

# Illness severity and the use of public health care by the privately insured. Is there a link?\*

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## Abstract

We study the link between illness severity and the use of public health care services by the privately insured under a National Health System. Our theoretical model shows that this relationship will depend on the prioritization established by the public authorities, the cost of waiting and the private doctors' strategic behavior. In our empirical exercise, we find the consistent pattern that most severe cases get treated under the public system. As our theoretical model points out, this is not necessarily a consequence of private doctors dumping the most severe cases, but it could be just a consequence of prioritization by the public sector.

## 1 Introduction

Different types of agents participate in a health system: insurers, providers and consumers. The heterogeneity in their characteristics and objectives is a salient feature of most health systems. In this paper, we focus on the public-private dichotomy, which has received considerable attention in the literature. In fact, the public-private relation is relevant not only to study equity and efficiency issues but also to understand more specific features as

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waiting lists, the demand for private health insurance and the voters support for a public system.

We consider a National Health System (NHS) where everyone is entitled to free treatment under the public health insurance and supply system. Despite the availability of free treatments through the NHS, a considerable fraction of the population buys private health insurance. Having private allows this group of people to obtain treatment through a separate set of suppliers: the private hospitals and doctors. Hence, this group of people enjoy double coverage as they can obtain health care from both the public and private suppliers. By obtaining health care through the private supplier, they circumvent both the waiting lists and the necessity to consult a general practitioner before receiving treatment from a specialist, two inconveniences that prevail under the public insurance. In contrast, waiting lists in the private system are almost nil and one can visit any specialist directly.

Our objective is to study the relationship between illness severity and the use of public health care by the privately insured. This is relevant for three main reasons: (i) to understand whether cost differences between public and private sectors reflect differences in efficiency or they reflect differences in the severity of the cases treated, (ii) to understand support for public health expenditure by the privately insured, (iii) while there is an important empirical literature that studies the determinants of horizontal equity in health care, little is known about the severity ranges for which private insurance is likely to contribute to this horizontal inequity.

Using a theoretical model, we study how waiting costs, prioritization by the public sector and dumping strategies by the private doctors combine and jointly determine the relationship between use of public health care and illness severity. Even with a simple economic model, we can show that the relationship cannot be determined a priori, and will depend on assumptions about agents' actions and objectives. We study in detail the case when the least healthy are treated by the public insurance. Our main finding is the following. The fact that the most severe cases get treated under the public insurance does not necessarily mean that private providers are having an active strategy to dump severe cases. On the contrary, this could also be due to prioritization under the public sector.

This can alternatively be stated in a more emphatic way: dumping by the private sector and prioritization in the public sector are observationally equivalent. We believe that our paper is the first one to point this equivalence out. The policy implications of this are important. One cannot identify strategic behavior by the private sector from observations on illness severity and on use of the choice of health care provider.

In the empirical part, we find that, for most of the illnesses, the most severe cases get treated under the public insurance even if the individual has a private insurance. The reader may wonder why should a patient who is privately insured be willing to wait for public treatment. Since this is actu-

ally observed, there must exist some intrinsic cost in using the private rather than the public system. For instance, even privately insured individuals bear some co-payment that is absent in most NHSs treatment. This co-payment may take the form of an increase in the following year insurance premium. In some cases, one might even think that the medical quality of the private system is deemed to be inferior: in Spain, physicians working in the public system must pass a national examination that is quite demanding, whereas those working in the private system are not required to.

The relation between illness severity and public versus private health care use has not been studied before in detail. For the UK, Propper (2000) estimates a discrete choice model to study whether people consumed only public services or if any private services were consumed. She focuses on the influence of waiting time, political ideology and the dynamics of use but very little on how illness severity influences such choice. Some anecdotal evidence is consistent with the view that most severe cases end up being treated under the public insurance. Richmond (1996) describes the private practice in the UK and mentions that “post-operative complications, although rare, may require an ambulance ride to the NHS hospital”. Besley et al. (1999) claims in their footnote 2 that “Even individuals with private health insurance depend on the NHS for some forms of treatment, especially for emergency and catastrophic treatment”. Propper and Maynard (1989) claim that “Private Medical Insurance sector provides predominantly cold elective surgery” and “The Private Medical Insurance sector specializes in procedures which are not life threatening but reduce considerably the quality of life of the potential patient”.

On a broader sense, our paper contributes to the literature on the interaction between public and private sectors within a NHS. An important strand of the literature has examined what factors influence the demand for private health insurance, in particular, waiting time. For the UK, Besley, Hall and Preston (1999) find that the probability of buying private health insurance is influenced by the size of the waiting list in the public sector. Propper et al. (2001) find that the availability of private sector facilities -in terms of both senior doctors and hospitals- is more strongly associated with the demand for private medical insurance than the total level of resources available to the NHS or NHS waiting lists. For Spain, Jofre-Bonet (2000) and Rodríguez and Stoyanova (2004) study how waiting lists, public, and private supply influence the demand for Private Medical Insurance.

The theoretical analysis of these issues is quite scarce. On the one hand, there are a few works studying the consequences of prioritization in the public sector waiting lists, but they are carried in the absence of risk selection by a private sector.<sup>1</sup> On the other hand, there are works on risk selection

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<sup>1</sup>See for instance, Goddard and Tavakoli (1994) and references thereof.

at the private sector, but waiting lists are absent.<sup>2</sup> An exception is Barros and Olivella (2004), who show that there is a close relationship between the rationing policy that is in place in the NHS and the possibilities for cream skimming. Our theoretical model partially draws from their analysis. These latter works are carried in the absence of prioritization.

## 2 The Model

The players are the following. First, the health authority (HA) who runs a single public hospital that is owned by the public health system. The specific contracts that align the government’s objectives with those of the hospital managers are ignored here. Second, private physicians, who we model as a single representative agent. We call this agent “the private doctor.” (PD) She also runs a single private hospital. Again, any agency problems between the doctor and the hospital managers are ignored. Finally, the patients, who suffer from some illness, the severity of which comes in three possible levels that are inverse to their health status. Health status  $h$  comes also in three levels, namely  $h = 0, 1/2, 1$ .<sup>3</sup> Hence, that  $h = 0$  means that the patient is in severe condition. That  $h = 1$  means that the patient is in mild condition. That  $h = 1/2$  means that the patient is an intermediate condition, neither too severe nor too mild. The percentages of each of these conditions in the population are given by  $f_h > 0$  for  $h = 0, 1/2, 1$ , with  $f_0 + f_{1/2} + f_1 = 1$ .

