The Determinants of Waiting Times for Elective Surgery in the Canadian Health Care System

By
Hassan Tamtam
3114917

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Supervisor: Professor Kathleen Day
ECO 7997

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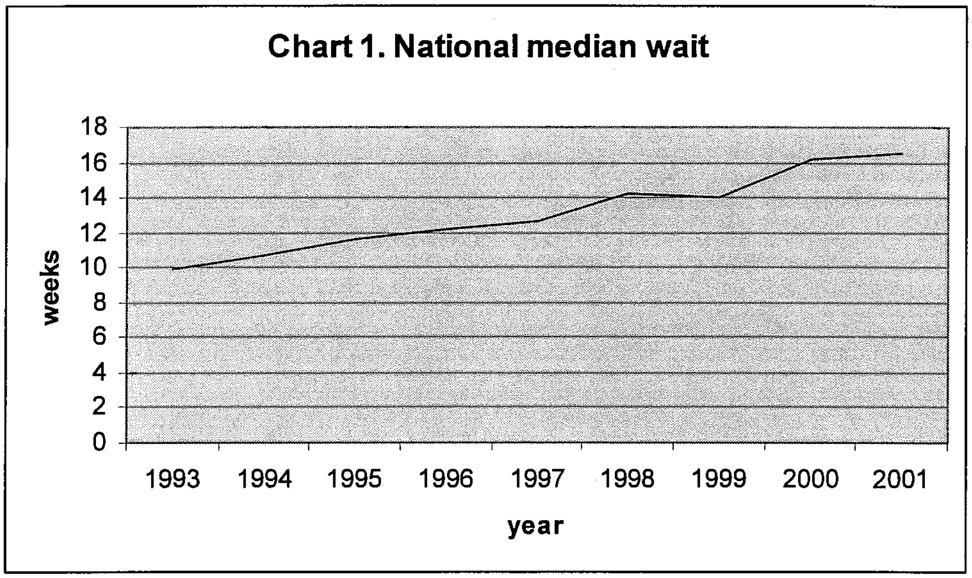
Abstract

Since the mid 1990s, there has been an increase in waiting times for elective surgery in all Canadian provinces. In this paper, I attempt to identify the determinants of waiting times by conducting an econometric analysis, adapting the general lines of Zelder's (2000) model. While Zelder investigates the variations in waiting times among Canadian provinces using health care expenditure as the key variable, both in aggregate and divided into several health spending components, I depart from him by including a variable related to physician productivity and interaction terms between health spending components. The main similarity between our results is the finding that there is little association between waiting times and aggregate spending. However, our results differ when spending is disaggregated. In his case, spending on drugs reduces waiting times, but my results do not support his findings.

1. Introduction

Waiting times for elective (non urgent) surgery are a significant problem faced by many industrialized countries including Canada. Chart 1, based on data published by the Fraser Institute, illustrates the change in waiting times from 1993 to 2001 for Canada as a whole. [1] The chart shows that the median wait for Canada increased fairly steadily from 1993 to 2001.



As table 1 shows, the increase in waiting times for Canada as a whole is due to increases in waiting times for all provinces since the mid 1990s. The median waiting time has increased by about 254% for Saskatchewan and by 8.6% for Prince Edward Island. The increase in waiting times is 53% for New Brunswick and 67% for Ontario. For the remaining provinces waiting times have increased by over 80%. However, waiting times actually deceased between 2000 to 2001 in British Columbia, Quebec and New Brunswick. In 2001, Saskatchewan had the longest waiting time of 32.6 weeks, compared to the shortest waiting time for Ontario, which is 14 weeks.

[1] For more details about the Fraser Institute data, see section 4.1.

While it is true that there is no single explanation for the existence of waiting times, it is important that their causes be thoroughly investigated before any action to reduce them or to allocate additional funding is taken. Such an investigation becomes more crucial in cases in which the quality of life of the patients is affected by the wait. Possible explanations for the increase in waiting times include changes in the health status of the population and reductions in government funding for health care.

In this respect, the Fraser Institute has published some econometric studies attempting to explain the determinants of waiting times. In particular, Zelder (2000) investigated the variations in waiting times among Canadian provinces by carrying out an econometric analysis of the relationship between waiting times and health care expenditure, both as an aggregate and as several health spending components. He concluded that there is no connection between increased spending and waiting times. In other words, the provinces that spend more (per capita) are not necessarily the ones that register shorter waiting times. However, when he considered the different components of spending, a connection between spending on drugs and waiting times was found. Therefore, what matters is not only putting additional money into the system, but, instead, assessing how money enters into the system and how it is spent.

In view of that, the main objective of the current paper is to carry out an econometric analysis of the determinants of waiting times in Canada. Although Zelder's study is interesting, he did not take into consideration factors related to productivity or the interaction between health spending components. My practical goal is thus to fill this gap by including these two factors in my empirical analysis.

The paper is divided into five sections. In the second section, I will describe briefly the theoretical arguments behind the use of waiting lists as a management tool for the available resources. In the next section, I will discuss the determinants of waiting times, and investigate the association between waiting times and several potential determinants of waiting times. I will introduce new determinants which could explain the variations of waiting times among Canadian provinces. In section four, I will apply regression analysis in an attempt to identify the impact of various determinants on waiting times in Canadian provinces. In this section I will extend Zelder's basic model by incorporating the two factors I mentioned previously. In the final section, I will lay out some conclusions and discussion.

2. Theoretical aspects of waiting lists

2.1 Waiting lists as rationing mechanisms

Waiting lists play an important role in health care rationing. In particular, they could be used as a management tool to better ensure the efficient use of scarce resources. However, excessive waits for more degenerative diseases may affect patients' quality of life. A transparent information system regarding waiting lists is necessary as a first step towards solving or at least reducing the magnitude of the problem, whose real scope is still unknown due to the absence of a standardized method of reporting and measuring waiting times.

The medical care sector has its own specificities which are different from those of other sectors of the economy. For example, one important criterion which characterizes health care is the nature of demand. As Arrow (1963) states, "an individual's demand for medical services is not steady in origin as, for example, for food or clothing, but irregular and unpredictable" (Arrow, 1963, 948). Therefore, it is difficult to make any predictions regarding the number of individuals joining waiting lists for medical services.

In health care, a waiting list is defined by Vissers et al. (2001) as a queue of patients waiting for access to a service. This situation characterizes the publicly funded health care system in most industrialized countries, and corresponds to a common situation in a market in which there is no price mechanism to equate supply and demand. In other words, waiting lists reflect, in terms of resources, the fact that the level of resources required to meet demand is not allocated at the current price of the good. Accordingly, the nature of demand for health care is episodic and unpredictable and, therefore, it is difficult to increase continuously the capacity of any system to allow its supply to meet demand at any time. To explain this unpredictability, Street and Duckett make the case that "it is not possible to operate at full capacity any system subject to random fluctuations in demand without a queue developing, and by maintaining a pool of patients the potential for under utilization of hospital resources is reduced" (1996, 2).

The amount of literature on the subject matter of waiting lists is enormous. Given the space and time constraints, to provide a complete account of this literature is beyond the scope of this paper. However, I will provide a description of some of the most relevant theories of waiting lists which are particularly pertinent for the purposes of my analysis of the determinants of waiting times.[2] In particular, my focus will be on the economic literature which relates waiting times to the demand for and supply of services. For example, on the one hand, Lindsay and Feigenbaum (1984) argue that the delay in delivery of service acts as the price of the service on the demand side in the sense that it

[2] For a rich review of the literature on waiting lists, interested readers are referred to Andjelic (2004).

discourages some patients from joining the list. On the other hand, Iversen (1993), for instance, emphasizes the supply side of the hospital care market. His analysis is based on the interaction between the hospital and the government. A third trend in the literature attempts to develop a theoretical model that synthesizes the demand and supply effects of waiting lists. A good case in point of this model is Martin and Smith (1999) who make use of the work of both Lindsay and Feigenbaum (1984) and Iversen (1993) to study the waiting list for admission to the British National Health Service. These papers and several others will be discussed in more detail in the following section.

2.2 Waiting lists, supply and demand

Lindsay and Feigenbaum (1984) distinguish two frameworks of economic theory in which the formation of queues is observed. The first one is related to the stochastic variation in one or both sides of the market, i.e., supply side and/or demand side. Such an environment creates issues of the determination of optimal capacity and equilibrium price. The second framework corresponds to the situation where price is below or above the market clearing level. The authors, on their part, give more attention to the case in which price is below the market clearing level. In this context, they argue that queues of demanders will form to ration the available supply. Their theory is based on two assumptions. On one hand, the delay in receipt of the good can lower its value to demanders. On the other hand, individual demand is unpredictable. They begin with the description of an individual's decision to join the list. They explain that "the effect of both the discount rate and diminishing demand may be expressed in exponential form. Rather than carry them both through the analysis, we will express their combined effect by an exponential demand decay rate *g*" (Lindsay and Feigenbaum, 1984, 407). Then individual behavior is aggregated by the market to describe the sensitivity of the rate of joining the waiting list to the expected delay of delivery. Demand is measured by the rate at which individuals join the queue, and the key argument of the demand function is the expected delivery delay. Their theory suggests a relationship between the rate of joining, the expected wait, the decay rate, and the value of the service.

As I mentioned earlier, the theory of supply is not sufficiently developed in their paper in that they simply hypothesize that the supply of treatment at a given time depends upon a vector of unknown determinants and is affected by the waiting time. However, they use specific variables as the determinants in the empirical section of their paper, which I will discuss later. Waiting time enters on both the demand and the supply side. They maintain that "the theory implies that the rate of joining will be negatively related to expected delay in supply and the rate at which demand diminishes over time. Supply, on the other hand, was hypothesized to respond positively to expected delay" (Lindsay & Feigenbaum, 1984, 417). Their focus on the demand side is due to the central assumption of their theory, which is that the delay in receipt of a good can lower its value to demanders and, consequently, this diminishing value produces the convergence to equality between demand and supply. We can write here the formulation of their demand and supply functions as follows:

Demand: $j = j\,(t, g, v)$ (Lindsay and Feigenbaum, 1984, 413),

Supply: $s_h = s_h(\tilde{w}, t)$ (Lindsay and Feigenbaum, 1984, 409),

where t is the expected wait, g the decay rate, v the value of the service, s_h the service rate at time h, j the joining rate, and $\tilde{w}$ a vector of unknown determinants. The market determination of t implies that "the rate of change in the numbers in the queue in any period h is therefore given by $\dot{Q}_h = j_h(t_h) - s_h(t_h)$" (Lindsay and Feigenbaum, 1984, 409). The authors further explain that we can obtain the expected wait in period h by dividing the total number in the queue Q_h by the service rate, so that, $t_h = Q_h / s_h$ and the equilibrium t^* is given when $t_h = t_{h+1}$. One can see that the equilibrium corresponds to the equality $j(t^*) = s(t^*)$. This means that market equilibrium permits the value of the expected wait to converge to the equilibrium value for which the rate of joining equates the rate of supply. In section 3 I will discuss the results of their empirical application of this model.

Because Lindsay and Feigenbaum (1984) focus more on the demand side, it becomes necessary for my purpose here to discuss as well the influential paper of Iversen (1993), in which a theoretical model of supply is extensively used. The approach to hospital waiting lists used by Iversen (1993) focuses on the supply side of hospital care and the interaction between a hospital and the government. He claims that in health systems where hospitals are rewarded with more funds if they maintain long waits, government initiatives to address the waiting list problem will have little long term effect. In particular, he analyzes several initiatives taken by the central government of Norway to reduce waiting time for surgery. He explains that if important funding is expected by local governments and hospitals, it is beneficial for the hospital to maintain a long wait.

In Iversen's model, the hospital utility is a function of expected waiting time (t), and the expected number of patients admitted to the waiting list (λ) during a period of time. The hospital maximizes this utility function with the amount of resources, s, as a constraint. The objective of the hospital is (Iversen, 1993, 61):

$$Max\ U = U(t, \lambda) \quad s.t \quad s(t, \lambda) = s.$$

The budget, the waiting time and the number of admissions are the result of the interaction between the government and the hospital. The hospital and the government are different in terms of their objectives and their decision variables. t and λ are the hospital's choice variables, while s is the government's choice variable. The level of s is determined by the budget decision.

