Do Public and Private Hospitals differ in Quality? Evidence from Italy

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Abstract

We investigate whether public and private providers differ in quality in Lombardy, a large Italian region. This region has adopted an "internal market" model where public and private providers are paid by DRG and compete for publicly-funded patients for both elective and emergency treatments. Using a large administrative sample in 2012-14, we measure clinical quality with 30-day mortality for the following emergency conditions: heart attack (AMI), stroke (ischemic and haemorrhagic) and hip fracture. For elective care, where mortality is negligible, we measure 30-day emergency readmission rates for hip replacement and knee replacement. Public and private hospitals may compete not only on clinical quality, but also on non-clinical aspects of patients' experience. We investigate whether private providers have shorter waiting times for hip and knee replacements. To control for unobserved differences in casemix between public and private providers we pursue an instrumental variable approach based on the distance between patient's residence and the closest public and private provider: longer distances to the closest private and public hospital are highly significant determinants of whether the patient is treated by a private versus a public provider. We find, with few exceptions, that public and private providers generally do not differ in elective and emergency quality, neither in waiting times. The only exception is AMI for which mortality risk is lower in private providers, and hip replacement for which readmission risk is higher in private providers.

Keywords: quality; public and private providers; patient casemix. *JEL*: I1.

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1 Introduction

Countries across the OECD differ systematically in the public-private mix in the provision of hospital services to publicly-funded patients (Barros and Siciliani, 2011). In some countries, like the United Kingdom and Norway, the vast majority of hospitals is public. In these countries, while private providers increasingly treat publicly-funded patients, they only treat a relatively small proportion of them and limit their services to elective (non-emergency) care (Siciliani et al., 2017). For example, in England in 2013 only 4.5 per cent of elective treatments were provided by private providers (Moscelli et al., 2018).

In other countries, such as the US, France, Germany and Italy, private providers are more prominent. In the US, around 60 per cent of hospitals are private not-for-profit, 20 per cent are private for-profit, and 20 per cent are public. In Italy about 28 per cent of hospitals are private, in France, about 60 per cent of providers are private, while in Germany 70 per cent of hospitals are private, half of which is for-profit. At the extreme of this wide spectrum we find the Netherlands where all providers are private. In these countries, private hospitals provide both elective (i.e., non-emergency) and emergency treatments, thus competing on a whole range of health care services.

In the last two decades, several healthcare reforms have been implemented in European countries mostly aimed at rationalising the use and provision of hospital care, improving its quality and appropriateness and reducing its costs. In the same period, we observe a more significant role of private sector provision of healthcare even in countries with National Health Services.

The extent to which entry of private providers should be encouraged or facilitated is often the subject of an intense political debate. A key element in deciding whether policy makers should involve private providers is the extent to which they provide better or worse quality than public providers. Economic theory provides mixed predictions on whether private hospitals provide higher or lower quality than public hospitals. The literature has identified different mechanisms that go in opposite direction. On one hand, because private hospitals have a stronger incentives to maximise profits, they might skimp on quality to obtain a higher financial surplus. On the other hand, precisely because they are more profit oriented, they have a stronger incentive to compete for demand by raising quality if demand is sufficiently elastic. Moreover, public hospitals may be able to attract more motivated workers who have a stronger preference for quality (Sloan, 2000; Glaeser and Shleifer, 2001; Lakdawalla and Philipson, 2006; Brekke et al., 2012).

The existing empirical literature on the impact of hospital ownership on quality also provides contrasting results. For the US, the systematic review by Eggleston et al. (2008) suggests that whether for-profit hospitals provide higher quality depends on the region, the data source and the period of analysis. Other studies, such as Picone et al. (2002) and Shen (2002) investigate the effect of ownership conversions and find that mortality increased in hospitals that changed from non-profit to for-profit status. For Australia, there is evidence that private hospitals provide higher quality in terms of lower unplanned readmission and mortality rates (Jensen et al., 2009). For France, Milcent (2005) finds that, after controlling for observable differences in severity, public hospitals and private not-for-profit hospitals have similar AMI mortality. Private for-profit hospitals have instead lower AMI mortality rate. In the period investigated, public and private not-for-profit hospitals were paid by a global budget, with the revenue of each public hospital was determined administratively on a historical basis, and private for-profit hospitals were paid by fee-for-service. Lien et al. (2008) finds that non-for profit hospitals have better quality that for-profit hospitals in Taiwan with quality being measured by mortality for stroke and cardiac treatment. Moscelli et al. (2018) find that private hospitals in England have similar quality, as measured by emergency readmission rates for elective treatments, to public hospitals. Perotin et al. (2013) find no difference in patient satisfaction between public and private hospitals in England, while Chard et al. (2011) report that private treatment centres in 2008/9 had higher quality for hip and knee and similar quality for varicose vein and hernia surgery. In summary, the evidence suggests that results differ both within and across health systems.