### 2.1 The Health Authority: Prioritization

The health authority chooses a prioritization policy. Suppose that in the absence of prioritization average wait is given by  $w_0$ . The intensity of prioritization is measured by a parameter  $0 < \pi < 2w_0$ . This parameter conveys the intensity with which an individual in severe condition is advanced to the front of the line and at the same time an individual in mild condition is sent to the end of the line. An individual in condition  $h$  expects to wait  $w(h, \pi)$ , a function that is constant in  $h$  if  $\pi = 0$  (no prioritization), and increases with  $h$  (the inverse of severity) at a larger speed the more intense prioritization is. We will use, for simplicity, the following functional form for  $w$ .

$$w(h) = w_0 + \pi(h - 1/2).$$

This formula hides several implicit assumptions. First, an intensification of prioritization does not imply an increase of resources. A counterexample. of

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<sup>2</sup>See, for instance, González (2002)

<sup>3</sup>We have taken this terminology to adapt the model to the data we are using. Patients do not report their severity but their health status. We take health status as an (inverse) proxy to the severity of their illness.

this would be the installation of a second server to treat individuals in severe condition only.<sup>4</sup> Second, when an individual in severe condition is advanced, it is not at the expense of some individual in medium condition, but at the expense of an individual in mild condition. Notice that the average waiting time ( $w_0$ ) conveys some measure of the total resources devoted by the HA. The higher these resources, the lower  $w_0$  will be.

## 2.2 The private doctor: Dumping

The only assumption we need in reference to the preferences of private doctors (PD) is the following.<sup>5</sup>

**Assumption 1** *If the private doctor is willing to treat a patient with health status  $h'$ , then she is also willing to treat any patient with health status  $h \geq h'$ .*

This assumption implies the following statement: “the cost of treating a patient in health status  $h'$  is higher than the cost of treating a patient with health status  $h > h'$ .” Thus, an implicit assumption is that treating more complex problems is more costly to the doctor. For instance, the (preparation) time and attention effort required increases with severity. This higher cost can also represent the increasing risk of future complications. If doctors are selfish and receive a flat fee per patient treated, then the above statement and Assumption 1 are equivalent.

On the other hand, whenever doctors are selfish but receive a fee that is decreasing in  $h$ , Assumption 1 requires that the fee decrease at a lower rate than treatment costs (as functions of  $h$ ). Finally, if doctors are altruistic and care for patients’ welfare, Assumption 1 requires that the cost of treating a patient decreases with  $h$  sufficiently fast to overcome the effect of doctor’s altruism. Thus, Assumption 1 allows a degree of generality in the analysis, as it can encompass different underlying behavioral models of doctors.

Notice that Assumption 1 is *necessary* for “cream-skimming” to be an issue to start with. For instance, suppose that the doctor’s fee decreases with  $h$  at a faster rate than treatment costs. Then doctors prefer the hardest cases. This would imply either that cream skimming is not an issue or that cream skimming means that the doctor chooses the hardest cases. We do not believe that this is the problem in most western economies.

An important consequence of Assumption 1 is that the only relevant decision on the part of the PD is the choice of the minimum health status she is willing to treat, which we denote by  $h^{\min}$ . Once this is chosen, all

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<sup>4</sup>To illustrate this point, an example of the waiting time as a function of severity could be  $w(h) = \begin{cases} w_0 + \pi(h - 1/2), & \text{if } h < 1/2. \\ w_0, & \text{if } h \geq 1/2 \end{cases}$ . Notice that this prioritization regime is never harmful to the patient, irrespective of his severity.

<sup>5</sup>This subsection draws heavily from Barros and Olivella (2003).

patients with health status above  $h^{\min}$  are offered the private treatment. Let us turn now to patients.

### 2.3 The patients

Patients minimize the total costs of treatment, which include waiting costs and any other pecuniary (e.g. treatment fees) or non-pecuniary costs. This is equivalent to assuming that patients maximize a utility function that is quasilinear in final wealth. The waiting costs of a patient with health status  $h$  who expects to wait  $w$  from the moment he becomes ill until his discharge from the hospital is given by  $c(w, h)$ . We use the following assumptions on the function  $c$ .

**Assumption 2**  $\frac{\partial c}{\partial w} > 0$ ,  $\frac{\partial c}{\partial h} < 0$ , and  $a(t, m)$  is continuous and twice differentiable.

We require that utility cost be increasing in waiting time and severity. Also, it would be natural to think that marginal cost of waiting ( $\frac{\partial c}{\partial w}$ ) is decreasing in health status (or  $\frac{\partial^2 c}{\partial w \partial h} < 0$ ). This would ensure that the more severe the condition of a patient is, the more he is willing to pay for a reduction in the waiting time. Nonetheless, we do not need to impose this.

All patients with status above  $h^{\min}$  are offered the possibility of resorting to a private treatment. The advantage of being treated in the private practice is that the waiting time is shorter. We assume, for simplicity, that waiting time in the private practice is zero. The advantage of being treated in the public practice is that the treatment is free, whereas the private treatment costs  $s > 0$  to the patient. This cost  $s$  may or may not coincide with the fee that a doctor receives in her private practice. The difference between the patient's payment and the doctor's remuneration may be financed either through cross-subsidization or by some third-party payers, as we discuss below. For exposition purposes, we refer to  $s$  as the "treatment fee."