The government willingness to pay in Iversen's model is also a function of waiting time and the expected number of patients admitted, $w(t, \lambda)$. The government objective function is (Iversen, 1993, 61):

$$Max\ V(t, \lambda) = w(t, \lambda) - s(t, \lambda),$$

where t is the waiting time announced by the hospital. According to Iversen (1993), in this context the reduction of waiting time depends on the type of interaction between the sponsor (government) and the hospital. He distinguishes two types of interaction which he refers to as a "non cooperative game" and "bargaining". In the first case, there is no contract or any kind of engagement between the two players. That is, there is no engagement from the local government with respect to the budget in the sense that the sponsor can revise the budget during the year, and the hospital is not constrained to achieve any specific waiting time. In the second case, budget and waiting time reductions are specified in a contract between a hospital and a local government. The author makes the important remark that "by rewarding the number of discharges, for instance by a sum related to diagnosis or type of operation a decline in long waits can be expected" (Iversen, 1993, 69). The author analyses these interactions in the context of Nash equilibrium and Stackelberg equilibrium. In Nash equilibrium, it is assumed that the government and the hospital decide simultaneously. According to Iversen (1993), in

Norway the budget allocation is based on waiting lists and waiting times in the sense that the hospital announces its targets t, λ and subsequently the local government decides the level of s. This situation corresponds to the Stackelberg equilibrium with the hospital as the leader and the government as the follower. He asserts that the introduction of contracts between the local government and a hospital could be an important tool to achieve a reduction in long waits.

Worthington (1991) observes that a key role in the demand for health care is played by doctors. In fact, a patient may decide on his or her own initiative to go to the doctor, but all the other consumption acts are decided by physicians. Worthington (1991) distinguishes two important phases of waiting lists, that is, from general practitioner (GP) to specialist and from specialist to treatment. He argues that the waiting list will decrease if the rate of service at each of these phases exceeds the demand. Using queuing theory, he investigates the way in which the demand for service often increases when waiting list size or waiting times decrease. Worthington (1987) refers to this mechanism as "feedback". Once again, it is worth pointing out that it is extremely crucial to take into consideration the theoretical development of both sides, namely, demand and supply, to better understand the complex phenomenon of waiting time.

Martin and Smith (1999), heavily relying on Lindsay and Feigenbaum (1984) and Iversen (1993), come up with a hybrid model of demand and supply for elective surgery. In order to use some important insights of queuing theory, they treat the National Health Service (NHS in the United Kingdom) as a single server with a single queue. They explain that "the insights of queuing theory may be useful, in the sense that they highlight the vital importance of two aspects of any queue in determining waiting times: the supply side (service capacity μ), and the demand side (arrival rate λ)" (Martin and Smith, 1999, 143). They further elaborate that standard queuing theory is based on the assumption that μ and λ are constant and independent of the length of waiting time. The authors consider this simplest situation in order to put emphasis on the importance of two aspects of any queue in determining waiting times, namely, the supply side μ and the demand side λ.

Contrary to this assumption the authors build a model in which the two components μ and λ depend on waiting times. Their model consists of three equations (demand, supply, and an equilibrium condition) and two endogenous variables (utilization and waiting times). The model of demand is a summary of the work of other authors, especially Lindsay and Feigenbaum (1984) and Cullis and Jones (1986), and Goddard et al. (1995). According to Martin and Smith (1999), the net gain to the patient undergoing treatment decreases as the treatment is delayed. They claim that the value of the treatment is expressed by an exponential decay function, and they assume the utility function to be a linear combination of its components (Martin and Smith, 1999, 144):

$$U(V, g, t, P, C) = Ve^{-gt} - P - C,$$

where P represents the cost of private care; t is waiting time; g is the decay factor; V is the individual's valuation of the health gain from treatment; and C is a fixed cost of seeking care that the patient is assumed to face whether NHS or private care. The authors account for three options for the patient: to join the National Health Service waiting list, to seek private care or to seek no treatment. They specifically make use of the first option and add that, "in summary, the numbers $d(\cdot)$ seeking NHS treatment will be negatively associated with exogenous increases in g, t and C and positively associated with P" (Martin and Smith, 1999, 146).

Their supply model is based primarily on Iversen (1993). On the supply side, the hospital managers seek to maximize the following utility function (Martin and Smith, 1999, 146-147):

$$W = W(t_1, \eta, N),$$

subject to the constraint that $S + N = B$, where t_1 represents the projected period 1 waiting time, η is the level of efficiency, N is resources devoted to non-surgical activity, S resources devoted to surgery and B is a total budget constraint. The authors interpret the future waiting time t_1 as a technological function of the parameters S, η and the current queue for surgery Q. I noticed here two important concepts, namely, the resources devoted to surgery (S) and the concept of efficiency (η). Unfortunately, these important variables were not taken into consideration when formulating their demand and supply equations, as can be seen from the following formulations (Martin and Smith, 1999, 151)[3]:

Utilization (demand) =f (waiting time (-), needs (+), family practitioner (?), provision of private inpatient beds (-)) (1)

Utilization (supply) =g (waiting time (+), provision of NHS beds (+)). (2)

The results of their empirical analysis are discussed in section 3.

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[3] The signs in parentheses in the equations below stand for the anticipated direction of each effect. The question mark indicates an unknown effect and the authors explain that whether primary care acts as a substitute or complement for patient surgery is an empirical matter to be determined. "Needs" includes any of the demographic determinants of utilization.

Zelder (2000) analyses the effects of health spending on waiting. The results of his empirical analysis for Canada are discussed in section 3; here I review only his theoretical arguments. Zelder considers three possible effects of increases in health spending on the supply of medical treatment available: an increase in supply, no change in supply, and a decrease in supply. Of these, he considers the first two outcomes to be the most likely. In particular, Zelder argues that if increases in spending are primarily due to wage and price increases, then they will have little effect on the number of treatments performed. Only if spending increases are used to finance increases in capacity (i.e., to increase the quantity of doctors, nurses, medical equipment, etc.) will they lead to an increase in the number of treatments. Moreover, he points out that if inputs to the production of treatments are complements rather than substitutes, then an increase in the quantity of only one type of input may not lead to increases in the number of treatments.

Although he thinks the third outcome is the least likely, Zelder defends the idea that it is possible that increased spending might actually reduce the supply of treatments, and provides two examples of situations in which this could occur. The first occurs if an increase in an input such as administration reduces the number of treatments performed. The second is the phenomenon of diseases, medical malpractice or infections contracted while in hospital, which results in patients staying in hospital longer so that fewer patients can be treated.

Besides these direct supply effects of spending, there are also some potential indirect effects, which shift the demand curve for treatments. Once again, Zelder gives examples of situations in which this could take place. Some patients who are not initially demanders of care (e.g., people with back pain, not a potentially fatal ailment) could join the waiting list for care, when they know that more treatments are now available. He explains that the overall effect of increased spending depends on this complex interaction between demand and supply shifts.

Despite my focus here on demand/supply analysis in explaining waiting lists or waiting times, the economic literature is interested in many other aspects of waiting lists. Such aspects include, for instance, the cost of waiting lists in terms of lost work time, fairness and equity. A system of waiting lists requires resources and among those are the resources needed for the administration of the system as well as the resources needed for the examination and treatment of patients. Propper (1990) estimated the total cost through an experiment in which subjects were asked to choose between immediate treatment (at a varying range of out-of-pocket costs), and delayed service (at a varying range of time intervals) at no out-of-pocket cost. The main conclusion of this study is that health care rationing by waiting lists is costly. Fairness and equity are among the main concerns regarding waiting list organization and management. In terms of waiting lists, this means universal, equitable access for all medical procedures based on the patient need. The implementation of a queue-management system is necessary to help ensure that all patients in need receive service in a timely and fair fashion. Consequently, the decision to prioritize patients should be done according to clear, transparent and agreed-upon criteria that reflect the patient's need.

In summary, the main question addressed by theoretical literature on waiting times is to the extent to which an increase in supply intended to reduce waiting time, would in the long term, induce additional demand. The importance of models of waiting lists for elective surgery is that they show that waiting times are the result of intricate supply and demand interactions. Waiting times will therefore depend on the variables that shift the supply and demand curves for elective surgery, including productivity and efficiency.

3. The determinants of waiting times

In this section, I begin by reviewing several descriptive analyses which will allow me to highlight some important determinants of waiting times. After a brief review of Street and Duckett (1996) on financial incentives for hospital, I will present Hurst and Siciliani's (2003) comparison of the policies introduced in some OECD countries to reduce waiting times. Such policies are supposed to be related to the determinants of waiting times. I will also draw upon Siciliani and Hurst's (2003) international comparison of some important indicators, especially those measuring the capacity of the health care system.

Although the descriptive analyses suggest some interesting relationships between waiting times and other factors, only an econometric analysis can pinpoint the role of each particular determinant of waiting times. Thus in section 3.2 I discuss the few econometric analysis of waiting times that currently exist. Finally, in section 3.3 I summarize what the literature suggests are the most likely determinants of waiting times.

3.1 Descriptive analyses

Street and Duckett (1996) deal with a policy where hospital financial incentives are related to the treatment of patients. Hospitals are paid on the basis of their output; each patient treated attracts payment according to the patient's diagnostic category. They describe how such incentives lead to a waiting list reduction. The two main conclusions of their paper are the following. First, it is possible to devise policies in order for hospitals to have an incentive to manage their own waiting lists. Second, hospitals do react to incentives to modify behavior, hence the success of the payment policy examined in reducing waiting lists in public hospitals. The authors suggest that the incentives which encourage consultants and hospital managers to maintain waiting lists must be tackled, and they discuss three steps that were taken to tackle waiting lists in the Australian state of Victoria: "First, a method for better defining the problem and categorizing patients was developed. Second, hospital funding was linked to activity to ensure hospitals had the resources to reduce waiting lists. Finally, financial incentives were related specifically to the treatment of patients on the waiting lists" (Street and Duckett, 1996, 7). Their study is based on the analysis of waiting list statistics before and after the introduction of the new funding system. There is no mention of any specific theory or model in their study.

Hurst and Siciliani (2003) compare the policies introduced in twelve countries in order to reduce waiting times. The authors contend that "in principle, waiting times can be reduced through supply-side policies, if the volume of surgery is not considered adequate, or through demand-side policies, if the volume of surgery is considered to be adequate" (Hurst and Siciliani 2003, 4). Subsequently, they give examples of policies related to the supply-side and demand-side. On the one hand, the supply-side initiatives could include raising public capacity and/or increasing productivity. Capacity could be increased by raising the number of specialists and beds, or by using the available capacity in the private sector. The main tool to increase productivity is to link the remuneration system to activity for doctors and hospitals. On the other hand, demand-side policies include tools such as a system of prioritizing patients according to needs and managing access to waiting lists.

Hurst and Siciliani divide the determinants of waiting times and lists into two categories, those which affect the demand-side (inflows), and those which affect the supply-side (outflows). They argue that the demand for elective surgery is determined by the health status of the population and the state of technology. In fact, they suggest that advances in surgical technology and in anesthesia could be a possible explanation for the increase in waiting times over the last three decades. It is true that with advanced technology many diseases can be diagnosed more easily than twenty or thirty years ago. The authors explain that "many procedures are now carried out at a lower unit cost, as day cases rather than involving one or more overnight stays in hospital. As a consequence, there have been dramatic increases in the demand for surgical procedures, especially elective (non urgent) procedures, such as cataract surgery, hip replacements and coronary artery bypass surgery in all OECD countries" (Hurst and Scicilinai, 2003, 10). In the same way, the Canadian Institute for Health Information (CIHI, 2006) points to the improved availability of the technology and a greater knowledge of diseases as factors that may explain the increased use of angioplasty.

