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Prioritisation, risk selection, and illness severity in a mixed healthcare system*

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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 mixed healthcare system. Our theoretical model shows that this relationship depends on (1) the prioritisation implemented by public healthcare providers, (2) the stringency of the gatekeeping system, (3) the skewness of the patients' severity distribution, and (4) the private sector's risk selection behaviour. Our empirical analysis reveals that the relationship between illness severity and public healthcare use is U-shaped. As our theoretical model points out, the increasing part of the U-shape is not necessarily a consequence of risk selection by private healthcare providers, but could instead reflect prioritisation within the public

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sector. According to our analysis, individuals in both extremes of the illness severity distribution will benefit from additional resources to shorten public sector waiting times.

1 Introduction

Despite the predominance of healthcare that is both publicly funded and publicly provided, the private sector also plays a significant role in many healthcare systems. This dual structure leads to a complex web of interactions between public and private providers across various stakeholders. For instance, some doctors work in both sectors, governments contract with private providers, and consumers may seek care from both sectors. These interactions are likely to impact the equity and efficiency of the health system, as well as voters' support for the public system (Barros and Siciliani, 2011).

Our objective is to examine the relationship between illness severity and public versus private use of specialised healthcare within the context of a mixed healthcare system, where everyone is entitled to publicly funded free healthcare arranged through a National Health Service (NHS). Despite the availability of such free care, a significant share of the population purchases private health insurance (PHI), allowing insured individuals to choose between publicly and privately funded healthcare, which amounts to enjoying double coverage.[1] Accessing care through PHI allows insured individuals to bypass NHS waiting lists, though it may involve out-of-pocket expenses such as deductibles, potential premium increases in subsequent years, or additional

[1]Some individuals also resort to private providers despite not enjoying any PHI coverage, that is, they pay the full cost of the treatment out-of-pocket. However, as this is relatively infrequent in the period of our empirical application, we restrict our attention to individuals who have purchased PHI both in our theoretical model and in our empirical analysis.

travel to reach private facilities.[2]

Understanding the relationship between public and private specialised healthcare use and illness severity is important for at least two reasons. First, given a fixed NHS budget, individuals who purchase PHI may indirectly benefit those who rely solely on NHS services, as their reduced demand for NHS care can increase per-capita resources for others (Propper and Green, 2001). The extent of this benefit depends on the pattern of public and private healthcare use across different levels of illness severity, as higher-severity cases generally entail higher treatment costs. Second, the NHS budget itself is not fixed; whether PHI insurees support tax increases to expand NHS funding may depend on the relationship between illness severity and NHS utilisation. In other words, PHI insurees may be more inclined to support NHS budget expansions if they frequently use NHS services, particularly for severe episodes.

In our theoretical model of specialised healthcare use, patients' choice between waiting for treatment in the NHS or seeking PHI-funded care depends on the total waiting costs and the monetary costs of private treatment, such as deductibles, copayments, and potential future premium increases. Total waiting costs are determined by both waiting time and severity, as a more severe condition entails a larger waiting cost for the same amount of waiting.

The tightness of the gatekeeping policy plays a crucial role in our model. To access specialised treatment, whether publicly or privately funded, patients must meet the severity threshold established by the gatekeeper. When gatekeeping is strict, only individuals with relatively high severity levels are

[2]See Propper (1989); Richmond (1996); Besley, Hall, and Preston (1999) and Propper, Rees, and Green (2001) for the UK; Jofre-Bonet (2000) for Spain; and Hurley and Johnson (2014) for Canada.

admitted. Consequently, even the least severe patients among those eligible for treatment are still in a somewhat severe condition. As a result, their waiting costs might be significant, which may lead them to prefer PHI-funded treatment.

Waiting time, in turn, depends on the degree to which NHS patients are prioritised based on severity.[3] With intensive prioritisation, patients with severe conditions face shorter waits, while those with milder conditions may wait considerably longer. Together, waiting time and severity determine the total cost of waiting.

Private healthcare providers also play a significant role in the relationship between illness severity and public/private use. Even if the most severe patients would prefer private treatment, the private sector may be unwilling to serve them due to their higher costs. This selection process may take two forms: *direct patient selection*, where providers directly refuse to treat patients with severe conditions, also referred as *dumping (*Ellis, 1998), or a more nuanced approach where providers underinvest in the technologies needed to treat the most severe conditions, which is closely related to the phenomenon referred in the literature as *service-level selection* (see Ellis and Layton 2014 for a survey). We will use the general term *risk selection* to refer to both phenomena.

Even with a simple economic model, we can show that the relationship between severity and demand cannot be determined *a priori* and will depend on the intensity of the prioritisation, how strict the gatekeeping policy is, the skewness of the severity distribution, and the severity threshold above

[3] Gutacker, Siciliani, and Cookson (2016) provide precise estimates of prioritisation in the UK for hip and knee replacements, finding that more severe patients experience shorter waiting times than less severe ones—approximately 24% shorter for hip replacements and 11% shorter for knee replacements.

which risk selection is carried out. We are however able to provide three interesting and novel results. First, risk selection by the private sector and prioritisation in the public sector are observationally equivalent. That is, if individuals in most severe condition are treated by the NHS, this does not necessarily mean that private providers are avoiding the most severe cases. Indeed, we show that this could also be due to a sufficiently intense severity-based prioritisation policy in the NHS. Hence, one cannot identify strategic behavior by the private sector from observations on illness severity and healthcare provider allocation.

Another key result of our analysis concerns those individuals who are in the least severe condition among those admitted for treatment. Specifically, if gatekeeping is lenient, very low severity individuals are admitted to specialised treatment. These individuals will opt for (and receive) treatment in the public sector. This outcome is largely due to their low severity, making them more willing to put up with waiting times in order to avoid the expenses associated with private treatment.[4]

Our third result regards PHI insurees' support for extra resources for the NHS. Our analysis reveals that not everyone benefits from additional resources to decrease waiting times in the NHS, and that who benefits and who doesn't largely depend on the underlying gatekeeping, prioritisation and risk selection regimes. We can draw two conclusions. First, in the presence of lenient gatekeeping, low severity individuals will always benefit from more NHS resources, although the size of the benefit will be small. Second, most severe individuals will benefit from increasing NHS resources if

[4]This result is reinforced if the reduction in waiting time for the more severe patients is accomplished with additional resources, that is, if individuals in mild condition are not made to wait more. However, this does not seem to be the case in our testing arena and time period Dimakou, Dimakou, and Basso (2015).

either prioritisation or risk selection are in place (but not if both are absent), with the benefit being higher if it is risk selection that is in place instead of prioritisation.

For our empirical investigation, we use the British Household Panel Survey, a multi-purpose UK panel household survey, which follows households over time, covering the period 1996-2008 (University of Essex, 2021). We use two different variables to measure the use of NHS-funded specialised healthcare services: whether the respondent had an NHS-funded consultation with a hospital consultant as an outpatient, and whether the respondent had an NHS-funded hospitalisation.

We proxy illness severity using individuals' responses to whether they suffer from 14 specified health problems or comorbidities (diabetes, cancer, stroke, digestive problems, heart and circulation problems,...) and build two indexes. One index weights all the comorbidities equally, while the other one gives more weight to comorbidities which are more correlated with self-assessed health.[5]

In our empirical analysis we find that the likelihood of using NHS-funded care as a function of severity is U-shaped, independently of the severity proxy used. In other words, individuals in the extremes of the severity range are more likely to be treated by the NHS, whereas individuals with intermediate severities are more likely to be treated by their PHI. According to our theoretical model, this U-shape implies both that either prioritisation or risk selection are in place and that gatekeeping is rather lenient. Interpreted through the lens of our theoretical model, our empirical findings allow us to

[5] Comorbidities indexes are routinely used for clinical prognosis research because comorbidities can worsen a wide range of illnesses faced by patients (Austin et al., 2015; Lieffers et al., 2011; Lix et al., 2011), and they have shown to be positively correlated with illness severity measures (Gross et al., 1991; Christensen et al., 2011).

conclude that individuals in the two extremes of the severity distribution will benefit from additional NHS resources, increasing the likelihood that these two groups will support additional resources towards shortening NHS waiting times.

Broadly, our paper contributes to the literature on the interaction between the public and private healthcare sectors (see reviews by Barros and Siciliani 2011; Goulao and Pereleman 2014; and Hurley and Johnson 2014). One strand of this literature examines the dynamics between public and private healthcare providers. For instance, Iversen (1997) explores how public hospital waiting times are influenced by the availability of private sector care, where consumers pay out-of-pocket. The effect of the private sector partly depends on whether access to public care is rationed. Grassi and Ma (2011, 2012) analyse optimal rationing policies, also considering scenarios in which individuals pay privately for healthcare. On a different front, Canta (2021) investigates the optimal mix of public and private healthcare provision when a third party reimburses providers and consumers can access both sectors at no cost, although they may face rejection by the private sector. In contrast to these studies, our theoretical model assumes that patients are privately insured and focuses on the allocation of patients with varying severity levels between the public and private sectors.

Our question hinges on the extent of prioritisation and risk selection. Gravelle and Siciliani (2008) analyse the welfare implications of prioritisation in contexts where some patients' characteristics which influence the benefit of treatment are unobservable. Studies by Goddard and Tavakoli (1994) and Dimakou, Dimakou, and Basso (2015) examine the effects of prioritisation on the waiting time distribution. Gutacker, Siciliani, and Cookson (2016) find modest prioritisation of hip and knee replacement patients in England, even in the absence of formal prioritisation policies. In terms of risk selection, Barros and Olivella (2005) develop a model where the private sector engages in risk selection in the presence of waiting lists in the public sector, although they abstract from prioritisation. Hence our approach is novel in the sense of addressing, simultaneously, prioritisation and risk selection.

Our article contributes to the empirical literature on the relationship between PHI and healthcare utilisation in mixed healthcare systems. A substantial body of research has examined the effect of PHI on the quantity of healthcare services used —outpatient or inpatient— without differentiating whether the services are publicly or privately funded (Cameron et al., 1988; Vera-Hernández, 1999; Barros et al., 2008; Moreira and Barros, 2010; Bíró, 2014; Schokkaert et al., 2010; Brenna and Giammanco, 2024; Doiron et al., 2014).

More closely related to our study is the literature that examines the influence of PHI on whether healthcare use is publicly or privately funded (Rodríguez and Stoyanova, 2004; Nicolás and Vera-Hernández, 2008; Cheng and Vahid, 2011; Søgaard et al., 2013; Cheng, 2014; Eldridge et al., 2016; Fabbri and Monfardini, 2016; Doiron and Kettlewell, 2018). Complementarily, Propper (2000) investigates how the choice between publicly and privately funded care depends on factors such as waiting times, political ideology, and dynamic patterns of healthcare utilisation. To our knowledge, we are the first empirical study to focus specifically on the relationship between illness severity and the choice between publicly and privately funded care in a mixed healthcare system.[6]

[6] A related literature explores the factors influencing demand for PHI. Besley, Hall, and Preston (1999) and Jofre-Bonet (2000) emphasise the role of waiting lists. Propper, Rees,

The remainder of the paper is structured as follows. Section 2 presents the theoretical model, and derive the relation between illness severity and the use of public vs. private healthcare under different scenarios. Also in this section, we address the issue of public support for allocating additional resources to reduce NHS waiting times. Section 3 describes the data and econometric models used in the analysis and reports the empirical results. It further connects these findings to the issue of public support for additional funds for the NHS, and provides several robustness checks to validate the baseline results. Finally, the concluding section summarises the paper's main contributions and discusses the limitations of both the theoretical framework and the empirical analysis.

2 Theory

In this section we develop a theoretical model that aims at establishing the interaction among four forces that determine how severity affects the final allocation of patients holding PHI across the public and the private sectors. These forces are the costs of waiting; the possible prioritisation policy implemented by the public provider; the strength of the gatekeeping (or rationing) policy of the public provider; and the possible risk selection carried out by the private provider. We are able to predict the public/private allocation profile across different levels of severity according to the relative strength of these four forces. In the empirical analysis, we will map patient severity to the observed public and private sector allocations. By combining the insights of the theoretical and empirical analysis, we can identify the severity levels

and Green (2001) focuses on the availability of private hospitals and physicians, while Buckley et al. (2012) consider the probability of receiving health care from the public system, and whether the public sector allocates care randomly or based on need.

of patients who would benefit most from additional NHS resources aimed at reducing waiting times.

In what follows, we start by describing the three players: the patient, a public supplier (NHS), and a private supplier.

2.1 The patient

The patient suffers pain and discomfort while waiting. The total cost of waiting is a function of the waiting time t and his or her condition. We summarise this condition with parameter s, for "severity". In principle, $s \in [0, s^{\max}]$. However, the population of interest has severity that lies in the closed interval $\left[s^{\min}, s^{\max}\right]$, with $s^{\min} \geq 0$, where the lower bound $s^{\min}$ is given by the rationing mechanism in place, whereby patients in sufficiently mild condition (in our notation, $s < s^{\min}$) are not admitted for specialised treatment. For instance, general practitioners act as gatekeepers to specialists in the UK and would refer only patients with $s \geq s^{\min}$ to specialised treatment. To sum up, waiting cost is given by $c\,(t, s)$, a function that is increasing in both waiting time and severity.