In this study we investigate empirically whether there are differences in healthcare quality between public and private hospitals treating publicly-funded patients in Italy, who seek elective (planned, non-emergency) treatments, and emergency treatments. We use administrative data on patients admitted to 189 Italian hospitals located in the Lombardy region, in the years from 2012 to 2014. Lombardy is a large Italian region having a population of about 10 million inhabitants. Similarly to the US, France and Germany, private providers are prominent in Lombardy, and provide both elective and emergency care. They account for about 50 per cent of providers, though they are generally smaller in size than public providers. Most of them are for-profit hospitals, with the number of non-profit hospitals, often with a religious affiliation, declining over time. Given that the price is fixed and is the same for public and private hospitals, providers compete on quality to attract patients, and "money follows the patient".

In our empirical investigation we conduct a comprehensive comparison of quality between public and private hospitals across different dimensions of emergency and elective care. We measure clinical quality with 30-day mortality from patient admission for a set of emergency conditions, namely, heart attack (AMI), stroke (ischemic and haemorrhagic) and hip fracture. For elective care, where mortality is negligible, we measure clinical quality with 30-day emergency readmission rates for hip replacement and knee replacement. Public and private hospitals may compete not only on clinical quality, but also on non-clinical aspects of patients' experience. One key aspect of patient responsiveness is how long patients have to wait to obtain treatment. Waiting times for elective treatments are a key concern across many publicly-funded health systems (Siciliani et al., 2013). We therefore investigate whether private providers have a stronger incentive to keep waiting times short for two common elective treatments, such as hip and knee replacements.

One methodological concern in comparing quality for public and private providers is that, driven by their profit motive, private providers may have a stronger financial incentive to avoid costly patients (e.g. whose cost is above the DRG tariff). To control for different case-mix we include a range of control variables, such as age, gender, Elixhauser comorbidities, and number of procedures. To control for unobserved differences in casemix we pursue an instrumental variable approach, which is similar to Lien et al. (2008) and Moscelli et al. (2018).

To instrument for the choice between a public and a private provider, we use the geographical *distance* of the patient's residence to the nearest public and nearest private hospital. The idea is that a longer distance to the closest *private* provider makes the patient *less* likely to be treated by a private hospital, while a longer distance to the closest *public* provider makes it more *likely* to be treated by a private hospital. We indeed find that the distance to the closest private and public hospital are highly significant determinants of whether the patient is treated by a private versus a public provider. This finding is consistent with empirical literature on patient choice which finds that distances to hospitals are a strong predictors of choice of hospital (e.g. Gaynor et al., 2016) and the theory literature on hospital incentives where patient demand is modelled within a Hotelling or Salop framework, where patients trade-off distance against provider quality (Brekke et al., 2011; 2012).

Our key findings in relation to quality differences between public and private providers are as follows. For *emergency* conditions, OLS results suggest that mortality rates are significantly lower (both statistically and economically) for private hospitals, but this is not the case under our instrumental-variable approach except for AMI where mortality is still lower for private hospitals after instrumenting. For *elective* conditions, our OLS results suggest no significant difference in coronary bypass mortality and in readmission for hip and knee replacement. These differences remain insignificant under the instrumental variable approach except for hip replacement where the readmission risk is higher for private hospitals. OLS suggests that waiting times are lower for private hospitals, while they are insignificant under the instrumental variable approach. As a whole, our results suggests that the evidence on whether private hospitals provide higher quality than public hospitals is mixed. Although several outcomes do not differ, AMI mortality risk is lower in private providers, and readmission risk for hip replacement is higher in private providers.

Our study makes a number of contributions to the existing literature on the effect of hospital ownership on quality. First, most of the literature is from US, while less is known about European countries. The health system in the US differs from other OECD countries, given the prominence of private health insurance, which is voluntary for individuals not covered by Medicare or Medicaid. Within European countries, there is evidence from England and France. However, as mentioned above, private providers in England only specialise in elective treatment, and treat a small proportion of publicly-funded patients. Therefore, a comparison for emergency care is not possible. Our study instead covers both elective and emergency care, and as far as the authors are aware, it is the first study which compares quality provision of public and private providers in Italy. The institutional set-up in Lombardy is also appealing, since public and private providers are paid according to the same DRG tariff, and therefore differences in quality cannot be attributed to differences in payment rules.

Second, this is one of the first studies which investigates differences in waiting times between public and private providers. Waiting times are a salient health policy issue, and it is therefore surprising that there is lack of literature on this important dimension of patient experience. This is likely due to lack of adequate data or policy interest (for example in the US waiting times are relatively short and are not perceived as a policy issue). Bjorvatn (2018) compares patient casemix between public and private hospitals treating patients with cardiovascular conditions in Norway and finds that private hospitals have for some DRGs lighter casemix and tend to specialise. Although it is not the focus of the analysis, the study finds that private hospitals have shorter waiting times for cardiovascular conditions.

Third, to motivate and guide our empirical analysis, we provide a theoretical framework which expands the one provided by Brekke et al. (2012). Differently from their model, we allow both public and private providers to compete in the same market. The model highlights the interactions between the two types of providers, in addition to predicting how profit motives affect the provision of quality.