Moreover, Hurst and Siciliani (2003) note that in practice, decreasing waiting times requires combining different policies directed towards supply and demand, or acting directly on waiting times. According to them, the dominant policy depends on the rate of surgery (if it is adequate or not). Hurst and Siciliani (2003) illustrate policies that act directly on waiting times by using the examples of the introduction of maximum waiting time guarantees or the implementation of financial and non financial incentives related to the achievement of reduction of waiting times. They further explain that "there is a wide range of examples of the implementation of maximum waiting-time guarantees. However, in a number of countries they have been modified or abandoned (Denmark, Norway, and Sweden). Moreover, there seems to be no great agreement on the way to formulate the guarantee" (Hurst and Siciliani, 2003, 41).

In another paper, Siciliani and Hurst (2003) compare twelve countries, including Canada, with waiting time problems for elective surgery to eight countries with no waiting time problem to see what factors may explain the absence of long waiting times. The first group (group without waiting times) includes Austria, Belgium, France, Germany, Japan, Luxemburg, Switzerland, and the United States. The second group (with waiting times) includes Australia, Canada, Denmark, Finland, Ireland, Italy, Netherlands, New Zealand, Norway, Spain, Sweden, and the United Kingdom. In the following discussion, I compare the reported data for Canada with data for a subset of the OECD countries examined by Siciliani and Hurst (2003) (for simplicity I choose only a subset of the OECD countries they examine).[4] All the data are extracted from their study.

Table 2 shows total health expenditure per capita in US$ purchasing power parities based on the price of a basket of health related goods and services. For instance, in 2000, total expenditure per capita in Canada was $2580 as compared to $3160 for Switzerland, a country with no waiting time. It is difficult to draw any conclusive association between spending and waiting, given the existence, as reported in Siciliani and Hurst (2003), of countries such as Austria, France, Belgium, and Japan that have lower waiting times while spending less than Canada.

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[4] I did not follow any particular rule in my choice of a subset of the OECD countries.

In table 3 we can see that countries without waiting times have more capacity in term of acute care beds than countries with a waiting time problem. For example, the ratio is 3.2 in 2000 in Canada compared to 6.7 for France. With the exception of the United States of America, all countries which do not report waiting times have a systematically higher number of acute care beds. This comparison suggests that there is a clear negative association between waiting times and capacity, measured in terms of beds.

In table 4 we can see that countries without waiting times tend to have more capacity in terms of physicians' density than countries with a waiting time problem. By way of illustration, in Canada the number of practicing physicians per 1000 population is 2.1 in 2000 compared to 3.3 for Germany. In Canada the number of practicing specialists is 1.1 in 2000 compared to 2.2 for Germany. However, the complete table in Siciliani and Hurst shows a few exceptions such as Denmark with waiting time problems despite having a higher number of practicing physicians and a higher number of practicing specialists.

Tables 5 and 6 involve two measures of the output of the health care system. While table 5 measures output in terms of total surgical inpatients per 1000 population, table 6 shows output in terms of total discharges per 1000 population. For instance, in 2000 the ratio of total surgical inpatients per 1000 population is 33.9 in Canada, as compared to 130.1 for Austria (table 4). Similarly, the ratio of total discharges per 1000 population is 93.9 in 2000 for Canada, as compared to 284.4 for Austria (table 5). These tables show that countries without waiting times have higher output. However, we don't know if this is due to higher levels of resources or to higher productivity.

Tables 7 and 8 show that countries without waiting time problems have higher productivity than countries with a waiting time problem, whether productivity is based on surgical inpatients (table 7) or on total discharges (table 8). These two tables report average productivity measured in three different ways: per acute care beds, per practicing physician or per practicing specialist. For instance, in Canada the number of surgical inpatients per practicing physician is 16.1 in 2000, compared to 51.7 for Luxemburg (table 7). On the other hand, the number of discharges per practicing physician in Canada is 44.7 in 2000, compared to 91.7 for Austria. However, it is difficult to derive a conclusive comparison of the productivity using this indicator reported in tables 7 and 8. In fact, Australia seems to be more productive than France if productivity is measured as discharges per acute care bed.

Tables 2 to 8 suggest that variations in expenditure may be an important determinant of waiting times, but it is certainly not the only one. It would be interesting to analyze the impact on waiting times not only of aggregate spending, but also of its components as does Zelder (2000) (to be discussed below). With respect to spending the important question may be how spending increases enter the health care system and how they are used, not what the overall level of spending is.

3.2 Summary of econometric analyses

While there is an abundant literature on the theoretical aspects of waiting lists, there is little empirical literature. The main reason for this, as pointed out by Godard and Tavakoli (1998, 545), "is undoubtedly the difficulty in obtaining data at a significant level of disaggregation to allow meaningful comparison between the two principal variables of interest: the duration of wait and the level of demand for treatment." Accordingly, it would be interesting to discuss the empirical results for these studies, especially those focusing on both demand and supply side variables. The paper by Lindsay and Feigenbaum (1984) is of interest because it constitutes, in terms of framework, the basis for several subsequent papers. Then I will discuss the paper of Martin and Smith (1999) which develops both the demand and supply sides, followed by a discussion of Siciliani and Hurst's (2003) paper. Finally, since I am going to carry out an econometric analysis of the determinants of waiting times in the Canadian context, I will discuss in more detail the paper of Zelder (2000).

In the empirical part of their paper, Lindsay and Feigenbaum (1984) test their model of waiting lists that was described in section 2.2. They use data on waiting lists for fourteen medical conditions in British health regions in 1974. They find that the rate of joining the list is negatively associated with the expected delay in receiving medical care and with the decay rate. Since Lindsay and Feigenbaum don't have data on numbers actually joining each queue in each period, they propose that in equilibrium, the rate of joining will equal the rate of output, for which they have data. They make use of data on mean waiting time for the year 1974 for each disease category by region. They test to which extent an increase in capacity may reduce waiting times without causing a significant increase in demand for surgery. Lindsay and Feigenbaum (1984) use as the dependent variable for the supply equation the number of cases treated per 1000 population. The available beds per capita and doctors per capita are expected to have a positive sign in their supply equation. In the same way, the wait (delay) is expected to have a positive sign, meaning the longer the expected wait per condition is, the higher is the rate of output. Hurst and Siciliani (2003, 15) also express the same expectation: "At the same time, higher waiting times may raise supply by encouraging public authorities to allocate more money to public hospitals with longer queues."

As they suppose that the rate of supply and the wait are jointly endogenous, they employ predictors of delay which are uncorrelated with the disturbance term. These predictors were obtained by regressing mean waiting time for each condition by region on exogenous supply and demand determinants (Lindsay and Feigenbaum, 1984, 414). The supply variables are hospital beds available by region per 1000 population and the number of doctors on hospital staffs per 1000 population. The demand variables are the proportion of the regional population 65 years and older and a dummy variable for disease category.

Because there is no objective measure of the decay rate *g*, with the assistance of a practicing physician the authors group patients into three categories. The first category corresponds to non-emergency cases for which alternatives to hospital care were available. The second category is also non emergency cases, that do not grow worse with delay in treatment such as hernia or cataracts but for which no alternative to hospital therapy is available. The third category is cases which rapidly grow more serious over time. This category was removed from the sample. In another specification, they include on the demand side the proportion of the population either over 64 or under 15 years, assuming that these age groups are disproportionate users of hospital care.

They use these predictors to estimate separately the demand and supply equations, using data for British health regions in 1974. Although their focus is on the parameter estimates of the demand and supply equations, they do report in a footnote the results for the reduced form equation used to generate an instrument for mean waiting time (Lindsay and Feigenbaum, 1984, 414, footnote 9). The results for this equation, which are of particular interest given my paper's focus on waiting times, show that hospital beds and physicians per capita have negative and statistically significant effects on waiting times. According to their estimates, an increase of 1 bed and 1 physician per capita reduce mean waiting time respectively by 1.3 and 9.6 weeks (Lindsay and Feigenbaum, 1984, 414). This means that an increase in the number of physicians reduces waiting time by considerably more than does an equal increase in the number of acute care beds. What is important to notice is the fact that waiting times or waiting lists are a result of a complex mechanism between demand and supply variables. Therefore, the analysis of waiting times for elective surgery would depend on the determinants considered to reflect these demand and supply variables.

Similarly, Goddard and Tavakoli (1998) found a negative link between waiting times and demand. They point out the reverse effect of the implementation of a maximum waiting time guarantee policy. According to these authors any attempt to guarantee a maximum wait may encourage more patients to joint the waiting lists. They use panel data for Scottish Health Board Areas during 1990-1992. They estimate their demand function for six specialties.

Martin and Smith (1999) use data for 1991-1992 covering 5000 local health areas throughout England to estimate equations (1) and (2) discussed earlier in section 2. They find that a 10% increase in bed supply is associated with a 2.4% reduction in mean waiting time. They note that the use of data at the regional level masks the intraregional variability in waiting times: "we should note that ideally we should have estimated our model at the level of the individual patient rather than the small area. However, no adequate data are available for such purposes" (Martin and Smith, 1999, 148).

In their model, the patient's decision to join a queue depends among other factors on waiting time, income and price of private treatment. The authors use the standardized waiting time defined as the ratio of actual waiting times in the region to clinically expected waiting times. They employ a multiplicative model and estimate linear equations after taking natural logarithms of all variables. According to their results, on the demand side the needs variable, an index for acute sector needs, is clearly significant and has the expected positive effect on demand. The coefficient of the waiting time variable is also significant, and implies that waiting time has a negative effect on the number joining the waiting lists. They conclude that waiting times are the result of a complicated interaction between supply and demand variables.

The determinants of waiting time used by Martin and Smith (1999) are different from those used by Lindsay and Feigenbaum (1984). They use on the supply side the provision of NHS beds, while Lindsay and Feigenbaum use, in addition to the latter, the number of doctors. Martin and Smith (1999) use the number of family practitioners on the demand side, but Lindsay and Feigenbaum (1984) do not. Also, the variable *Need* used on the demand side by Martin and Smith is different from the one used by Lindsay and Feigenbaum (1984). As mentioned in the previous paragraph, Martin and Smith (1999) use an index for acute sector needs developed at the University of York. According to them, this index "seeks to measure the relative per capita NHS costs expected in an area as a proportion of the national average costs, after adjusting for supply factors and age and sex" (Martin and Smith, 1999, 150).

The objective of the study carried out by Siciliani and Hurst (2003) is to isolate the partial statistical associations between waiting times and several possible determinants of waiting times. They derive these potential determinants from the comparison of several indicators observed for two groups of OECD countries that was discussed in the previous subsection. Multivariate regression analysis is used to quantify the impact of different determinants on variations in waiting times, but the availability of data differs among countries. The formulation of their model is the following:

$$W_{ijt} = const. + \sum_j d_j \alpha_j + \sum_t d_t \alpha_t + x_{1(it)} \beta_1 + x_{2(ijt)} \beta_2 + error\ term,$$

where the subscript i indicates the country, j the type of surgical procedure, and t the year.

Siciliani and Hurst use two options for the dependent variable: mean or median waiting times. The data cover the period 1996-2001 when they use mean waiting times as the dependent variable. $x_{1(it)}$ and $x_{2(ijt)}$ are vectors of explanatory variables. The first vector varies across time and country but not at the surgical procedure level. The second vector varies across time, country and type of surgical procedure. The variables d_j and d_t are dummies associated with surgical procedure j and year t. They include health care expenditure per capita (total and public), the percentage of procedures carried out as day-surgery, the age of patients and the percentage of the patients who are female as explanatory variables.

They consider different specifications of the model and estimate them using different subsamples of their data set. In one case, they include among the explanatory variables acute care beds and physicians, but not health expenditure in order to avoid multicolinearity. In another case, they include the number of specialists as opposed to the number of physicians. They also include two additional dummy variables, one for countries whose hospitals are partly paid through activity-based funding, and one for countries whose doctors are partly paid on a fee-for-service basis. In all specifications, they include the percentage of procedures carried out in day-surgery.

Their results show a clear negative association between waiting times and capacity, measured either in terms of the number of beds or the number of practicing physicians. A higher level of health spending is systematically associated with lower waiting times. In one specification, they find that at the sample mean, an increase of 0.1 in acute care beds (per 1000 population) and in practicing physicians (per 1000 population) reduce mean waiting time respectively by 5.6 days and 8.3 days. In another specification, they find that an increase in per capita health expenditure of $100 reduces mean waiting time by 6.6 days in the case of total health spending, and by 5.6 days in the case of public health spending. According to their results, the coefficient on the percentage of older population is positive as expected but not always significant.