Once the individual becomes ill and his severity is not below $s^{\min}$, he must choose between seeking treatment at the public provider, which is free but requires waiting, and seeking treatment at the private provider, which is also costly for the patient even if he holds PHI (as we will explain below). The trade-off between public and private costs determines which patients seek treatment in which sector. However, in the presence of risk selection, the private provider could avoid providing treatment to some patients, hence we must distinguish between seeking treatment in the private sector and receiving it. This will also be further discussed below. Finally, we assume that $c(0, s) = c(t, 0) = 0$ for any s and t. Indeed, there is no cost of waiting if one does not wait and there is no cost of waiting if one is not ill.

We assume that privately funded treatment would be received immediately, so the patient's waiting cost in the private sector is null. However, the patient bears another cost of receiving treatment in this sector, which we denote by $p \geq 0$. Since the patient holds PHI, p represents the deductible and/or the present discounted value of any 'malus' clause. For instance, in a Financial Times (FT) article, it is claimed that 'some FT readers with insurance are wary of claiming for fear of boosting their premiums. They use the NHS when they can, and turn to insurance only when waiting lists are very long.' (O'Neil, 2023). In addition, the levels of yearly deductibles are relatively small in the UK, our empirical setting.[7] This justifies that we assume that p does not depend on severity and is therefore constant. However, our results extend to the case where p is mildly increasing in severity. In any case, p goes to the insurer, not the private provider. Finally, we are going to assume that, out of indifference, the patient seeks treatment in the private sector.

With all these assumptions in mind, the patient will seek treatment from

[7] According to Propper (1993, p. 289): 'In comparison with larger medical insurance markets, the range of policies offered in the UK market is small. [...] Cost-sharing features (coinsurances and deductibles), widely used in other health insurance markets to limit moral hazard, are not a feature of policies sold in the UK.' Although the importance of cost-sharing features has probably increased towards the end of our sample period (2008), we believe that they remain limited. Distant from the end of our sample period, in 2022, the largest private health insurer only offered, through their website, yearly deductibles in the [£0, £500] range, with £1000 and £2000 only available over the phone. Similarly, the online offer of the second largest insurer was restricted to [£0, £500], with larger deductibles only available over the phone and only together with other coverage restrictions. The third largest offered a wider choice of yearly deductible, but no larger than £5,000. Two well-known industry sources have confirmed to us the lack of published data on deductibles.

the public provider if and only if

$$c(t, s) < p. \tag{1}$$

2.2 The public provider and prioritisation: who seeks private treatment?

The public provider's behavior is modelled in reduced-form. The waiting time allocated to the patient depends solely on his severity, that is, $t = \pi(s)$, a non-increasing function $\pi : [s^{\min}, s^{\max}] \to \mathcal{R}_+$, which reflects prioritisation. Since π is non-increasing, π (and hence wait) reaches a maximum value at $s = s^{\min}$. Under budget balance, a prioritisation regime will entail that patients, with mild severity levels will be de-prioritised, that is, delayed. We will use the latter term henceforth. We assume that, even if an extreme prioritisation regime is in place, meaning that the patient in most severe condition ($s = s^{\max}$) is treated immediately, the corresponding delay imposed on the patient in best condition among those with $s \in [s^{\min}, s^{\max}]$ is bounded. Formally, we assume that $\pi(s^{\min}) < \infty$.[8]

By replacing t by the function π in the waiting cost function, we obtain the *indirect waiting cost function (*IWCF henceforth*)*

$$\tilde{c}(s) \equiv c(\pi(s), s). \tag{2}$$

We assume that $\tilde{c}$ is continuous and that the range of $\tilde{c}(s)$ is bounded

[8] As mentioned above, patients with $s < s^{\min}$ are not accepted for specialised treatment. This could be interpreted as an infinite wait. This just means that the prioritisation policy is discontinuous in the left at $s^{\min}$:

$$\pi(s) = \begin{cases} \infty \text{ if } s < s^{\min} \\ \pi(s) < \infty \text{ otherwise.} \end{cases}$$

above for any prioritisation policy, i.e., we assume that for any π,

$$c^{\max} \equiv \max_{s\in[s^{\min},s^{\max}]} \tilde{c}(s).$$

is well-defined. We also define

$$c^{\min} \equiv \min_{s\in[s^{\min},s^{\max}]} \tilde{c}(s).$$

Simple differentiation yields the following result:

$$\frac{d\tilde{c}(s)}{ds} = \underbrace{\frac{\partial c}{\partial t}}_{+}\underbrace{\frac{\partial \pi}{\partial s}}_{\leq 0} + \underbrace{\frac{\partial c}{\partial s}}_{+}, \tag{3}$$

which has an ambiguous sign. Intuitively, an increase in severity increases the waiting costs for a given waiting time but it also reduces the waiting time if prioritisation is present. In order to simplify the analysis, we make the following assumption:

Assumption 1. *The indirect waiting cost function is quasi-concave.*[9]

In other words, for any value of $p \geq 0$, the inequality $\tilde{c}(s) \geq p$ holds only for a closed interval $[s_0, s_1] \subseteq [s^{\min}, s^{\max}]$ where s_0 and s_1 are unique.

[9] Let us provide an example where $\tilde{c}$ is concave and therefore quasi-concave. Notice that

$$\frac{d^2\tilde{c}(s)}{ds^2} = \underbrace{\frac{\partial^2 c}{\partial t^2}}_{A}\underbrace{\left(\frac{\partial \pi}{\partial s}\right)^2}_{\geq 0} + \\ +\underbrace{\frac{\partial^2 c}{\partial t \partial s}}_{X}\underbrace{\frac{\partial \pi}{\partial s}}_{\leq 0} + \underbrace{\frac{\partial c}{\partial t}}_{+}\underbrace{\frac{\partial^2 \pi}{\partial s^2}}_{B} + \underbrace{\frac{\partial^2 c}{\partial s^2}}_{C},$$

which cannot be signed. However, if (i) c grows linearly in both t ($A = 0$) and s ($C = 0$); (ii) t grows linearly in s ($B = 0$); and (iii) the marginal cost of waiting with respect to time increases with severity ($X = \frac{\partial^2 c}{\partial t \partial s} > 0$), then $\frac{d^2\tilde{c}(s)}{ds^2} \leq 0$ and $\tilde{c}$ is concave.

Obviously, the private sector would be inactive if $p > c^{\max}$ (and $[s_0, s_1]$ would be empty) and the public sector would be inactive if $p < c^{\min}$ (and $[s_0, s_1] = \left[s^{\min}, s^{\max}\right]$).

Consistent with our assumption on the IWCF (quasi-concavity), $\tilde{c}$ could be 'hump-shaped', increasing, or decreasing. We now characterise these three cases and explain the implications for the relationship between severity and the likelihood of using the public provider. In doing so, we also discuss in what cases Assumption 1 fails to hold. To simplify exposition, we rule out risk selection for the rest of this subsection.

As previously indicated, we assume that prioritisation of the most severe cases, that is, those with severity around $s^{\max}$, is likely to entail the delay of the patients in mildest condition, that is, those with s around $s^{\min}$ (Gravelle and Siciliani 2008; Iversen and Siciliani, 2012.). For a given distribution of severity across individuals ('*distribution*' from now on), a more intense prioritisation clearly entails a longer delay for mild severity patients. Similarly, for a given degree of prioritisation, delay for mild severity patients will be longer (shorter) the more skewed to the left (right) the distribution of patients across severities is (see Appendix A).

We proceed the analysis for a pre-specified cost for the patient of private treatment $p > 0$, with the premise that, in the absence of prioritisation, where the wait is the same for all, say $t(s) = t_0$ for all s, we have that $c\left(s^{\min}, t_0\right) < p$.

Let us start at $s^{\min}$. Namely, does a patient in mildest condition demand treatment at a public provider? The answer is yes if $p > \tilde{c}\left(s^{\min}\right)$, which will hold if (i) $s^{\min}$ is small or (ii) $t\left(s^{\min}\right)$ is short. Notice that (i) holds if gatekeeping is lenient. As for (ii), two conditions favor this requirement: (a) prioritisation is not too strong; (b) delay is shared among a large proportion of the population, which is more likely to happen if the distribution is skewed to the right. In both cases, $t\left(s^{\min}\right)$ is close to t_0 and $c\left(t_0, s^{\min}\right) < p$ by assumption. In sum, any of the following three sufficient conditions ensure that patients with severity $s^{\min}$ demand public treatment:

1) Gatekeeping is sufficiently lenient ($s^{\min}$ is small enough so that $c\left(s^{\min}, t\right) < p$ even if t is large);[10] or

2) Prioritisation is sufficiently weak (so that $t\left(s^{\min}\right)$ is close to t_0 and hence $c\left(s^{\min}, t\left(s^{\min}\right)\right) < p$); or

3) The distribution is sufficiently skewed to the right (so that $t\left(s^{\min}\right)$ is again close to t_0).[11]

We refer to this set of sufficient conditions as *'public-at-the-bottom conditions.'* For now, we assume that at least one of these conditions is satisfied.

Case A. Public at the bottom

Let us first analyse the decision of patients close to, but above, $s^{\min}$. As s increases, delay will be reduced (the '*decreased-delay effect'*) but severity increases (the '*severity effect*'). Let us first assume that the second effect dominates.

Case A.1. The severity effect dominates

Here, $\tilde{c}$ increases to the right of $s^{\min}$. This may occur under two scenarios: (i) weak or nil prioritisation (as in condition (2)) and (ii) prioritisation

[10] To see this, as we have assumed that (i) there is no cost of waiting when one is in perfect health ($s = 0$), if we now assume that there is no gatekeeping ($s^{\min} = 0$), then we have that $c(0,t) \equiv \tilde{c}(0) = \tilde{c}\left(s^{\min}\right) = 0 < p$ for all t.

[11] The data that we use in our empirical appplication is clearly right-skewed.

is strong but the distribution is sufficiently right-skewed (consistent with condition (3)). Let us discuss these two scenarios in turn.

Case A.1.1. Weak or nil prioritisation. In this scenario, since prioritisation is weak or nil, $\tilde{c}$ will continue to grow up to $s^{\max}$. If the private sector is to be active at all, patients at some severity level $s_0 \in (s^{\min}, s^{\max})$ will start preferring treatment at the private sector, formally, $\tilde{c}(s) > p$ for $s > s_0$. This is illustrated in Figure 1. Our prediction here is that the likelihood of demanding treatment through the public sector is decreasing in severity, as the labels 'PUBLIC/PRIVATE' in the horizontal axis of Figure 1 indicate.

Case A.1.2. Strong prioritisation and right-skewed distribution (weak delay effect). Here, patients with high severity (that is, around $s^{\max}$) prefer the public sector because the waiting time in the public sector is very small. Moreover, if the private sector is to be active, there must exist a closed interval of severities $[s_0, s_1]$ such that $\tilde{c}(s) > p$ for all $s \in [s_0, s_1]$.[12] Hence, in this scenario we predict a U-shaped relationship between severity and the likelihood of demanding treatment at the public sector. This case is illustrated in Figure 2 (see again the "PUBLIC"/"PRIVATE" labels shown in the horizontal axis).

Case A.2. The decreased-delay effect dominates (strong delay effect)

Let us now assume that $\tilde{c}$ decreases to the right of $s^{\min}$. That is, as severity increases, delay for low severity patients decreases so fast that this

[12] As a technical aside, recall that we have assumed that patients choose the private sector out of indifference. The interval becomes a singleton if $s_0 = s_1$, but an active private sector would then require a mass of patients with severity s_0.

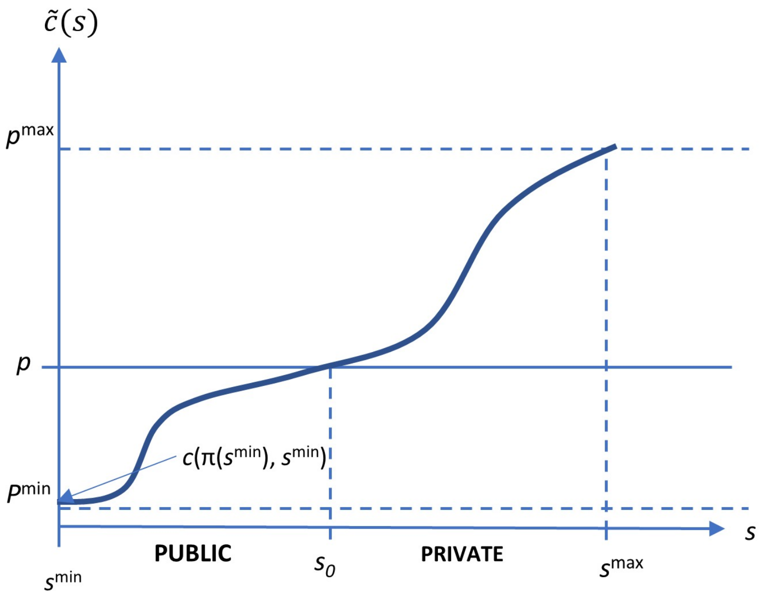

Figure 1: (i) The figure shows an Indirect Waiting Cost Function under sufficiently mild or nil prioritisation. (ii) The horizontal axis shows patients' preferences between sectors for an intermediate patient's private sector treatment cost p.