Although our focus is on differences in hospital quality by type of ownership, the study relates also to the literature on patient choice and hospital competition. The first stage regression of choice between public and private provider is a reduced form of a patient choice model with distance as its key determinant. There is an extensive literature from the US and, to a lower extent, other OECD countries that models patient choice of each hospital against distance and some quality (process or structure) measures, commonly operationalised with a conditional logit model, and typically finds that the demand responds to quality but the demand elasticity is low (see Gaynor et al., 2016; Gutacker et al., 2016; Moscelli et al., 2016, and references therein).[1]

The study is organised as follows. Section 2 provides a brief institutional background. Section 3 develops a theoretical framework. Section 4 illustrates methods and the data. Section 5 discusses the results. Section 6 concludes.

2 Institutional background

The Italian National Health Service provides universal healthcare coverage. The health system is highly decentralized. Health funding is transferred to the regional governments that are responsible for the organisation and management of their health services through local purchasers of health services. The 20 regions enjoy significant autonomy in determining the structure and functioning of their health systems within the general framework designed at the national level. The national framework is developed under the form of guidelines which establish the *Basic Levels of Care* ("Livelli Essenziali di Assistenza").

The Lombardy region was the first in 1997 to implement an innovative quasi market model that introduces and promotes competition among healthcare providers (regional law 31/1997). The aim of the policy was to improve the quality of services, and at the same time to controlling the rise of health expenditure. The main features of the reform were: the separation between purchasers and providers, competition between public and private accredited providers in the presence of at third-party payer, and patients' freedom of choice between providers. More precisely, the reform has

[1] In our first stage regression we do not include quality as a regressor since this is our main outcome variable in the second stage regression.

introduced a split between Local Health Authorities (LHAs), the local purchasers, and hospitals. LHAs are responsible for programming, financing and monitoring the quality and quantity of NHS activities in their target area.

The health reform has introduced competition between public and private providers by allowing the latter to provide free healthcare under the condition that they satisfy minimum technology and organizational standards set by the region. Private non-profit and for-profit hospitals that satisfy such standards become "accredited" to provide care to publicly-funded patients free of charge. Under these arrangements, patients are assigned to the LHA based on their place of residence but have freedom of choice across all hospitals, both public and private.

Since 1995 the Lombardy region has implemented a financing mechanism based on a Prospective Payment System. It pays a predetermined fixed tariff to the hospital for each patient treated based on her Diagnosis-Related Group (DRG), which is identified through the clinical information reported in the hospital discharge chart. The tariff for each DRG does not vary with the length of stay if it falls within a given threshold. This type of fixed price regulation induces hospitals to compete primarily on quality. Although the region monitors the distribution of risk-adjusted quality measures across hospitals through its quality evaluation programme, only hospital managers can access such information. Therefore, quality competition relies on informal reputation mechanisms (see Brenna, 2011, for further details about the Lombardy health system).

3 Economic theory

We model a hospital market with both public and private providers, and is adapted from Brekke et al. (2012). Each public hospital $i = 1, .., I$ provides quality q_i^u and each private hospital $k = 1, ..., K$ provides quality q_k^r. Patients choose hospitals based on the quality they provide. We assume that health care is free at the point of consumption and there are no copayments. Therefore, quality is a key determinant of hospital choice of the patient.

We assume that the demand function for public hospital i is

$$D_i^u(q_1^u, ..., q_i^u, ..., q_I^u, q_1^r, ..., q_k^r, ..., q_K^r), \tag{1}$$

with demand increasing in its own quality, $\partial D_i^u / \partial q_i^u > 0$, and decreasing in the quality of any other hospital, either public or private, e.g. $\partial D_i^u / \partial q_1^u < 0$, $\partial D_i^u / \partial q_k^r < 0$. If a hospital increases quality, more patients are likely to choose it. We assume that qualities are imperfect substitutes (due to travelling costs and switching costs), $|\partial D_i^u/\partial q_i^u| > |\partial D_i^u/\partial q_k^r|$. Quality can affect demand both through informal mechanisms, such as word of mouth, or formal ones, such as public reporting. Hospitals that have consistently higher quality build a reputation which is then transmitted between patients through family, friends and informal networks. Primary care doctors who refer patients to hospitals also advise patients based on their perceived quality which is based on the cumulated experience of the numerous patients they attend every day. Therefore, quality affects demand even in the absence of public reporting.[2]

Similarly, the demand for private hospital k is

$$D_k^r(q_1^u, ..., q_i^u, ..., q_I^u, q_1^r, ..., q_k^r, ..., q_K^r), \tag{2}$$

with demand increasing in its own quality, $\partial D_k^r/\partial q_k^r > 0$, and decreasing in the quality of any other hospital, either public or private. We write these demand functions in a more compact style as

$$D_i^u(\mathbf{q}^u, \mathbf{q}^r),\ D_k^r(\mathbf{q}^u, \mathbf{q}^r) \text{ with } i = 1, .., I \text{ and } k = 1, ..., K, \tag{3}$$

and $\mathbf{q}^u = (q_1^u, ..., q_i^u, ..., q_I^u)$ is the vector of quality of public hospitals and $\mathbf{q}^r = (q_1^r, ..., q_k^r, ..., q_K^r)$ is the vector of quality of private hospitals. We assume that demand is separable in qualities.