To explain variations in waiting times for elective surgery between Canadian provinces, Zelder (2000) focuses mainly on real per capita aggregate health spending. In addition, he includes explanatory variables representing other factors which differ among provinces such as demographics, income, strike activity in the health sector and politics.

Comparing the variation in waiting times across the provinces, it is natural to ask whether governments in the provinces with shorter waiting times achieve this result by spending more on health care. Zelder (2000) used data on median weighted waiting times for elective surgery compiled by the Fraser Institute from 1993 to 1998 based on specialists' responses to a survey. He used the median total waiting times between referral from a general practitioner to treatment, averaged across all twelve specialties. The twelve specialties included are plastic surgery, gynecology, ophthalmology, otolaryngology, general surgery, neurosurgery, orthopedic surgery, cardiac and vascular surgery, urology, internal medicine, radiation oncology and medical oncology. For cardiac and vascular surgery, the Fraser Institute includes the median total expected waiting times for emergent and urgent cases for cardiovascular surgery. Most of the other data were obtained from the National Health Expenditure Data (CIHI).

A series of linear regressions were run by Zelder. In these regressions, the dependent variable is waiting time. The explanatory variables are real per capita government health spending (*RPCP*), the percentage of population aged 65 or older (*OVER64*), two dummy variables (*LIB* with the value of 1 if the province's premier was liberal, *CON* with the value of 1 if the province's premier was conservative), health sector strike days per capita, *time* (a time trend), and real disposable per capita income. Zelder (2000) notes that it is not possible to derive any plausible interpretation of the dummies (*LIB, CONS*), because of the lack of any theoretical basis related to political party effects. According to Zelder, these regressions are supply equations, where the government's effective decision to supply particular waiting time is determined by a variety of factors.

I will not analyze all the results of Zelder (2000), but rather discuss only some important results which I can compare with my empirical study. In the first equation, he includes all the explanatory variables I mentioned previously. Here, it should be mentioned that the strike activity variable is not sufficiently defined; in particular, I couldn't identify which health professionals are subsumed under this variable. However, the only variables which have statistically significant coefficients in the regression are those measuring the percentage of population aged 65 or older, and time. Both coefficients are positive as expected (Zelder, 2000, table 6). In order to rule out the possibility that the lack of a significant relationship between spending and waiting is the consequence of provincial differences, Zelder adds provincial dummy variables to his estimating equation, but he once again finds that spending has no significant effect on waiting Zelder (2000, table A1). After the addition of the provincial dummy variables, the coefficient of *OVER64* is no longer statistically significant. What is important to mention here is that the coefficient of the health spending variable (per capita) is not significant, nor does it even have the expected negative sign. In addition, the coefficient is small and equal to 0.0021 in the case without provincial dummies and to 0.0034 in case with provincial dummies. Only the variable *time* is statistically significant in both cases, indicating that waiting times have grown over the sample period 1993-1998.

The other possibility analyzed by Zelder is that the absence of a significant connection between waiting times and health spending might be due to the use of aggregate government spending per capita. He therefore divides government spending into seven components: hospitals, other institutions, physicians, other professionals, drugs, capital and other (the definitions of these components are provided by the author). When the control variables (*OVER64*, income, politics, strike activity) are excluded from the equation, he finds that two categories of spending have an impact on waiting time, namely, other professionals and drugs. However, when control variables were taken into consideration, only one spending category, that is drugs, significantly reduces waiting time. [5]

Zelder investigates the consequences of shifting spending among the seven categories while holding aggregate per capita spending constant. He concludes that in the current configuration of the health care system, shifting spending from "other institutions", "hospitals", "physicians", "capital" and "other" into "drugs", will reduce waiting times. [6] He conducted further empirical analysis at the specialty level, and again reaches the conclusion that only spending on drugs reduces waiting time.

Thus according to Zelder (2000), shifting spending from other components into drugs while holding the aggregate spending per capita constant could reduce waiting times. Moreover, he adds that untargeted spending is ineffectual in improving waiting times. Zelder then proposes that only an important reform of the current system permitting care provision by for-profit hospitals, changing the remuneration system for doctors and nurses and introducing user fees for patients would improve the health care system.

In my opinion it is difficult to predict the effects of such shifting of spending from one component into another one on waiting times because of complementarity between the components of spending. This complementarity between the components of spending is not taken into consideration by Zelder (2000). In addition, he does not include any variables related to productivity. In fact, the methods of financing hospitals and remunerating physicians are also an important determinant of waiting times in the sense that they impact productivity. It is clear that different methods available to pay

[5] See tables A4 and A8 of Zelder (2000).
[6] ibid tables A9 to A12.

physicians have differing economic incentives on physician's behavior. According to Phelps (1994) for example, Fee-For-Service (FFS) creates incentives for physicians to treat more patients, since each unit of care provided increases their revenue. In section 4 I attempt to address this problem by adding a fee-for-service variable to the model.

3.3 Other determinants of waiting times

In this section, I will try to list other possible determinants of waiting times. Despite the fact that it is not possible to include all of them in my econometric analysis, they could constitute a basic framework for other empirical work in the future.

One of the important determinants of variations in waiting times mentioned by Siciliani and Hurst (2003) is productivity. I noticed an important gap between Canada and OECD countries without a waiting time problem, regardless of whether the productivity measure is based on surgical inpatients or on total discharges. Productivity is a factor which attracted my curiosity, especially since we know that in Canada physicians can only perform the number of procedures allowed by provincial governments. I have been unable to obtain precise information on the nature of the limits on physicians, but Hurst and Siciliani (2003, 29) note that physicians' compensation is "subject to various forms of individual physician or global ceiling." I thus wonder what the impact of such constraints is on waiting times and the productivity of the Canadian health care system. Nevertheless, to answer such question would require more time and more research which is beyond the scope of my paper.

Physician productivity is impacted by a large range of independent variables, including characteristics of the physician (age and sex for example) and the organization in which the physician practices. Consequently, physicians do not exercise complete control over their productivity. One aspect that is difficult to understand is how all health professionals interact with one another and the impact this ultimately has on their productivity. According to Haines (2002?), "an individual doctor's personal productivity is controlled by four factors: the doctor's Style, the practice's System, Staffing to support the doctor, and Space to support the doctor." [7](The author called these factors the four S's of Production.) With respect to space to support the doctor, one variable comes immediately to mind, namely, the number of operating rooms. However, it is not only the number of available operating rooms which impacts output, but also the level of efficiency of use of these resources. Since elective surgeries are scheduled in advance, it would be interesting to measure the percentage of cancelled surgeries.

Another efficiency issue is whether different health care professionals are being used efficiently. Senator Michael Kirby (May 12, 2003, 4) refers to some conclusions of the Ontario Health Services Restructuring Commission, and gives some examples of the efficiency problems in Canadian context:

> One third of billings by specialists in Ontario in 1997 were for work that could have been done by family doctors. The five most frequently used billing codes by Ontario family doctors in 1997, which accounted for about 69% of the total amount billed by these doctors were for services that could well be provided by nurses practitioners and well-trained other health professionals.

From a report related to the use of Emergency departments (ED) published recently by CIHI (2005a), about 57% of ED visits in 2003-2004 were for less urgent or non-urgent conditions. If health professionals are not used efficiently in emergency departments, waiting times for elective surgery would likely increase since hospital staff would have less time to perform such surgery. The length of stay in hospitals is also another

[7] The publication date given is the copyright date for the website, since no date.

determinant of waiting times related to efficiency. It is possible that some hospitals do not have the guidelines and policy to maintain an appropriate length of stay which would permit them to free beds quickly.

It is clear that any attempt to explain the determinants of waiting times should take into account many determinants reflecting demand and supply variables. Supply variables are those related to capacity (in terms of physician density and acute care beds) or available resources (in terms of health spending). On the demand side, the demographic characteristics of the population should be considered. But there is a clear distinction between need and demand. In fact, according to Vissers et al. (2001, 134), "need stands for what the body of professional opinion accepts as legitimate wants. Demand stands for what prospective patients want". He therefore claims that real need can only be approached via data based on epidemiology.

In my opinion, more research is required to identify the determinants of waiting time related to productivity or to the level of efficiency of the health care system. These determinants depend on the organization of the health care system. In Canada we can observe some differences among provinces. For instance, while some provinces allow doctors to practice in both public hospitals and private clinics, others do not allow such practices. [8]

Finally, as my focus is to discuss all possible determinants of waiting times for elective surgery, one might guess that the use of additional resources for urgent patients would mean that non-urgent patients would have to wait longer. Put it in another way: do the waits for scheduled surgery increase when there is a higher proportion of urgent surgery? According to Decoster et al. (1998), this was not found to be the case in

[8] See Flood and Archibald (2000) for a discussion of the legal constraints on privately financed health care.

Manitoba. According to the authors, the median wait for scheduled surgery was shorter in the years during which there was a higher proportion of urgent cases. CIHI (2006) points out that 87% of hip fracture cases enter the system through hospital emergency departments. This study notes that the median wait for hip replacement is shorter than the median wait for knee replacement. It seems to me logical that the high proportion of cases which enter the system as urgent cases would push the wait for hip replacements to be low as compared to the wait for knee replacements which are not considered as urgent.

4. An econometric analysis of the determinants of waiting times in Canada

4.1 Model specification

In this section of my paper, I carry out an empirical analysis of the relationship between waiting times, health care expenditure and some other control variables, using pooled time-series cross-section data for the ten Canadian provinces over the period 1993 to 2001 (90 observations). As in Zelder (2000), the dependent variable is the median waiting time averaged across twelve specialties as published by the Fraser Institute.[9] This indicator includes two segments of waiting time: the wait between referral by a General Practitioner (GP) and visit to a specialist for consultation; and the wait between the specialist's decision that treatment is required and the treatment itself. Here my focus will be on the aggregate waiting times, which include twelve specialties.

To the best of my knowledge, the only current source of national information on waiting times is the waiting list data compiled annually by the Fraser Institute by means

[9] I thank the Fraser Institute for providing me with the data in electronic form. The data can be found in Zelder (2000, table 2) and in various editions of the Fraser Institute publication, *Waiting Your Turn: Hospital Waiting Lists in Canada.*

of a survey of Canadian specialist physicians. According to Esmail and Wanlker (2002), the response rate was 30 percent in 2001. The survey is conducted in all ten Canadian provinces, and includes twelve different medical specialties. The Fraser Institute estimates both segments of waiting time separately and then adds them together.

Shortt (2000) points out that the data on waiting times published by the Fraser Institute are subject to bias due, among other factors, to the yearly change in the respondents. Hence in some years the sample may be dominated by specialists with long waiting lists (whose patients experience longer waits), while in other years it may be dominated by specialists with short waiting lists. Consequently, it is possible that the estimated waiting time is subject to a high degree of sampling variability.

When examining measures of waiting times, I noticed the extensive use of two concepts, namely mean and median waiting times. The results of an analysis could be different depending on which of these measures is used. The disadvantage of using mean waiting times is the presence of outliers, that is, long waiting times for a few patients, which pull the mean upwards. The use of the median avoids this problem.

I estimate seven different linear specifications. In the first specification, I use real per capita public health expenditure (*RPCS,* table 9*)* in 1997$ as the key explanatory variable. Theoretically, this variable is expected to have a negative effect on waiting times. The data for this variable are obtained from CIHI (2003). We can see from tables 1 and 9 that although Alberta and Saskatchewan spend more money on health care than Quebec and Ontario, they have longer waits. This demonstrates that provinces that spend more money do not always have the shortest wait, as is the case for Saskatchewan and Newfoundland for example. From table 9 we can see that real per capita public health expenditure (in 1997$) ranges from a minimum value of $1572 (Nova Scotia, 1996) to a maximum value of $2576 (Manitoba, 2001).