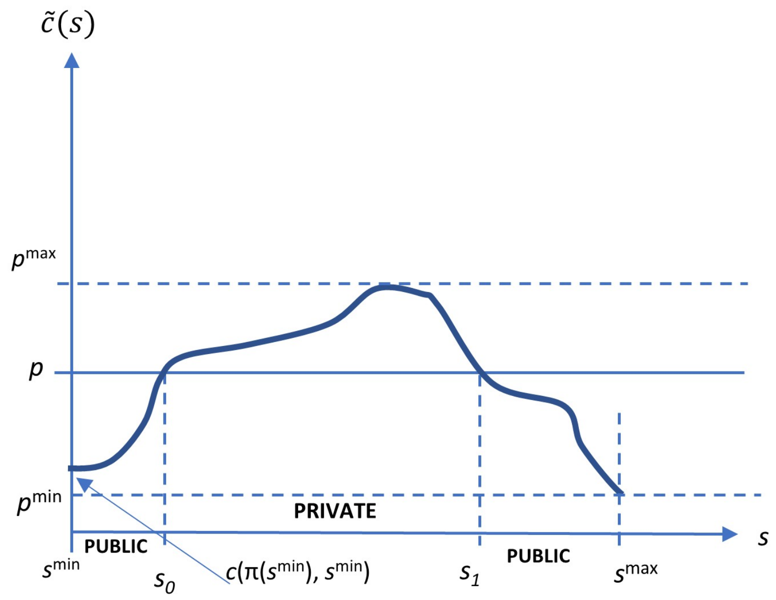

Figure 2: (i) The figure shows an Indirect Waiting Cost Function under sufficiently strong prioritisation, lenient gatekeeping, and a right-skewed severity distribution. (ii) The horizontal axis shows patients' preferences between sectors for an intermediate patient's private sector treatment cost p.

compensates the increase in severity. Notice that this requires some minimal prioritisation and that the distribution is left-skewed. However, this is only consistent with the public-at-the-bottom conditions if gatekeeping is extremely lenient, as strong delay plus high severity at $s^{\min}$ would imply that the patient prefers the private system. Moreover, since patients with $s = s^{\min}$ prefer the public sector, this will continue to be so as severity increases slightly above $s^{\min}$. This implies that, if the private sector is to be active at all, $\tilde{c}$ will have to increase at some severity level in order to have $\tilde{c} > p$ at some (high) severity level. Notice that this leads to a contradiction of Assumption 1. However, in the empirical section we argue that the distribution is right-skewed. It is important to remark that our prediction would be that the relationship between public use and severity would be inverse-U-shaped.

Let us now turn to the case where the public-at-the-bottom conditions are not satisfied.

Case B. Private at the bottom $\left(c\left(s^{\min}, t\left(s^{\min}\right)\right) > p\right)$

This requires that neither of the 3 conditions given above holds. That is:

1) Gatekeeping must be somewhat strict (so that $s^{\min}$ is not zero and hence $c\left(s^{\min}, t\left(s^{\min}\right)\right)$ is not zero either), and

2) Prioritisation must not be too weak (otherwise delay would be weak and consequently $t\left(s^{\min}\right)$ could be close to t_0 and recall that $c\left(t_0, s^{\min}\right) < p$ by assumption); and

3) The distribution must not be very skewed to the right (otherwise $t\left(s^{\min}\right)$ would be again close to t_0).

The relevance of this case is limited because of the following two reasons:

(i) the empirical distribution of severity is right skewed, and (ii) a strict gatekeeping policy together with strong prioritisation would lead to a unduly harsh scenario for individuals around $s^{\min}$, who would be in quite a severe condition but still considerably delayed. Despite this limited relevance, we analyse this scenario for completeness. Note that the public sector would only be active in this scenario if there exists some $\hat{s}$ such that $\tilde{c}(\hat{s}) < p$. Let us first maintain Assumption 1. If the prioritisation effect dominates everywhere, this leads to Figure 3, where $\tilde{c}$ is decreasing everywhere. If the severity effect dominates around $s^{\min}$, while the prioritisation effect dominates for large values of s, this leads to Figure 4, where $\tilde{c}$ is hump-shaped. Notice that, in both cases, patients with s around $s^{\max}$ prefer treatment at the public sector, so prioritisation must be strong enough. Importantly, we obtain that the likelihood of patients seeking public treatment is increasing with severity. This is also illustrated in Figures 3 (monotonically decreasing IWCF) and 3b (hump-shaped IWCF), as the labels 'PRIVATE'/'PUBLIC' on the horizontal axis once more indicate.

Finally, note that also under case B one could have situations that violate Assumption 1 and where both sectors are active. For instance, one could have that some severity level s^{**} exists such that the delay effect dominates the severity effect at the left of s^{**} (requiring a left-skewed distribution) whereas the opposite holds to the right of s^{**} (requiring prioritisation to be weak).

The above discussion has been made in the absence of risk selection. As we will see in the next two subsections (2.3 and 2.4), risk selection will lead to an U-shaped relationship between severity and the use of public providers even if the preference for the public providers is decreasing in severity. In subsection 2.3 we address an ex-ante form of risk selection that is equivalent

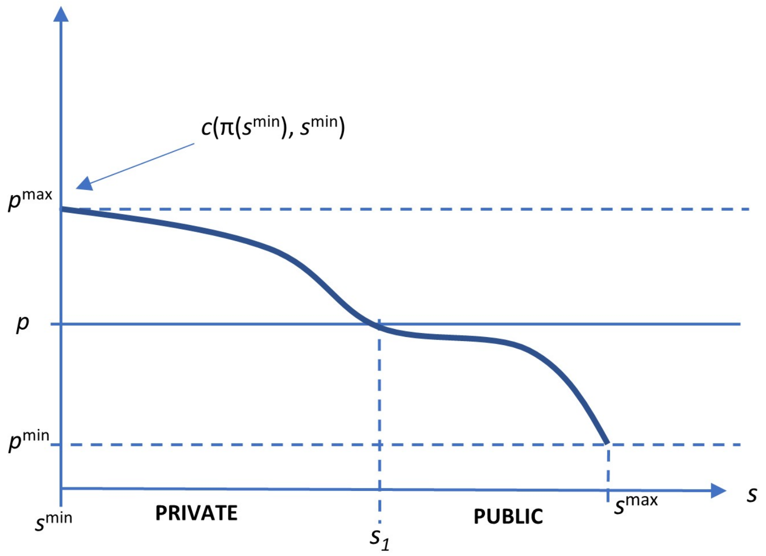

Figure 3: (i) The figure shows an Indirect Waiting Cost Function when (1) gatekeeping is relatively strict, so severity is high at s^{min}, and therefore waiting is also high at s^{min}; (2) the patients' severity distribution is skewed to the left, so delay at the bottom is long; (3) prioritisation is so intense that waiting cost at s^{max} is low; and (4) as severity increases, waiting time decreases fast enough to compensate the increase in waiting cost induced by the increase in severity. (ii) The horizontal axis shows patients' preferences between sectors for an intermediate patient's private sector treatment cost p.

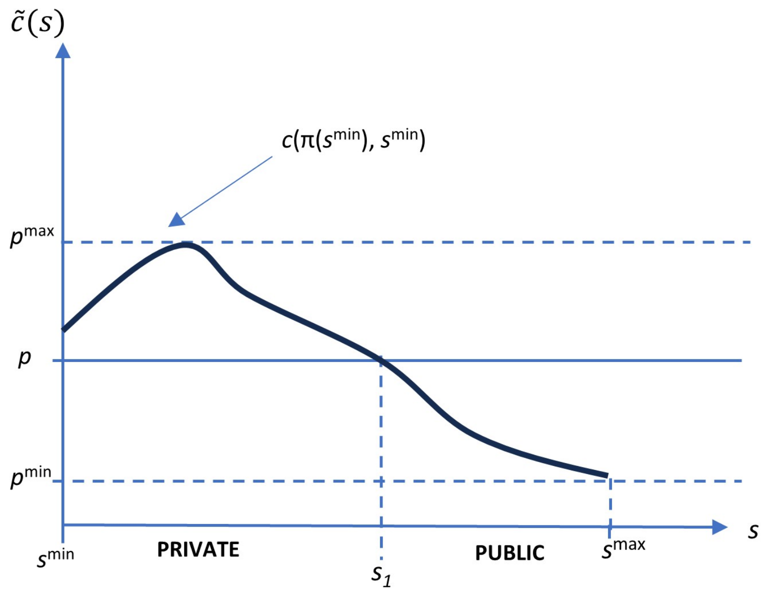

Figure 4: (i) The figure shows an Indirect Waiting Cost Function under the same conditions as in Figure 3, except that here waiting time decreases slowly above and around s^{min} and fast for high s. (ii) The horizontal axis shows patients' preferences between sectors for an intermediate patient's private sector treatment cost p.

to a (admittedly, rather extreme) case of quality differential in favour of the public sector. Namely, the private sector lacks the means to treat the most severe cases. We refer to this form of dumping as service level selection, for reasons that are explained below. In subsection 2.4, we examine a more conventional form of ex-post risk selection —namely, the direct rejection of the most severe cases— which we refer to as direct patient selection.

2.3 Quality differential: service-level selection in the private sector

The previous discussion has been framed in a world where there is no quality differential between the private and the public treatment. We will now study the implications of quality differences between the public and private providers. We do not feel that comfortable making an assumption on which sector offers higher quality for low and intermediate levels of severity, as there may be counterbalancing forces. On one hand, hotel services will be better in the private sector and patients' contact time with more senior doctors might also be higher in the private sector, but on the other hand, some patient care in the public sector might take place in teaching hospitals, where medical research more commonly takes place, so the quality of medical care might be superior.

As for the upper tail of severity, there is extensive qualitative evidence that the private sector may not have the required technology for an adequate treatment.[13] We refer to this underinvestment in complex treatments as

[13] 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, Hall and Preston (1999) claim 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

service-level selection (SLS henceforth), as it is reminiscent of this well studied phenomenon in the context of Managed Competition (Ellis and Layton 2014).[14]

In our context, SLS consists of providers distorting their technology choices in order to push away high risk patients when the payment they receive per treatment does not cover high-complexity treatment costs. This could be because the amount of patients that would use this technology might be too small to cover the fixed cost.

We represent this scenario by positing that there exists a threshold of severity, say s^{sls}, such that the private sector is unable to provide adequate treatment to those with severity $s \geq s^{sls}$. An important consequence of this is that, even if prioritisation is nil or very mild (Case A.1.1), so that all patients with severity above s_0 *would* seek treatment in the private sector, some of them (namely, those with $s \geq s^{sls}$) end up being treated in the public sector. Hence if an econometrician only has data on the sector at which the patient *is* treated, one cannot distinguish between the scenario with strong prioritisation and the scenario with SLS. Indeed, the intervals describing the final allocation of patients in Figure 2 (lenient gatekeeping,

Medical Insurance sector specialises in procedures which are not life threatening but reduce considerably the quality of life of the potential patient.' In an article published by the BBC in 2019, authors state that 'private hospitals in the UK have been accused of cherry-picking less complex and lucrative surgeries over complex cases that require more resources, such as emergency care and intensive care units.' (BBC News, 2019) Finally, in a Financial Times article in 2023, the author claims that 'Clearly, a private hospital may appear better because you get a room on your own and better food. Nevertheless, many private hospitals don't have full emergency facilities. If things go wrong, you may be transferred to the NHS' (O'Neil, 2023).

[14]Managed Competition refers to a healthcare system in which individuals select their insurer and choose healthcare providers from the options offered by their insurer's network. Insurers receive a fee for each client that they attract and (part of) this fee comes from a common fund that is usually risen from employees' contributions (Enthoven, 1978).

