Excess Burden of Infectious Diseases:

Evidence from the SARS outbreak in Ontario, Canada

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Abstract

Infectious diseases lower social welfare by distorting behavior of individuals. We exploit exogenous timing of the SARS outbreak in Ontario, Canada to examine the extent to which SARS distorted behavior of individuals in the market for medical services.

We find that SARS had negative temporary impact on utilization of medical services, but no long-lasting impact. About three quarters of the temporary SARS impact is explained by a decline in the visits of patients per physician, while the remaining quarter of the impact is due to changes in the intensity of medical treatment and in the mix of medical services.

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1. Introduction

Infectious diseases, such as AIDS and malaria, impose major economic costs on the affected countries[2]. In addition to inflicting direct costs such as the human loss and the expenditures on prevention and treatment, infectious diseases also distort the behavior of individuals, further lowering social welfare. The welfare loss caused by these behavioral distortions, termed the 'excess burden' by Philipson (1995a), can sometimes be so large that public expenditures are justified even for low prevalence diseases with small caseload costs[3].

Yet, the empirical evidence on the size of behavioral distortions caused by infectious diseases is scant[4]. The main difficulty appears to be in isolating the impact of the infectious disease on the behavior of individuals from the impact of a myriad of confounding factors. In this paper, we attempt to overcome this difficulty by exploiting the exogenous timing of the Severe Acute Respiratory Syndrome (SARS) outbreak in the Canadian province of Ontario. We examine utilization of medical services for evidence of any behavioral distortion and we ask whether SARS had any temporary and/or permanent impact on utilization of these services.

Changes in the utilization of medical services caused by the SARS outbreak may affect social welfare in at least two ways. First, medical care is usually considered an important determinant of population health[5]. In turn, population health is associated with a number of economic outcomes, such as productivity of workers, returns to education and job experience, and growth in per capita income[6]. Therefore, the incidence of SARS may have long-term consequences by influencing future economic outcomes through its impact on population health.

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[2] For surveys of the economic impact of AIDS and malaria see Dike (2002) and Chima et al. (2002), respectively.
[3] Philipson (1995a) mentions polio in the U.S. as an example of a disease for which all welfare loss is due to the excess burden, since the prevalence of polio in the U.S. is practically zero.
[4] Two exceptions are Philipson (1995b), who looks at measles vaccination in the U.S., and Ahituv et al. (1995), who look at the demand for condom and the prevalence of AIDS.
[5] Historical evidence has attributed changes in some health outcomes, such as reduced mortality, more to improved nutrition and housing and less to medical care (Fogel (1997)). Recent literature, however, posits a stronger role for medical care in improving health, especially in certain areas such as heart disease (Deaton (2002)).
[6] Two comprehensive surveys are Currie and Madrian (1999) and Bloom and Canning (2000).

Second, changes in utilization of medical services have a direct effect on the welfare of physicians. Most physicians in Ontario, Canada, and in many other developed countries, are compensated for medical services they provide on the 'fee-for-service' basis, and changes in utilization of medical services directly influences their income.

There are many pathways through which SARS may have affected utilization of medical services. On the demand side, the incidence of SARS unambiguously increased the costs of medical services because patients visiting physicians were exposed to the risk of contracting SARS. On the supply side, SARS had certainly influenced the number of practicing physicians because many physicians fell ill with SARS and many others were quarantined. In addition, SARS could have influenced the number and type of medical services for a number of reasons. A particularly interesting possibility is that physicians may have attempted to induce more demand for their services to offset the expected decline in the demand[7]. Lastly, the Ontario government imposed a number of SARS-control policies that can be expected to influence both the number and type of medical services provided and the number of patients treated.

In our empirical analysis, we first analyze the net impact of SARS on utilization of medical services and then assess the importance of demand and supply factors and government policies in mediating the impact of SARS. Our identification strategy is to compare utilization of medical services before and after the SARS outbreak, after controlling for a time trend and a full set of seasonal dummies. This strategy has considerable merit given that the SARS outbreak was clearly an exogenous shock to the health system. It was a new disease for which there was no definitive diagnosis, no proven treatment method, and only limited knowledge about transmission mechanisms. In addition, outside of Asia, Canada was hit the hardest by SARS, and most of the 251 cases of SARS and all 43 deaths in Canada took place in Toronto, the capital of Ontario. If

[7] This hypothesis is known in the literature as the physician-induced demand (PID) hypothesis. McGuire (2000) presents an excellent survey of theoretical and empirical research on the PID.

SARS had any impact on the utilization of medical services, we should be more likely to find it Ontario, one of the epicenters of the SARS outbreak.

We use administrative data on medical service utilization maintained by the Ontario Ministry of Health and Long Term Care. This data is detailed, comprehensive and fairly accurate and compares favorably with previous studies of the economic costs of infectious diseases that have often relied on self-reported diagnosis and expenditures from household surveys, or on the estimates provided by the official reporting systems with varying degrees of accuracy[8].

Our results indicate that SARS had a significant temporary impact on medical care utilization (about -8%) and this effect was largest in Toronto, the epicenter of the outbreak. The results also indicate that SARS had no lasting effect on medical care utilization.

About three quarters of the temporary SARS impact is explained by the decline in the ratio of patients per physician, suggesting that SARS had a significant effect on the demand for medical services. We also find that the SARS impact varied systematically with several measures of the prevalence of SARS and the expected costs of SARS infection, such as the number of reported SARS cases and the number of SARS-related deaths. These findings are important for policy because they imply that individuals behave rationally, as predicted by economic theory, and government policies should this behavior into the account when designing infectious disease control policies.

SARS also had significant impact on the number of services per patient (the intensity of medical treatment) and on the average cost of medical services (the mix of medical services). In particular, we find that in the post-SARS period the mix of services shifted towards those services that are remunerated at lower rates. On the other hand, SARS increased the intensity of medical treatment provided by specialists, and decreased the intensity of services provided by GP/FPs. While these results accept several alternative explanations, the physician-induced demand hypothesis appears not to be one of them.

[8] See Chima et al. (2002) for a critical review.

We also present evidence that government SARS-control policies had a significant impact on the utilization of medical services. In particular, the timing of the government emergency coincided closely with significant drops in utilization of medical services, and the reduction in utilization was largest for services suspended by the government during the emergency (in-patient elective procedures).