The variable *OVER64* represents the percentage of the population aged 65 or older.[10] It reflects needs and is expected to have a positive effect on waiting times. Holding health spending constant, provinces with a higher percentage of elderly residents would require longer waiting times. From table 10, we can see that Saskatchewan has the highest proportion of the population aged 65 or older. The data range from a minimum percentage of 9.3% (Alberta, 1993) to a maximum of 14.8 % (Saskatchewan, 2001).

The variable *INCOME* is the real personal disposable income per capita in 1997$. To calculate this variable I retrieved from E-STAT data on personal disposable income and divided them by the population. Then, using the Consumer Price Index (CPI), the data are transformed to real personal disposable income (1997$). [11] Table 11 demonstrates that in 2001 Alberta had the highest real personal disposable income per capita in Canada at $22,530. Ontario is ranked second among the provinces at $21,159 and British Columbia had the third highest real personal disposable per capita income at $19,924. The data range from a minimum value of $14,426 (Newfoundland, 1997), to a maximum of $22,530 (Alberta, 2001). The coefficient of *INCOME* is expected to have a negative sign, which means that residents of richer provinces are able to avail themselves of surgery within or outside the province.

The variable *t* is a time trend that equals 1 in 1993 and increases by one in each subsequent year. This variable stands for all other factors which evolve over time. Given

[10] To construct this variable I retrieved from E-STAT the estimates of population for all ages and the estimates of population aged 65 and over. All the CANSIM II table numbers and series identifiers are provided in table A1.

[11] See the data appendix for the CANSIM II table and series identifiers.

the general upward trend in the data, one would probably expect a positive coefficient for this variable, unless changes in the other variables can account for the observed increase.

In the second specification, I include dummy variables for every province except Saskatchewan.[12] The purpose of adding provincial dummy variables is to test for fixed differences in waiting times across provinces. If such differences exist but have not been accounted for in the estimating equation by allowing the constant term to vary across provinces, one has a problem of specification error that will result in biased parameter estimates.

It is also interesting to see if the composition of health spending matters. Therefore, in the third equation, I use eight health spending components instead of aggregate spending. These components are provincial government spending on hospitals *(HOSP)*, other institutions *(OTHINS)*, Physicians *(PHYS)*, other professionals *(OTHPRO)*, drugs *(DRUG)*, capital *(CAP)*, administration *(ADM)*, and other (*OTHER*).[13] In order to make meaningful comparisons among provinces, these components are calculated in real per capita terms (1997$). Because the data in CIHI (2003) were per capita at current dollars, I use the government implicit price index (IPI) for each province to transform these data into real per capita terms.[14] The largest of the eight components over the period 1993-2001 is hospitals, with a mean value of $818 per capita (1997 dollars). The data range from a minimum value of $628 per capita (Saskatchewan, 1996) to a maximum value of $1059 (Newfoundland, 2001). The next largest component is spending on physicians, with a mean value of $317 over the sample period. The data vary

[12] Saskatchewan is arbitrarily chosen from the bottom of the list of provinces arranged in alphabetical order.

[13] CIHI (2003), Health Expenditure components: National Health Expenditure trends, 1975-2003, Provincial government health expenditure, by use of funds, 1974-1975 to 2003-2004, current dollars, Tables F.3.1.3, F.3.2.3, F.3.3.3, to F.3.10.3 (10 tables).

[14] The data source for IPI is provided in the appendix.

from a minimum value of $232 (Newfoundland, 1994) to a maximum value of $452 (Ontario, 1993). Again, it is also interesting to use these components with dummy variables for each province, so the fourth equation includes both provincial dummies and the eight components of provincial per capita health spending, as well as *OVER*64, *INCOME,* and *t*.

When discussing the effect of health spending components, one important issue is the possibility of complementarities and interactions between these components. This problem is discussed by Zelder (2000), but not taken into consideration in his empirical analysis. Due to a lack of degrees of freedom, it is not possible to examine all possible interactions, so I suggest that the interactions between spending on hospitals and physicians and between spending on physicians and drugs are likely to be particularly important. The two largest components of spending are hospitals and physicians; hence it is interesting to include the interaction between these two components. As for drugs, according to Zelder (2000), spending on drugs is the only component which reduces waiting times. Since spending on drugs is mainly initiated by physicians it is also of interest to include the interaction between these two components. I therefore re-estimate equation (4), adding two new variables. The first one is the product of the variables *HOSP* and *PHYS* (*HOSP***PHYS*). The second variable is the product of *PHYS* and *DRUG*.[15]

In order to investigate the effect of a fee for service (*FFS*) system of physician remuneration on waiting times, I also re-estimate equations (1) and (2) adding this variable. In fact, as I mentioned previously I expect this variable to have a negative

[15] It should be noted that other interaction terms could be also tested; I ran some regressions with other interaction terms but the estimated coefficients are not statistically significant.

impact on physicians' productivity since more fee-for-service creates an incentive for physicians to provide more services as Phelps (1994) suggests.[16] It is defined as the share of payments to physicians that are made on a fee-for-service basis to physicians by provincial medical care insurance plans. Since the data for this variable are available only from 1996 to 2001, the sample period for equations (6) and (7) covers these years only. Table 12 shows that for Manitoba the level of FFS was 40% in 1998/1999 but rose to 64.1% in 2002/2003. For New Brunswick, the level was between 50 and 58% during the period 1998/1999 to 2000/2001, but increased to more than 80% since 2001/2002. The level was 63.1% for Nova Scotia in 1998/1999, but decreased to 37.9% in 2000/2001, and increased again to 69.8% in 2001/2001. What is interesting to notice from this table is that the provinces with a lower level of FFS have long waiting times, except for Saskatchewan, where FFS is high and waiting times are long

To summarize, the seven equations estimated can be written as follows:

$$Wait_{ip} = C + x'_{1(ip)}\beta_1 + h_{1(ip)}\beta_2 + \varepsilon_{ip}, \qquad (1)$$

$$Wait_{ip} = C + x'_{1(ip)}\beta_1 + h_{1(ip)}\beta_2 + \sum_j d_{j(ip)}\alpha_j + \varepsilon_{ip}, \qquad (2)$$

$$Wait_{ip} = C + x'_{1(ip)}\beta_1 + h'_{2(ip)}\beta_3 + \varepsilon_{ip}, \qquad (3)$$

$$Wait_{ip} = C + x'_{1(ip)}\beta_1 + h'_{2(ip)}\beta_3 + \sum_j d_{j(ip)}\alpha_j + \varepsilon_{ip}, \qquad (4)$$

$$Wait_{ip} = C + x'_{1(ip)}\beta_1 + h'_{3(ip)}\beta_4 + \sum_j d_{j(ip)}\alpha_j + \varepsilon_{ip}, \qquad (5)$$

$$Wait_{ip} = C + x'_{1(ip)}\beta_1 + h'_{4(ip)}\beta_5 + \varepsilon_{ip}, \qquad (6)$$

$$Wait_{ip} = C + x'_{1(ip)}\beta_1 + h'_{4(ip)}\beta_5 + \sum_j d_{j(ip)}\alpha_j + \varepsilon_{ip}, \qquad (7)$$

The row vector $x'_{1(ip)}$ includes t, *INCOME*, and $OVER64$. $h_{1(ip)}$ consists of just one health spending variable, *RPCS*. $h'_{2(ip)}$ is a row vector that contains the eight health

[16] Professor Armstrong of the Department of Economics of the University of Ottawa argues that fee-for-service would instead create incentives to provide more surgery than necessary, which should increase wait times.

spending components. $h'_{3(ip)}$ is a row vector that includes the eight health spending components and the two interaction terms. $h'_{4(ip)}$ is a row vector that contains *RPCS* and *FFS*. The subscript *i* indicates the year and *p* the province. The provincial dummies $d_{j(ip)}$ are defined as being equal to 1 for all observations for province j and zero otherwise. ε_{ip} is the disturbance term, which represents all those variables that are omitted from the model but which affect the dependent variable. C, β_1, β_2, β_3, β_4, β_5, and α_j are the coefficients I will estimate using the method of Ordinary Least Squares (OLS). This method is used under the assumption that the error terms ε_{ip} are normally distributed with mean equal to zero and constant variances. However, I will begin by carrying out some diagnostic tests for heteroskedasticity and specification error (RESET tests).

4.2 Results

Table 13 summarizes the results of the diagnostic tests for all models.[17] Looking at the results of White's test for heteroskedasticity, we can reject the null hypothesis for models (1), (2), and (3), which means that there is a heteroskedasticity problem in these equations. On the other hand we cannot reject the null hypotheses for models (5) and (7), and we can accept the null hypothesis at the 10% level for models (4) and (6). To correct for heteroskedasticity, we could estimate models (1), (2) and (3) for each province separately to allow for the possibility that the variance differs across provinces. Unfortunately, we don't have enough data to do so. Another possibility is to re-estimate these models with standard errors corrected for heteroskedasticity.

[17] The tests were carried out using EViews 5.

I did RESET tests for specification error with the standard errors corrected for heteroskedasticity for models (1), (2), and (3) and with uncorrected standard errors for the remaining models. Based on the results of the tests (table 13), I can reject the null hypothesis of no specification error in all models. However, these tests do not tell us how to resolve the specification error. Is it due to data errors or to omitted variables? I would have liked to use other data on waiting times such as actual waiting times versus expected waiting times. Unfortunately, these data are not available. Another possibility is to include other explanatory variables such as the percentage of urgent surgery and the percentage of day-surgery, but these data are not available either. These two variables are already used in the some of the papers I mentioned previously; for example, Siciliani and Hurst (2003) included the percentage of day-surgery in their model, and Decoster et al. (1998) found that in years during which there was a higher percentage of urgent cases, the median waits for elective surgery were shorter in Manitoba. I will discuss later other possibilities to resolve the problem of specification error and the heteroskedasticity problem.

Another important issue which is also interesting to investigate is the possibility of multicollinearity. A quick glance at table 14, which contains the OLS estimates for the seven models, reveals that many of the coefficient estimates are not significantly different from zero, yet all the F statistics have very low p-values, implying that the regression equations do have explanatory power. This is one of the classic symptoms of multicollinearity. To test for multicollinearity, in addition to computing the pairwise correlation coefficients in table 15, I ran some auxiliary regressions in which each explanatory variable was regressed on all the other explanatory variables in each equation. Table 15 shows the possibility of multicollinearity between some health spending components and also between *INCOME* and spending on *PHYS* and *OTHER*. The R^2 values for the auxiliary regressions are summarized in table 16. What I notice here is that the addition of provincial dummies increases the auxiliary R^2's.[18] Their values are high in all equations compared to equations (1) and (6). It seems that adding the provincial dummies and health spending components causes the problem of multicollinearity.

To check to what extent provincial variations are driving these results, I regress *WAIT*, *OVER*64, *INCOME*, and *RPCS* on the provincial dummies and the constant. The R^2 values are higher when I use *OVER*64 (0.93), and *INCOME* (0.86) as dependent variables, as compared to *RPCS* (0.32). *OVER*64 and *INCOME* are highly correlated with the provincial dummies, likely because of the persistence of regional disparities in those variables. The R^2 of 0.25 for *WAIT* implies that waiting time differences between provinces have not been constant over time, as provincial differences explain only a small proportion of the change in waiting times. The R^2 of 0.32 for *RPCS* implies that provincial differences in *RPCS* have not been constant over time. Thus one can separately identify the effects of *RPCS* on waiting times from those of the provincial dummies.

Returning to the coefficient estimates in table 14, the White correction of the standard errors is used for models (1), (2) and (3).[19] The constant term is statistically significant in equations (3), (5) and (7), but insignificant in all other equations. The coefficient of the variable *OVER64* is always positive, as expected, except for models (2), (4) and (7). The unexpected signs and insignificant coefficients in these three equations

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[18] See Gujarati (2003, 361) for more information on the use of auxiliary R^2 s to test for multicollinearity.
[19] All estimation was carried out using EViews 5.

may be a symptom of multicollinearity. The coefficient of *OVER64* is statistically significant at 5% in equation (1), and at 1% in equation (6).

