of the fixed effects is as the skill of the physician in terms of *both diagnosis and disposition of patients*. In some cases, such as revisits to an ED, we view a positive $\overline{S}_j^H$ fixed effects as unambiguously negative. In other cases, such as office or hospital external clinic visits, a positive coefficient is likely positive, as an office visit might constitute a useful follow-up (further testing) that would prevent future ED visits or hospitalizations. Coefficients on future costs regressions are more ambiguous, as costs within a relatively short term might forestall future costs.

We also estimate regressions where $\mathcal{I}$ includes just patients who are diagnosed specifically with TIA (as opposed to TIA+) in the initial ED visit. The interpretation of these coefficients is as the skill of the ED physician for *enacting the appropriate disposition for the patient given the diagnosis*. We note that the variation for these regressions is less plausibly exogenous than for the TIA+ sample: physicians who are better at diagnosing TIA from the TIA+ patient pool may be faced with a different underlying mix of patients with the TIA diagnosis than physicians who are worse at diagnosing TIA.

We can obtain another measure of the importance of *diagnosis skills* by examining the gap between (1) the TIA+ fixed effect (which indicates diagnosis and disposition together) and (2) the TIA fixed effect (which indicates disposition conditional on diagnosis).

Thus far, we have discussed our model and estimation framework with respect to TIA. We perform identical analyses for angina+/angina samples as well. The exact modeling framework is similar because in both cases, there are components of skill with respect to both diagnosis and disposition, and in both cases, the potential for more serious complications.

4 Results

We now consider the impact of ED physicians across different measures and diseases by reporting statistics on $\overline{S}_j^H$ and $\overline{S}_j^C$. First, we consider the mean physician effects for the angina+ sample on a hospital-by-hospital basis. We then report the analogous results for the TIA+ sample. Each regression includes fixed effects for each physician in the sample and controls for demographics. Because of the number of coefficients and lack of comparability across hospitals, we do not report the coefficient values.

Figure 1 presents the probability density function of physician fixed effects (which are demeaned relative to own-hospital peers) associated with spending during the initial ED visit for the angina+ sample (i.e., "practice-style fixed effects"). Figure 2 presents the probability density function of physician fixed effects associated with hospital spending in the first 5 days (i.e., "skills fixed-effect").

Figures 3 and 4 present the same probability density functions but for the TIA+ sample.

Figure 1:

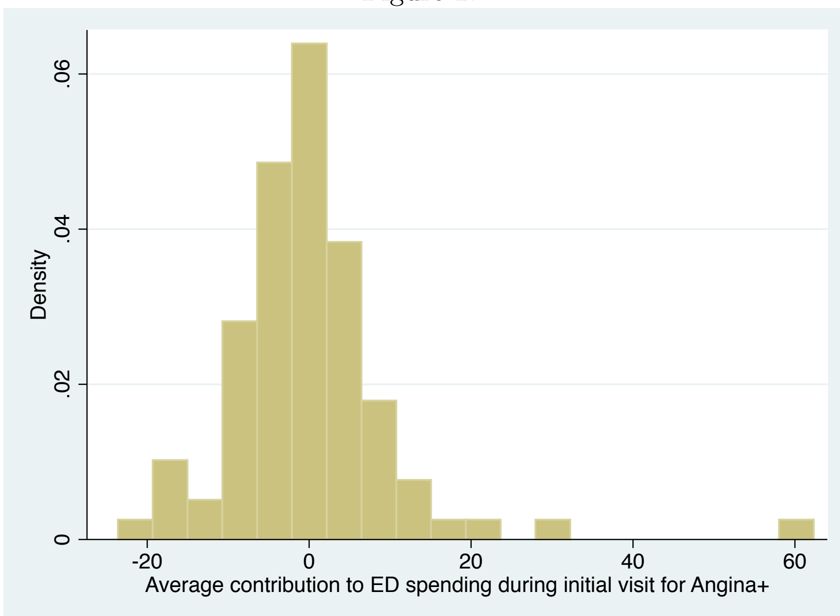


Figure 2:

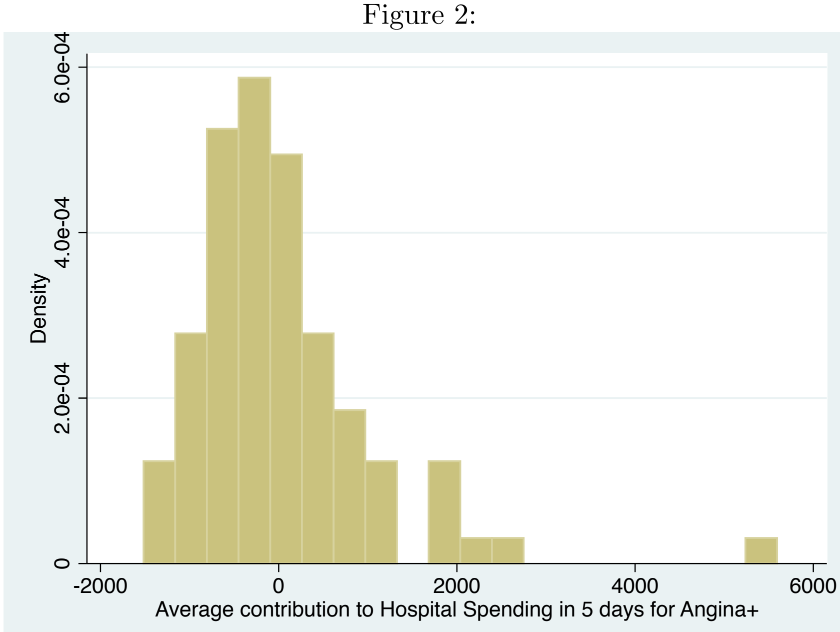


Figure 3:

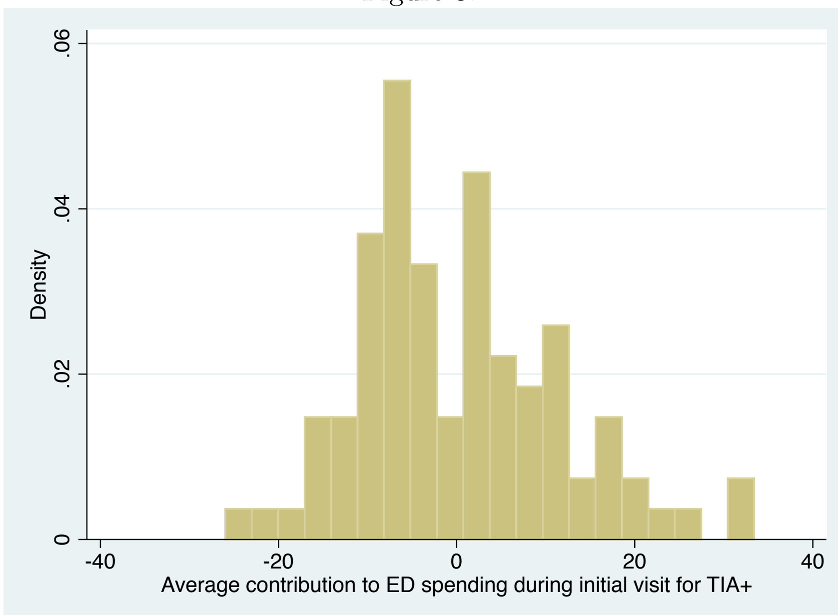
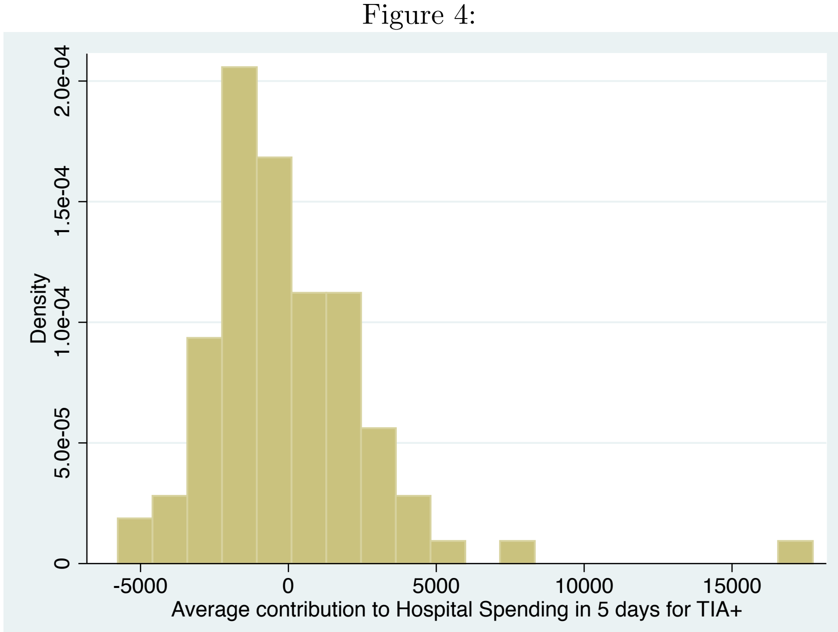