While we focus primarily on the behavioral distortions of SARS in the market for medical services, our study also contributes to the emerging literature on the economic impact of SARS[9]. Firstly, most analyses focused on the impact of SARS on travel, tourism and retail sales industries, while many other sectors of the economy that may have also been adversely affected received much less attention. We provide one of the first systematic studies of the impact of SARS on the health sector[10]. Second, some of the studies were conducted while the SARS outbreak and local transmissions had not yet been successfully contained[11]. Without the benefit of longer hindsight, these studies cannot address the full temporary impact of SARS, nor can they evaluate if SARS had any longer term impact. Our sample period includes sufficient data in the pre-SARS period and in the post-SARS period to provide estimates of both temporary and permanent SARS effects. Lastly, some macroeconomic studies estimated significant and sizeable impacts of SARS on GDP per capita[12]. Our study contributes to the development of a growing body of microeconomic evidence that will validate these results and allow us to explore the potential causal mechanisms.

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[9] Lee and McKibbin (2003) study the global macroeconomic impact of SARS. They also cite other studies that provide estimates of the economic impact of SARS in China, Hong-Kong and Taiwan, but these studies mainly focus on tourism and retail service sector. Wong (2003) estimates the impact of SARS on the housing market in Hong-Kong. There are also a large number of studies of the economic impact of SARS conducted by analysts in the government and the private sector in different countries.

[10] Woodward et al. (2004) also look at utilization of Ontario's health system during the SARS outbreak. However, they limit their analysis to comparing the number of medical services provided during the 2003 SARS outbreak and the number of services provided during the same period in 2002. However, it is not clear whether differences in utilization they report are statistically significant. In addition, they do not control for any confounding factors.

[11] For example, researchers at the Asian Economic Panel meeting in Tokyo presented their preliminary findings on May 11-12, 2003, well before the SARS outbreak has been contained. Some authors subsequently revised their studies as information on SARS was updated.

[12] See for example Lee and McKibbin (2003).

The remainder of the paper proceeds as follows. Section 2 describes the anatomy of the SARS outbreak and discusses the expected effects of SARS on medical care utilization. In Section 3, we present our empirical framework, while section 4 describes the data. We report our results in section 5 and then conclude in section 6.

2. Background

2.1 Chronology of the SARS outbreak in Canada[13]

The first known SARS case is believed to have occurred in the Guangdong province of China in November 2002. The chain of events that would bring SARS to Canada and other countries started in February 2003 when a doctor who had treated SARS patients in Guangdong traveled to Hong Kong. The doctor infected at least twelve individuals, including a woman from Toronto, the capital of Canadian province of Ontario.

The timeline of the more important events during the SARS outbreak in Canada are presented in table 1. The number of probable cases of SARS, by the date of onset, and the number of SARS-related deaths, by the date of occurrence, are presented in figures 1 and 2, respectively.

The first day of the SARS outbreak in Canada, as defined by Health Canada, the highest federal government health agency, was March 13, 2003, a day before the Ontario government declared SARS a provincial emergency. The last day of the outbreak was June 30, 2003, about two weeks after the last local transmission of SARS in Toronto was reported. By the end of the outbreak, 251 probable cases of SARS were reported and 43 people had died. Most SARS cases and all deaths occurred in Toronto, Ontario.

The SARS outbreak in Canada can be divided into two waves: the initial wave that lasted from March 13 to April 7, 2003 (SARS I), and the second wave that started on May 23 and ended

[13] For a more detailed account of the SARS episode in Canada, see Health Canada (2003).

by June 30, 2003 (SARS II). The two waves differ with respect to the intensity of the outbreak and the extent of government intervention to control the spread of SARS.

During SARS I, the Ontario government declared SARS a provincial emergency. Code Orange was applied to all hospitals in Ontario and all non-essential services were suspended. Hospitals were also required to limit visitors, create isolation units for potential SARS patients, and implement protective clothing measures for the exposed staff (i.e. gowns, masks, and goggles). Outpatient clinics were closed, and hospital employees were barred from working at other institutions.

Family physicians practicing in the community received SARS guidelines much later (about three weeks after the beginning of the outbreak). These guidelines suggested ways to keep potential SARS patients outside of doctors' offices using signs, pre-recorded phone messages and screening questionnaire, to safely treat SARS patients that did enter the office and to protect physicians and staff from infection.

By the end of April, health officials felt the outbreak was contained. But just as confidence began to grow, the World Health Organization (WHO) issued an advisory recommending that visitors to Toronto postpone all but the most essential travel. However, the controversial advisory was withdrawn within a week. Soon afterwards, the WHO removed Toronto from the list of areas with recent local transmission and Ontario lifted the SARS emergency. The first wave of SARS was over.

The failure to isolate a SARS case without clinical symptoms led to SARS II. During this wave, all hospitals in the Toronto area were asked to resume previously abandoned infection-control policies. However, only four hospitals in Toronto were designated as SARS facilities where all suspected cases of SARS were to be treated. In addition, the provincial government did not declare a new SARS emergency. The outbreak was smaller, the virus was better understood, and the necessary precautions and routines were already established. The last local transmission of SARS in Toronto was reported on June 12, 2003. Two weeks later, Toronto was removed from the WHO list of areas with recent local transmission and the SARS episode in Canada came to an end.

2.2. Implications for utilization of medical services

There are many pathways through which SARS may have affected medical care utilization. These pathways can be usefully analyzed within a standard demand and supply model for medical care, augmented to include policies implemented by the provincial government during the SARS outbreak.

On the demand side, the incidence of SARS unambiguously increased the cost of medical services to patients because patients visiting physicians were exposed to the risk of contracting SARS[14]. With no attendant changes in the expected benefits of medical care, the demand for medical care should therefore fall during the outbreak. In addition, the drop in demand should result more from the decline in the number of patients seeing physicians than from a reduced volume of medical services demanded by each patient.

Economic theory provides a number of additional predictions about the impact of infectious diseases on the demand for medical services[15]. First, the drop in the demand for medical services should be larger the higher is the cost of infection. For new infectious diseases, such as SARS, the cost of infection is not known with certainty, especially in the initial period. As patients learn more about the disease over the course of the outbreak, their estimate of the cost of infection will be adjusted and there would be a corresponding change in the demand for medical services. For example, reports of new SARS-related deaths will make patients revise their estimates of the costs of infection upwards and the demand for medical services would fall.

[14] In principle, patients were exposed to the risk of contracting SARS anywhere, not just in hospitals and in contacts with physicians. However, all SARS patients were treated in hospitals and most transmissions of SARS occurred in hospitals.