The parameter  $s$  admits several interpretations. First,  $s$  may denote the deductible or a bonus/malus regime of a private health insurance policy. Second, PDs may be less skilled.<sup>6</sup>

We assume for the moment that  $s$  is independent of severity. Nonetheless, this assumption can be justified using the first interpretation for  $s$ . Firstly, since we restrict our attention to a specific illness or specialty, the assumption that the fee  $s$  is independent of severity is somewhat justified. Of course, this will not be true in all circumstances. For example, there can be different fees for hip replacement depending on whether the hip has been replaced before. Nonetheless, the assumption holds for many procedures, especially for those

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<sup>6</sup>For instance, in Spain specialists who work in the public sector must pass a highly demanding examination called the MIR. This is not required if a specialist works for the private sector only.

in which medical associations have a say in price setting. Moreover, different prices for essentially the same operation are often regarded as unethical. In consequence, although doctors may receive a payment that increases with severity, the patient's outlay is often constant.

Secondly, if  $s$  is the deductible in a private insurance policy, then it is possible that, although the fee that the doctor receives is increasing in the severity of the case, the out-of-pocket payment by the patient is not.<sup>7</sup>

For simplicity, we also assume the following.

**Assumption 3**  $c(w, 1) = 0$  for all  $w$  and  $c(0, h)$  for all  $h \in \{0, 1/2, 1\}$ .

This is to be interpreted as follows. First, a patient with perfect health status does not need any treatment. Second, if a patient gets instant treatment, he suffers no loss due to his illness.

## 2.4 Timing

The last movers are the patients. We solve the optimal decision of patients for four different scenarios: (i) absence of both prioritization and dumping; (ii) prioritization only; and (iii) dumping only. Notice that game (i) has a single stage, as the PD and the HA remain passive. In game (ii) the HA moves first and the PD remains passive. In game (iii) the PD moves first and the HA remains passive. We now solve each of these games in turn.

## 3 First-come/first-served in the NHS, universal coverage in the private sector

If the queuing regime is first-come/first-served, then  $\pi = 0$  and  $w(h)$  reduces to  $w_0$ . A patient with health status  $h$  will choose the private sector if  $c(w_0, h) \leq s$ . Since  $c$  is monotonically decreasing in  $h$ , and by virtue of Assumption 3 (so that  $c(w, 1) = 0 > s$  is impossible) we only have a two possible cases for each fixed  $w_0$ :

- a) Only the patients in worse health status attend the private sector, that is,  $c(w_0, 0) > s \geq c(w_0, 1/2) > c(w_0, 1) = 0$
- b) Both patients in bad and medium health status attend the private sector, that is,  $c(w_0, 0) > c(w_0, 1/2) > s > c(w_0, 1) = 0$ . This is illustrated in Figure 1.

Notice that in both cases, the tendency to use either sector is monotone in health status. The intuition is the following. The fact that individuals in more severe condition suffer higher waiting costs for the same waiting time implies that the more severely sick are willing to pay for private treatment.

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<sup>7</sup>Of course, the next question is whether a deductible independent of illness severity is the optimal insurance policy to set. Such a discussion is beyond the scope of this paper.

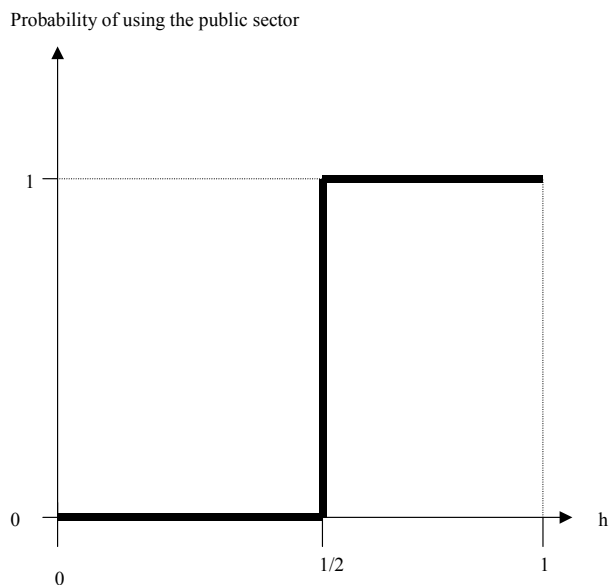


Figure 1:

If health status (the inverse of severity) is in the horizontal axis, then we find an upward sloping relationship between the probability of using the public facilities and health status.

#### 4 Prioritization in the NHS, universal coverage in the private sector

The patient with health status  $h$  will use the private sector if

$$c(w(h), h) = c(w_0 + \pi(h - 1/2), h) > s.$$

It is important to notice here that there are two effects of health status on costs. First, a negative direct effect, which we already studied in the previous section: costs are higher if your health status worsens. Second, a positive indirect effect coming through prioritization. As your health status worsens, you expect a shorter wait, which in turn lowers your waiting costs. Which of the two effects dominates depends on the specific functional forms chosen. More importantly, there exist plausible functional forms that yield a non-monotone relationship between health status and waiting costs, and therefore between health status and public usage. We use the following notation in the remainder of this section:  $c^*(h) \equiv c(w(h), h)$ .

We prove this last assertion by example. Take  $c(w, h) = w(1 - h)$ . Notice

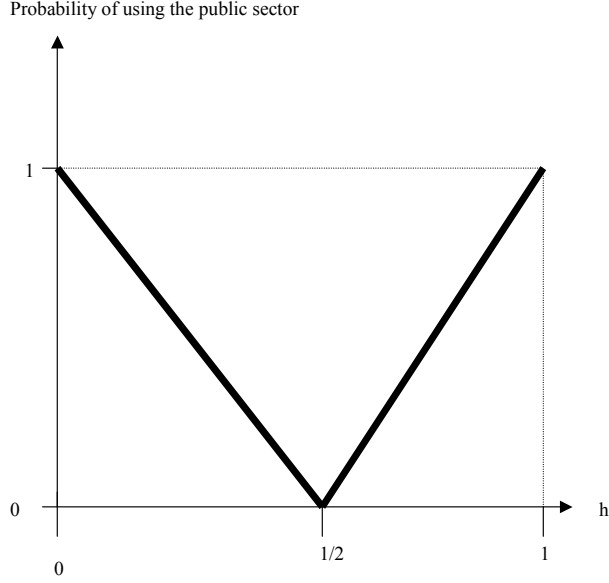


Figure 2:

that both Assumptions 2 and 3 are satisfied. Then  $c^*(h) = c(w_0 + \pi(h - 1/2), h) = (w_0 + \pi(h - 1/2))(1 - h) = \begin{cases} w_0 - \frac{1}{2}\pi & \text{if } h = 0, \\ \frac{1}{2}w_0 & \text{if } h = 1/2, \\ 0 & \text{if } h = 1. \end{cases}$