The coefficient of the variable *t* is positive in all equations, meaning that holding all else constant, waiting times have increased over the sample period (1993 to 2001) by 1.05 weeks in equation (1) and by 2.14 weeks in equation (7). On the other hand, this coefficient is only 0.5264 in equation (5). It is not statistically significant in equation (5) with interaction variables, but significant in all other equations.

All coefficients for provincial dummies included are significant in equation (2), except for Alberta and Prince Edward Island. In equation (5), only the coefficient of the dummy variable for Manitoba is statistically significant. In equation (7), all coefficients for dummies are statistically significant except those for Alberta, British Columbia, and Ontario. I also test the null hypothesis that the coefficients of the provincial dummy variables are jointly zero for both equations (2) and (4). I did these tests with the standard errors corrected for hetroskedasticity for the equation (2). The results allow us to reject the hypothesis that the coefficients of dummies are jointly zero for both equations.[20]

The coefficient of the variable *INCOME* changes slightly from -0.000487 in equation (1) to -7.87E-05 in equation (2) and from -0.00099 in equation (3) to -0.00090 in equation (6). The coefficient of *INCOME* is negative as expected in all specifications except equations (4) and (5), but statistically significant in equations (1), (3) and (6). The coefficient of *INCOME* becomes insignificant when I add provincial dummies. The coefficient itself is very small and implies that any increase in this variable will have only a small impact on waiting times.

[20]The F-statistic is 4.1497 and p-value is 0.002 for equation (2) while the F-statistic is 3.0596 and p-value is 0.0048 for equation (4).

Now turning to the government spending variables in table 14, we can see that the coefficient of real capita spending on health is positive in contrast to the expected negative sign and statistically significant at the 10% level in equation (2), suggesting a weak connection between spending and waiting time. Adding provincial dummy variables changes this coefficient from 0.002421 in equation (1) to 0.006241 in equation (2). Adding the variable *FFS* to equation (1), the coefficient of *RPCS* is 0.003796 in equation (6) and 0.004555 in equation (7) after adding provincial dummies.

Despite the fact that the estimated coefficients are not precisely measured –many are insignificant- it is interesting to look at the magnitudes of their effects on waiting times. The results in table 14 suggest that an increase in real public per capita spending of $100 (in 1997$) will increase waiting times by 0.24 weeks in equation (1) and by 0.62 weeks in equation (2), holding all else constant. [21]

When analyzing the effect of health spending components, spending on hospitals, other institutions, drugs, and capital reduce waiting times in equation (3), whereas spending on physicians and capital reduce waiting times in equation (4). On the other hand, in equation (5), the coefficients of the variables *OTHINS, OTHPRO*, *DRUG*, *HOSP*PHYS*, *CAP* and *ADM* have negative signs. However, only the coefficient of *HOSP*PHYS*, *HOSP* and *PHYS* are statistically significant. According to the results in table 14, an increase in spending on hospitals of $100 (1997$) will decrease waiting times by 0.4 weeks in equation (3), holding all else constant.[22] An increase in spending on other institutions of $100 will reduce waiting times by 0.9 weeks in equation (3).[23] In

[21] The p-values for the predicted effect of a $100 change in *RPCS* are *0.3107* for equation (1) and *0.0796* for equation (2).
[22] The p-value is 0.4597 for *HOSP*.
[23] The p-value is 0.4873 for *OTHINS*.

equation (4), an increase in spending on physicians of $100 will decrease waiting times by 0.1 weeks.[24]

The coefficient of the variable *DRUG* suggests that an increase of $100 on spending per capita on drugs will reduce waiting times by 3.2 weeks in equation (3).[25] This coefficient is -0.0379 in equation (5). The full effect of this variable on waiting times is now (-0.03796+0.*000155*PHYS*). Spending on physicians at the sample mean is equal to $317, so the effect of a $100 increase in spending on drugs on waiting times is to increase waiting times by 1.12 weeks, when we include the interaction variables.[26]

Similarly, in equation (5) the effect of the variable *PHYS* on waiting times is now ($C_7 + C_{13} HOSP + c_{14} DRUG$). At the sample mean the effect on waiting times of a $100 increase in spending on physicians is an increase of 2.4 weeks.[27] In the same way, the effect of any change in *HOSP* on waiting times is ($C_5 + C_{13}\ PHYS$). The effect on waiting times of a $100 increase in spending on hospitals is to increase them by 0.08 weeks.[28]

The estimated coefficient of (*FFS*) is equal to 0.10039 in equation (6) and equal to 0.014 in equation (7). It is positive but statistically significant only in equation (6). In contrast, Hurst and Siciliani (2003) note that Mot (2002) found that in the Netherlands the substitution of specialists' fee-for-service with fixed budget payments reduced on average the admissions rate and consequently increased waiting times.

Additionally, I re-estimated my equations (1), (2), and (3) for the period 1993-1998 to see to what extent the differences between my results and those of Zelder (2000) are due to the difference in the sample period. Our estimates of some important

[24] The p-value is 0.6775.
[25] The p-value is 0.3401.
[26] The p-value is 0.7753.
[27] The p-value is 0.7750.
[28] The p-value is 0.0251.

coefficients are compared in table 17. However, it should be noted that I did not use all the same variables as Zelder. He used, for example, strike activity in health care for which I could not get data. Nevertheless, I will compare the results for two coefficients, namely, *RPCS* and *OVER64.* My coefficient for real per capita spending is -0.0014 and my coefficient for OVER64 is 0.482 compared to 0.002 and 0.483 respectively for (Zelder 2000, table 6). Our results become similar only when I include provincial dummies. In this particular case, my coefficient is 0.0038 for the variable *RPCS* compared to his value of 0.0034, whereas the coefficient for the variable *OVER64* is 0.571 for me as opposed to Zelder's value 0.443 (Zelder 2000, table A-1). I notice that the results are sensitive to any small changes in the variables, which probably constitutes a symptom of multicollinearity. In equation (3), my coefficient for *OVER*64 is positive (0.056), as opposed to his which is negative (-0.073) (Zelder 2000, table A-5). The coefficients of the health components also differ in value and sign. The estimated coefficient of *DRUG* is quite similar in both cases and is the only statistically significant coefficient. In his case the estimated coefficient for this variable is -0.0686 compared to my estimated coefficient of -0.0628. Zelder (2000) did not include provincial dummies when he used health spending components, which is why I could not compare my equation (4) with his results.

To summarize all these results, the coefficient of aggregate per capita public spending is significant in equation (2) and insignificant in all other equations, suggesting little or no association between spending and waiting times. The coefficient of *OVER64* is significant in equations (1) and (6). The coefficient of *t* is always significant except in equation (5). The coefficient of *INCOME* is always negative as expected, but not always significant. The coefficients of the variables *HOSP*, *OTHINS*, *PHYS*, *OTHPRO*, *HOSP*PHYS*, *CAP* and *ADM* have a negative sign, but only the coefficient of *HOSP*PHYS* is statistically significant. However, the variables *HOSP* and *PHYS* do not reduce waiting times.

According to the results of the diagnostic tests mentioned previously, it is difficult to decide which of these seven specifications is the more adequate. However, when I re-estimated my equation (1) for the period 1993-1998, I noticed that the estimated coefficient of *RPCS* is negative, as expected. Despite the fact that this coefficient is not statistically significant, I investigated the source of the change in sign of this estimated coefficient after extending my estimation to cover the period 1993-2001. I started my investigation by doing the same diagnostic tests for equation (1) for the period 1993-1998, and found that there is no heteroskedasticity problem and that the model is correctly specified. In an attempt to figure out what happened after 1998, I examined the data on waiting times and noticed that there are a few observations with long waits. This is the case for Saskatchewan with three long waits (34.5 in 1999, 28.9 in 2000, and 32.6 in 2001), and for New Brunswick (25.8 in 2000). In attempt to find an explanation for these outliers, I contacted the Fraser Institute requesting any possible explanation. I was referred to their annual publication *Waiting Your Turn* in which they remark on these abnormalities. However, they too are unable to explain them. In order to prevent the analysis from being distorted by a few outliers, I excluded these observations from the sample.

Surprisingly, when I re-estimate equation (1) without these four observations, the results of the diagnostic tests suggest that there is no heteroskedasticity problem and that the model is now correctly specified. Now the estimated coefficient of *RPCS* is 0.0011, but not statistically significant. The estimated coefficient of *INCOME* is -0.00033 and significant at 5%.

When I re-estimated equation (2) without these four observations, I did the diagnostic tests and found that there is still a heteroskedasticity problem and the model is not correctly specified. Thus the outliers cannot completely explain the heteroskedasticity and model specification problems. The estimated coefficient of *RPCS* is 0.0041 and statistically significant at 10%. The coefficient of *INCOME* is -0.00021, but not statistically significant. The variable t is statistically significant in both equations (1) and (2).

5. Conclusion and discussion

The current paper has conducted an econometric analysis of the determinants of waiting times for elective (non urgent) surgery in Canada, along the general lines of Zelder (2000). I depart from Zelder's analysis, however, by including a variable related to physician productivity and interaction terms between health spending components in my empirical implementation of the model. I also extend his sample period from 1993 to 2001.

Several features of the results are of interest. First, the results of White's test for heteroskedasticity show that there is a heteroskedasticity problem in equations (1), (2), and (3). Second, according to the RESET tests, all models are incorrectly specified.

Third, the addition of provincial dummies and health spending components exacerbates the problem of multicollinearity.

The most pertinent findings are those with respect to the public policy variables. The estimated coefficient of real per capita spending on health is statistically significant at the 10% level of significance only in equation (2) which includes provincial dummies, but with an unexpected positive sign. When health spending is disaggregated into its components, I find that none of the coefficients of these components is statistically significant in equation (3) which does not include provincial dummies, and (4) which does include provincial dummies. When interaction variables between some of the health spending components are introduced, the coefficient estimates imply that none of the spending variables reduce waiting times. However, the coefficients of spending on hospitals and on physicians are now statistically significant with a positive sign, while the estimated coefficient of the interaction between spending on hospitals and physicians is negative and statistically significant. When a fee-for-service variable is included in equations with the aggregate health spending variable, the results are again inconsistent. Only the time trend has a statistically significant coefficient in all but one of the seven models. The estimated coefficient of the time trend implies that holding all else constant, waiting times have increased over the sample period.

A comparison between my results and those of Zelder (2000) shows that the results are sensitive to any small change in the sample period, which could be a symptom of multicollinearity. The main similarity between our results is the finding that there is little association between waiting times and aggregate spending. However, we differ in our results when spending is disaggregated. In his case, spending on drugs reduces waiting times, but this not the case for my equation (3).

Given such weak econometric results, it is difficult to derive any conclusive policy implications. However, it seems highly pertinent to further elaborate on why such a weak connection between spending and waiting exists. First, I think that the main explanation for the existence of little or no association between waiting times and health spending lies in data problems. Given that the data basically correspond to the perceptions of physicians about the expected waiting time, I argue that the results should be interpreted with caution, especially since completely different types of surgeries are grouped together. As a matter of fact, even within the same specific medical specialty, individuals differ completely in their medical condition and in the severity of their problem. That is why I want to emphasize that even if the analysis had been done at the individual level, it would still have been difficult to take into account such factors (e.g., medical conditions) when interpreting waiting time data.

Furthermore, including data on potential determinants of waiting times such as the number of physicians per capita, the number of acute care beds per capita and the number of operating rooms might have a considerable impact on any analysis of waiting times. It would be very interesting, for example, to replace the spending variable with the number of physicians per capita and the number of acute care beds per capita, to see whether the expectation that the sign of their coefficients is negative indeed holds. Unfortunately, I was unable to obtain data on these variables. [29]

Since it is not possible to derive any direct and conclusive policy implications from my empirical work, I would rather only give some comments on policies related to

[29] I contacted CIHI requesting these data, but unfortunately my attempts were not effective.

waiting times. First of all, despite the lack of evidence of a connection between waiting times and health spending, I would not go so far as to maintain the conclusion drawn by Zelder (2000). While he argues that only a structural reform of the system towards privatization would resolve the problem of waiting times, I strongly believe that the Canadian health care system is so complex that it requires a multitude of solutions instead, such as the implementation of policies to promote healthy behavior and to create incentives for hospitals and physicians to increase the level of efficiency and productivity.