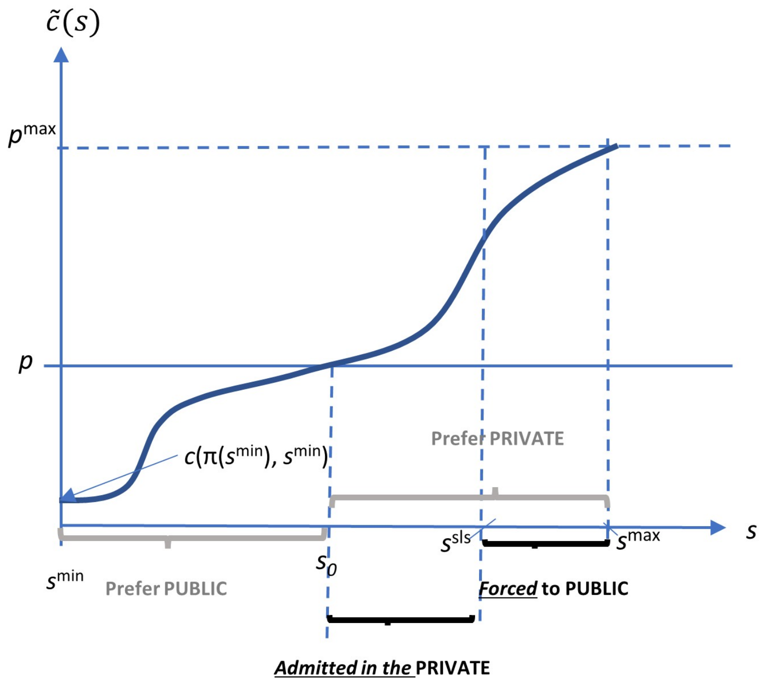

Figure 5: (i) The figure shows an Indirect Waiting Cost Function under sufficiently mild or nil prioritisation. (ii) The horizontal axis shows patients' preferences between sectors for an intermediate patient's private sector treatment cost p, as well as the final allocation of patients under SLS.

strong prioritisation, and short delay) in the absence of SLS are akin to the intervals in Figure 1 (lenient gatekeeping and weak or nil prioritisation and –consequently– weak or nil delay) when SLS is present (see Figure 5).[15]

[15] If (i) prioritisation is strong (Figures 2, 3 and 4) and (ii) $s_1 \leq s^{\text{sls}}$, then SLS becomes irrelevant. Patients who would be rejected would not seek private treatment in the first place.

2.4 Direct patient selection in the private sector

We show here that direct patient selection (DPD) has a similar effect as SLS, except that it is carried out at a latter stage. Since the patient enjoys PHI, the private provider receives a fee for service (FFS) from the insurer, say $p^*(s)$, when a patient with severity s is treated. If the fee is cost-adjusted, it will be increasing in s. Of course, the costs that the private provider bears from treating a patient will also increase in severity, and we denoted these costs by $\psi(s)$. We assume the following:

Assumption 2

(i) ψ *is (weakly) convex*

(ii) p^* *is (weakly) concave*

(iii) $\psi\left(s^{\min}\right) = 0$

(iv) $p^*\left(s^{\min}\right) > 0$.

Assumption (i) is quite natural and standard. Assumption (ii) reflects the possibility that cost-adjustment of the FFS may not be perfect, while assumptions (iii) and (iv) ensure that the incentives for DPD disappear at the lowest end of severity. Overall, Assumption 2 implies that only two mutually exclusive cases are possible:

(a) p^* and ψ do not cross at all in $(s^{\min}, s^{\max}]$, so there is no DPD;

(b) p^* and ψ cross exactly once in $(s^{\min}, s^{\max}]$ say at s^c, and $p^*(s) < \psi(s)$ for all $s \in (s^c, s^{\max}]$, so the private provider will avoid patients with severities in the latter interval.

Hence, the threshold s^c acts exactly in the same way as the threshold s^{sls}. That is, DPD has the same consequences for the patient allocation among sectors as SLS.[16]

2.5 Risk selection vs. prioritisation, who are the gainers and losers?

We now discuss patients' preferences over prioritisation, risk selection, and the absence of them. Let us start with an scenario, the *status quo*, where neither prioritisation nor risk selection is in place. We have shown that there exists a threshold s_0 such that patients with $s \geq s_0$ ($s < s_0$) seek and obtain treatment in the private (public) sector. We can now compare two new scenarios. In the first one, risk selection is absent but a sufficiently strong prioritisation is introduced so that an interval of patients in severe condition, namely, with $s \in (s_1, s^{\max}]$, switch to the public sector. In the second scenario, prioritisation is absent but patients in the same interval $(s_1, s^{\max}]$ are excluded due to risk selection. We assume that the two intervals coincide in order to simplify the analysis. By revealed preference, patients with $s \in (s_1, s^{\max}]$ prefer prioritisation over the *status quo*, while risk selection is less preferred than the *status quo*. Patients who are forced out of the private sector cannot be in a better position than if they had preferred to switch.

As for the patients with severity between s_0 and s_1, the three scenarios are equivalent. They prefer the private sector in the *status quo*; the same is true under prioritisation (which does not affect the private sector quality); and

[16] However, DPD may be much more difficult to detect since, as it is likely prohibited by law, and it might be implemented by private providers in rather subtle ways. For instance, in the context of the Dutch health system, van de Ven et al. (2017, p.175) state that 'There are many ways that insurers can selectively market their health plans. In addition, many people do not buy their health plan directly from the insurer but via an insurance agent [...]. Insurers often provide insurance agents with a bonus fee for each (new) applicant. [...] Insurance agents can easily distinguish between over- and undercompensated individuals (e.g., just by observing and asking questions about health status) and use this information when channeling applicants to health plans.'

they would not be rejected by the private sector under risk selection. Finally, for patients with $s < s_0$, they would be unaffected by risk selection but some of them will be affected negatively by prioritisation since such prioritisation brings about a necessary delay for the mild cases.

To sum up, risk selection harms the most severe patients while prioritisation increases the welfare of the most severe while it lowers the welfare of the least severe. Overall, this discussion highlights that a patient's preference over prioritisation versus risk selection depends on his/her severity.

2.6 Public support for a well-financed public system

Here we investigate how support for additional resources devoted to decreasing waiting time across all severities depends on individuals' health status, and how this issue is affected, in turn, by the extent of prioritisation. We believe that this is a novel issue, although it is certainly more complex than the one addressed just above. We take the ex-ante perspective, in which individuals are still not ill but we assume that the worse their health status is, the more severe their condition will be. For instance, individuals in very good (bad) health are more likely to have low (high) levels of s if they become ill.

We restrict attention here to the 'public at the bottom' case, that is, where gatekeeping is sufficiently lenient and/or the severity distribution is sufficiently right-skewed.

Let us start by considering the *status quo*, that is, where neither prioritisation nor risk selection is present. As we have seen, in this scenario all patients with severity below some threshold s_0 will obtain treatment in the public sector and the rest in the private sector. An overall decrease in wait will shift this threshold s_0 upwards, say to s_0', since those who were close to indifference between sectors will now prefer the public sector. Hence, there are two types of individuals who favour the increased resources: those in very good health status (likely to suffer $s < s_0$), who stay in the public sector; and those with intermediate health status (likely to suffer $s \in (s_0, s_0'))$, who switch to the public system. Notice, however, that the first group bears a very small waiting cost and therefore the overall benefit for individuals in this group is rather small.

Let us now consider an scenario where there is no risk selection but prioritisation is intense and the severity distribution is right-skewed, so there is a U-shaped relationship between public use and severity. Hence, there exist s_0 and s_1 such that patients with both $s \in [s^{\min}, s_0)$ and $s \in (s_1, s^{\max}]$ prefer and are served by the public sector. Here, the overall reduction in waiting due to the additional resources will shift s_0 upwards, say to s_0', and s_1 downwards, say to s_1'; for the same reasons as before. We now have four groups of individuals favouring the increased resources: those in very good health status (likely to suffer $s < s_0$, or 'healthy non-switchers'), those in very bad health status (likely to suffer $s > s_1$,'unhealthy non-switchers'), those in intermediate but relatively healthy status (likely to suffer $s \in (s_0, s_0')$, 'healthy switchers'), and those in intermediate but relatively bad health status (likely to suffer $s \in (s_1', s_1)$, 'unhealthy switchers').

Finally, assume that the U-shaped relationship is caused by risk selection instead of prioritisation. In other words, in the initial situation, all patients with severity $s \in [s^{\min}, s_0)$ prefer the public sector, patients with severity $s \in [s_0, s^{sls})$ prefer the private sector and are served by that sector, and all patients with severity $s \in \left[s^{sls}, s^{\max}\right]$ are forced to go to the public sector. An improved public system will be welcomed by the very healthy non-switchers (likely to suffer $s \in [s^{\min}, s_0))$ and by the healthy switchers (likely to suffer $s \in [s_0, s_0'))$. It will also benefit those in bad health status, likely to suffer $s \geq s^{sls}$, who are rejected by the private sector.

If we compare the last two scenarios just discussed, while assuming that $s^{sls} = s_1$ to ease this comparison, we can see that an increase in public sector resources has an additional effect in case of prioritisation: while s^{sls} is independent of public resources, s_1 will decrease. This means that a new segment of individuals give support to the increased resources, namely, those in relatively bad health status, as they are likely to suffer from an illness in the $[s_1', s_1)$ severity interval (equivalently, in the interval $[s_1', s^{sls})$, again by assumption). Moreover, if one is to speak of the *intensity* with which individuals provide support to the increase in public sector resources, then individuals likely to suffer $s > s^{sls}$ (again, equivalently $s > s_1$) are much more supportive of this policy when risk selection is present than when prioritisation is strong. The reason is that individuals with severity $s > s_1$ already had lower waiting times because they were already benefiting from prioritisation.

In this analysis, we have not considered the costs to individuals of contributing to the additional resources through taxes. This simplification is justified by our focus on individuals with PHI, who have higher incomes and therefore exhibit lower variation in tax contributions compared to the entire population.

Our analysis reveals that not everyone benefits from additional resources to decrease waiting times in the public sector, and that who benefits and who doesn't largely depends on the underlying prioritisation and risk selection regimes. We can draw two conclusions. First, individuals in very good health status will always benefit from more NHS resources, although the size of the benefit will be small. Second, individuals in poor health will benefit from increased NHS resources if either prioritisation or risk selection is in place (with the benefit being greater under risk selection than prioritisation), but not if neither is present. This is the most relevant result of our analysis, as in the empirical section we find evidence that either prioritisation or risk selection are indeed in place.

3 Empirical Application: the UK NHS

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 healthcare by PHI enrollees. The relation ultimately depends on assumptions on exogenous factors, namely, the distribution of patients across severities and how the waiting cost increases with illness severity for a given waiting time; as well as on the actions taken by the healthcare providers: the prioritisation and gatekeeping policies in place in the public sector and the risk selection policy in place in the private sector. This makes the empirical analysis necessary to determine the nature of the relationship under scrutiny. We focus on the UK and estimate the relation between health status and use of publicly funded healthcare.

3.1 Institutional Setting

In the UK, the NHS provides comprehensive health coverage to all citizens and is funded through general taxation and compulsory social security contributions. NHS-funded care (doctor visits, hospitalisations, diagnosis, etc.)

is free at the point of consumption, except for prescription drugs and dental care, for which there are copayments.

Despite the comprehensive coverage provided by the NHS, a share of the population has PHI, which provides access to medical treatment without putting up with long waiting lists, offers choice of specialists, and provides better hotel services (individual rooms in hospitals,...). Individuals with PHI can still access NHS-funded treatment, and do not get any tax rebate for using PHI providers.

3.2 Data

We use the British Household Panel Survey (BHPS), a multi-purpose panel household survey, which follows households over time even if they split. All adult household members are interviewed. We restrict the sample to waves 6 to 18 (1996-2008) because they are the ones that include questions on PHI. We only include in the sample individuals with PHI. This is because in that period it was uncommon for those without PHI to use private healthcare as they would have to pay the full cost out-of-pocket.

We use two different variables to measure the use of public healthcare services: NHS outpatient consultations (NHS hospitalisations), which takes value 1 if the individual's hospital outpatient visits (individual's hospitalisations) were funded by NHS, and 0 if they were funded privately or mixed. There is no information on the specific cause of the hospitalisation or the consultation, except for whether the hospitalisation was for childbirth. Because PHI does not cover maternity services, we exclude women from the analysis of hospitalisation if they have had a childbirth-related hospitalisation in the relevant time period.

Table 1 reports sample descriptive statistics for the sample of individuals who have PHI and either had a hospital outpatient consultation, or a hospitalisation: 66.7% of those with a hospital outpatient consultation had it funded by the NHS, and 58.9% of those with a hospitalisation had it funded by the NHS. There are no important differences in the average and standard deviation of the covariates between those who had a hospital outpatient consultation, and those with a hospitalisation. As expected, the sample of those with an hospital outpatient consultation is significantly larger than the sample of those who have had a hospitalisation (5982 vs. 1433).