The profit function of public hospital i is given by

$$\pi_i^u(\mathbf{q}^u, \mathbf{q}^r) = [p - c^u(q_i^u)]\, D_i^u(\mathbf{q}^u, \mathbf{q}^r) - C^u\left(q_i^u\right), \quad i = 1, ..., I, \tag{4}$$

where p is a fixed price per patient treated, $c^u(q_i^u)$ is the cost of treating a patient which we assume to be increasing in quality, and $C^u\left(q_i^u\right)$ is the fixed cost of quality. Similarly, the profit function of private hospital k is given by

$$\pi_k^r(\mathbf{q}^u, \mathbf{q}^r) = [p - c^r(q_k^r)]\, D_k^r(\mathbf{q}^u, \mathbf{q}^r) - C^r\left(q_k^u\right), \quad k = 1, ..., K. \tag{5}$$

We therefore allow the treatment costs of treating patients and the fixed cost of quality to vary

[2] Quality is a multidimensional concept, and includes both clinical aspects of quality and amenities, such as the comfort and size of the room, quality of the food, friendliness of reception, quality of the interiors (Dranove and Satterthwaite, 2000). In this study, we focus on clinical aspects of the quality, since these are arguably more important and also we do not have information on patient reported outcomes on patient experience.

between public and private hospitals, $c^u(q) \gtrless c^r(q)$ and $C^u(q) \gtrless C^r(q)$. Differences could arise as a result of different organisational arrangements (e.g. efficiency of the operating theatre), which is likely to affect treatment costs, or different tendering processes, which is likely to affect the fixed cost of quality through acquisition of expensive machines (e.g. MRI, CT scans).

Following the seminal study by Ellis and McGuire (1986), we model healthcare providers as altruistic. More precisely, the payoff function of public hospital i is given by

$$V_i^u(\mathbf{q}^u, \mathbf{q}^r) = (1-\delta)\,\pi_i^u(\mathbf{q}^u, \mathbf{q}^r) + \alpha^u b\,(q_i^u) - g\,(q_i^u)\,, \tag{6}$$

where α^u denotes the degree of altruism of intrinsic motivation from providing higher quality, and $b\,(q_i^u)$ is a patient benefit function, which is increasing in quality. In addition to monetary costs, we assume that there are non-monetary (effort) costs associated with providing quality above a minimum level (normalised to zero). These non-monetary costs are captured by the function $g\,(q_i^u)$, which is also increasing in quality. The parameter $\delta \in [0, 1)$ reflects the constraints imposed by a regulator hospitals ability to distribute profits. Public hospitals cannot distribute profits in cash but have to spend any positive net revenues on perquisites.[3]

Hospitals are complex organisations. The quality provided is the outcome of several agents involved including doctors, nurses, the managers in charge of the hospital finances, and the protocols agreed between medical and managerial staff. Doctors are likely to give higher weight to patients benefit than hospital managers. One possible interpretation of the weight given to patient benefit, α^u, is that this is the outcome of a negotiation between doctors and managers (Chone and Ma, 2011).

Similarly, the payoff function of private hospital k is given by

$$V_k^r(\mathbf{q}^u, \mathbf{q}^r) = \pi_k^r(\mathbf{q}^u, \mathbf{q}^r) + \alpha^r b\,(q_i^r) - g\,(q_i^r)\,. \tag{7}$$

We therefore allow the degree of altruism to differ between public and private hospitals, $\alpha^u \gtrless 0$, as it has been argued for example that public hospitals may be able to attract more motivated employees.

We assume that quality is chosen simultaneously and independently (given that prices are fixed,

[3] A similar approach is used by Glaeser and Shleifer (2001) and Ghatak and Mueller (2011) to model difference between non-profit and for-profit firms.

quality is the only choice variable of the hospital). The first-order conditions for public hospital $i = 1, ..., I$ and private hospital $k = 1, ..., K$ are given by

$$\begin{aligned}\frac{\partial V_i^u}{\partial q_i^u} &= (1-\delta)\left[(p - c^u(q_i^u))\frac{\partial D_i^u(\mathbf{q}^u,\mathbf{q}^r)}{\partial q_i^u} - \frac{\partial c^u(q_i^u)}{\partial q_i^u}D_i^u(\mathbf{q}^u,\mathbf{q}^r) - \frac{\partial C^u\left(q_i^u\right)}{\partial q_i^u}\right] \\ &\quad +\alpha^u\frac{\partial b\left(q_i^u\right)}{\partial q_i^u} - \frac{\partial g\left(q_i^u\right)}{\partial q_i^u} = 0, \end{aligned} \tag{8}$$

and

$$\begin{aligned}\frac{\partial V_k^r}{\partial q_k^r} &= \left[(p - c^r(q_k^r))\frac{\partial D_k^r(\mathbf{q}^u,\mathbf{q}^r)}{\partial q_k^r} - \frac{\partial c^r(q_k^r)}{\partial q_k^r}D_k^r(\mathbf{q}^u,\mathbf{q}^r) - \frac{\partial C^r\left(q_k^r\right)}{\partial q_k^r}\right] \\ &\quad +\alpha^r\frac{\partial b\left(q_k^r\right)}{\partial q_k^r} - \frac{\partial g\left(q_k^r\right)}{\partial q_k^r} = 0. \end{aligned} \tag{9}$$