Notice that, by assumption  $[\pi \leq 2w_0]$ , we have  $c^*(0) = w_0 - \frac{1}{2}\pi \geq 0$ . Moreover, for any  $0 < w_0 < \pi < 2w_0$ , we have  $c^*(1) = 0 < c^*(0) < c^*(1/2)$ . Therefore, we have three cases:

a)  $c^*(1) = 0 \leq s < c^*(0) < c^*(1/2)$ , that is, only patients in good health status use the public sector;

b)  $c^*(1) = 0 < c^*(0) \leq s < c^*(1/2)$ , that is, both patients in good health status and patients in bad health status use the public sector, while patients in medium health status use the private sector. This is illustrated in Figure 2.

c)  $c^*(1) = 0 < c^*(0) < c^*(1/2) \leq s$ , that is, all patients use the public sector.

To conclude, we have the following

**Proposition 1** *There exist parameter values such that a non-monotone relationship appears between public usage and health status.*

The intuition for this non-monotonicity is best understood by isolating the effects of prioritization when health status does not influence the costs of waiting. Of course, this assumption is not realistic. We proceed in this

way in order to clarify the effects at play. Hence, we postpone the intuition for the non-monotonicity result to the end of this section.

#### 4.1 The effects of prioritization alone

Consider a situation where waiting costs are independent of health status. In this case the waiting costs of a patient in health status  $h$  who must wait  $w$  units of time is given by  $c(w)$ . Due to prioritization, his final costs of waiting will be

$$c^*(h) = c(w(h) = c(w_0 + \pi(h - 1/2))) = \begin{cases} c(w_0 - \frac{1}{2}\pi) & \text{if } h = 0, \\ c(w_0) & \text{if } h = 1/2, \\ c(w_0 + \frac{1}{2}\pi) & \text{if } h = 1. \end{cases}$$

Notice that, for all  $\pi > 0$ ,  $c(w_0 - \frac{1}{2}\pi) < c(w_0) < c(w_0 + \frac{1}{2}\pi)$ , or  $c(0) < c(1/2) < c(1)$ . This implies that we have 4 possible cases depending on the size of  $s$ :

- a)  $s < c(0)$ , where, all patients use the private facility
- b)  $c(0) \leq s < c(1/2)$ , where only patients in health status  $h = 1/2, 1$  use the private facility.
- c)  $c(1/2) \leq s < c(1)$ , where only patients in health status  $h = 1$  use the private facility.
- d)  $s > c(w_0 + \frac{1}{2}\pi)$ , where no patients use the private facility.

Hence, we obtain a monotone relationship between health status and public usage. However, notice that the relationship is exactly the opposite to the one obtained in Section 3.

Of course, by changing the functional forms and the parameter values, one could obtain that the composition between an increasing schedule and an increasing one could be concave and even inverse-U-shaped rather than convex and U-shaped. Our point is that our model is flexible enough to encompass both.

#### 4.2 The intuition

We are now ready to explain the intuition behind the U-shaped relationship between health status and public usage.

Take an individual in very good health status. On the one hand, he is willing to wait for treatment at the NHS since his waiting costs are small. On the other hand, prioritization makes his wait in the NHS be longer. We have posited particular functional forms for the waiting costs and prioritization regime so that the first effect countervail the second so that he prefers to use the NHS.<sup>8</sup>

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<sup>8</sup>Notice that this result is reinforced if, as discussed in a previous footnote, prioritization does not harm patients in good condition because prioritization is implemented by installation of an additional server. In this case only the first effect is at work. In this

Take now an individual with a bad health status. Since his waiting costs are very large, he is willing to pay for immediate treatment in the private sector. On the other hand he is greatly prioritized so his wait at the NHS may be extremely short. Again, the functional forms posited imply that the second effect counterbalances the first so that he also prefers to use the NHS.

## 5 First-come/first-served in the NHS, dumping in the private sector

As in Section 3, the queuing regime is first-come/first-served, so that  $\pi = 0$  and  $w(h)$  reduces to  $w_0$ . A patient with health status  $h$  will choose the private sector if  $c(w_0, h) \leq s$ . However, if the PD rejects the hardest cases, that is, the patients in worse health status are dumped, then we have different cases depending on where does the PD draw the line. Since patients in good health status are never willing to pay a private fee, the only interesting cases are  $h^{\min} = 0$  and  $h^{\min} = 1/2$ .

a) The private sector is willing to treat any condition. That is,  $h^{\min} = 0$ .

In this case we are back to the model without dumping. In consequence, we have two subcases, corresponding to the same two cases studied there. Namely,

a.a) Only the patients in worse health status attend the private sector, that is,  $c(w_0, 0) > s \geq c(w_0, 1/2) > c(w_0, 1) = 0$

a.b) Both patients in bad and medium health status attend the private sector, that is,  $c(w_0, 0) > c(w_0, 1/2) > s > c(w_0, 1) = 0$ . Figure 1 applies.

b) The private sector is only willing to treat patients in either good or medium condition. That is,  $h^{\min} = 1/2$ .

b.a) Only the patients in worse health status would like to attend the private sector, that is,  $c(w_0, 0) > s \geq c(w_0, 1/2) > c(w_0, 1) = 0$ , but they are rejected from that sector. In consequence, the private sector remains inactive.

b.b) Both patients in bad and medium health status would like to attend the private sector, that is,  $c(w_0, 0) > c(w_0, 1/2) > s > c(w_0, 1) = 0$ . However, only the later are admitted in the private sector. Therefore, only the patients in medium health status end up in the private sector. Figure 2 Applies.