Correspondingly, recently the Canadian government has suggested the introduction of a maximum waiting time guarantee. In my opinion, this is not an appropriate policy given that physicians are private delivery services and are not necessarily employees of hospitals -- a fact which would lead us to the question of who should be responsible for respecting and delivering this waiting time guarantee, hospitals or physicians. Besides, I agree with Hurst and Siciliani (2003) regarding the risks associated with a waiting-time guarantee, such as increases in demand for surgery, and the diversion of resources from services for which there are no such maximum waiting-time guarantees.

Finally, the observation that substantial improvements in the current Canadian waiting list situation have been made, especially in more degenerative surgery cases, such as cardiovascular and radiation oncology, shows that some kind of solution is very much possible within the current public system (CIHI, 2006). While it is unlikely that health care spending really has no effect on waiting times, more spending would increase efficiency only if it is devoted to addressing a specific known problem. There is still a lot of work to be done by all the parties concerned to better understand the current situation of the waiting lists and waiting times.

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Table 1. Weighted median Total Expecting Time from Referral from GP to Treatment, in weeks.

Province	1993	1994	1995	1996	1997	1998	1999	2000	2001	Variation in %	
										2001/1993	2001/2000
BC	9.7	10.9	12.7	13.4	12.6	15.2	15.8	18.9	18.3	88.7	-3.2
AB	9.6	9.1	10.5	12.2	12.4	14	16.3	16.9	17.5	82.3	3.5
SK	9.2	9.7	10.4	12.6	17.1	20.2	34.5	28.9	32.6	254.3	12.8
MB	9	11	10.5	9.7	11.5	12.4	11.2	16.7	17.8	97.8	6.6
ON	8.4	9.3	9.9	10.3	10.2	11.9	11.8	13.9	14	66.7	0.7
QC	7.4	8.2	8.6	9.6	12.5	11.9	12.4	16.5	16	116.2	-3
NB	12.9	13.1	13.2	11.8	12	14.1	15.8	25.8	19.7	52.7	-23.6
NS	9.7	11.7	11.7	12.1	12.3	11.9	12.8	16.6	18	85.6	8.4
PE	13.9	16.9	19.3	19.7	12.5	16	18.8	15	15.1	8.6	0.7
NF	9.7	7.5	9.7	10.6	13.7	14.5	19.5	14.6	17.4	79.4	19.2
CANADA	9.95	10.71	11.65	12.2	12.68	14.21	14	16.2	16.5	65.8	1.8

Source: Zelder (2000, table 2); various editions of the Fraser Institute publication Waiting Your Turn: Hospital Waiting Lists in Canada.

Table 2. Total per Capita Expenditure on Health in US$ PPP			
Countries without waiting time problems	1998	1999	2000
France	2096	2211	2387
Germany	2520	2615	2780
Luxembourg	2361	2685	2719
Switzerland	2952	3080	3160
Countries with waiting time problems			
Canada	2288	2433	2580
Denmark	2238	2344	2398
Australia	2079	2224	2350
Source: Siciliani and Hurst (2003, 49).			

Table 3. Acute Care Beds per 1000 population			
Countries without waiting time problems	1998	1999	2000
Austria	6.4	6.3	6.2
France	7	6.9	6.7
Germany	6.5	6.4	6.4
USA	3.1	3	2.9
Countries with waiting time problems			
Canada	3.5	3.2	3.2
Australia	3.9	3.8	3.8
Source: Siciliani and Hurst (2003, 50).			

Table 4. Physicians' Density (number/1000 population)						
	Practicing physicians			Practicing specialists		
Countries without waiting time problems	1998	1999	2000	1998	1999	2000
Austria	3	3	3.1	1.7	1.7	1.8
France	3.3	3.3	3.3	1.7	1.7	1.7
Germany	3.2	3.2	3.3	2.1	2.1	2.2
Countries with waiting time problems						
Canada	2.1	2.1	2.1	1.1	1.1	1.1
Australia	2.5	2.5	2.4	1.1	1.1	1.2
Denmark	3.3	3.4	3.4	2.1	2.1	2.2
Source: Siciliani and Hurst (2003, 52)						

Table 5. Total Surgical In-patients per 1000 population			
Countries without waiting time problems	1998	1999	2000
Austria	128.4	129.8	130.1
Luxemburg	128.6	129.4	129.2
Countries with waiting time problems			
Canada	35.2	34.6	33.9
Australia	51	51.2	50
Source: Siciliani and Hurst (2003, 52)			

Table 6. Total Discharges per 1000 population			
Countries without waiting time problems	1998	1999	2000
Austria	272.2	280.6	284.4
Luxemburg	207.1	220	228.5
Countries with waiting time problems			
Canada	98.8	96.6	93.9
Australia	159.7	158.2	157.7
Source: Siciliani and Hurst (2003, 53)			

Table 7. Productivity Indicators Based on Surgical Inpatients									
	Surgical inpatient per acute care beds			**Surgical inpatient per acute care bed**			**Surgical inpatient per acute care bed**		
Countries without Waiting time problems	1998	1999	2000	1998	1999	2000	1998	1999	2000
Austria	20.1	20.6	21	75.5	76.4	72.3	42.8	43.3	42
Luxemburg	18.1	18.5	19.3	80.4	76.1	80.8	53.6	51.8	51.7
Countries with waiting time problems									
Canada	10.1	10.8	10.6	32	31.5	30.8	16.8	16.5	16.1
Australia	13.1	13.5	13.2	46.4	46.5	41.7	20.4	20.5	20.8
Source: Siciliani and Hurst (2003, 56)									

Table 8. Productivity Indicators Based on Total Discharges									
	Discharges Per acute care bed			**Discharges per practicing specialist**			**Discharges per practicing physician**		
Countries without W.T	1998	1999	2000	1998	1999	2000	1998	1999	2000
Austria	42.5	44.5	45.9	160.1	165.1	158	90.7	93.5	91.7
France	35.2	36.1	37.3	145	146.5	146.8	74.7	75.5	75.6
Countries with W.T									
Canada	28.2	30.2	29.3	89.8	87.8	85.4	47	46	44.7
Australia	40.9	41.6	41.5	145.2	143.8	131.4	63.9	63.3	65.7
Source: Siciliani and Hurst (2003, 57).									

Table 9. Real per Capita Health Public Expenditure in 1997$ (*RPCS)*

Province.	NF	PE	NS	NB	QC	ON	MB	SK	AB	BC
1993	1,646.70	1,673.25	1,644.39	1,735.92	1,792.16	1,892.69	1,961.13	1,883.65	1,920.83	2,159.96
1994	1,671.80	1,658.53	1,572.52	1,735.03	1,786.74	1,884.31	1,935.19	1,875.89	1,756.83	2,117.48
1995	1,724.41	1,687.22	1,586.50	1,776.15	1,763.80	1,850.09	1,948.15	1,868.62	1,641.59	2,058.79
1996	1,755.26	1,747.31	1,571.71	1,733.04	1,709.31	1,835.48	1,925.30	1,875.95	1,660.37	2,019.88
1997	1,852.54	1,689.18	1,789.95	1,734.95	1,760.10	1,825.72	1,982.46	1,944.64	1,744.31	2,015.98
1998	2,047.42	1,757.14	1,898.85	1,811.30	1,903.63	1,910.62	2,064.29	2,029.42	1,823.81	2,056.24
1999	2,304.77	1,828.47	1,963.12	1,904.67	1,910.60	2,009.76	2,320.25	2,136.83	2,035.20	2,195.72
2000	2,355.91	1,831.67	1,956.41	1,960.66	1,953.30	2,113.66	2,444.88	2,184.94	2,121.65	2,299.97
2001	2,573.06	2,051.53	2,072.00	2,121.61	2,067.59	2,181.18	2,576.55	2,361.66	2,321.53	2,492.17

Source: CIHI (2003).

Table 10. Percentage of the Population Aged 65 or Older (*OVER*64)

Province	AB	BC	MB	NB	NF	NS	ON	PE	QC	SK
1993	9.3026	12.637	13.481	12.245	9.9209	12.663	11.881	13.104	11.449	14.352
1994	9.4628	12.595	13.517	12.329	10.141	12.749	11.991	13.076	11.617	14.433
1995	9.6257	12.584	13.544	12.424	10.408	12.842	12.11	13.048	11.81	14.484
1996	9.7638	12.557	13.535	12.538	10.712	12.941	12.231	12.92	11.991	14.498
1997	9.8501	12.626	13.604	12.724	11.008	13.082	12.333	12.998	12.238	14.554
1998	9.886	12.79	13.665	12.895	11.334	13.218	12.424	13.204	12.463	14.592
1999	9.9669	12.938	13.632	12.988	11.599	13.341	12.485	13.305	12.65	14.644
2000	10.063	13.086	13.641	13.11	11.859	13.505	12.51	13.43	12.857	14.719
2001	10.159	13.231	13.654	13.283	12.136	13.679	12.518	13.629	13.048	14.805

Source: see Table A1

Table 11. Real Personal Disposable Income per Capita in 1997$ (*INCOME*)

Annual	NF	PE	NS	NB	QC	ON	MB	SK	AB	BC
1993	14,573	15,977	16,657	15,719	16,387	19,826	17,429	15,653	19,438	18,870
1994	14,661	15,675	16,481	15,786	16,716	19,793	17,437	15,340	19,048	18,686
1995	14,809	15,817	16,566	16,118	16,791	19,771	17,479	16,099	19,086	18,607
1996	14,564	15,437	16,233	16,002	16,779	19,377	17,619	16,696	18,886	18,355
1997	14,426	15,561	16,480	15,991	16,769	19,628	17,194	15,745	19,611	18,484
1998	14,969	15,942	17,106	16,666	16,957	20,176	17,806	16,266	20,153	18,625
1999	15,450	16,502	17,611	17,201	17,385	20,625	17,919	16,747	20,221	19,038
2000	15,807	16,905	17,715	17,337	17,940	21,452	18,203	17,057	21,041	19,632
2001	16,503	16,775	18,020	17,607	18,229	21,159	18,374	16,954	22,530	19,924

Source: See Table A1.

Table 12. Level of Fee-For-Service as a % payment.							
Province	96/97	97/98	98/99	99/2000	2000/2001	2001/2002	2002/2003
BC	78.2	78.4	78.9	78.7	73.2	81.6	80.7
AB	98	98	98	98	98	93.2	91.3
SK	83.7	81.2	81.3	81.6	81.7	81.6	73.3
MB	47	41	40	30.2	30	65.8	64.1
ON	94	94	93	93	83	88.1	88.4
QC	88	88	87	83	82	79.2	77.5
NB	36.6	60.2	58.3	51.2	50.3	82	81.5
NS	67.6	59.5	63.1	52.8	37.9	69.8	68.4
PE	92	76	55	62	55	81.9	75
NF	77	72	71	70	70	61.1	57.8

Source: Various editions of CIHI National Grouping System Categories Report.

Table 13. Results of Diagnostic Tests

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
White test	24.05075	39.07496	35.56526	42.80929	39.41703	16.34308	23.56024
	[0.002247]	[0.001745]	[0.033785]	[0.07703]	[0.278865]	[0.090223]	[0.213565]
RESET test							
$\gamma=2$	5.398108	14.12806	18.46934	15.685	17.64653	3.989384	5.4796
	[0.006252]	[0.000006]	[0.000000]	[0.000003]	[0.000001]	[0.024443]	[0.007589]
$\gamma=3$	3.816974	9.291591	13.61327	10.48123	11.74226	3.278206	4.578321
	[0.012958]	[0.000028]	[0.000000]	[0.000010]	[0.000003]	[0.028257]	[0.007314]
$\gamma=4$	2.845895	7.992098	10.11053	8.091577	9.586024	2.495025	4.262265
	[0.029142]	[0.000022]	[0.000001]	[0.000023]	[0.000004]	[0.054538]	[0.005632]

Notes: 1. γ is the number of fitted terms.