In the symmetric equilibrium, defined with q^{*u}, q^{*r}, the following two conditions hold:

$$\begin{aligned}&(1-\delta)\left[(p - c^u(q^{*u}))\frac{\partial D^u(\mathbf{q}^{*u},\mathbf{q}^{*r})}{\partial q_i^u} - \frac{\partial c^u(q^{*u})}{\partial q_i^u}D^u(\mathbf{q}^{*u},\mathbf{q}^{*r}) - \frac{\partial C^u\left(q^{*u}\right)}{\partial q_i^u}\right] \\ &+\alpha^u\frac{\partial b\left(q^{*u}\right)}{\partial q_i^u} - \frac{\partial g\left(q^{*u}\right)}{\partial q_i^u} = 0, \end{aligned} \tag{10}$$

and

$$\begin{aligned}&\left[(p - c^r(q^{*r}))\frac{\partial D^r(\mathbf{q}^{*u},\mathbf{q}^{*r})}{\partial q_k^r} - \frac{\partial c^r(q^{*r})}{\partial q_k^r}D^r(\mathbf{q}^{*u},\mathbf{q}^{*r}) - \frac{\partial C^r\left(q^{*r}\right)}{\partial q^r}\right] \\ &+\alpha^r\frac{\partial b\left(q^{*r}\right)}{\partial q_k^r} - \frac{\partial g\left(q^{*r}\right)}{\partial q_k^r} = 0. \end{aligned} \tag{11}$$

The optimal quality is set such that the sum of the marginal monetary and non-monetary benefits (given by revenues and intrinsic motivation) is equal to the marginal monetary and non-monetary (disutility) costs. A higher degree of altruism and lower treatment or fixes costs tends to increase quality.

Profit constraints reduce the relative weight given to financial considerations as opposed to non-financial ones. We now investigate how an increase in profit constraints δ affects quality. Applying Cramer's rule, we obtain:

$$\frac{\partial q^{*u}}{\partial \delta} = -\frac{1}{\Gamma}\left[(p - c^u(q^{*u}))\frac{\partial D^u(\mathbf{q}^{*u},\mathbf{q}^{*r})}{\partial q_i^u} - \frac{\partial c^u(q^{*u})}{\partial q_i^u}D^u(\mathbf{q}^{*u},\mathbf{q}^{*r}) - \frac{\partial C^u\left(q^{*u}\right)}{\partial q_i^u}\right] \tag{12}$$

and, using (10),

$$\frac{\partial q^{*u}}{\partial \delta} = \left(\alpha^u \frac{\partial b\left(q^{*u}\right)}{\partial q_i^u} - \frac{\partial g\left(q^{*u}\right)}{\partial q_i^u}\right) \frac{1}{(1-\delta)\Gamma} \tag{13}$$

and

$$\frac{\partial q^{*r}}{\partial \delta} = -\frac{1}{\Delta} \frac{\partial c^r\left(q^{*r}\right)}{\partial q_k^r} \left(\sum_{k=1,\dots,K} \frac{\partial D^r\left(\mathbf{q}^{*u}, \mathbf{q}^{*r}\right)}{\partial q_k^u}\right) \frac{\partial q^{*u}}{\partial \delta}, \tag{14}$$

where Δ and Γ are positive expressions that relate to the second order conditions of the problem, $\Delta > 0$ and $\Gamma > 0$.

The intuition behind the key result is as follows. The effect of a lower weight on profits (i.e. an increase in δ) on the quality of public providers, given by (13) is in general indeterminate. It depends on the relative magnitude of altruism relative to the marginal disutility of quality. If altruism is low, then the marginal profit is positive, and a lower weight on profit reduces quality. If altruism is high so that the marginal profit of quality is negative, then a lower weight on profit increases quality. This is in line with the result of Brekke et al. (2012). Since qualities are strategic complements, higher profit constraints by public hospitals also induces a change in quality by private hospitals, as suggested by (14): an increase (reduction) in quality by public hospitals will increase (reduce) quality by private hospitals.

From (12), we can also see that the optimal quality is a function of the equilibrium demand, $D^u(\mathbf{q}^{*u}, \mathbf{q}^{*r})$, and the demand responsiveness to quality, $\partial D^u(\mathbf{q}^{*u}, \mathbf{q}^{*r})/\partial q_i^u$. In turn, these depend (see (3)), on the number of public providers I and the number of private providers K. If we assume that total demand across all hospitals is fixed, an increase in the number of (public or private) providers will increase the demand responsiveness to quality, making the market more competitive. But because equilibrium quality differs across public and private providers and qualities are strategic complements, then the number of private providers K (or proportion of private providers $K/(K+I)$) will also affect quality.

The key insights from the model are as follows. (i) Whether constraints on profits, a feature of public hospitals, increases or reduces quality is in principle indeterminate, with higher altruism (disutility) leading to profit constraints to increase (reduce) quality. Differences in quality can also be driven by differences in degree of altruism, and differences in treatment costs, with lower costs leading to higher quality (since it increases price mark-up). (ii) Public and private hospitals compete for the same patients; if profit constraints induce public hospitals to have higher (lower) quality this also increases (reduces) the quality of private hospitals in the same market if qualities are strategic complements. In turn, this suggests that the quality of hospitals in a given market depends on the number of hospitals in the market, but also the public-private mix of the market (as for example captured by the number or the proportion of private hospitals).