Notice that case (b.b) is observationally equivalent to case (b) in the previous section. This is an important result of our analysis. Stated more formally,

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sense, we are obtaining the "right arm" of the U-shape in the worst scenario for this to occur.

**Proposition 2** *If only the relationship between health status and public sector usage is taken into account, dumping and prioritization may be observationally equivalent*

There is a stronger version of this proposition if one tries to deduce opportunistic behavior in the private sector by just looking at the individuals in worse health status. That is, it is incorrect to conclude that the private system is dumping the worst cases (i.e., those patients in worst health status) by noting that these individuals have a higher probability of using the NHS. This may be due, exclusively, to the fact that these patients are prioritized. By only looking at the individuals in worst health status, the next section extends the results obtained under prioritization alone.

## 6 A general analysis of the individuals in worst health status

In this section we analyze a much more general version of the model, with a continuum of illness severities, and general preferences and technology. In order to obtain our results we do have to impose some restrictions. Moreover, we restrict prioritization policies to be of the same form to the ones explored in the previous sections. Formally, we introduce the following assumptions.

**Assumption 4** *The prioritization policy takes the form  $w(h, \pi, w_0) = w_0 + \pi(h - \frac{1}{2})$  for all  $h$ .*

The same comments made in Section 4 apply here. We believe that the simplicity of the prioritization policy can be justified on the grounds that the HA must be able to send a clear message. Indeed, casual observation suggests that the government rarely commits to a certain expenditure, letting consumers calculate the rational expectations equilibrium involved in calculating the waiting time that results from the consumers' best response (in terms of choice of sector for treatment) to the announced expenditure. Instead, HAs usually make announcements on waiting time that should be expected by consumers in different health conditions.

We also generalize the fees paid in the private sector. Instead of a constant fee that is independent of health status, we now allow for severity-sensitive fees. However, we do need to impose a lower bound on the fee that is paid. This could represent the fixed costs in treating a patient, like the tests that must be performed before the treatment is actually applied. Formally,

**Assumption 5**  *$s(h) = s_0 - s_1(h)$  with  $s_1(0) = 0$ ,  $s_1' \geq 0$ , and  $s_0 > 0$ .*

As for consumer's preferences, we assume that waiting costs are not convex on waiting time. Thus, the marginal cost of waiting one additional unit of time does not increase as current waiting time increases. This is indeed a strong assumption, but recall that we are providing sufficient conditions ensuring that our results hold. We also assume that the marginal cost of waiting an additional unit of time does not increase with health status. This is quite plausible. Individuals in better health status should suffer a smaller marginal cost of waiting. These two assumptions are spelled out in the following.

**Assumption 6**  $\frac{\partial^2 c}{\partial^2 w} \leq 0$  and  $\frac{\partial^2 c}{\partial h \partial w} \leq 0$ .

We now define the function that gives the actual cost of waiting for any given health status  $h$ , prioritization policy  $\pi$ , and average waiting time  $w_0$ . The aim of this section is to show that this function is increasing in health status at the worst health status. This ensures that the likelihood to remain in the public system increases as severity gets closer to the worst possible severity.

**Definition 1**  $c^*(h, \pi, w_0) \equiv c(w(h, \pi, w_0), h) + s_1(h) = c(w_0 + \pi(h-1/2), h) + s_1(h)$ .

The last assumption that we need is quite technical. In words, take the individual in worst health status. Suppose that his health improves a little. This will imply, directly, a decrease in waiting costs. However, due to prioritization, this effect will be compensated because the patient will be prioritized less, so he will have to wait more. This is the indirect effect. We assume that at least for some value of the prioritization intensity  $\pi$  and for some value of the average waiting time  $w_0$ , the indirect effect exactly compensates the direct effect. Formally,

**Assumption 7** *There exists  $\bar{w}_0 > 0$  and  $0 < \bar{\pi} < 2\bar{w}_0$  such that  $\bar{\pi} \frac{\partial c}{\partial w}(\bar{w}_0 - \frac{1}{2}\bar{\pi}, 0) + \frac{\partial c}{\partial h}(\bar{w}_0 - \frac{1}{2}\bar{\pi}, 0) = 0$ .*

Notice that these assumptions do not violate the maintained assumptions on the parameters of the model.<sup>9</sup> By virtue of all these assumptions, we have the following

**Proposition 3** *For all  $w_0 > \bar{w}_0$ , there exists an increasing function  $\pi^{\min}(w_0)$  such that, for all  $\pi^{\min}(w_0) < \pi < 2w_0$ , we have that  $\frac{\partial c^*(0, \pi, w_0)}{\partial h} > 0$ .*

**Proof.** Notice first that the function  $c^*(h, \pi, w_0)$  defined above is  $C^1$  in  $h$ . Therefore, it suffices to show that its derivative at  $h = 0$  is positive.

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<sup>9</sup>For the functional form used previously.

Notice that  $\frac{\partial c^*(h, \pi, w_0)}{\partial h} = \frac{\partial c(w_0 + \pi(h-1/2), h)}{\partial w} \pi + \frac{\partial c(w_0 + \pi(h-1/2), h)}{\partial h} + s'_1(h)$ . At  $h = 0$ ,  $\frac{\partial c^*(0, \pi, w_0)}{\partial h} = \underbrace{\frac{\partial c(w_0 - \frac{1}{2}\pi, 0)}{\partial w}}_+ \underbrace{\pi}_+ + \underbrace{\frac{\partial c(w_0 - \frac{1}{2}\pi, 0)}{\partial h}}_- + \underbrace{s'_1(0)}_+$ . Since  $s'_1 \geq 0$ , a sufficient condition for the last expression to be positive is that

$$D(\pi, w_0) \equiv \pi \frac{\partial c}{\partial w}(w_0 - \frac{1}{2}\pi, 0) + \frac{\partial c}{\partial h}(w_0 - \frac{1}{2}\pi, 0) > 0. \quad (1)$$