Figure 4:



Furthermore, Tables 5 and 6 report the mean difference between the 75th and 25th percentile of physician effects across each hospital and the standard deviation of this mean for the angina+ and TIA+ samples, respectively.

Table 5: Difference between 75th and 25th percentile physician for angina+

Dependent variable	Mean difference between 75th & 25th percentile	Mean of standard deviation of difference
Spending during ED visit ($)	8.72	
Number of procedures during ED visit		
Number of ED revisits 0-5 days	.082	
Number of ED revisits 6-90 days	.197	
Number of office visits 0-30 days	.131	
Number of external clinic visits 0-30 days	.211	
Number of hospitalizations 0-5 days	.052	
Number of hospitalizations 6-90 days	.062	
Costs of hospitalization 0-5 days ($)	992.13	
Costs of hospitalizations 6-90 days ($)	1022.83	

Note: each row provides the mean, across hospitals, of the difference between the 75th and 25th percentile of the given statistic, and of the standard deviation of the difference.

Table 6: Difference between 75th and 25th percentile physician for TIA+

Dependent variable	Mean difference between 75th & 25th percentile	Standard deviation of mean difference
Spending during ED visit ($)	14.81	
Number of procedures during ED visit		
Number of ED revisits 0-5 days	.165	
Number of ED revisits 6-90 days	.509	
Number of external clinic visits 0-30 days	.258	
Number of office visits 0-30 days	.415	
Number of hospitalization 0-5 days	.119	
Number of hospitalization 6-90 days	.137	
Cost of hospitalization 0-5 days ($)	3084.16	
Cost of hospitalization 6-90 days ($)	2135.17	

Note: each row provides the mean, across hospitals, of the difference between the 75th and 25th percentile of the given statistic, and of the standard deviation of the difference.

Having considered the means of the physician effects, we now turn to examining the relationships between the different effects within and across physician. More specifically, we correlate different measures of the physician fixed effects $\overline{S}_j^H$ and $\overline{S}_j^C$ with each other. Because we cannot compare these effects across hospitals, we difference each physician's effect from the mean level at the ED at which she works. The correlations that we report are then performed on the means.

Table 7 reports the correlation across different physician fixed effects for the angina+ sample, while Table 8 reports the analogous correlations for the TIA+ sample. Several results are worth noting.

First, physicians who have higher physician-related spending in the initial ED visit do not appear to have lower follow-up spending (and may in fact, be associated with higher spending). In particular, the correlation between the initial spending and the number of ED revisits is 0.189 for the angina+ sample, and positive but not statistically for the TIA+ sample. Similarly, the relationship between the number of procedures and the number of ED revisits is positive but not statistically significant for the both samples. The correlation (not reported in the table) in physician fixed effects associated with the number of procedures and the total-physician-related costs during the initial visit are 0.359 (and highly significant) and 0.521 for the angina+ and TIA+ samples, respectively. Taken together, these results suggest that physician who are associated with greater spending and more procedures (i.e., whose practice style is resource intensive) are not necessarily those who are associated with good outcomes (i.e., whose "skills" are considered better). That is, greater ED-physician-related spending or greater number of procedures during the initial ED visit does not appear to reduce future use of care.