2. The null hypothesis for White's test is that there is no heteroskedasticity, assuming no interaction terms (the test regression using only squares of the regressors.
3. The null hypothesis for the RESET tests is that the model is correctly specified.
4. Values in square brackets are p-values.

Table14. Estimated Coefficients (see next page).

Variable	Model (1)	(2)	(3)	(4)	(5)	(6)	(7)
CONSTANT	3.949085	26.95507	19.88222	3.25219	-93.3970	-4.42705	89.29946
	(0.60709)	(1.06587)	(1.99397)	(0.112899)	(-1.8377)	(-0.43791)	(1.94153)
	[0.5454]	[0.2899]	[0.0496]	[0.9104]	[0.0705]	[0.6632]	[0.0585]
RPCS	0.002421	0.006241				0.003796	0.004555
	(1.01979)	(1.77695)				(1.20242)	(0.81931)
	[0.3107]	[0.0796]				[0.2344]	[0.4169]
OVER64	0.682003	-1.63894	0.560582	-0.199223	0.67827	1.288854	-3.65674
	(2.11406)	(-0.9685)	(1.2456)	(-0.09831)	(0.3278)	(2.80880)	(-1.2141)
	[0.0374]	[0.3359]	[0.2166]	[0.9220]	[0.7441]	[0.0069]	[0.2310]
INCOME	-0.000487	-7.87E-05	-0.00099	0.000278	9.01E-05	-0.00090	-0.00178
	(-1.920582)	(-0.08011)	(-2.1780)	(0.246209)	(0.07995)	(-2.6853)	(-1.3524)
	[0.0581]	[0.9364]	[0.0324]	[0.8063]	[0.9365]	[0.0096]	[0.1830]
t	1.050009	1.014008	1.13624	0.764435	0.52641	1.31409	2.14010
	(5.337551)	(3.76229)	(4.7373)	(1.85502)	(1.25029)	(3.047138)	(2.8883)
	[0.0000]	[0.0003]	[0.0000]	[0.0679]	[0.2155]	[0.0036]	[0.0059]
FFS						0.10039	0.014061
						(3.20863)	(0.29511)
						[0.0022]	[0.7693]
HOSP			-0.00396	4.96E-05	0.10862		
			(-0.7430)	(0.0054)	(2.2899)		
			[0.4597]	[0.9957]	[0.0252]		
OTHINS			-0.00912	0.00019	-0.0016		
			(-0.6979)	(0.007377)	(-0.0593)		
			[0.4873]	[0.9941]	[0.9529]		
PHYS			0.005477	-0.001303	0.28767		
			(0.41745)	(-0.04387)	(2.19609)		
			[0.6775]	[0.9651]	[0.0316]		
OTHPRO			0.003549	0.032647	-0.06592		
			(0.06737)	(0.21681)	(-0.4223)		
			[0.9465]	[0.8290]	[0.6741]		
DRUG			-0.03239	0.004898	-0.03796		
			(-0.9598)	(0.096435)	(-0.2867)		
			[0.3401]	[0.9235]	[0.7752]		
HOSP*PHYS					-0.00034		
					(-2.3309)		
					[0.0228]		
PHYS*DRUG					0.000155		
					(0.39533)		
					[0.6938]		

Table 14

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CAP			-0.00034	-0.00475	-0.00446		
			(-0.02839)	(-0.3869)	(-0.3724)		
			[0.9774]	[0.7338]	[0.7107]		
ADM			0.03265	0.005276	-0.00023		
			(1.61814)	(0.22186)	(-0.0099)		
			[0.1097]	[0.8251]	[0.9921]		
OTHER			0.018048	0.07961	0.07796		
			(0.580462)	(1.58200)	(1.57738)		
			[0.5633]	[0.1182]	[0.1194]		
DAB		-13.0506		-8.95008	-2.22548		-19.3189
		(-1.4323)		(-0.8276)	(-0.1981)		(-1.2509)
		[0.1562]		[0.4107]	[0.8435]		[0.2174]
DBC		-8.88340		-7.03098	-8.70278		-11.0843
		(-2.0907)		(-1.2941)	(-1.6178)		(-1.6689)
		[0.0399]		[0.1999]	[0.1104]		[0.1021]
DMB		-9.48886		-8.63806	-8.92699		-12.6246
		(-3.61763)		(-2.2082)	(-2.3965)		(-2.8006)
		[0.0005]		[0.0306]	[0.0193]		[0.0075]
DNB		-5.94246		-1.01312	-1.96072		-12.3267
		(-1.75495)		(-0.1413)	(-0.2796)		(-2.1646)
		[0.0833]		[0.8880]	[0.7806]		[0.0358]
DNF		-12.20029		-3.92219	-4.27337		-23.3589
		(-1.95969)		(-0.4191)	(-0.4650)		(-2.3503)
		[0.0537]		[0.6764]	[0.6434]		[0.0232]
DNS		-7.351627		-2.39221	-3.15993		-12.8666
		(-2.4478)		(-0.3149)	(-0.4257)		(-2.6982)
		[0.0167]		[0.7538]	[0.6716]		[0.0098]
DON		-11.37516		-9.38879	-14.1583		-13.2050
		(-1.964)		(-1.0383)	(-1.5432)		(-1.4808)
		[0.0532]		[0.3027]	[0.1275]		[0.1456]
DPE		-3.828941		0.41108	1.09941		-12.5072
		(-1.433649)		(0.08307)	(0.22714)		(-2.6806)
		[0.1558]		[0.9340]	[0.8210]		[0.0102]
DQC		-10.7128		-5.09868	-4.35011		-16.5611
		(-2.508609)		(-0.6718)	(-0.5858)		(-2.4655)
		[0.0143]		[0.5040]	[0.5599]		[0.0176]
n	90	90	90	90	90	60	60
Adj. R squared	0.451423	0.601133	0.504102	0.575152	0.595293	0.435138	0.640766
F	19.30949	11.31784	9.224771	7.024343	6.950545	10.09007	8.517011
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.00000]	[0.000001]	[0.00000]

Note: values in parentheses are t statistics. Values in square brackets are p-values.

Table 15. Pairwise Correlation Matrix

	OVER64	INCOME	TIME	HOSP	OTHINS	PHYS	OTHPRO
OVER64	1	-0.2334	0.2256	-0.2138	0.5836	0.0243	-0.3602
INCOME	-0.2334	1	0.3007	-0.3366	-0.1647	0.7136	0.5515
TIME	0.2256	0.3007	1	-0.0052	0.2227	0.1705	-0.1938
HOSPI	-0.2138	-0.3366	-0.0052	1	-0.1619	-0.2872	-0.3009
OTHINSI	0.5836	-0.1647	0.2227	-0.1619	1	0.054	-0.0995
PHYSI	0.0243	0.7136	0.1705	-0.2872	0.054	1	0.5041
OTHPROI	-0.3602	0.5515	-0.1938	-0.3009	-0.0995	0.5041	1
DRUGI	-0.2059	0.582	0.4121	0.1139	-0.2728	0.6505	0.1892
ADMI	0.0431	0.5155	0.4528	-0.4376	0.4078	0.374	0.4811
CAPI	0.2146	0.048	0.2759	-0.0838	0.3014	0.137	0.0531
OTHERI	0.1334	0.5524	0.4478	-0.3633	0.5368	0.5104	0.2968
HOSPPHYS	-0.0913	0.5334	0.172	0.2729	-0.0376	0.8405	0.3479
PHYSDRUG	-0.087	0.7118	0.317	-0.1031	-0.1151	0.8926	0.3473

	DRUG	ADM	CAP	OTHER	HOSPPHYS	PHYSDRUG
OVER64	-0.2059	0.0431	0.2146	0.1334	-0.0913	-0.087
INCOME	0.582	0.5155	0.048	0.5524	0.5334	0.7118
TIME	0.4121	0.4528	0.2759	0.4478	0.172	0.317
HOSP	0.1139	-0.4376	-0.0838	-0.3633	0.2729	-0.1031
OTHINS	-0.2728	0.4078	0.3014	0.5368	-0.0376	-0.1151
PHYS	0.6505	0.374	0.137	0.5104	0.8405	0.8926
OTHPRO	0.1892	0.4811	0.0531	0.2968	0.3479	0.3473
DRUG	1	0.1777	0.1237	0.1646	0.7039	0.9116
ADM	0.1777	1	0.4503	0.7362	0.1332	0.2861
CAP	0.1237	0.4503	1	0.349	0.0964	0.1215
OTHER	0.1646	0.7362	0.349	1	0.3165	0.3504
HOSPPHYS	0.7039	0.1332	0.0964	0.3165	1	0.8272
PHYSDRUG	0.9116	0.2861	0.1215	0.3504	0.8272	1

Table 16. Auxiliary R^2				Model			
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RPCS	0.5021	0.8347	-	-	-	0.5612	0.9100
INCOME	0.2697	0.9647	0.7956	0.9716	0.9728	0.3466	0.9731
OVER64	0.2054	0.9790	0.6309	0.9844	0.9858	0.2751	0.9893
TIME	0.4424	0.7840	0.6609	0.9016	0.9102	0.5714	0.9077
HOSP	-	-	0.4582	0.8432	0.9944	-	-
OTHINS	-	-	0.7505	0.9447	0.9525	-	-
PHYS	-	-	0.8126	0.9687	0.9985	-	-
OTHPRO	-	-	0.6948	0.9680	0.9716	-	-
DRUG	-	-	0.7782	0.9161	0.9882	-	-
CAP	-	-	0.3490	0.4709	0.4712	-	-
ADM	-	-	0.7990	0.8760	0.8785	-	-
OTHER	-	-	0.8126	0.9387	0.9395	-	-
DAB	-	0.9860	-	0.9894	0.9907	-	0.9931
DBC	-	0.9356	-	0.9581	0.9592	-	0.9628
DMB	-	0.8311	-	0.9138	0.9150	-	0.9192
DNB	-	0.8986	-	0.9759	0.9760	-	0.9493
DNF	-	0.9700	-	0.9859	0.9860	-	0.9834
DNS	-	0.8712	-	0.9785	0.9786	-	0.9278
DON	-	0.9654	-	0.9849	0.9860	-	0.9793
DPE	-	0.8371	-	0.9494	0.9497	-	0.9245
DQC	-	0.9363	-	0.9785	0.9786	-	0.9636
FFS	-	-	-	-	-	0.2780	0.8020
HOSP*PHYS	-	-	-	-	0.9980	-	-
PHYS*DRUG	-	-	-	-	0.9957	-	-

Table 17		*RPCS*	*OVER64*	*DRUG*
equation 1	my results	-0.0014	0.482	
		[0.5892]	[0.0676]	
	Zelder (2000, Table 6)	0.00206	0.0483	
		[0.4365]	[0.0928]	
equation 2	my results	0.00385	0.5712	
		[0.2999]	[0.7318]	
	Zelder (2000, Table A-1)	0.00342	0.4433	
		[0.2510]	[0.747]	
equation 3	my results		0.056	-0.0628
			[0.8818]	[0.0371]
	Zelder (2000, Table A-5)		-0.073	-0.0686
			[0.808]	[0.00213]
Values in square brackets are p-values.				

Appendix

The following table provides detailed information regarding the sources of the data used to construct the variables *INCOME, OVER*64, and the components of health spending.

Table A1. CANSIM II Table and Series Identifiers.

	Table 384-0012 : Sources and disposition of personal income, PEA, Personal disposable Income.							
Personal disposable income	v691582	v691598	v691614	v691630	v691646	v691662		
	v691678	v691694	v691710	v691726				
	Table 051-0001: Estimates of population, by age group and sex, Canada, provinces and territories (Persons)							
Total population	v466983	v467298	v467613	v467928	v468243	v468558	v468873	v469188
	v469503	v469818						
Population over 64	v467001	v467316	v467631	v467946	v468261	v468576	v468891	v469206
	v469521	v469836						
	Table 384-0036: Implicit Price Indexes, Gross Domestic Product(GDP), provincial economic accounts, annual (Indexes, 1997=100)							
Government Implicit price index	v3840600	v3840629	v3840658	v3840687	v3840716	v3840745	v3840774	
	v3840803	v3840832	v3840861					