Notice that  $\frac{\partial D(\pi, w_0)}{\partial \pi} = \frac{\partial c}{\partial w} - \frac{1}{2}\pi \frac{\partial^2 c}{\partial^2 w} - \frac{1}{2} \frac{\partial^2 c}{\partial h \partial w} > 0$ , by Assumption 3, whereas  $\frac{\partial D(\pi, w_0)}{\partial w_0} = \pi \frac{\partial^2 c}{\partial^2 w}(w_0 - \frac{1}{2}\pi, 0) + \frac{\partial^2 c}{\partial h \partial w}(w_0 - \frac{1}{2}\pi, 0) < 0$ . Consider the equation  $D(\pi, w_0) = 0$ . By Assumption 4 this has a solution for  $w_0 = \overline{w_0}$ , and this solution is  $\pi^{\min}(\overline{w_0})$ . Hence the following identity defines the solution for  $\pi$  for each possible  $w_0$ :

$$D(\pi^{\min}(w_0), w_0) \equiv 0.$$

By the implicit function theorem, the function  $\pi(w_0)$  has derivative given by

$$\pi^{\min}'(w_0) = -\frac{\frac{\partial D(\pi, w_0)}{\partial \pi}}{\frac{\partial D(\pi, w_0)}{\partial w_0}} > 0.$$

Therefore, for each  $w_0$ , if  $\pi^{\min}(w_0) < \pi < 2w_0$ , we have that  $D(\pi, w_0) > 0$ .  
10 ■

This proposition can be read as follows. For a sufficiently intense prioritization regime, individuals in worst health status are more likely to prefer the private system rather than the public system. Moreover, the lower bound for the intensity of prioritization decreases as the resources devoted to the public system decrease.

Let us explain this result intuitively. Notice first that the fact that the private fee may be increasing reinforces our result. Starting from the consumer in worse health status,  $h = 0$ , if his health status improves then he will be more likely to use the private system. This explains why our sufficient conditions are independent of the function  $s(h)$ . Assumption 4 ensures that an increase in health status has no effect on the actual cost of waiting at  $\overline{w_0}$  and  $\overline{\pi}$ . However, if one increases prioritization intensity without changing the other parameters, the indirect effect an improvement in health status will overwhelm the direct effect on waiting costs, Hence this individual will be more prone to use the private sector.

<sup>10</sup>The following illustrates Lemma ??? for the specific functional form used in the previous sections. Let  $s(h) = s_0$ , that is,  $s'_1(0) = 0$ . Let  $c(w, h) = w(1-h)$  so that  $c_w = 1-h$  and  $c_h = -w$ . Then Assumption 3 is satisfied, as  $\frac{\partial^2 c}{\partial^2 w} = -1 < 0$  and  $\frac{\partial^2 c}{\partial h \partial w} = -1 < 0$ . Now  $D(\pi, w_0) \equiv \pi \cdot 1 - (w_0 - \frac{1}{2}\pi) = \frac{3}{2}\pi - w_0 = 0$  yields  $\pi^{\min}(w_0) = \frac{2}{3}w_0$ . Hence, for all  $\frac{2}{3}w_0 < \pi < 2w_0$  we have  $D(\pi, w_0) > 0$ .

Finally, the reason why the lower bound on prioritization intensity increases with the resources devoted in the system is that if resources are very small then the marginal effect of an increase in prioritization is more greatly felt by individuals in bad condition.

## 7 Empirical Analysis

In the previous section, we have shown that even a simple economic model cannot generate an unambiguous relation between illness severity and the use of public health care. The relation ultimately depends on assumptions about the actions taken by the private doctors, the prioritization policy in place in the public sector, as well as how the waiting cost evolves with time and illness severity. This makes the empirical analysis necessary to determine the nature of the relationship under scrutiny.

We will use the 1994 Catalonian Health Survey for our empirical analysis. The Catalonia Health Survey includes information on health, sociodemographic characteristics, insurance status, and use of health care services for 15000 individuals. This large sample size for a relatively homogenous territory is very important for us as we will have to focus on a subsample: those individuals that are both privately and publicly insured. Moreover, the health system in Catalonia exhibit features that makes it suitable for our analysis. In Catalonia, people enjoy a National Health Service where coverage for treatment are free under the public system.<sup>11</sup> However, there are substantial waiting lists for both elective surgery and consultations with specialists. Consequently, about a 20% of the population by Private Medical Insurance. In fact, Catalonia is the Spanish autonomous region with the largest proportion of the population enjoying double coverage (both public coverage and Private Medical Insurance).<sup>12</sup> This is the group of people in which we focus our analysis.

Most health surveys have very limited information about the type of health care services used by the population. Health surveys often ask for the amount of health services obtained in a large period of time, i.e. a year, but details of these services are only obtained for the last services obtained. Typically, they just offer detailed information about the last hospitalization episode and the last visit within the last fifteen days to a health care professional. However, this would be potentially insufficient for our purposes as many individuals will no have used any health care services for the reference period. Moreover, analyzing the last visit may cause a systematic bias as

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<sup>11</sup>Drugs are subject to a 40% out of pocket payment for the non-retired population. Coverage for dentist services is very limited.

<sup>12</sup>People can buy Private Medical Insurance but they cannot opt out from the Public Insurance. That is why we say they have double coverage. The Civil Servants, a small fraction of the population, are an exception as they can freely choose between public and private insurance.

people might decided to use public services to obtain second opinions for more complicated cases or some other systematic pattern that might bias our results. The Catalonian Health Survey has the additional advantage that ask individuals for the type of health care coverage most frequently used during the last 12 months. This will be our dependent variable to describe the use of public health care. Out of 2334 individuals both older than 14 years and with double coverage, 32.4% have use the public system most frequently, 56.5% used private coverage, and the remaining 11% did not use any health care service in the last year.<sup>13</sup> We concentrate our analysis on the group that used any health care service. After dropping observations with missing values, we will have 2061 valid observations that correspond to individuals living in 65 different municipalities. The definitions and summary statistics of the most important variables of the analysis are reported in Table 1.