4 Empirical model and data

We wish to estimate the effect of hospital ownership on the quality of healthcare. To this end, we consider the following empirical specification:

$$y_{ij} = \alpha_0 + \beta p_{ij} + \mathbf{X}_i' \boldsymbol{\gamma}_0 + \mathbf{S}_j' \boldsymbol{\lambda} + \varepsilon_{ij}, \tag{15}$$

where y_{ij} is the health outcome for patient i admitted in hospital j; p_{ij} is a dummy variable taking value of 1 if the hospital chosen by patient i is *private;* $\mathbf{S}_j$ a vector of variables related to hospital characteristics (e.g. teaching hospital) and local market structure (number of competitors, and proportion of private providers within a 30km catchment area); $\mathbf{X}_i$ is a vector of patient's characteristics that includes age, gender, morbidity (proxied by the Elixhauser comorbidity index), the number of procedures, and a dummy for one of the thirteen provinces where the patient resides, controlling for unobserved factors at the province level; ε_{ij} is the error term. Our key parameter of interest is β, which indicates whether private hospitals differ from public hospitals in the provision of quality.

In estimating equation (15), one major concern is that unobservable characteristics, such as patient's morbidity, may be correlated with the choice of going to a private hospital, leading to possible bias in the estimated coefficient. This is because private providers may have a stronger financial incentive to attract more profitable and less severe patients (a practice also known as cream skimming) than public ones and to avoid costly patients (Berta et al., 2010; Ellis, 1998).

To address this issue, we adopt an instrumental-variable approach. We follow the approach outlined in Lien et al. (2008) and Moscelli et al. (2018) and take as instruments the geographical distance of patient i's place of residence to the nearest public hospital and its squared term and the distance to the nearest private hospital and its squared term (McClellan et al., 1994; McClellan and Newhouse, 1997; Sloan et al., 2001). The place of residence is measured as the centroid from one of the (around) 1500 municipalities (the much smaller administrative geographical areas compared to the twelve provinces). It is plausible to assume that, ceteris paribus, patients prefer to be admitted to hospitals that are geographically closer to their residence. Distance is systematically a strong, if not the strongest, predictor in patient choice models (e.g. Gutacker et al., 2016 and Brekke et al., 2014 for a review of the literature). The idea is that distance, conditional on locations of patients and hospitals, while being a key driver of patient's choice, is uncorrelated with unobserved patient characteristics, particularly a patient's severity upon admission. We estimate model (1) by instrumental variables in the context of a linear probability model, although we also use Logit estimation in a robustness check.

Our instrumental variable approach relies on the assumption that unobserved patient characteristics are uncorrelated with (differential) distance. This assumption may be invalid in the presence of spatial sorting where individuals who are more likely to use healthcare services tend to live near hospitals rather than far away from them. However, we do not think this is an issue within the Italian context and our analysis, and this is also confirmed by the balance tables provided in Section 4.2. Several of our health conditions are emergency ones (heart attack, hip fracture, stroke) where it seems unlikely that individuals will predict they will be sick and move closer to a hospital with higher quality. This is potentially more of an issue for hip and knee replacement, but these are routine high-volume conditions that are provided once or twice in a lifetime, and again it seems unlikely that individuals will be willing to move in order be closer to a specific hospital. This is further reinforced within the Italian cultural context, where individuals have strong family ties, and this, together with job opportunities (for those who are not retired), are the main drivers of location decisions. Moreover, there are high taxes on selling or buying a house, which further hampers mobility.

4.1 Data

We use administrative data on all patients admitted to any hospitals in Lombardy, in the years from 2012 to 2014. Data on patients have been extracted from the Hospital Discharge Chart available for each patient. These include socio-demographic patient characteristics such as age, gender, and the municipality and the province of residence; clinical information (co-morbidities), type of admission (elective or emergency), and mode of discharge. We also gathered information on mortality of patients from the General Register Office. The characteristics of the hospital include its ownership (e.g. private or public), and teaching status. Most of private hospitals are for-profit, and are bundled with non-profit hospitals that often have a religious affiliation.

We use nine measures of quality across both emergency and elective (non-emergency) admissions to investigate whether results are sensitive to the type of admission. Patients requiring emergency admission have very limited hospital choice, often determined by external factors such as bed availability or the ambulance service. Five are based on mortality, two on hospital readmissions and two on (inpatient) waiting times. For emergency admissions we measure mortality with a dummy variable equal to one if the patient dies within 30 days from patient admission for acute myocardial infarction (AMI), ischaemic and haemorragic stroke, and hip fracture.

For elective admissions we measure mortality (within 30 days from patient admission) for coronary bypass. We do not measure mortality for hip replacement and knee replacement because it is very low and therefore does not provide sufficient variation to compare hospitals. We instead measure quality with a dummy variable equal to one if the patient is readmitted as an emergency within 30 days from discharge. We measure the inpatient waiting time (expressed in number of days) for elective hip and knee replacement. Inpatient waiting time is defined as the time from which the patient is added to the list to the time the patient is admitted to the hospital for treatment. The DRG codes used to select the seven conditions are listed in the Appendix.