[15] For a survey, see Philipson (2000).

Second, the drop in the demand for medical services should also be larger the lower is the cost of postponing the medical treatment. The cost of postponing treatment is smaller for patients with relatively minor health problems. Since specialists treat more complex problems than general practitioners/family physicians (GP/FPs) do, the drop in the demand for medical services of specialists should be relatively smaller, controlling for other factors.

Third, the drop in demand should be larger the more prevalent is the disease. Higher prevalence of disease increases the risk of infection and therefore also the expected cost of medical services. Therefore, the drop in demand for medical services should vary systematically with the number of reported SARS cases and depending on whether the patient is located in Toronto, the epicenter of the outbreak, or in the rest of Ontario.

On the supply side, the SARS outbreak certainly affected the number of physicians providing medical services and may have affected the number and the type of services provided by each physician.

The number of physicians providing medical services during the outbreak was unambiguously reduced as many physicians fell ill with SARS, over 1,000 physicians (i.e. about 5 per cent of all Ontario physicians) were quarantined, and one physician died of SARS.

On the other hand, the impact of SARS on the number and type of medical services provided by each physician is more ambiguous because of a number of conflicting factors. First, many health care workers fell ill with SARS and were quarantined, and two nurses died. Indeed, no segment of society was hit harder than health care workers, a group that accounted for over 40% of all SARS infections. A lower supply of health care workers is expected to influence both the number and type of medical services provided by physicians, because these workers are an important input in the production of medical services. In general, we expect that physicians were able to supply fewer medical services and perhaps also to shift to services that require relatively less input from other health care workers.

Second, the government infectious control procedures such as screening, masking and gowning are expected to negatively influence the productivity of physicians, and may have contributed to a reduction of throughput and patient volumes. In addition, the government suspended all non-essential services in the hospitals and asked physicians working in hospitals to assist with the SARS emergency. This policy is expected to reduce the number of services provided by these physicians and to shift their work toward the essential services. GP/FPs practicing in communities should be less influenced by these policies because they don't practice in hospitals, and because they received rough guidelines much later than the government instructions for specialists practicing in hospitals.

Lastly, physicians may have responded to the expected loss of income resulting from both the expected lower demand for medical services and from the government intervention policies in at least two ways. First, they may have increased their hours of work; and second, they may have attempted to induce patients to consume more medical services and services that are compensated at higher rates. Both of these responses would result in an increase in the number of services provided by physicians. However, the two behavioral responses may be distinguished because physician-induced demand also implies a change in the mix of services provided, while the change in hours of work does not. It is also important to note that GP/FPs had more leeway to adjust their behavior compared to hospital-based specialists, whose behavior was more heavily regulated by the government.

3. Empirical Framework

To assess the temporary and permanent effects of the SARS outbreak on medical care utilization in Ontario, we initially estimate the following model:

$$(1)\ \log(y_{tg}) = \alpha+\beta_0\times X_{tg}+\beta_1\times \text{Toronto}_g+\beta_2\times \text{Specialist}_g+\beta_3\times \text{SARS}_t+\beta_4\times \text{Post-SARS}_t+\varepsilon_{tg}$$

where y represents the utilization of medical services, measured as the medical expenditure per physician; Toronto is an indicator for physicians located in Toronto; Specialist is an indicator for physicians who are specialists; SARS is an indicator for the SARS outbreak period (March 13, 2003 to June 30, 2003); and Post-SARS is an indicator for the period after and inclusive of March 13, 2003. The subscript t denotes time period and is measured in days, and the subscript g denotes the group of physicians (specialists in Toronto, specialists in the rest of Ontario, GP/FPs in Toronto, and GP/FPs in the rest of Ontario). The set of covariates X includes a time-trend in days (a quadratic), a set of seasonal dummies (the day of the week, the month of the year, and the public holidays[16]), and the interactions of the time trend and the seasonal dummies with indicators for physicians located in Toronto and for physicians who are specialists.

Any confounding factors that are time-invariant are absorbed by the group fixed effects: the indicators for physicians located in Toronto and for physicians who are specialists. The inclusion of seasonal indicators controls for the fact that utilization is usually lower on weekends, public holidays, and during certain months of the year. The time trend variable should absorb any continuous and slow-evolving factors such as changes in the demographic composition of the population and their health needs. The interaction of the time-trend and seasonal dummies with indicators for physicians located in Toronto and for physicians who are specialists is intended to capture any group-specific trends and seasonal effects.

Our identification assumption is that SARS was an unanticipated shock to the Ontario health system. If this assumption is true, then the parameter β_3 estimates the average temporary impact of SARS on medical care utilization, while β_4 estimates the average permanent impact of SARS.

In the next step, we examine how the SARS impact varies by the location and the specialty of physicians. In particular, we augment model (1) as follows:

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[16] The public holidays in Ontario are: New Year, Good Friday, Victoria Day, Canada Day, August Civic Holiday, Labour Day, Thanksgiving, Christmas, and Boxing Day.

$$(2)\ \log (y_{tg}) = \alpha+\beta_0\times X_{tg}+\beta_1\times \text{Toronto}_g + \beta_2\times \text{Specialist}_g + \beta_3\times \text{SARS}_t + \beta_4\times \text{Post-SARS}_t$$
$$+ \gamma_1\times \text{Toronto}_g\times \text{SARS}_t+\gamma_2\times \text{Toronto}_g\times \text{Post-SARS}_t+\gamma_3\times \text{Specialist}_g\times \text{SARS}_t$$
$$+\gamma_4\times \text{Specialist}_g\times \text{Post-SARS}_t+\gamma_5\times \text{Toronto}_g\times \text{Specialist}_g+\lambda_1\times \text{Toronto}_g\times \text{Specialist}_g\times \text{SARS}_t$$
$$+\lambda_2\times \text{Toronto}_g\times \text{Specialist}_g\times \text{Post-SARS}_t +\varepsilon_{tg}$$

The temporary impacts of SARS in this model are: β_3 for GP/FPs located in the rest of Ontario, $\beta_3+ \gamma_1$ for GP/FPs in Toronto, $\beta_3+ \gamma_1 + \gamma_3$ for specialists in the rest of Ontario, and $\beta_3+ \gamma_1 + \gamma_3+\gamma_5+\lambda_1$ for Toronto specialists. The permanent SARS impacts can be defined similarly[17].