Table 7: Correlation in physician fixed effects for Angina+ patients

	Spending during ED visit	ED revisits 0-5 days	ED revisits 6-90 days	Office visits 0-30 days	External clinic visits 0-30 days	Inpatient costs 0-5 days ($)	Inpatient costs 6-90 days ($)
Spending during ED visit ($)	1						
ED revisits 0-5 days	0.189*	1					
ED revisits 6-90 days	−0.093	0.119	1				
Office vists 0-30 days	0.039	−0.158	0.276**	1			
External clinic visits 0-30 days	0.148	0.085	0.066	−0.316***	1		
Inpatient costs 0-5 days ($)	0.102	−0.110	0.060	−0.130	−0.008	1	
Inpatient costs 6-90 days ($)	0.055	0.078	0.159*	−0.178*	−0.027	0.114	1

Note: *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 8: Correlation in physician fixed effects for TIA+ patients

	Spending during ED visit	ED revisits 0-5 days	ED revisits 6-90 days	Office visits 0-30 days	External clinic visits 0-30 days	Inpatient costs 0-5 days ($)	Inpatient costs 6-90 days ($)
Spending during ED visit ($)	1						
ED revisits 0-5 days	0.142	1					
ED revisits 6-90 days	0.121	0.072	1				
Office vists 0-30 days	−0.181	−0.153	−0.000 6	1			
External clinic visits 0-30 days	0.086	0.219**	0.092	0.079	1		
Inpatient costs 0-5 days ($)	0.125	0.211**	0.038	0.003	0.370***	1	
Inpatient costs 6-90 days ($)	0.113	0.009	0.329***	−0.225**	0.145	0.169	1

Note: *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

The results also suggest that physicians who are associated with more ED-revisits during the first 5 days have greater external clinic visits in the first 30 days and greater hospitalization costs in the first 5 days when treating TIA+ patients. The results also suggest that ED revisits in the 6 to 90 day period are positively correlated to inpatient costs during the same period for the two samples: angina+ and TIA+. Inpatient care costs in the first 5 days are also positively correlated with external clinic visits in the first 30 days for the TIA+ sample. Taken together, these results suggest that ED revisits, external clinics and hospitalizations all serve as complements to each other. This is not surprising as ED revisits are likely an 'entry' point to both external clinic and inpatient care. That is, patients who ultimately return to the ED are more likely to be transferred to external clinic or hospital care.

Office visits, on the other hand, appear to work as substitutes to both external clinic visits (for the angina+ sample) and inpatient care (for both the angina+ and TIA+ samples). This could suggest that good follow-up care (in the form of office visits) may serve as a way to limit the patient's need for external clinic or in-hospital care. This is particularly interesting in the Quebec context where a large proportion of the population does not have a primary caregiver. The lack of primary care (through office visits) may thus result in patients ultimately relying on external clinic or in-hospital care.

Table 9: Correlation in physician fixed effects across Angina+ and TIA+ patients

	Spending during ED visit TIA+	Spending during ED visit angina+	ED revisits 0-90 days TIA+	ED revisits 0-90 days angina+	Hospital spending 0-90 days TIA+	Hospital spending 0-90 day angina+
Spending during ED visit TIA+ ($)	1					
Spending during ED visit angina+ ($)	0.585***	1				
ED revisits 0-90 days TIA+	0.154	−0.111	1			
ED revisits 0-90 days angina+	0.164	−0.017	−0.139	1		
Hospital spending 0-90 days TIA+	0.149	−0.231**	0.206**	0.208**	1	
Hospital spending 0-90 days angina+ ($)	0.145	0.104	−0.100	0.116	−0.051	1

Note: *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Having analyzed the correlation of physician effects within the two samples, we next seek to understand the relation between physician effects across these two illness categories. Table 9 reports correlations in physician effects across the angina+ and TIA+. We choose here a smaller set of correlations to report than in previous tables due to space constraints.

The most striking finding here is the strong correlation of ”practice style” types across the two samples. That is, physicians who spend more on average in the initial ED visit for the angina+ sample also spend more on average for the TIA+ sample. More specifically, the correlation between physician average contribution (i.e., practice style) to physician-related costs during the initial ED visit across angina+ and TIA+ samples is 0.582 and highly significant. Similarly (although not reported in the table), the correlation between physician average contribution (i.e., practice style) to the number of procedures during the initial ED visit is 0.620 and highly significant. Taken together these results suggest (i) that differences in spending and the number of procedures performed during the initial ED visits is driven in part by who the patient sees and (ii) that high-resource-use types are so across illness categories.