Among the control variables we include age in year bands (40-60, 60-70, 70-80, over 80, with less than 40 used as the reference group), gender, the Elixhauser index (Elixhauser et al., 1998) and the total number of procedures. We also have hospital characteristics, a dummy variable equal to one if the patient is admitted in a teaching hospital, and two measures of local market structure: i) the number of competitors providing the same treatment or condition, and ii) proportion of private providers within a 30km catchment area.[4] These were computed using hospital address and its geographical coordinates to draw a fixed radius of 30km and count the total number of hospitals (public or private) falling into this radius, and the proportion of hospitals with private ownership. We also control for province fixed effect measured at the patient level (i.e. a dummy equal to one if the patient resides in one of the twelve provinces).

To implement our instrumental variable approach, for each patient we compute the straight-line ellipsoidal distance between the patient residence (through the geographical coordinates of the municipality where the patient resides) and the closest public hospital and private hospital (through the geographical coordinates of hospital address). There are about 1500 municipalities in Lombardy.

[4] The choice of a 30km radius is in line with previous work from England (Gaynor et al., 2013, and references therein) and with a previous study on Lombardy which focuses on hospital competition (Berta et al., 2016).

Before presenting the descriptive statistics, we motivate the choice of our outcome measures. For emergency admissions, we focus on AMI (heart attack), stroke and hip fracture. AMI mortality has been extensively used as a marker of hospital quality in particular in relation to the literature investigating the effect of hospital competition (e.g. Gaynor, 2006; Bloom et al., 2015). Stroke causes 10–12% of deaths across Western countries (Donnan et al., 2008). The lifetime risk of hip fracture is 18% for women and 6% in men with an 30-day mortality of 6%. 20% of individuals die within one year following a hip fracture, and 25% require long-term care (Gillespie, 2000).

For elective admissions, we focus on hip and knee replacement, two common elective treatments for which the mortality rate is negligible. For these we instead focus on emergency readmissions since these are commonly used as a performance indicator in the policy domain (e.g. within the NHS Outcomes Framework in England; HSCIC, 2013) and is commonly used to measure quality in the clinical literature (e.g. Blunt et al., 2015) and the health economics literature (e.g. Moscelli et al., 2016). Finally, coronary artery bypass graft is a common elective surgical procedure to treat individuals with heart disease with severe angina (chest pain) and at risk of a heart attack. The mortality rate for this procedure is far from negligible, which combined with high volumes, makes it a suitable quality indicator. For coronary bypass we do not measure instead readmissions due to concerns of selection through mortality (i.e. a hospital may have a high readmission rate because it is successful in reducing mortality, which in turn increases the severity of the patients who survive; Laudicella et al., 2013).

4.2 Descriptive statistics

Tables 1a and 1b offer some descriptive statistics for each of the quality measures included in the analysis. 30-day mortality for AMI is lower in private hospitals compared to public providers (6.6% vs 9.4%). This is the case also for stroke, either ischaemic (10.7% vs 14%) or haemorragic (18% vs 24.6%), and, to a lower extent, for hip fracture (5.1% vs 5.8%). 30-day mortality for elective coronary bypass ranges between 1.2 and 1.3% for both types of providers. Emergency readmissions rates for elective hip and knee replacements are about 3.6-4% with no clear pattern. Waiting times appear to be shorter in private hospitals by about 20-30 days.

The number of private hospitals is comparable to the one for public hospitals. For emergency admissions, the number of private or public hospitals is between 79 and 93 hospitals. However, public hospitals treat at least two to three times as many patients than private hospitals. This is not the case for elective treatments. For hip and knee replacement, there are more public hospitals (63-64) than private ones (46) but private hospitals treat more patients than public ones. This may be the result of private providers specialising in a sub-set of high-volume elective procedures to exploit scale economies, and offering better amenities, while public hospitals have less scope to specialise and are under the obligation of offering a wider range of surgical procedures. For coronary bypass, there is the same number of public and private hospitals but more patients are treated by public providers, probably as a result of their larger size. The latter also suggests that whether public or private providers are preferred depends on the treatment and various institutional constraints and hospital configurations.

About 20-40% of patients across the sample (including the seven conditions) were treated in teaching hospitals. On average, each hospital competed with 30-40 hospitals in their 30 km catchment area of which around 30% were private.

The average distance from patient municipality of residence to the closest hospital (either public or private) varies between 4 and 11.7 km, depending on the procedure, except for coronary bypass for which it is higher for both public and private hospitals (respectively equal to 15 and 24.6 km) possibly due to higher degree of hospital concentration and specialization.

Our instrumental variable approach relies on the assumption that patient characteristics do not vary systematically with the distance to a private or public hospital. To investigate this issue, we have carried a set of balance tests, by splitting patients into two groups, according to two alternative definitions. First, we compare patient characteristics between patients for whom the closest hospital is private (so that the differential distance between the closest private and public hospital is negative) and those patients whose closest hospital is public (and the differential distance between closest private and public hospitals is positive). Second, we compare patient characteristics between patients whose differential distance is below the median and those whose differential distance is above the median.