We hypothesize that SARS should affect medical care utilization stronger in Toronto than in the rest of Ontario. Toronto was the epicentre of the outbreak, with a high probability of contracting SARS, more strictly applied policies to control the spread of SARS, and more health workers that fell ill with SARS. These factors would tend to decrease the demand for, and the supply of, medical services in Toronto relatively more than in the rest of Ontario.

On the other hand, the impact of SARS on medical care utilization by specialty of physicians is ambiguous. On one hand, government policies would tend to amplify the impact of SARS on utilization of services provided by specialists. As mentioned, the provincial government restricted the number and type of services provided by specialists working in hospitals. In addition, specialists had less opportunity to adjust their hours of work and/or induce additional demand for their services relative to GP/FPs because government policies were implemented earlier for the hospitals and the procedures were more stringent and extensive than the guidelines issued for community-based GP/FPs. Since the expected adjustment in physicians' behaviour (more hours and/or more induced demand) would tend to diminish the impact of SARS on medical care utilization, the utilization of medical services provided by specialists should fall

[17] β_4 for GP/FPs located in the rest of Ontario, $\beta_4+ \gamma_2$ for GP/FPs in Toronto, $\beta_4+ \gamma_2 + \gamma_4$ for specialists in the rest of Ontario, and $\beta_4+ \gamma_2 + \gamma_4+\gamma_5+\lambda_2$ for Toronto specialists.

relatively more than the utilization of services provided by GP/FPs. On the other hand, the demand for complex and serious medical conditions usually treated by specialists should be less elastic with respect to the prevalence of SARS compared to the demand for routine checkups and visits provided in the offices of GP/FPs. In this case, the impact of SARS on utilization of services provided by specialists should be relatively weaker than for services provided by GP/FPs.

To gain more insight into the impact of SARS, the utilization of medical services can be decomposed as follows:

$$(3)\quad \frac{\text{Expenditure}}{\text{Physician}} = \frac{\text{Patients}}{\text{Physician}} \times \frac{\text{Services}}{\text{Patient}} \times \frac{\text{Expenditure}}{\text{Service}}$$

Changes in the expenditure per physician, our measure of medical care utilization, will be the product of changes in each of these three components, and we re-estimate models (1) and (2) using the log of each of the components as the dependent variable.

The patients/physician ratio indicates the average number of patients that have visited a physician during a given day. We expect this ratio to be lower during the SARS outbreak for any of the following reasons: if patients postponed visits to physicians' offices to avoid contact with individuals who may have SARS; if patients with minor medical conditions were prevented from visiting physicians in hospitals; and if government policies reduced the productivity of physicians.

The services/patient ratio indicates the intensity of treatment per visit, and the expenditure/service ratio indicates the mix of medical services provided. We expect these two ratios to be affected by a similar set of factors. Both ratios will be higher during the SARS outbreak if patients who pay visits to physicians are sicker than the average patient in the population and if physicians induce demand for their services. On the other hand, a lower supply of health care workers, who are an essential input in the production of medical services, is expected to reduce the intensity of treatment, but its impact on the mix of services provided is ambiguous. Similarly, the government policy to suspend all non-essential services during the outbreak will affect both the intensity of treatment and the mix of services, but the direction of the impact is in general ambiguous.

We also examine the hypothesis that changes in the demand for medical services should vary systematically during the SARS outbreak with the perceived cost of infection and the prevalence of the disease. We firstly evaluate whether the SARS impact varied systematically with the number of probable SARS cases reported and with the number of SARS-related deaths. The number of probable SARS cases and the number of SARS related deaths are allowed to have lasting effects into the future, taking into account that individuals may discount these events at a given rate. In particular, we re-estimate model (1) by adding a variable that measures the count of SARS probable cases (SARS related deaths) as follows:

(3) SARS-Cases_t (Deaths) = $\Sigma_{s<=t}$ (Number of SARS cases (Deaths) during day s) $\times\ \alpha^{(t-s)}$

α is the discount factor. In our empirical analysis, we use discount factors ranging from 0.1 to 0.5.

Secondly, we examine whether the number of patients per physician varied systematically with a number of specific announcements that the WHO made during the SARS outbreak. In particular, we examine the impact of the WHO travel advisory, and the impact of Toronto being put on the WHO list of areas with recent local transmission during the first and the second wave of SARS. These announcements are expected to be correlated with the prevalence of SARS outbreak, and we hypothesize that the decline in the number of patients per physicians should be larger following these events and that it should be larger in Toronto relative to the rest of Ontario.

The last hypothesis we examine is whether the government SARS-control policy had any negative impact on the utilization of medical care. The purpose of this policy was to prevent the spread of SARS, but many have questioned whether the government went too far, specially by closing down hospitals and denying access to patients for "non-essential" services. Assessing the extent to which medical service utilization was affected by the government policy should provide an important input into the relevant cost-benefit analysis.

Firstly, we examine whether the day the Ontario government announced SARS a provincial emergency and the day when the government lifted this emergency status had any significant impact on the utilization of medical services. Secondly, we examine whether suspending all non-essential services in hospitals had any effect on the mix of medical services provided during the outbreak. We rely on Woodward et al. (2004) to define a set of in-patient procedures and to classify them into elective and urgent procedures. Then for each group of procedures we estimate model (1), using the number of patients and the number of services as the dependent variables.

4. Data

In Ontario, comprehensive and detailed data is available for the utilization of medical services provided by physicians on a fee-for-service (FFS) basis. This restriction does not significantly limit our study because FFS payments are the predominant payment method for physicians in Ontario; in 2003, service fees accounted for 84.3% of the income of specialists and 87.1% of the income of GP/FPs[18].

The data comes from the Ontario Health Insurance Plan (OHIP) database, maintained by the Ministry of Health and Long Term Care (MOHLTC). The accuracy of OHIP data is expected

[18] Other categories include salary, alternative funding plans, sessional payments and other. Among these categories, salary is the single largest group, accounting for 10.4% of the gross income of specialists and 6.3% of the gross income of GP/FPs. Source: Ontario Medical Association Human Resource Committee, "Survey of Ontario Physicians, 2003".

to be high. Ontario physicians are compensated based on their claims submitted to the MOHLTC, and the MOHLTC conducts frequent audits of these claims to ensure their accuracy. The OHIP database provides the details of all services rendered by each physician on a daily basis, including the number of physicians providing the services, the geographic location and specialty of physicians, the number of patients treated, the number of medical services provided, the fee code of each service, and the amount billed for each service. To remove the effects of fee changes over the sample period, fees are adjusted using the percentage change in fees implemented by the MOHLTC.