Measuring severity is an important step in our analysis. Health surveys typically measure self declared health status as measuring illness severity could be prohibitively expensive. In the Catalonia Health Survey, each individual ranks her health status in a scale between 0 and 100, where 100 indicates the best possible health status. This is our variable *Health* reported in Table 1 where we have re-scaled to be between 0 and 1. For a list of pre-specified 15 different illnesses or ailments, we know whether or not the individual report to suffer each of them. The list of illnesses is also reported in Table 1. Table 2 shows a simple OLS regression of *Health* over the dummy variables for the different illnesses. Except for allergies, the rest of illnesses have a negative partial correlation with *Health*. Some of them are not statistically significant from zero, but these are mostly the least frequent ones. For instance, the coefficient for *Stroke* is negative but not significant. This is not strange given that just a 1% of the sample has suffered from *Stroke*. We have three illnesses that are quite related: *Heart*, *High Blood*, and *Cholesterol*. It is reassuring that the coefficient of *Heart*, probably the most severe one, is larger in absolute value than the ones of *High Blood* or *Cholesterol*. Though the estimates in Table 1 indicate that our measure of *Health* is reasonable, we must also recognize that there are clear problems in using the variable of self-declared health status. For instance, according to Table 2, suffering from *Arthritis* decreases *Health* about the same than suffering jointly from *High Blood* and *Heart*. Probably, this reflects more the influence of pain and limitation associated with *Arthritis* than the medical complexity and costs associated with its treatment. This is limitation

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<sup>13</sup>The 56.5% can be divided in 43.5% that used the Private Medical Insurance to cover the cost of the treatment, and 13% that fully paid the cost out of pocket even if they had Private Medical Insurance. This could be the case if they visited a Private Doctor that was not among the providers offered by their insurer. We restrict our analysis to individuals older than 14 years old as many of the variables that we use are not available for younger children.

of our work that should be contemplated. At the end of this section, we will show additional results with one objective measure of medical complexity that corroborate our main finding.

Our theoretical model clearly showed how the relation between severity and use of public services might crucially depend on the intensity of prioritization that is taking place in the public sector. It is clear that the intensity of prioritization might be different depending on the specific illness. The public health authorities might decide to impose strong levels of prioritization in some illnesses while not so much in others. Consequently, our empirical strategy should allow for different relations between severity and use of public health care services depending on the illness that the individual suffers. In order to take this into account, we will specify the model:

$$\Pr(Usepub_i = 1) = \Phi(\alpha_0 + \alpha_1 * X_{1i} + \sum_{j=1}^2 H_i^j * \beta_j + \sum_{k=1}^{15} \sum_{j=0}^2 D_{k,i} * H_i^j * \gamma_{k,j}), \quad (2)$$

where the subscript  $i$  refers to the individual, and the subscript  $k$  refers to each of the 15 listed illnesses,  $D_{k,i}$  takes value 1 if the  $i$ -th individual suffers from illness  $k$ ,  $H_i^j$  refers to the value that the variable *Health* takes for the  $i$ -th individual at the power of  $j$ ,  $X_{1i}$  refer to other covariates, and  $\Phi()$  refer to a cumulative distribution function. The model above allows that the changes in *Health* might differently influence the probability of use of public services depending on the illness that the individual might suffer.

Among the set of covariates  $X_{1i}$ , we will consider age and its square, sex, region, month when the interview took place, size of the municipality where the person lives, dummies for levels of education, as well as whether she is self-employed or not. While some of these variables are general control variables, others can be interpreted in light of our theoretical model. People living in small municipalities might have less supply of private health care available. This might mean that they have to travel more to get the necessary private services or, alternatively, face a more restricted choice. In terms of our theoretical model, this means that the fee  $s$  is larger. Self-employed and higher educated individuals usually have a bigger opportunity cost of waiting, and consequently they are more prone to use private services. This obviously relates to  $c(w, h)$  of our theoretical model.

## 7.1 Results

We estimate the parameters  $(\alpha_0, \alpha_1, \beta_j, \gamma_{k,j})$  in equation (2) using a Probit model estimated by maximum likelihood. Individuals living in the same municipality might face common unobserved characteristics, probably related to health care supply or illness environment. Consequently, we estimate standard errors taking into account clustering at the municipality level. The

second column of Table 3 shows the parameter estimates using the whole sample. Notice that our regressor  $H_i$  is censored as nobody can report a health status less than 0 or larger than 1. The literature has recently recognized that the use of censored regressors might cause "expansion bias" (Rigobon and Stoker, 2003). That is, in the presence of censored regressors the parameter estimates might be too large in absolute value. Contrary to the case where censoring occurs in the dependent variables, the estimates obtained by considering non-censored observations will be consistent (Rigobon and Stoker, 2003).<sup>14</sup> The third column of Table 3 shows the estimates when we drop those observations that have not reported the minimum nor the maximum admissible value for  $H_i$ . Though the number of censored observations is small (133 observations), the estimates of the parameters for Health ( $\beta_1$ ) and Health squared ( $\beta_2$ ) falls dramatically in absolute value, being consistent with the idea that the the estimates of these two parameters in the second column of Table 3 are suffering of "expansion bias". Consequently, we will use the non-censored observations when we use  $H_i$  as a regressor. In the third column of Table 3 we find that many of the estimates of  $\gamma_{k,1}$  and  $\gamma_{k,2}$  are not statistically significant from zero at the usual levels of confidence. It is well known that a linear relationship might exist but the collinearity between the linear and square term of the polynomial renders both terms as non significantly different from zero. Consequently, we constrain the parameters of the squared terms that are not significantly different from zero at the 10%. The results are shown in the fourth column of Table 3. In the following, we will comment on these results.

The first estimate of the fourth column indicates that, for those individuals that do not suffer any of the pre-listed illness conditions, the less healthy the individual is, the more likely he is to obtain treatment by the public insurance. The estimates of the parameters  $\gamma_{k,1}$  and  $\gamma_{k,2}$  are not significantly different from zero for most of the illnesses. Consequently, individuals suffering most of the 15 pre-listed illnesses do not seem to exhibit a pattern different than the standard one. Consequently, it seems very robust in the data that the least healthy individuals use the public most frequently. This coincides with last subsection of the theoretical model where we could give sufficient conditions for this to be an expected result when prioritization takes place in the public insurance.