3.2.1 Severity measures

Indexes based on chronic conditions (diabetes, cancer, stroke, heart and circulation problems, etc.), such as the Charlson Comorbidity Index (Charlson et al. 1987; Deyo et al. 1992) and the Elixhauser score (Elixhauser et al. 1998, van Walraven et al. 2009) are routinely used in clinical prognosis research (Austin et al. 2015; Lieffers et al. 2011; Lix et al. 2011). These indexes are routinely used in medical research to provide a comprehensive view of a patient's health (Obermeyer et al. 2019), and they have shown to be positively correlated with illness severity measures and mortality (Gross et al. 1991; Christensen et al. 2011) possibly because comorbidities can worsen a wide range of illnesses faced by patients.[17] Hence, we will rely on the information on comorbidities collected in the BHPS to build a proxy for illness severity.

In particular, the BHPS asks whether respondents suffer from 14 differ-

[17] Indexes which include information on chronic conditions have recently also been used to describe the evolution of health inequalities (Borrella et al. 2024; Danesh et al. 2024; Russo et al. 2024).

ent and pre-specified health and disability problems (diabetes, cancer, stroke, disability in the limbs, difficulty hearing, digestive problems, heart and circulation problems, etc.) as well as an 'other' category. To proxy for illness severity, we will consider two different measures: one is the number of comorbidities that the individual reports to suffer from. The second measure, a comorbidity index, weights each comorbidity differently. To obtain the index, we estimate an ordered Probit regression of self-assessed health (SAH) (5 categories) over the comorbidities and age, and use the coefficients as weights. We re-scale the index between 0 and 1 to ease comparisons. Figure 6 shows the distribution of the two severity proxy measures that we use, which are both right-skewed.[18]

3.3 Empirical model

To describe the relation between our proxy for illness severity and the use of NHS-funded care, we use the following Probit regression:

$$E[y|Severity, X] = \Phi(\alpha_0+\alpha_1(Severity)+\alpha_2(Severity)^2+...\alpha_P(Severity)^P+\beta X), \tag{4}$$

where y takes value 1 if the use of healthcare was entirely NHS-funded, and 0 if it was partially or fully privately funded and $\Phi(\cdot)$ is the cumulative distribution function of the standardised Normal distribution.

The model includes a polynomial of order P in either of our two severity proxy measures ($Severity$): either the number of comorbidities or the comorbidity index. X is a vector of covariates that includes gender, cohabitation

[18] In Tables A1-A8 of Appendix C, we show that the probability of hospitalisation and the probability of outpatient consultations (independently of whether they are NHS or privately funded) are positively related to our comorbidity measures, which would be expected if our comorbidity indexes are good proxies for illness severity.

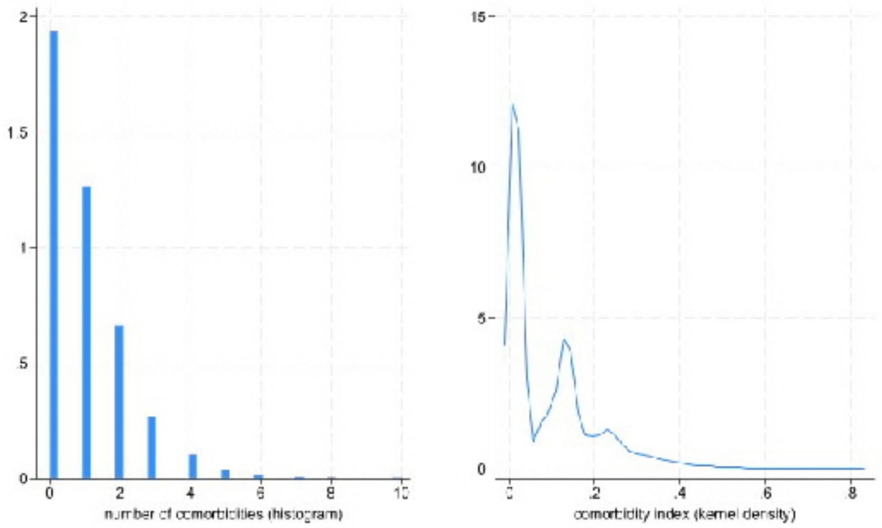

Figure 6: Distribution of severity proxy measures.

status, a quadratic polynomial in age, region dummies, wave dummies, and a cubic polynomial in the duration of the period in which the healthcare use is measured (time exposed).[19] Depending on the specification, we also control for education dummies and the log of household income.

Our parameters of interest are α_0, α_1, ...,α_P, which describe the relation between illness severity and the use of NHS-funded healthcare. We report standard errors clustered at the individual level to consider that observations of the same individual are not independent across waves. We report analytical standard errors when we use the number of comorbidities as severity measure, but we use block bootstrap when using the comorbidity index to

[19] At the time of the annual interview, which takes place between September of year t and March of year t+1, respondents are asked whether they used health care services between September of year t-1 and the time of the interview. This means that the time period that is relevant for the use of healthcare can vary between 12 and 18 months, depending on whether they were interviewed in September or March. We control for this differential time of exposure in our empirical analysis through a cubic polynomial.

consider the uncertainty associated with the prediction. In particular, in each replication of the bootstrap procedure, we randomly draw individuals with replacement and estimate (using all observations of the individuals drawn) both the severity index and the α_0, α_1, ...,α_P parameters. We compute the standard errors as the standard deviation of the distribution of estimated α_0, α_1, ...,α_P parameters obtained after 1000 bootstrap replications.

3.3.1 Descriptive analysis

Figure 7 and 8 show the relation between the probability of using NHS-funded healthcare services and our severity proxy measures. For both measures of healthcare (hospitalisations and outpatient consultations), the figures show a U-shaped pattern between our proxies for illness severity and the probability of using NHS-funded healthcare services.

3.4 Regression Results

Table 2 and 3 report the coefficients of Probit models for NHS outpatient consultations and NHS hospitalisations respectively, where we use the number of comorbidities as severity proxy. The coefficients of the polynomials in columns (1)-(3) clearly show a U-shape pattern between the illness severity proxy and the probability of NHS-funded care, irrespective of whether we control for education and income. The minimum of the U-shape is quite similar across specifications, and smaller for NHS hospitalisations than NHS outpatient consultations (2.17 vs. 2.64 comorbidities). Table 4 and 5 report similar findings but using the comorbidity index, scaled between 0 and 1, as the severity proxy.

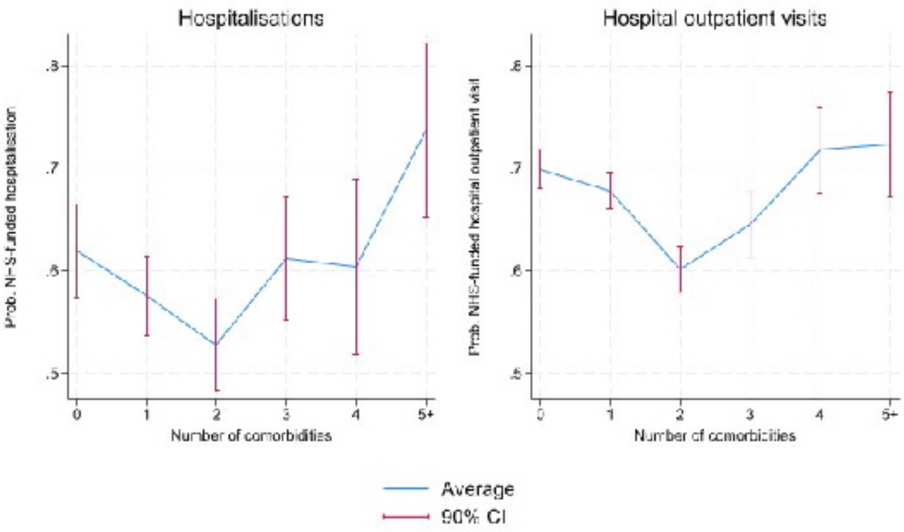

Figure 7: Relation between the use of NHS services and the number of co-morbidities.

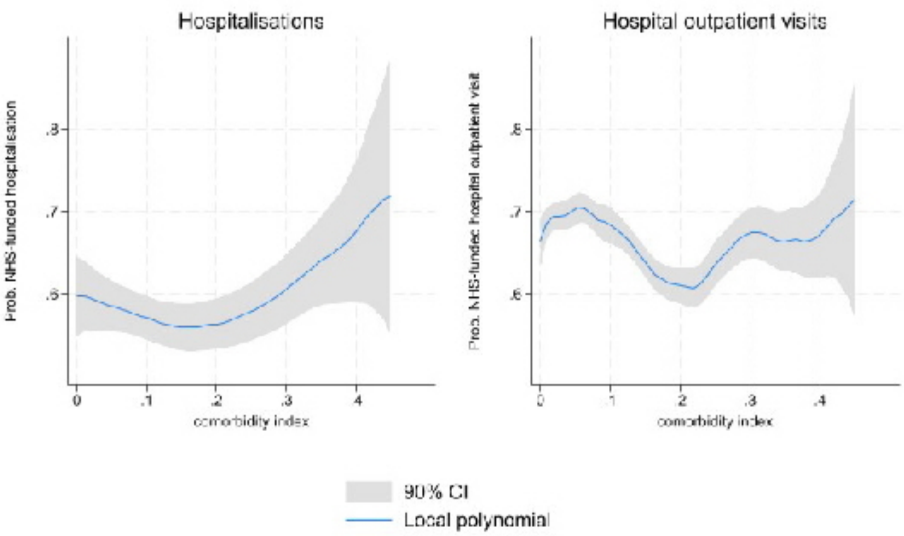

Figure 8: Relation between the use of NHS services and the comorbidity index.

The results indicate that the minimum point of the U-shape is higher for consultations than for hospitalisations. To understand this, consider the value of the severity proxy where the likelihood of NHS use reaches its minimum. If the value of the severity proxy increases above this point, the prioritisation effect starts to dominate the severity effect, so the likelihood of NHS use starts to rise. If the minimum of the U-shape is higher for consultations than hospitalisations, it must be because the prioritisation kicks-in at lower levels of the severity proxy for hospitalisations than for consultations. This is to be expected, since for the same comorbidity profile, an individual requiring hospitalisation would be perceived to be in greater need of an early treatment.

Columns (4) and (5) of Tables 2-5 report the coefficient estimates when we introduce a cubic or quartic polynomial on the severity proxy. The coefficients of those columns are largely not statistically significant, indicating that the quadratic polynomial captures relatively well the underlying pattern as Figures 7 and 8 had already shown.

Tables A9 to A12 of Appendix C show the results of estimating the same specifications as Tables 2 to 5 of the main text, but using Linear Probability models instead of Probit models. The coefficients of the Linear Probability model are also consistent with the U-shaped pattern, and the minimum of the U-shape is very similar independently of whether we use a Probit or Linear Probability model (2.17 vs. 2.24 comorbidities for hospitalisations, and 2.64 vs. 2.70 comorbidities for outpatient consultations). These results should dispel concerns that our findings are due to the non-linearity embedded in the Probit model.

Tables 6 and 7 report the estimated marginal effects of our two illness severity proxies (number of comorbidities and comorbidity index) on NHS-funded healthcare use (hospitalisations and outpatient consultations). Consistent with the U-shape pattern, we find that the marginal effects are negative at low severity levels and positive at higher severity levels. Moreover, the estimated marginal effects are very similar independently of whether they are estimated using a Probit or a Linear Probability model.

As an alternative estimation strategy, we use Two Stages Least Squares to estimate whether the care was NHS or privately funded over the self-assessed health variable (which takes values 1, 2, 3, 4 and 5, where 1 is excellent and 5 very poor) and its square term, and all other covariates. We use the number of comorbidities and its square term as instruments. The results are reported in Appendix C Table A13. The coefficients on the self-assessed health and its square term are statistically different from zero, and also follow a U-shape pattern.

3.5 Omission of private health insurance coverage levels

Individuals differ in the level of PHI coverage (i.e. the amount of the deductible) but this information is not available in the dataset. The level of PHI coverage possibly affects whether to choose NHS or PHI-funded care. Because of asymmetric information, individuals in worst health status might have chosen insurance contracts with more generous coverage (Rothschild and Stiglitz, 1976). Hence, our severity proxy variable might be endogenous because it could be correlated with the level of PHI coverage, which is omitted from regression (4). The standard solution to an endogeneity problem is to find valid instruments for the endogenous variable, in this case the severity proxy. However this would be very challenging because severity is an individual attribute rather than a choice variable, so it would be difficult to find factors external to the individual that shift illness severity.[20] Given this, we combine theoretical and empirical arguments and pursue three different strategies to hopefully allay concerns that our results are driven by the omission of the level of PHI coverage. Although none of the strategies is perfect, we believe that in combination they will increase the confidence in our results.

First, building on Olivella and Vera-Hernández (2013), we focus on employees and compare the healthcare use of those who obtain their PHI through their employer (33.8%) with those employees who purchased the insurance themselves (35.1%), while excluding those who obtained their insurance through a relative (31.1%). This comparison is informative, as employees who receive insurance from their employer do not select the level of coverage themselves; instead, it is determined by the employer. We re-estimate regression (4) but now including a dummy variable of whether the insurance is employer provided and interactions between this dummy and the severity proxies (linear and quadratic terms). We find that none of the coefficients of the interaction terms are statistically significant, and hence we cannot reject that both groups exhibit the same U-shape (Tables 8 and 9).