The sample period extends from April 1, 1992 to December 31, 2003. This time period includes sufficient data in the pre-SARS period and in the post-SARS period to provide estimates of both temporary and permanent SARS effects.

Based on our discussion of the expected impact of SARS on the utilization of medical services, we distinguish between four groups of physicians: specialists in Toronto, specialists in the rest of Ontario, GP/FPs in Toronto, and GP/FPs in the rest of Ontario. For each of these groups of physicians, we have 4,292 daily observations.

Figure 3 presents the average daily medical service utilization on a monthly basis, measured as the fee-adjusted expenditures per physician, for the four groups of physicians defined by their specialty and geographic location.

Two vertical lines in the figure indicate the beginning and the end of the SARS outbreak period. The figure suggests that there was a temporary drop in the utilization of medical services for all groups of physicians, but that the utilization has recovered in the post-SARS period. What is also evident from the graph is that it is necessary to control for both the time-trend and the seasonality factors in order the isolate the impact of SARS. In our empirical analysis, we control for these factors in a multivariate regression framework.

5. Results

5.1 Basic Results

The estimates of model (1) are presented in the upper panel of table 2[19]. The average temporary SARS impact on the utilization of medical services is negative 8 per cent. This estimate is quite large and highly significant. On the other hand, the SARS permanent effect on the utilization of medical services is very small, negative and not statistically significant.

The bottom panel of table 2 presents the estimates of the SARS temporary and permanent impact by the location and specialty of physicians, as specified in model (2). We find that the utilization of services for all four groups of physicians was negatively and significantly affected during the SARS outbreak. The temporary effect was largest for those physicians located in Toronto, as expected, but there were no significant differences between specialists and GP/FPs, in either Toronto or the rest of Ontario. On the other hand, there was no significant permanent SARS impact on utilization of services for any group of physicians.

5.2 Decomposition of the SARS impact

Table 3 presents the estimates from models (1) and (2) when the dependent variables are the three components of medical service utilization: patients/physician, services/patient, and expenditure/service.

The upper panel presents the average SARS effects, while the bottom panel presents the effects disaggregated by the location and specialty of physicians. The first column is identical to table 2, and is reproduced for convenience.

Our results indicate that the average temporary SARS impact on utilization of medical services per physician (- 8 %) is due mainly to the decline in the number of patients per physician (-5.67 %). The rest of the decline in the utilization of medical services is attributable to the

[19] All models are estimated by ordinary least squares with robust standard errors.

change in the mix of medical services provided (-2.44 %), with no temporary change in the intensity of medical treatment.

With respect to the average permanent SARS effect, we find that the drop in the number of patients per physicians is not significantly different from the pre-SARS period. On the other hand, both the intensity of medical treatment (services/patient) and the mix of services provided (expenditure/service) are significantly different from the pre-SARS period. In particular, it appears that the medical treatment is more intense (by 2.44%) and that the mix of services is less costly (by -3.13%) in the post-SARS period relative to the pre-SARS period. These two effects offset each other, explaining why we found no average permanent effect on the utilization in the medical services in table 2.

Our results in the bottom panel of table 3 indicate that the temporary drop in the number of patients per physicians was stronger in Toronto than in the rest of Ontario and stronger for specialists than for GP/FPs, but only the former difference is statistically significant. As discussed before, these results are consistent with a number of explanations, and in the next subsection, we will try to disentangle the impact of SARS on the demand for medical services by testing the hypothesis that the impact on demand should vary systematically with the intensity of the outbreak and events that influence patients' perception of the cost of infection and the prevalence of the disease.

In contrast, there were no significant permanent SARS effects on the number of patients per specialists, but the number of patients per GP/FP seems to be significantly higher in the post-SARS period relative to the pre-SARS period.

With respect to the intensity of medical treatment, we find that the number of services provided by specialists per patient was significantly higher both during the SARS outbreak and in the post-SARS period relative to its pre-SARS level. On the other hand, the number of services provided by GP/FPs per patient was significantly lower during the SARS outbreak, but SARS did not have any permanent effects. With respect to the mix of medical services, we find that the fee-adjusted expenditure per service fell for physicians of all specialties and in all locations, both temporarily and permanently.

As discussed before, SARS may have affected a number of factors that would alter the intensity of medical treatment and the mix of medical services provided. While it is difficult to ascertain the relative importance of each of these factors, the results for the mix of services provided do not support the hypothesis that physicians induced demand for their services, because physicians would induce demand for services that are compensated at higher, not lower, rates. Similarly, the results for the intensity of medical treatment provided by GP/FPs – that the number of services per patient was smaller during the SARS outbreak – is also not consistent with the physician-induced demand hypothesis. On the other hand, the number of services per patient for specialists was larger in the post-SARS period, and this is in agreement with the physician-induced demand (PID). However, this evidence for the PID is rather weak, given that patients in Ontario may see specialists only if their family doctors refer them to specialists.

5.3 The SARS impact by time period

In this section, we examine whether the drop in the number of patients per physician is consistent with the hypothesis that the drop should be larger the more prevalent is the disease and the higher is the perceived cost of infection.

Firstly, we look at the number of SARS probable cases, which is intended to capture the prevalence of SARS, and the number of SARS-related deaths, which may influence the perceived cost of infection among patients. The results are presented in table 4 for the discount factor of 0.1[20].

Our results indicate that the number of probable SARS cases decreased the number of patients per physician, both in Toronto and in the rest of Ontario. However, this effect is

[20] Our results in tables 4, 5, and 6 are reasonably robust to variation in the discount factor between 0.1 and 0.5.

statistically significant only for Toronto, indicating that each additional SARS case reduced the number of patients per physician by 0.1 per cent beyond the average SARS effect. Consistent with our previous findings, the average temporary SARS impact remains negative and significant, while the average permanent effect remains small and insignificant.

With respect to the number of SARS-related deaths, our results indicate that the impact of additional deaths decreased the number of patients per physician by 0.6 percent in the rest of Ontario and by 1.2 percent in Toronto. Both of these effects are estimated precisely. As before, the results also indicate a significant temporary impact of SARS and no significant permanent effect.

Secondly, we examine whether the number of patients per physicians varied systematically with a number of announcements that the WHO made during the SARS outbreak. In particular, we examine the impact of the WHO travel advisory, and the impact of Toronto being put on the WHO list of areas with recent local transmission during the first and the second wave of SARS.