Also interesting is the strong and positive correlation between a physician’s contribution to ED revisits within the first 90 days and hospitalization costs during the same time period across the two samples. This finding would also suggest that physician skills (measured in revisits to EDs or hospitalizations), or lack there of, correlate positively across patient populations.

We next turn to the question of the correlations between the angina and angina+ samples and between the TIA and TIA+ samples, respectively. Recall that fixed-effect estimated using the TIA+ and angina+ samples reflect skills for patient diagnosis *and* disposition, while the fixed-effect estimates using the angina and TIA samples reflect skills at patient disposition, with the assumption that the distribution of unobservables ε_i among the diagnosed angina (or TIA) population is orthogonal across ED physicians within an ED.

Table 10: Correlation in physician fixed effects across angina and angina+ patients

	Spending during ED visits angina	Spending during ED visit angina+	ED revisits 0-90 days angina	ED revisits 0-90 days angina+	Hospital spending 0-90 days angina	Hospital spending 0-90 day angina+
Spending during ED visit angina ($)	1					
Spending during ED visit angina+ ($)	0.347***	1				
ED revisits 0-90 days angina	0.296***	−0.054	1			
ED revisits 0-90 days angina+	0.039	0.025	0.107	1		
Hospital spending 0-90 days angina ($)	0.116	−0.042	0.247**	−0.052	1	
Hospital spending 0-90 days angina+ ($)	−0.147	0.123	−0.105	0.161	0.074	1

Note: *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Tables 10 and 11 report these correlations for angina/angina+ and TIA/TIA+ samples, respectively. First, we find a strong positive correlation between the average contribution to ED resource-use across the angina and angina+ samples as well as across the TIA and TIA+ samples. This would suggest that high spending is not fully explained, or conditional on, a severe diagnosis (i.e., TIA or angina).

There is also very little correlation between the similar fixed effects (associated with future healthcare consumption) for angina/angina+ and for TIA/TIA+ samples. This would suggest that there variation in diagnosis skills may be quantitatively more important than variation in disposition skills. That is, outcomes are very different once one conditions on an angina or TIA.

–

Table 11: Correlation in physician fixed effects across TIA and TIA+ patients

	Spending during ED visits TIA	Spending during ED visit TIA+	ED revisits 0-90 days TIA	ED revisits 0-90 days TIA+	Hospital spending 0-90 days TIA	Hospital spending 0-90 day TIA+
Spending during ED visit TIA ($)	1					
Spending during ED visit TIA+ ($)	0.625***	1				
ED revisits 0-90 days TIA	0.067	0.131	1			
ED revisits 0-90 days TIA+	−0.192	−0.171	−0.128	1		
Hospital spending 0-90 days TIA ($)	0.096	−0.005	0.108	−0.339**	1	
Hospital spending 0-90 days TIA+ ($)	−0.084	−0.267	0.226	−0.199	−0.034	1

Note: *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

5 Conclusion

In this paper, we have used detailed data from emergency departments in Montreal, Quebec, Canada in order to understand how ED physicians contribute to healthcare costs and outcomes. A central advantage of our data is that we observe the patient-to-ED-physician assignment and observe future interactions with the provincial medical system within 90 days of the initial ED visit. We use the fact that the assignment of ED physicians in Montreal, conditional on choice of ED, is close to random. The random assignment allows us to identify each physician's average contribution to health outcomes. We develop this point fully in a theoretical model.

Using our data, we compute the physician effect on various outcomes for three samples of patients, those who are diagnosed with conditions that might indicate angina (angina+) and those who are diagnosed with conditions that might indicate a transient ischemic attack (TIA+).

Our results suggest that physicians vary in both their average contribution to ED physician-related costs (and number of procedures) during the initial ED visit as well as to future outcomes. Results also suggest that physicians who systematically use more ED resources (measured as the physician related expenses and the number of procedures) do not also systematically achieve better outcomes. Thus, spending more at the ED (on physician-related costs) does not necessarily lead to better outcomes. In fact, results suggest that those who spend more during the initial ED visit may in fact yield worse outcomes - at least with respect to greater ED-revisits during the first five days, for the angina+, and greater hospital external clinic visits in the first 30 days and inpatient costs during the first 5. Our results also suggest that ED revisits, hospitalizations and external hospital clinic visits act as complements to each other. Office visits, on the other hand, appear to act as substitutes to bad and costly outcomes.