Second, our estimates are very similar when we condition on education and income, which tend to be correlated with both the level of PHI coverage and health status. If the omission of the level of health insurance coverage was empirically important, we would expect our estimates to change when

[20] A similar challenge is recognized in the field of personnel economics, where the difficulty of estimating the causal effect of intrinsic motivation (a personal characteristic) on job performance is well documented (Finan, Olken, and Pande, 2017). Researchers have often relied on indirect methods, such as experiments where participants were asked to reflect on the importance of public service and advocate for it, both in writing and in person (Belle, 2012).

we include education and income in the regressions as they should partially absorb the effect of the level of insurance coverage.

Third, for the sake of argument let's assume that the actual relationship between the probability of using the NHS and severity is monotone decreasing or monotone increasing, and check whether the omission of insurance coverage from the regression could lead us to wrongly estimate a U-shape. To start with the monotone decreasing relationship, assume an even simpler case in which the probability of NHS-funded care decreases linearly with severity. This case is shown in Figure 9. The top line represents the true relationship between severity and the probability of using NHS-funded care for low-risk individuals, while the bottom line represents the same true relationship but for high-risk individuals. The low-risk line is above the high-risk one because we would expect the low-risk individuals to have chosen low PHI coverage (i.e. higher deductible) while high-risk individuals to have chosen more complete insurance coverage (Rothschild and Stiglitz, 1976). The blue (red) dots represent data points coming from low (high)-risk individuals. As expected, low-risk individuals are more likely to have low severity episodes (and hence there are more blue dots at low severity levels) while high-risk individuals are relatively more likely to have high severity episodes (and hence there are more red dots at high severity levels). The grey line between the low-risk and high-risk line represents the best fit line if the econometrician does not observe who is low-risk and who is high-risk. As it is clear from Figure 9, the best fit line is decreasing rather than U-shaped.

Although Figure 9 assumes that the true relationship between severity and probability of using NHS-funded care is linear, our conclusion holds for non-linear decreasing relationships. To discard that the best fit is U-shaped,

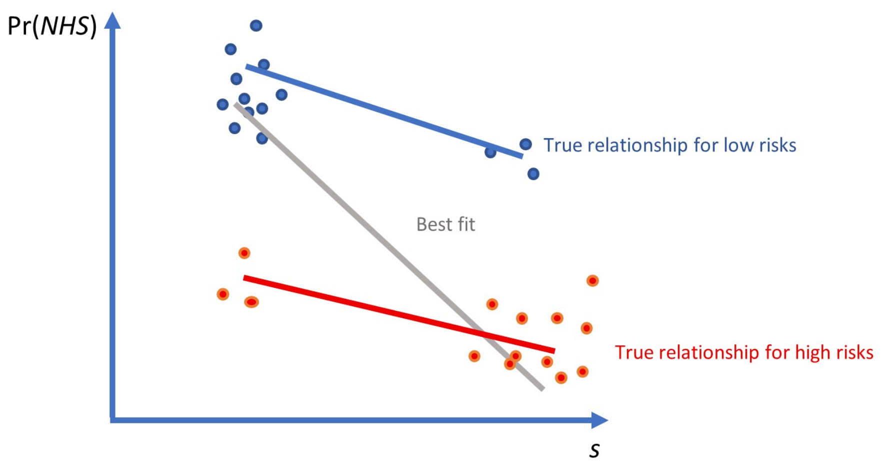

Figure 9: Hypothetical example of the estimated relationship (best fit) between the probability of using NHS services and severity when the true relationship within each risk class is decreasing.

it is sufficient to discard that the average probability of NHS use at high severity is larger than the average probability of NHS use at medium severity. For this to happen, we would need that low-risk individuals have relatively more high severity episodes than medium severity ones, which seems counterintuitive. Hence, if the real relationship between the probability of NHS use and severity is decreasing, then it cannot be the case that the estimated relationship is U-shaped even if the level of PHI coverage is omitted from the regression. A formal proof is given in the Appendix B.

Assume now that the actual relationship between the probability of using the NHS and severity is increasing. As depicted in Figure 10, there are cases in which omission of the level of insurance coverage could lead us to estimate a U-shape (in grey). However, in practice we believe that such an increasing relationship is unlikely because, as we saw in subsection 'Case B. Private at the bottom', an increasing relationship would require the three following conditions to hold simultaneously: (1) gatekeeping to be somewhat strict, (2) prioritisation not to be too weak, and (3) that the severity distribution must not be skewed to the right. However, assumptions (1) and (2) suggest an unduly unfair scenario. If gatekeeping has already been somewhat strict, delaying treatment for these individuals inflicts a high waiting cost on them. Moreover, with respect to (3), Figure 6 shows that the distribution of severity is skewed to the right.

4 Conclusions

In the UK's mixed public-private healthcare system, privately insured individuals cannot opt out of public coverage and therefore continue to have access to NHS-funded care. Hence, they enjoy double coverage. Support for

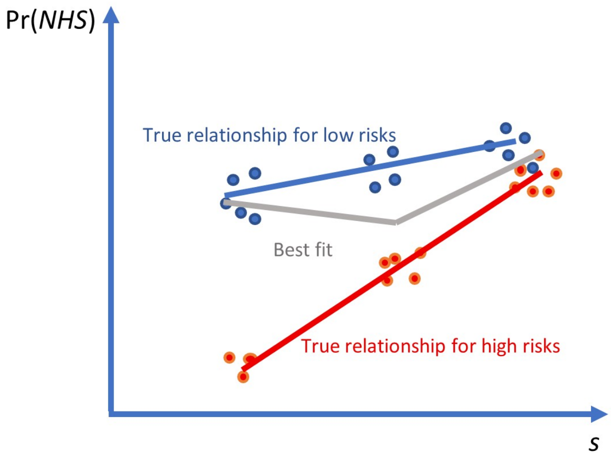

Figure 10: Hypothetical example of the estimated relationship (best fit) between the probability of using NHS services and severity when the true relationship within each risk class is increasing.

tax increases and improvements in publicly funded care among these individuals might depend on how frequently they use NHS-funded services and for what levels of severity.

Using a theoretical model that incorporates waiting times, prioritisation, gatekeeping, and risk selection, combined with empirical analysis from the British Household Panel Survey, we examine the relationship between public and private specialised healthcare use and illness severity among those with double coverage. Our findings reveal that the likelihood of using NHS services follows a U-shaped pattern relative to our proxy for illness severity. Overall, the results suggest that privately insured patients continue to rely on NHS services, particularly at high severity levels, which may influence their support for additional funding for the NHS.

The theoretical model offers several valuable insights. First, it illustrates that the potential shapes of the relationship between public vs. private specialised healthcare use and illness severity are varied, including non-linear forms such as the U-shaped relationship that we find in the data. Importantly, the prevailing relationship cannot be determined solely on theoretical grounds, as it depends on the relative strength of several factors (prioritisation, gatekeeping leniency, skewness of the severity distribution, and risk selection) which emphasises the need for empirical analysis. Second, the model shows that the U-shape is consistent with lenient gatekeeping —which determines the decreasing segment of the U-shape– alongside either prioritisation or risk selection (or both) –which determine the increasing segment. Third, it reveals that risk selection by the private sector and prioritisation within the NHS are observationally equivalent, meaning that strategic behavior by the private sector cannot be distinguished based solely on observations of illness severity and healthcare use.

Compared to the previous literature, our main theoretical contribution is to combine prioritisation by the NHS with rationing and risk selection, where the latter two issues were already studied by Barros and Olivella (2005) and Grassi and Ma (2011, 2012).[21] This extension has two main consequences. One impinges on the upper end of the severity distribution: a sufficiently intense prioritisation of the most severe cases induces individuals in such condition to choose NHS services. This is consistent with the increasing part of the U-shape that we find in the data. The other extension affects the lower end of the severity spectrum: prioritisation at the upper end of the severity distribution induces delay in the lower end. Here is where skewness of the severity distribution and gatekeeping (that is, rationing) become relevant. Indeed, a thin tail at high severity levels (leading to mild delay at low severity) together with a lenient gatekeeping (implying a low waiting cost for a given waiting time at low severity) tilts preference towards the NHS services at low severity. This is consistent with the decreasing part of the U-shape that we find in the data. These insights are also novel.

From a policy standpoint, and given the U-shaped pattern that we uncover, the theoretical model also identifies which PMI enrollees are likely to benefit from additional NHS resources and, by extension, which ones may be more supportive of such funding. Individuals with low-severity conditions consistently gain from additional NHS resources, albeit with relatively modest individual benefits. Those with moderate-severity conditions, however, are less likely to benefit, as they are the ones most likely to obtain

[21] Pardo-Garcia and Sempere-Monerris (2018) combine prioritisation and risk selection, but the former takes an extreme form: patients are either in mild or severe condition and individuals in severe condition are treated immediately in the NHS. Moreover, there is no scope for severity-based rationing in their model

care through their private health insurance. In contrast, individuals with the highest severity levels stand to benefit from increased NHS resources, provided either prioritisation or risk selection mechanisms are present (though not in the absence of both). Given again our empirical finding of a U-shaped relationship between severity and NHS use, we can infer that either prioritisation or risk selection is indeed present.

While our finding of a U-shaped relationship between NHS use and severity is novel and interesting in its own right, it also helps to explain a common finding in mixed healthcare systems where increasing the role of private health insurance does not diminish support for publicly funded care. Kullberg, Blomqvist, and Winblad (2022) and Martinussen and Magnussen (2019) both find that holding private health insurance does not reduce support for publicly funded care in Sweden and Norway, respectively. Similarly, Propper and Green (2001) conclude that "it is unlikely that increasing private finance at the margin will alter the support for the NHS, and thus willingness of individuals to pay taxes for public care."

Median elective waiting times in the NHS have remained exceptionally high in the aftermath of the COVID-19 pandemic, exceeding 12.5 weeks between December 2021 and December 2023 (Warner 2024). Although changes in the definition and measurement of waiting times render direct comparisons with our sample period (1996–2008) highly tentative, it is worth noting that our data also cover a prolonged period of elevated waiting times—specifically, above 12 weeks from June 1996 to June 2003.[22] As such, our findings may

[22] The measurement of waiting time was redefined in August 2007, changing from the time between the decision to admit and treatment to the time between referral and treatment. During the transition period from August 2007 to January 2009, when both measures were reported simultaneously, the referral-to-treatment metric consistently showed higher values than the previous decision-to-admit measure.

still offer relevant insights into patterns of public and private healthcare use in the post-pandemic context. Having said that, it is worth noting that, at least theoretically, an increase in waiting time would be consistent with a U-shape which is wider at the bottom.[23]

Our article has several limitations. On the theory side, we assume that the private sector faces neither returns to scale nor capacity constraints. Introducing either of these would make the analysis of the strategic role of the private sector much more complex, in particular, the ex-post selection of patients (our direct patient selection) would depend on the NHS prioritisation regime. On the empirical side, there are two limitations to note. First, we do not observe the extent of PHI coverage, which could in principle bias the estimation of the shape of the relationship between severity and NHS use. We address this potential issue using three indirect approaches as we cannot find suitable instrumental variables, which would be the standard approach. Second, due to data limitations, we cannot leverage NHS prioritisation policies to disentangle whether the increasing portion of the U-shape is driven by NHS prioritisation or risk selection by private providers.

Statement on the use of Artificial Intelligence

During the preparation of this work the authors used ChatGPT 4.0 in order to improve language and readability. After using this tool, the authors

[23]The low-severity individual who was initially indifferent between public and private care now faces a longer wait in the public system and will therefore opt for private care. As a result, the new indifferent individual must have even lower severity—that is, lie further to the left in the severity distribution. At the upper end, if risk selection is in place, there is no clear reason why the threshold for choosing private over public care should shift. In contrast, under a prioritisation regime, the high-severity individual who was previously indifferent will now experience longer public-sector waits and may switch to private care. Consequently, the new indifferent individual must have even higher severity, such that the benefits from prioritisation outweigh the increase in overall waiting time.

reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Table 1. Descriptive Statistics

	Individuals who had at least one hospital outpatient consultation			Individuals who had at least one hospitalisation		
	Number	Average	Standard Deviation	Number	Average	Standard Deviation
Dependent Variables						
1 if Outpatient hospital consultation was funded by the NHS, 0 if partially or fully privately funded	5982	0.667	0.471			
1 if Hospitalisaitons were funded by the NHS, 0 if partially or fully privately funded				1437	0.589	0.492
Covariates						
Age/100	5982	0.479	0.160	1437	0.501	0.174
1 if Female, 0 if male	5982	0.554	0.497	1437	0.538	0.499
1 if No Qualification, 0 otherwise	5982	0.103	0.304	1437	0.125	0.330
1 if Compulsory Secondary Education, or commercial qualification or other qualification, 0 otherwise	5982	0.058	0.233	1437	0.056	0.231
1 if O Levels, Appenticeship or equivalent, 0 otherwise	5982	0.170	0.375	1437	0.174	0.379
1 if A Levels, 0 otherwise	5982	0.124	0.330	1437	0.122	0.328
1 if Higher Education Degree (includes Nursing, Teaching or Other Higher qualification), 0 otherwise	5982	0.508	0.500	1437	0.482	0.500
1 if MSc, MA, PhD or equivalent, 0 otherwise	5982	0.037	0.189	1437	0.040	0.197
1 if Married or cohabitating	5982	0.704	0.456	1437	0.688	0.463
LN(household income in 2008 £)	5982	-0.960	0.688	1437	-1.051	0.719
Exposure time	5982	13.483	1.371	1437	13.564	1.537

Sample includes individuals with private health insurance in the previous wave, who either had at least one hospital outpatient consultation (left panel) or at least one hospitalisation (right panel).