Our results are presented in table 5. As expected, all three WHO announcements had significant negative effect on the number of patients per physician in Toronto with no effect in the rest of Ontario. The estimates are large in magnitude (-10% for the travel advisory and about -7% for each of the WHO list announcements), and do not affect the estimate of the temporary and permanent SARS average effects.

5.4 The impact of SARS and the government policy

In this last subsection, we examine the impact of government SARS-related policies. Firstly, we test whether the day the Ontario government announced SARS a provincial emergency and the day when the government lifted this emergency had any significant impact on the utilization of medical services per physician.

The results are presented in table 6. We find that the start of the SARS emergency status had a negative impact on the utilization of medical services, but the impact was significant only in Toronto. This impact was above and beyond the average temporary impact of SARS. Consistent with our previous results, the average temporary impact is negative and significant, while the permanent average impact is insignificant. In addition, we find that the end of the SARS emergency status had a positive effect on the utilization of medical services. This impact is significant for both Toronto and the rest of Ontario, and holds even after we control for the average and temporary impact of SARS. These two results are entirely consistent with the fact that government policy had an important impact on the utilization of medical services during the SARS outbreak.

Secondly, we test whether the drop in the in-patient procedures was consistent with the government policy according to which all non-essential services in hospitals were suspended. We divide a subset of in-patient procedures into elective and urgent and then estimate model (1) using the log of the number of patients and the log of the number of services as the dependent variables. Since most of physicians providing these procedures are specialists, we omit the indicator for the type of specialty and its interactions with the rest of the independent variables.

The results are presented in table 7. We find that SARS had significant negative temporary impact on both the elective and the urgent procedures, and for both physicians located in Toronto and physicians located in the rest of Ontario. This impact holds for both the number of patients and the number of services. Moreover, and for each dependent variable, the SARS impact was larger for elective procedures than it was for urgent procedures. These findings are consistent with hypothesis that government policy effectively reduced the utilization of medical services during the SARS outbreak.

On the other hand, SARS had no permanent impact on the number of patients, but the number of services seems to have increased significantly in the post-SARS period, for both elective and urgent procedures, and for both Toronto and the rest of Ontario physicians.

6. Conclusions

Economic costs of infectious diseases include not only the caseload costs but also welfare loss due to distortions in individuals' behaviour. Understanding the extent to which infectious diseases distort individuals' behaviour is therefore critical to appreciate the full welfare cost of these diseases, and to guide the allocation of society's scarce resources on prevention and treatment between various diseases. Moreover, understanding how individuals respond to the prevalence of infectious diseases informs us about the dynamics of infectious diseases and should help us to design disease-control policies more effectively.

In this paper, we exploited exogenous timing of the SARS outbreak in Ontario, Canada to examine the extent to which SARS distorted behavior of individuals in the market for medical services. The evidence indicates that the SARS outbreak had a negative temporary impact on utilization of medical services, but no long-lasting effect. There are at least two welfare consequences implied by these results. First, the welfare of physicians during the outbreak was unambiguously reduced, as their gross incomes fell in tandem with the fall in utilization of medical services. Second, lower utilization of medical services may cause long-term welfare loss if the forgone medical services negatively affect population health in the future.

Most of the drop in medical care utilization can be attributed to the fall in the visits of patients per physician, suggesting that the SARS impact was strongest on the demand for medical care. This finding is important for policy because it implies that individuals behave rationally during the course of infectious diseases, and that any government policy to control the spread of disease must take individuals' behaviour into the account. This implication is drastically different from the epidemiology studies, which studies the dynamics of disease transmission in a fixed environment and with assuming that individuals do not respond to the incidence and prevalence of diseases.

We have also shown that government policy was effective in reducing the utilization of medical services. The extent to which this policy was cost-efficient and effective in controlling the spread of SARS is still debated. It would be interesting to see if other countries affected by SARS and whose governments implemented different control policies also experienced lower utilization of medical services.

Lastly, our results indicate that SARS had significant impact on the number and type of medical services provided. Our data is too aggregate to discriminate between alternative explanations for these results; however, it is interesting to note that our results are not supportive of the physician-induced demand hypothesis. Further research into this topic, perhaps focusing on specific types of medical services, would be most useful.

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Table 1. Timeline of the SARS Outbreak in Ontario, Canada

SARS I: March 13, 2003 – April 7, 2003

March 14, 2003	MOHLTC[1] issues its first alert regarding SARS
March 15, 2003	Toronto first appears on the WHO list[2]
March 26, 2003	SARS declared a provincial emergency in Ontario.

Between the Waves: April 8, 2003 – May 22, 2003

April 23, 2003	WHO issues a travel advisory for Toronto
April 29, 2003	WHO withdraws its travel advisory
May 14, 2003	Toronto removed from the WHO list[2]
May 17, 2003	Ontario lifts the SARS emergency

SARS II: May 23, 2003 – June 30, 2003

May 26, 2003	Toronto put back on the WHO list[2]
June 12, 2003	The last probable case detected in Toronto
July2, 2003	Toronto stops appearing on the WHO list[2]

[1] Ministry of Health and Long-Term Care in Ontario.
[2] The WHO list of areas reporting local transmission of SARS.

Sources:

1. Health Canada, http://www.hc-sc.gc.ca/english/protection/warnings/sars/learning.html
2. World Health Organization, http://www.who.int/csr/sars/

Table 2. SARS impact of utilization of medical services

Dependent variable = log (fee-adjusted expenditures/physician)	
Average Temporary Impact	**-0.0800**
Average Permanent Impact	-0.0015
Temporary Impact, By Specialty and Location	
Specialists, Toronto	**-0.0930**
Specialists, Rest of Ontario	**-0.0600**
GP/FPs, Toronto	**-0.0995**
GP/FPs, Rest of Ontario	**-0.0668**
Permanent Impact, By Specialty and Location	
Specialists, Toronto	0.0092
Specialists, Rest of Ontario	0.0060
GP/FPs, Toronto	-0.0090
GP/FPs, Rest of Ontario	-0.0121

The coefficients in bold are significant at 5% or better. Robust standard errors are in parentheses. The coefficients are presented in percentage terms, obtained from the estimates by taking their anti-logs (to base e) and subtracting 1. The regression models also include an indicator for physicians located in Toronto and for physicians who are specialists, a quadratic time-trend, a set of seasonal dummies, and the interactions of the linear trend and the seasonal dummies with indicators for the physicians located in Toronto and specialists. The number of observations is 17,168 (4 groups and 4,292 time periods). Source: Ontario Health Insurance Plan database (April 1, 1992 to December 31, 2003), Ministry of Health and Long-Term Care, Ontario, Canada.