When comparing physician-fixed effects across illness categories (for a given outcome), several results are worth noting. First, physicians who are associated with high spending (on physician services) during the initial ED visit when treating angina+ patients are associated with high spending when treating the TIA+ patients as well. This suggests that physicians' costs are driven by elements which are invariant (at least in part) to the patient to which they are presented.

Finally, our results suggest that diagnosis plays a large part in contributing to future outcomes. More specifically, we find that physicians who are associated with bad outcomes when treating patients who may or may not have angina (or TIA) are not necessarily associated with bad outcomes once one conditions on an angina (or TIA) diagnosis.

Collectively, these results suggest that who a patient sees is likely to have an impact not only on the quantity of care they will receive in the ED (measured by physician related costs and number of procedures) but also their use of future care (measured by the number and costs associated with revisits to EDs, visits to hospital outpatient clinics and office, as well as hospitalizations). The results also suggest that physicians who consistently spend more, do not necessarily achieve better outcomes. The results would further suggest that there is room for improvement on both the cost and quality dimensions and that quality need not be associated with greater costs. Finally, they suggest that any improvements in diagnosis skills and access to office visits (which is an important issue in the environment studied) may both serve at improving outcomes and reducing costs.

References

[1] Abaluck, J. and Agha, L. (2014). Negative tests and the efficiency of medical care: What determines heterogeneity in imaging behavior? Working Paper, Yale.

[2] Doyle, J., Graves, J., Gruber, J., and Kleiner, S. (2014). Measuring returns to hospital care: Evidence from ambulance referral patterns. *Journal of Political Economy*, Forthcoming.

[3] Doyle, J., Wagner, T., and Ewer, S. (2010). Returns to physician human capital: Analzying patients randomized to physician teams. *Journal of Health Economics*, 29:866–882.

[4] Dranove, D., Kessler, D., McClellan, M., and Satterthwaite, M. (2003). Is more information better? the effects of "report cards" on health care providers. *Journal of Political Economy*, 111(3):555–588.

[5] Hastings, S., Whitson, H., Purser, J., Sloane, R., and Johnson, K. (2009). Emergency department discharege diagnoses and adverse health outcomes among older adults. *Journal of the American Medical Association*, 57:1856–1861.

[6] Kachalia, A., Gandhi, T., Puopolo, A., Yoon, C., Thomas, E., Griffey, R., Brennan, T., and Studdert, D. (2007). issed and delayed diagnoses in the emergency department: a study of closed malpractice claims from 4 liability insurers. *Annals of Emergency Medicine*, 49:196–205.

[McSweeney et al.] McSweeney, J., Cody, M., O'Sullivan, P., Elberson, K., Moser, D., and Garvin, B.

[8] Pope, J., Aufderheide, T. P., Ruthazer, R., Woolard, R. H., Feldman, J. A., Beshansky, J. R., Griffith, J. L., and Selker, H. P. (2000). Missed diagnoses of acute cardiac ischemia in the emergency department. *New England Journal of Medicine*, 342:1163–1170.

[9] Pope, J. and Edlow, J. (2012). Avoiding misdiagnosis in patients with neurological emergencies. *Emergency Medicine International*, 2012.

[10] Porter, M. E. (2010). What is value in health care. *New England Journal of Medicine*, 363:2477–2481.

[11] Rothrock, S. and Pagane, J. (2000). Acute appendicitis in children: emergency department diagnosis and management. *Annals of Emergency Medicine*, 36:39–51.

[12] Rothwell, P., Giles, M., Chandratheva, A., Marquardt, L., Geraghty, O., Redgrave, J., Lovelock, C., Binney, L., Bull, L., Cuthbertson, F., Welch, S., Bosch, S., Carasco-Alexander, F., Silver, L., Gutnikov, S., and Mehta, Z. (2007). Effect of urgent treatment of transient ischemic attack and minor stroke on early recurrent stroke (express study): a prospective population-based sequential comparison. *The Lancet*, 370:1432–1442.

[13] Taubman, S. L., Allen, H. L., Wright, B. J., Baicker, K., and Finkelstein, A. N. (2014). Medicaid increases emergency-department use: Evidence from oregon's health insurance experiment. *Science*, 17(17):263–268.