Table 2. Number of comorbidities and NHS outpatient consultations. Probit coefficients

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Basic	Basic + Education	Basic + Education + Income	Basic + Education + Income (3rd-polynomial)	Basic + Education + Income (4th-polynomial)
Number of comorbidities	-0.115***	-0.123***	-0.124***	-0.126**	-0.107
	[0.039]	[0.039]	[0.040]	[0.062]	[0.094]
(Number of comorbidities)^2	0.024***	0.025***	0.024***	0.025	0.008
	[0.008]	[0.008]	[0.008]	[0.024]	[0.063]
(Number of comorbidities)^3				-0.000	0.004
				[0.002]	[0.014]
(Number of comorbidities)^4					-0.000
					[0.001]
Female	-0.088*	-0.120**	-0.129**	-0.129**	-0.129**
	[0.050]	[0.051]	[0.051]	[0.051]	[0.051]
Age/100	-2.928***	-2.919***	-2.235**	-2.234**	-2.241**
	[0.956]	[0.973]	[0.980]	[0.981]	[0.981]
(Age/100)^2	2.427**	2.187**	1.220	1.218	1.226
	[0.960]	[0.975]	[0.987]	[0.988]	[0.988]
Married or cohabitating	-0.037	-0.030	0.056	0.056	0.056
	[0.058]	[0.058]	[0.059]	[0.059]	[0.059]
Compulsory Secondary Education		-0.209	-0.187	-0.187	-0.187
		[0.138]	[0.136]	[0.136]	[0.135]
O Levels or Apprenticeship		-0.210*	-0.178	-0.177*	-0.178*
		[0.108]	[0.108]	[0.108]	[0.108]
A Levels		-0.356***	-0.306***	-0.306***	-0.306***
		[0.117]	[0.116]	[0.116]	[0.116]
Higher Education Degree		-0.409***	-0.337***	-0.336***	-0.337***
		[0.102]	[0.102]	[0.102]	[0.102]
MSc, MA or PhD		-0.605***	-0.454***	-0.454***	-0.454***
		[0.149]	[0.153]	[0.153]	[0.153]
LN(household income/100,000)			-0.265***	-0.265***	-0.265***
			[0.046]	[0.046]	[0.046]
Exposure time	-0.135	0.071	0.240	0.239	0.245
	[1.576]	[1.585]	[1.607]	[1.607]	[1.607]
(Exposure time)^2	0.001	-0.012	-0.022	-0.021	-0.022
	[0.101]	[0.102]	[0.103]	[0.103]	[0.103]
(Exposure time)^3	0.000	0.000	0.001	0.001	0.001
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Minimum U shape	2.347	2.443	2.636		
Average dep. vble	0.667	0.667	0.667	0.667	0.667
Observations	5,982	5,982	5,982	5,982	5,982

Sample includes individual with private health insurance in the previous wave, who had at least one outpatient visit. Dependent variable takes value 1 if the outpatient visits were funded by the NHS, and 0 if they were partially or fully privately funded. Standard errors clustered at individual level in brackets. 19 region and 12 wave dummies included. *** p<0.01, ** p<0.05, * p<0.1.

Table 3. Number of comorbidities and NHS hospitalisation. Probit coefficients

VARIABLES	(1) Basic	(2) Basic + Education	(3) Basic + Education + Income	(4) Basic + Education + Income (3rd-polynomial)	(5) Basic + Education + Income (4th-polynomial)
Number of comorbidities	-0.120*	-0.140**	-0.152**	-0.127	-0.364*
	[0.065]	[0.065]	[0.067]	[0.117]	[0.201]
(Number of comorbidities)^2	0.032***	0.036***	0.035***	0.023	0.232
	[0.012]	[0.012]	[0.012]	[0.044]	[0.146]
(Number of comorbidities)^3				0.001	-0.053
				[0.004]	[0.035]
(Number of comorbidities)^4					0.004*
					[0.003]
Female	0.021	-0.011	-0.021	-0.022	-0.024
	[0.084]	[0.085]	[0.086]	[0.086]	[0.086]
Age/100	-2.880*	-3.021**	-2.114	-2.130	-2.015
	[1.504]	[1.521]	[1.519]	[1.518]	[1.517]
(Age/100)^2	2.372*	2.219	0.839	0.855	0.730
	[1.439]	[1.442]	[1.441]	[1.441]	[1.439]
Married or cohabitating	-0.073	-0.063	0.108	0.107	0.108
	[0.097]	[0.097]	[0.103]	[0.103]	[0.103]
Compulsory Secondary Education		-0.346*	-0.299	-0.299	-0.306
		[0.208]	[0.205]	[0.205]	[0.205]
O Levels or Apprenticeship		-0.296*	-0.249	-0.250	-0.246
		[0.157]	[0.159]	[0.159]	[0.160]
A Levels		-0.399**	-0.340*	-0.341*	-0.330*
		[0.181]	[0.176]	[0.176]	[0.177]
Higher Education Degree		-0.554***	-0.456***	-0.458***	-0.453***
		[0.140]	[0.140]	[0.140]	[0.140]
MSc, MA or PhD		-0.462**	-0.276	-0.278	-0.270
		[0.210]	[0.221]	[0.221]	[0.222]
LN(household income/100,000)			-0.444***	-0.444***	-0.445***
			[0.080]	[0.080]	[0.080]
Exposure time	-5.187*	-5.373*	-5.962*	-5.950*	-6.107*
	[3.132]	[3.156]	[3.303]	[3.301]	[3.294]
(Exposure time)^2	0.307	0.319	0.362*	0.361*	0.370*
	[0.201]	[0.202]	[0.212]	[0.212]	[0.211]
(Exposure time)^3	-0.006	-0.006	-0.007	-0.007	-0.007*
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Minimum U shape	1.854	1.929	2.168		
Average dep. vble	0.589	0.589	0.589	0.589	0.589
Observations	1,437	1,437	1,437	1,437	1,437

Sample includes individual with private health insurance in the previous wave, who had at least one hospitalisation. Dependent variable takes value 1 if the hospitalisations were funded by the NHS, and 0 if they were partially or fully privately funded. Standard errors clustered at individual level in brackets. 19 region and 12 wave dummies included. *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Comorbidity index and and NHS outpatient consultations. Probit

VARIABLES	(1) Basic	(2) Basic + Education	(3) Basic + Education + Income	(4) Basic + Education + Income (3rd-polynomial)	(5) Basic + Education + Income (4th-polynomial)
Comorbidity index	-1.040**	-1.144***	-1.178***	-1.440**	-0.669
	[0.418]	[0.425]	[0.428]	[0.692]	[1.248]
(Comorbidity index)^2	2.202***	2.315***	2.126**	3.464	-3.104
	[0.852]	[0.868]	[0.866]	[2.920]	[8.810]
(Comorbidity index)^3				-1.566	15.451
				[3.302]	[21.066]
(Comorbidity index)^4					-13.068
					[15.437]
Female	-0.089*	-0.121**	-0.129***	-0.129***	-0.129***
	[0.049]	[0.049]	[0.049]	[0.049]	[0.049]
Age/100	-2.991***	-2.986***	-2.285**	-2.285**	-2.276**
	[0.980]	[0.987]	[0.996]	[0.997]	[0.998]
(Age/100)^2	2.483**	2.244**	1.260	1.257	1.253
	[0.980]	[0.986]	[1.002]	[1.002]	[1.003]
Compulsory Secondary Education		-0.213	-0.190	-0.189	-0.191
		[0.141]	[0.140]	[0.140]	[0.139]
O Levels or Apprenticeship		-0.212*	-0.180	-0.178	-0.179
		[0.113]	[0.112]	[0.112]	[0.112]
A Levels		-0.358***	-0.308***	-0.307***	-0.308***
		[0.118]	[0.117]	[0.117]	[0.117]
Higher Education Degree		-0.410***	-0.337***	-0.336***	-0.336***
		[0.104]	[0.104]	[0.104]	[0.104]
MSc, MA or PhD		-0.610***	-0.458***	-0.457***	-0.459***
		[0.148]	[0.151]	[0.150]	[0.150]
Married or cohabitating	-0.040	-0.033	0.054	0.054	0.055
	[0.061]	[0.062]	[0.063]	[0.063]	[0.063]
LN(household income/100,000)			-0.268***	-0.268***	-0.268***
			[0.046]	[0.046]	[0.046]
Exposure time	-0.088	0.122	0.294	0.279	0.302
	[1.644]	[1.659]	[1.686]	[1.687]	[1.689]
(Exposure time)^2	-0.002	-0.015	-0.025	-0.024	-0.026
	[0.106]	[0.106]	[0.108]	[0.108]	[0.108]
(Exposure time)^3	0.000	0.000	0.001	0.001	0.001
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Minimum U shape	0.236	0.247	0.277		
Average dep. vble	0.667	0.667	0.667	0.667	0.667
Observations	5982	5982	5982	5982	5982

Sample includes individual with private health insurance in the previous wave, who had at least one outpatient visit. Dependent variable takes value 1 if the outpatient visits were funded by the NHS, and 0 if they were partially or fully privately funded. Bootstrap standard errors clustered at individual level in brackets. 19 region and 12 wave dummies included. *** p<0.01, ** p<0.05, * p<0.1.

Table 5. Comorbidity index and and NHS hospitalisations. Probit coefficients

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Basic	Basic + Education	Basic + Education + Income	Basic + Education + Income (3rd-polynomial)	Basic + Education + Income (4th-polynomial)
Comorbidity index	-0.836	-1.040	-1.223	-1.254	-3.197
	[0.769]	[0.770]	[0.789]	[1.402]	[2.649]
(Comorbidity index)^2	3.166**	3.557**	3.496**	3.651	20.383
	[1.521]	[1.516]	[1.536]	[5.780]	[19.737]
(Comorbidity index)^3				-0.181	-44.777
				[6.411]	[51.439]
(Comorbidity index)^4					35.755
					[43.124]
Female	0.008	-0.023	-0.031	-0.031	-0.033
	[0.088]	[0.089]	[0.090]	[0.090]	[0.090]
Age/100	-3.012**	-3.155**	-2.249	-2.248	-2.261
	[1.518]	[1.534]	[1.560]	[1.562]	[1.562]
(Age/100)^2	2.440*	2.296	0.919	0.918	0.918
	[1.459]	[1.466]	[1.488]	[1.490]	[1.490]
Compulsory Secondary Education		-0.338	-0.294	-0.293	-0.298
		[0.219]	[0.221]	[0.222]	[0.222]
O Levels or Apprenticeship		-0.283*	-0.240	-0.240	-0.236
		[0.169]	[0.171]	[0.172]	[0.172]
A Levels		-0.389**	-0.332*	-0.332*	-0.324*
		[0.188]	[0.184]	[0.185]	[0.185]
Higher Education Degree		-0.543***	-0.447***	-0.447***	-0.444***
		[0.149]	[0.150]	[0.151]	[0.151]
MSc, MA or PhD		-0.457**	-0.272	-0.272	-0.269
		[0.216]	[0.230]	[0.231]	[0.232]
Married or cohabitating	-0.079	-0.070	0.100	0.100	0.101
	[0.099]	[0.099]	[0.106]	[0.106]	[0.105]
LN(household income/100,000)			-0.440***	-0.440***	-0.441***
			[0.085]	[0.085]	[0.085]
Exposure time	-5.266	-5.423*	-5.964*	-5.967*	-6.030*
	[3.232]	[3.278]	[3.477]	[3.470]	[3.471]
(Exposure time)^2	0.312	0.322	0.361	0.362	0.366
	[0.207]	[0.210]	[0.223]	[0.223]	[0.223]
(Exposure time)^3	-0.006	-0.006	-0.007	-0.007	-0.007
	[0.004]	[0.004]	[0.005]	[0.005]	[0.005]
Minimum U shape	0.132	0.146	0.175		
Average dep. vble	0.589	0.589	0.589	0.589	0.589
Observations	1,437	1,437	1,437	1,437	1,437

Sample includes individual with private health insurance in the previous wave, who had at least one hospitalisation. Dependent variable takes value 1 if the hospitalisations were funded by the NHS, and 0 if they were partially or fully privately funded. Bootstrap standard errors clustered at individual level in brackets. 19 region and 12 wave dummies included. *** p<0.01, ** p<0.05, * p<0.1.