Table 3. Decomposition of the SARS impact

	Fees / Physician	Patients / Physician	Services / Patient	Fees / Service
Average Temporary Impact	**-0.0800**	**-0.0567**	-0.0003	**-0.0244**
Average Permanent Impact	-0.0015	0.0062	**0.0244**	**-0.0313**
Temporary Impact, By Specialty and Location				
Specialists, Toronto	**-0.0930**	**-0.0810**	**0.0104**	**-0.0232**
Specialists, Rest of Ontario	**-0.0600**	**-0.0406**	**0.0242**	**-0.0434**
GP/FPs, Toronto	**-0.0995**	**-0.0725**	**-0.0243**	-0.0050
GP/FPs, Rest of Ontario	**-0.0668**	**-0.0317**	**-0.0110**	**-0.0256**
Permanent Impact, By Specialty and Location				
Specialists, Toronto	0.0092	-0.0118	**0.0389**	**-0.0169**
Specialists, Rest of Ontario	0.0060	-0.0045	**0.0441**	**-0.0321**
GP/FPs, Toronto	-0.0090	**0.0170**	0.0050	**-0.0304**
GP/FPs, Rest of Ontario	-0.0121	**0.0247**	0.0100	**-0.0455**

Notes: Same as for table 2.

Table 4. SARS cases and SARS-related deaths

Dependent variable = log (patients/physician)		
SARS Cases	-0.0002	
SARS Cases × Toronto	**-0.0016**	
Temporary Impact	**-0.0379**	
Permanent Impact	0.0061	
SARS Deaths		**-0.0067**
SARS Deaths × Toronto		**-0.0116**
Temporary Impact		**-0.0372**
Permanent Impact		0.0075

Notes: The discount factor is 0.1. The rest of the notes are as for table 2.

Table 5. WHO: Travel advisory and List of areas with local transmission

Dependent variable = log (patients/physician)			
Travel Advisory	0.0300		
Travel Advisory × Toronto	**-0.1039**		
Temporary Impact	**-0.0545**		
Permanent Impact	0.0062		
WHO List I		0.0463	
WHO List I × Toronto		**-0.0719**	
Temporary Impact		**-0.0575**	
Permanent Impact		0.0062	
WHO List II			0.0069
WHO List II × Toronto			**-0.0785**
Temporary Impact			**-0.0537**
Permanent Impact			0.0062

Notes: Same as for table 4. Definition of variables: *Travel Advisory*: the WHO advisory for postponing travel to Toronto (April 23, 2003); *WHO List I*: Toronto put on the WHO list of affected areas during the first SARS wave in Ontario (March 15, 2003); *WHO List II*: Toronto put on the WHO list of affected areas during the second SARS wave in Ontario (May 26, 2003).

Table 6. Ontario provincial emergency

Dependent variable = log (fee-adjusted expenditures/physician)		
Start of Emergency	-0.0758	
Start of Emergency × Toronto	**-0.1474**	
Temporary Impact	**-0.0677**	
Permanent Impact	-0.0015	
End of Emergency		**0.1204**
End of Emergency × Toronto		-0.0457
Temporary Impact		**-0.0872**
Permanent Impact		-0.0015

Notes: Same as for table 4. Definition of variables: *Start of Emergency*: Ontario government declares SARS a provincial emergency (March 26, 2004); *End of Emergency*: Ontario government lifts up SARS emergency (May 17, 2004).

Table 7. In-patient procedures

	Dependent Variable:	
	Log (Patients)	Log (Services)
<u>Elective Procedures</u>		
Temporary Impact		
Toronto	**-0.1236**	**-0.1214**
Rest of Ontario	**-0.1167**	**-0.1108**
Permanent Impact		
Toronto	-0.0058	**0.1317**
Rest of Ontario	0.0078	**0.1462**
<u>Urgent Procedures</u>		
Temporary Impact		
Toronto	**-0.0613**	**-0.0484**
Rest of Ontario	**-0.0678**	**-0.0508**
Permanent Impact		
Toronto	**-0.0499**	**0.0914**
Rest of Ontario	-0.0330	**0.1128**

Notes: Elective in-patient procedures include: elective abdominal aortic surgery, cholecystectomy, hip/knee replacement, and transurethral resection of prostate. Urgent in-patient procedures are: carotid endartectomy, colectomy, thoracotomy, total prostatectomy, lumpectomy or mastectomy, and initiaon of mechanical ventilation. For more details, see Woodward et al. (2004).

Figure 1. Number of Probable Cases of SARS in Canada
February 23 to June 30, 2003