The results for some of the 15 pre-listed illness conditions deserve further explanation. The term  $\gamma_{k,1}$  is positive and significant for individuals with urinary conditions. However, the sum  $\beta_1 + \gamma_{k,1}$ , though negative, this is only

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<sup>14</sup>This strategy might lead to lose too much precision if the proportion of censored observations is large. However, this is a minor problem in our sample as the number of censored observations is 133 out of 2061. Moreover, the accuracy of our estimates is mostly driven by the number of clusters, rather than the number of observations. Rigobon and Stoker 2003 also propose other solutions that would be useful in case the proportion with censored observation in the sample was large.

significant at the 14%, consequently the relationship between public care use and health is not clear for individuals facing from urinary conditions. For the case of Arthritis, we can find an inverted U-shaped relationship. This is the only illness for which we find an empirical pattern that our theoretical model cannot easily accommodate. Given our results in Table 2, this might be because the self-assessed health status measures pain rather than medical complexity for people that suffers from Arthritis. For varicose veins, we find a clear U-shape relationship between the use of public health care and health. This is consistent with Figure 2 of our theoretical section.

The estimates also show that self-employed individuals use the public services less frequently. As we mentioned before, this could be because they face higher opportunity cost of waiting. Consistent with the same hypothesis, we also find that more educated individuals tend to use public services less frequently<sup>15</sup>. Individuals living in small municipalities use public insurance more frequently. This is probably because the choice of private providers is more limited in small municipalities.

Our empirical results confirm, except for individuals that suffer from arthritis or urinary conditions, that the least healthy cases use the public services more frequently. One possible criticism is that our measure of self-assessed health status is not objective. We would like to show the robustness of our main finding by using an extreme but clear indicator of very poor health. The last column of Table 3 shows the results when we do not use the self-assessed health status, but we use *Severe Dependency* that takes value 1 if the individual declares that he cannot do a normal life as he has to heavily rely on a machine (pacemaker, automatic kidney) or treatment (oxygen, strict diet). This should be a good indicator of very high illness severity. Our estimate at the bottom row of the fourth column of Table 3 shows that individuals with a severe dependency do a more frequent use of public insurance. The estimate is significantly different from zero at the 6%. This corroborates our main finding that the least healthy individuals are treated in the public.<sup>16</sup>

## 8 Conclusions

We have set up a model that explain the relation between illness severity and the use of public health care as a function of the prioritization policy by the public authorities, the private doctor's strategic behaviour and the cost of waiting. Even a simple theoretical model cannot provide an unambiguous solution as this depends on assumptions about agents' actions and

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<sup>15</sup>We do not report these results on Table 3. They are available from the authors upon request.

<sup>16</sup>As we are not using the variable Health, we include everyone in this regression, and not just with uncensored Health.

objective function. Our empirical analysis shows that the most unhealthy individuals get treated in the public insurance, even if they have private insurance. Our theoretical model shows that this might not be necessarily mean that the private doctors dump the most severe cases, but it might just be a consequence of prioritization by the public authorities. This is because prioritization by the public authorities and dumping by the private doctors are observationally equivalent.

Even If one restricts attention to the most severe cases, the result that prioritization may produce the same effects as dumping is very relevant for policy analysis. Indeed, policies that aim at subsidizing treatment of the most costly cases in the private sector may be completely useless. Since this is quite a strong statement, we have tried to give the weakest set of assumptions that ensures this result. Basically, one needs the combination of two elements at the NHS: scarce resources and intense prioritization.

Thanks to the combination of our theoretical and empirical work, we can reject that health care supply is passive. That is, either prioritization by the public authorities and/or dumping by the private doctors take place in a National Health Service.

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Table 1: Variable definitions and summary statistics

Variable	Mean	Std. Dev.	
Usepub	0.364	0.481	1 if individual used public services more frequently in the last 12 months, 0 if private
Health	0.716	0.187	Continuous measure of health. 1 means best possible health status, 0 the worst possible health status.
High Blood	0.167	0.373	1 if individual declares to have suffered from high blood pressure, 0 otherwise
Heart	0.069	0.254	1 if individual declares to suffer from heart related diseases 0 otherwise
Varicose	0.148	0.356	1 if individual declares to suffer from varicose veins 0 otherwise
Arthritis	0.321	0.467	1 if individual declares to suffer from arthritis, rheumatism, and/or back pain, 0 otherwise
Allergies	0.138	0.345	1 if individual declares to suffer from allergies 0 otherwise
Asthma	0.04	0.195	1 if individual declares to suffer from asthma 0 otherwise
Bronchitis	0.056	0.23	1 if individual declares to suffer from chronic bronchitis 0 otherwise
Diabetes	0.045	0.207	1 if individual declares to suffer from diabetes 0 otherwise
Ulcers	0.056	0.229	1 if individual declares to suffer from stomach and/or duoden ulcers, 0 otherwise
Urinary	0.077	0.266	1 if individual declares to suffer from urinary and/or prostate problems, 0 otherwise
Cholesterol	0.112	0.316	1 if individual declares to suffer from high cholesterol 0 otherwise
Cataracts	0.061	0.239	1 if individual declares to suffer from cataracts 0 otherwise
Skin	0.061	0.239	1 if individual declares to suffer from skin related problems 0 otherwise
Constip.	0.099	0.299	1 if individual declares to suffer from chronic constipation 0 otherwise
Depression	0.101	0.302	1 if individual declares to suffer from depression 0 otherwise
Stroke	0.012	0.108	1 if individual declares to have suffered from a stroke or embolism, 0 otherwise
Self	0.177	0.382	1 if individual declares to be self employed 0 otherwise
Age	0.468	0.19	Age in year divided by 10
Female	0.556	0.497	1 if individual is female, 0 if male
Female_40	0.212	0.409	1 if individual is female and between 18 and 40 years old, 0 otherwise
Sev. Dep.	0.015	0.122	<sup>22</sup> 1 if individual cannot do a normal life as he has to heavily rely on a machine (pacemaker, automatic kidney...) or treatment (oxygen, severe diet), 0 otherwise