Table 6. NHS health care use and number of comorbidities. Marginal effects

	NHS hospitalisations				NHS outpatient consultations			
	Probit		LPM		Probit		LPM	
Number of comorbidities	Basic	Basic + Education + Income	Basic	Basic + Education + Income	Basic	Basic + Education + Income	Basic	Basic + Education + Income
0	-0.044*	-0.053**	-0.035	-0.045**	-0.039***	-0.041***	-0.039***	-0.042***
	[0.023]	[0.023]	[0.022]	[0.022]	[0.013]	[0.013]	[0.013]	[0.013]
1	-0.021	-0.029*	-0.016	-0.025	-0.023**	-0.027***	-0.022**	-0.027***
	[0.017]	[0.017]	[0.016]	[0.016]	[0.009]	[0.009]	[0.009]	[0.009]
2	0.004	-0.004	0.003	-0.005	-0.006	-0.011	-0.006	-0.011*
	[0.012]	[0.012]	[0.012]	[0.011]	[0.007]	[0.007]	[0.007]	[0.007]
3	0.028**	0.021*	0.023**	0.015*	0.011	0.006	0.010	0.005
	[0.012]	[0.011]	[0.009]	[0.009]	[0.008]	[0.008]	[0.007]	[0.007]
4	0.051***	0.045***	0.042***	0.036***	0.028***	0.022**	0.026***	0.021**
	[0.016]	[0.016]	[0.011]	[0.011]	[0.011]	[0.011]	[0.009]	[0.009]
5	0.070***	0.067***	0.061***	0.056***	0.043***	0.037***	0.042***	0.036***
	[0.020]	[0.020]	[0.015]	[0.015]	[0.014]	[0.015]	[0.013]	[0.013]
6	0.081***	0.081***	0.081***	0.076***	0.055***	0.050***	0.059***	0.052***
	[0.019]	[0.020]	[0.021]	[0.021]	[0.014]	[0.016]	[0.017]	[0.018]
Observations	1,437	1,437	1,437	1,437	5,982	5,982	5,982	5,982

For NHS hospitalisations, sample includes individual with private health insurance in the previous wave, who had at least one hospitalisation. Dependent variable takes value 1 if the hospitalisations were funded by the NHS, and 0 if they were partially or fully privately funded. For NHS consultations, sample includes individual with private health insurance in the previous wave, who had at least one outpatient visit. Dependent variable takes value 1 if the outpatient visits were funded by the NHS, and 0 if they were partially or fully privately funded. Standard errors clustered at individual level in brackets. 19 region and 12 wave dummies included. *** p<0.01, ** p<0.05, * p<0.1.

Table 7. NHS health care use and the comorbidity index. Marginal effects

	NHS hospitalisations				NHS outpatient consultations			
	Probit		LPM		Probit		LPM	
Comorbidity index	Basic	Basic + Education + Income	Basic	Basic + Education + Income	Basic	Basic + Education + Income	Basic	Basic + Education + Income
0	-0.310	-0.430*	-0.234	-0.347	-0.355***	-0.391***	-0.364***	-0.414***
	[0.272]	[0.260]	[0.245]	[0.239]	[0.136]	[0.134]	[0.141]	[0.141]
0.01	-0.287	-0.406	-0.215	-0.327	-0.342***	-0.379***	-0.349**	-0.400***
	[0.264]	[0.253]	[0.237]	[0.231]	[0.133]	[0.131]	[0.136]	[0.136]
0.05	-0.194	-0.310	-0.138	-0.247	-0.286**	-0.328***	-0.288**	-0.341***
	[0.230]	[0.222]	[0.209]	[0.204]	[0.118]	[0.117]	[0.117]	[0.117]
0.1	-0.076	-0.187	-0.042	-0.147	-0.212**	-0.261***	-0.212**	-0.267***
	[0.187]	[0.182]	[0.175]	[0.171]	[0.098]	[0.097]	[0.096]	[0.096]
0.15	0.043	-0.062	0.054	-0.046	-0.136*	-0.190**	-0.135*	-0.193**
	[0.149]	[0.146]	[0.145]	[0.141]	[0.080]	[0.080]	[0.078]	[0.078]
0.2	0.161	0.063	0.150	0.054	-0.057	-0.116*	-0.059	-0.119*
	[0.125]	[0.123]	[0.120]	[0.117]	[0.070]	[0.070]	[0.067]	[0.067]
0.25	0.278**	0.188	0.246**	0.154	0.022	-0.041	0.017	-0.045
	[0.122]	[0.119]	[0.106]	[0.103]	[0.071]	[0.071]	[0.066]	[0.065]
0.3	0.392***	0.311**	0.342***	0.254**	0.101	0.034	0.093	0.029
	[0.141]	[0.137]	[0.107]	[0.103]	[0.084]	[0.084]	[0.075]	[0.074]
0.35	0.501***	0.430***	0.438***	0.354***	0.179*	0.109	0.170*	0.103
	[0.171]	[0.166]	[0.121]	[0.117]	[0.103]	[0.103]	[0.091]	[0.090]
0.4	0.600***	0.543***	0.534***	0.454***	0.254**	0.183	0.246**	0.177
	[0.201]	[0.198]	[0.146]	[0.141]	[0.123]	[0.125]	[0.112]	[0.110]
0.45	0.686***	0.645***	0.630***	0.554***	0.325**	0.255*	0.322**	0.251*
	[0.223]	[0.224]	[0.177]	[0.170]	[0.142]	[0.146]	[0.135]	[0.133]
0.5	0.752***	0.730***	0.726***	0.655***	0.391**	0.323**	0.399**	0.325**
	[0.230]	[0.237]	[0.211]	[0.203]	[0.157]	[0.164]	[0.159]	[0.157]
Observations	1,437	1,437	1,437	1,437	5,982	5,982	5,982	5,982

For NHS hospitalisations, sample includes individual with private health insurance in the previous wave, who had at least one hospitalisation. Dependent variable takes value 1 if the hospitalisations were funded by the NHS, and 0 if they were partially or fully privately funded. For NHS consultations, sample includes individual with private health insurance in the previous wave, who had at least one outpatient visit. Dependent variable takes value 1 if the outpatient visits were funded by the NHS, and 0 if they were partially or fully privately funded. Block bootstrap standard errors clustered at individual level in brackets. 19 region and 12 wave dummies included. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 8. Relation between the number of comorbidities and NHS health care use

	NHS hospitalisations		NHS outpatient consultations	
VARIABLES	Probit	LPM	Probit	LPM
Number of comorbidities	-0.118	-0.049	-0.029	-0.010
	[0.224]	[0.068]	[0.109]	[0.034]
(Number of comorbidities)^2	0.036	0.014	0.003	0.001
	[0.057]	[0.017]	[0.025]	[0.008]
PMI Employer	-0.341	-0.110	-0.112	-0.030
	[0.223]	[0.073]	[0.107]	[0.033]
PMI Employer * Number of health conditions	-0.094	-0.026	-0.107	-0.037
	[0.268]	[0.087]	[0.126]	[0.041]
PMI Employer* (Number of health conditions)^2	-0.008	-0.004	0.003	0.001
	[0.068]	[0.022]	[0.030]	[0.010]
Female	0.016	-0.004	-0.071	-0.021
	[0.130]	[0.044]	[0.071]	[0.024]
Age/100	-1.262	-0.533	-2.742	-0.914
	[4.134]	[1.435]	[2.252]	[0.722]
(Age/100)^2	0.883	0.441	2.001	0.685
	[4.717]	[1.637]	[2.528]	[0.819]
Married or cohabitating	-0.066	-0.017	-0.031	-0.012
	[0.159]	[0.053]	[0.077]	[0.025]
Compulsory Secondary Education	-1.330***	-0.338***	-0.349*	-0.108*
	[0.386]	[0.115]	[0.203]	[0.063]
O Levels or Apprenticeship	-1.019***	-0.250***	-0.347**	-0.105**
	[0.317]	[0.078]	[0.169]	[0.049]
A Levels	-0.953***	-0.230***	-0.418**	-0.131**
	[0.331]	[0.082]	[0.176]	[0.052]
Higher Education Degree	-1.109***	-0.279***	-0.412***	-0.125***
	[0.287]	[0.062]	[0.156]	[0.045]
MSc, MA or PhD	-0.920**	-0.208*	-0.558**	-0.182**
	[0.397]	[0.117]	[0.222]	[0.074]
LN(household income/100,000)	-0.612***	-0.201***	-0.341***	-0.110***
	[0.147]	[0.047]	[0.072]	[0.023]
Exposure time	-0.666	-0.333	1.736	0.564
	[5.357]	[1.613]	[2.343]	[0.757]
(Exposure time)^2	0.028	0.017	-0.119	-0.039
	[0.345]	[0.103]	[0.150]	[0.048]
(Exposure time)^3	-0.000	-0.000	0.003	0.001
	[0.007]	[0.002]	[0.003]	[0.001]
Average dep. vble	0.592	0.592	0.677	0.677
Observations	591	591	2,741	2,741

Sample includes employees with private health insurance in the previous wave, either provided by their employer as a fringe benefit or bought by themselves, who had at least one hospitalisation (first two columns) or at least one outpatient consultation (last two columns). Dependent variable takes value 1 if the hospitalizations were funded by the NHS, and 0 if they were partially or fully privately funded. Standard errors clustered at individual level in brackets. 19 region and 12 wave dummies included. *** p<0.01, ** p<0.05, * p<0.1.

Table 9. Relation between the comorbidity index and NHS health care use

	NHS hospitalisations		NHS outpatient	
VARIABLES	Probit	LPM	Probit	LPM
Comorbidity index	0.507	-0.004	0.969	0.292
	[2.162]	[0.702]	[1.053]	[0.328]
(Comorbidity index)^2	-0.618	0.132	-2.532	-0.785
	[5.042]	[1.663]	[2.302]	[0.738]
PMI Employer	-0.328	-0.111	-0.070	-0.018
	[0.233]	[0.078]	[0.108]	[0.034]
PMI Employer * Comorbidity index	-1.575	-0.423	-1.901	-0.624
	[2.906]	[0.990]	[1.259]	[0.411]
PMI Employer* (Comorbidity index)^2	1.436	0.329	2.170	0.662
	[7.476]	[2.584]	[2.970]	[1.006]
Female	0.014	-0.004	-0.073	-0.022
	[0.131]	[0.044]	[0.071]	[0.024]
Age/100	-1.045	-0.513	-2.808	-0.941
	[4.132]	[1.438]	[2.252]	[0.722]
(Age/100)^2	0.599	0.404	1.993	0.687
	[4.715]	[1.644]	[2.530]	[0.819]
Married or cohabitating	-0.086	-0.023	-0.036	-0.013
	[0.158]	[0.052]	[0.076]	[0.025]
Compulsory Secondary Education	-1.337***	-0.338***	-0.347*	-0.107*
	[0.386]	[0.116]	[0.204]	[0.063]
O Levels or Apprenticeship	-1.028***	-0.250***	-0.338**	-0.103**
	[0.317]	[0.079]	[0.170]	[0.050]
A Levels	-0.947***	-0.225***	-0.405**	-0.127**
	[0.329]	[0.081]	[0.176]	[0.052]
Higher Education Degree	-1.108***	-0.276***	-0.399**	-0.121***
	[0.284]	[0.062]	[0.157]	[0.045]
MSc, MA or PhD	-0.891**	-0.192	-0.545**	-0.179**
	[0.394]	[0.117]	[0.222]	[0.074]
LN(household income/100,000)	-0.601***	-0.196***	-0.342***	-0.110***
	[0.147]	[0.048]	[0.071]	[0.023]
Exposure time	-0.720	-0.338	1.801	0.590
	[5.375]	[1.618]	[2.340]	[0.757]
(Exposure time)^2	0.031	0.017	-0.123	-0.040
	[0.346]	[0.104]	[0.150]	[0.048]
(Exposure time)^3	-0.000	-0.000	0.003	0.001
	[0.007]	[0.002]	[0.003]	[0.001]
Average dep. vble	0.592	0.592	0.677	0.677
Observations	591	591	2,741	2,741

Sample includes employees with private health insurance in the previous wave who bought it themselves or obtained through their employer, who had at least one hospitalisation (first two columns) or at least one outpatient consultation (last two columns). Dependent variable takes value 1 if the hospitalisations (outpatient consultations) were funded by the NHS, and 0 if they were partially or fully privately funded. Standard errors clustered at individual level in brackets. 19 region and 12 wave dummies included. *** p<0.01, ** p<0.05, * p<0.1.

Declaration of interests

☐ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☒ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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