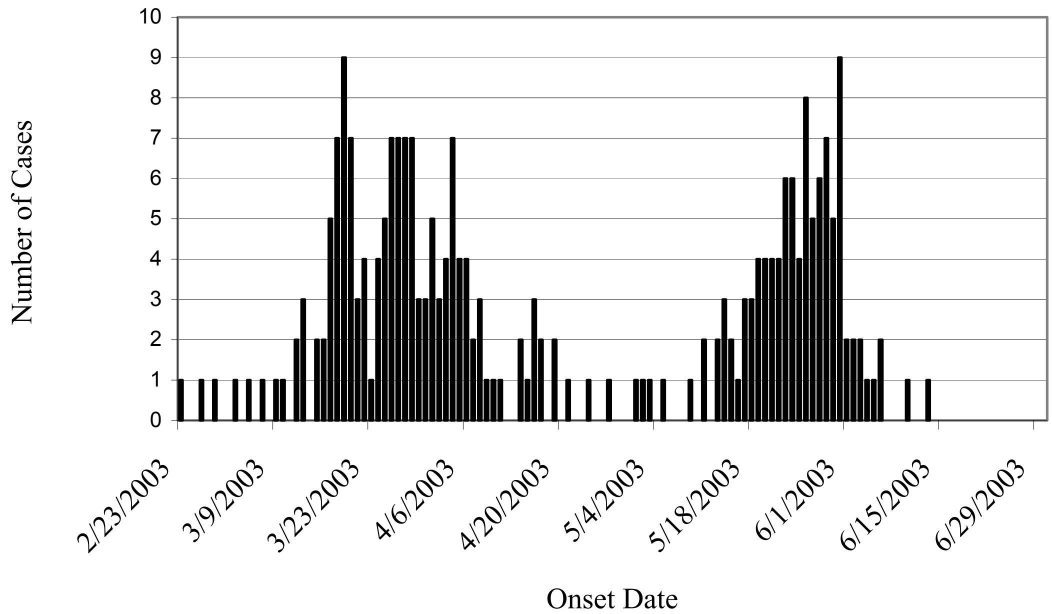
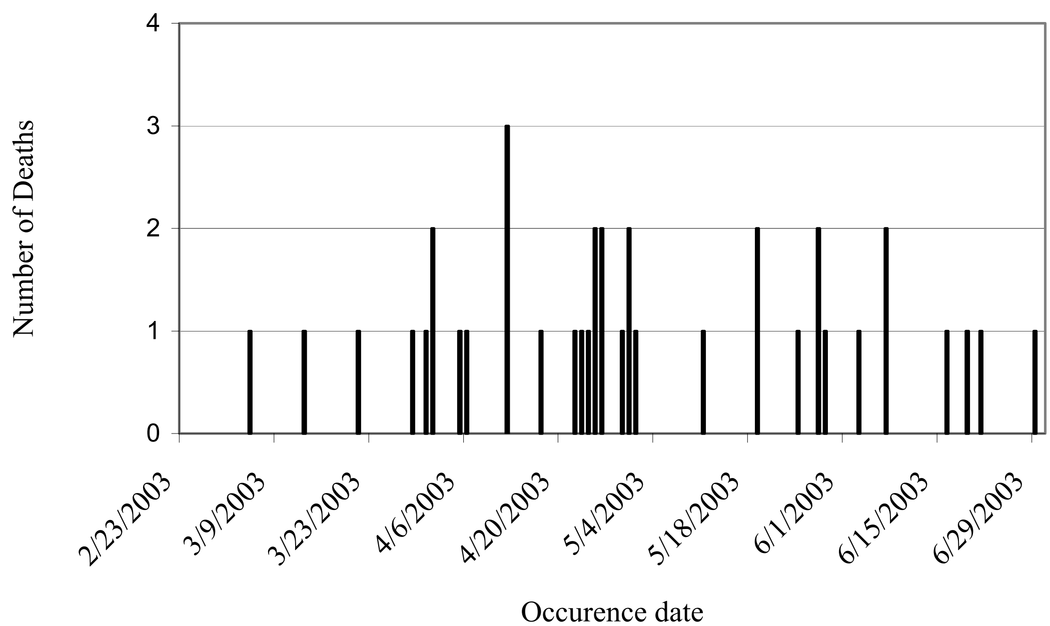


Figure 2. Number of SARS deaths in Canada
February 23 to June 30, 2003



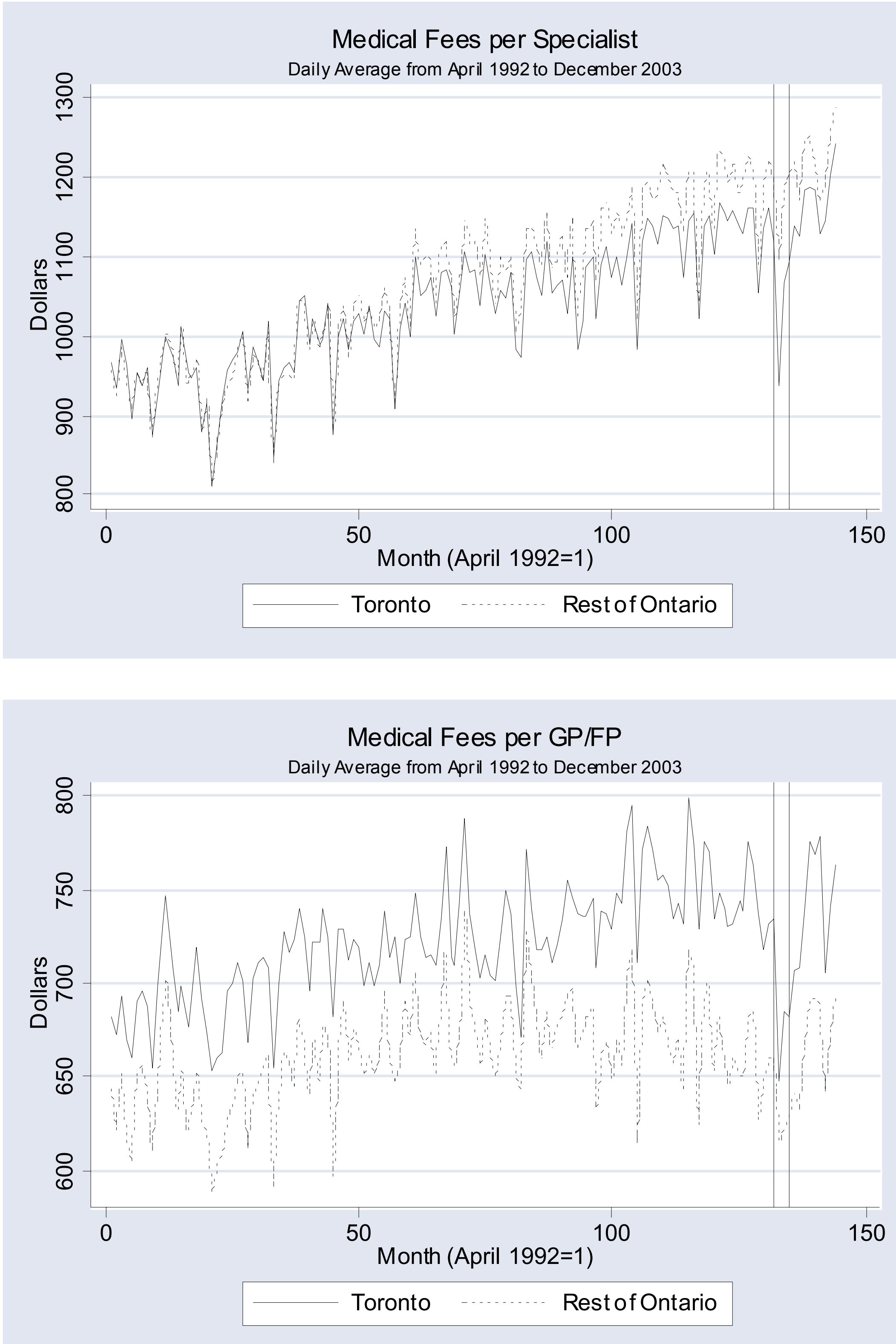


Figure 3. Medical fees per physician, by specialty and location.