The results are reported in Table 1c. The difference in the proportion of male patients between those who are closest to a public and a private hospital (or those whose differential distance is below or above the median) is always less than 0.5 percentage points (except for coronary bypass where it is still less than 1.5 pp, and around 4pp for hip and knee replacement only for the second distance measure). Similarly, the difference in age between the two groups is systematically below one year. The difference in the proportion of patients with Elixhauser comorbidities is less than

2pp for most conditions. This proportion is higher for coronary bypass patients who live relatively closer to private hospitals (by about 5-6 pp) but lower for patients with a hip fracture (by about 2-7pp). There is a positive difference for AMI and ischaemic stroke patients (by respectively 3 and 8pp) but only when comparing patients whose differential distance between closest private and public is below and above the median, but there is no difference for the same AMI and ischaemic stroke patients when comparing those who live closest to a private hospital relative to a public hospital. The number of interventions between the two groups is below 0.2 interventions in most cases, and 0.25 for two conditions, and at most 0.45 for hischaemic stroke with more procedures for those living closest to a private hospital but this differences drops to -0.04 when comparing those whose differential distance is below or above the median. Overall, these results suggest that there is no systematic relation between distance and observed patient characteristics.

5 Results

We first present our first stage regressions on the determinants of the probability of being treated by a private or public provider as a function of distance and other patient characteristics, and then present the second stage results on differences in quality between public and private providers.

5.1 First stage regression

The first stage regression results are reported in Table 2. They suggest that the distance to the closest private and public hospital are highly significant determinants of whether the patient is treated by a private versus a public provider. One additional kilometer from patient residence to the closest public hospital increases the probability of being treated by a private provider, at the sample mean, by 1.2-1.3 percentage points. Similarly, one additional kilometer from patient residence to the closest private hospital decreases the probability of being treated by a private provider, at the sample mean, by 1.5-2.8 percentage points. The effect of distance to the closest hospital is non-linear and decreasing with distance. The results are consistent with the literature on hospital patient choice, commonly operationalised with a conditional logit model, which suggests that distance to each provider is the arguably the most important driver of patient choice (see Gaynor et al., 2016; Gutacker et al., 2016; Moscelli et al., 2016, for evidence from the UK and references therein for other OECD countries).

For hip and knee replacement, we also find that more severe patients with a higher Elixhauser comorbidities index are less likely to be admitted to private hospitals. This is consistent with the idea that private hospitals tend to treat relatively less severe patients either because of dumping, cream-skimming, scale economies and specialisation in routine cases, or because they lack the facilities to treat more severe patients (see Berta et al., 2010, for a more detailed discussion).

The first stage regression results on the instruments appear relevant in that they have the first stage F statistics comfortably larger than the Stock and Yogo (2005) critical value of 16.38 for type-1 error of 5% and a maximum 10% bias with respect to OLS.

5.2 Second stage regression

Tables 3a-3b provides the results from OLS and 2SLS regressions on the effect of being treated by a private hospital on the probability of dying or being readmitted within 30 days, conditional on patient and hospital characteristics. The first line provides the OLS coefficient, and the second line the 2SLS one. We also report the coefficients associated to the covariates for the 2SLS regression.

Table 3a provides the results for 30-day mortality. In line with the descriptive statistics, OLS results suggest that private hospitals have lower mortality rate for some emergency conditions such as AMI (by 2.7 percentage points), ischemic stroke (3 pp), and haemorragic stroke (6.8 pp) and the coefficients are significant at 1 percent level. Private hospitals have also lower mortality for coronary bypass and hip fracture mortality but they are not significant at 5% level. However, once instrumented the difference in mortality between public and private hospitals is not significant anymore except for AMI mortality, where the difference remains significant at the 5% level with a similar magnitude (3.5 pp).

The results in Table 3a suggest that for emergency conditions, unobserved severity can affect the comparison between public and private providers but the direction in which it does depends on the condition. For hip fracture, haemorragic and ischemic stroke private providers have lighter casemix which remains unobserved, and that once accounted for eliminates the difference in quality across public and private providers. However, for AMI, the pattern goes in the opposite direction, with private providers having more severe unobserved patients, so that the gap in mortality between public and private providers widens once accounted for. For coronary bypass, which is an elective condition, unobserved dimensions of severity do not appear to matter, and quality remains similar across public and private providers when accounting for unobserved severity.

Table 3b provides the results for 30-day readmissions and waiting times for hip and knee replacement. As for 30-day readmission rates, OLS results suggest no statistically significant difference for hip and knee replacement. However, once private ownership is instrumented, the probability of readmission for hip replacement is higher and statistically significant in private hospitals by 3.6 percentage points. This is consistent with private providers having a lighter casemix along dimensions which remain unobserved and not captured by the risk-adjustment.

OLS results also suggest that waiting times for hip and knee replacement are shorter in private hospitals by about 25-35% but these differences are not statistically significant once we instrument for the choice of provider type. In turn, this suggests that there are unobserved dimensions affecting the ability to wait that relate to severity, health and socioeconomic status (e.g. education) which are correlated with both waiting times and the propensity to be treated at a private provider. For example, patients who are self employed may have a higher disutility from waiting (given they cannot work while waiting), be more severe and more likely to choose a private provider while employees may have a lower disutility from waiting (since better covered by social security) and more likely to opt for public hospitals.

The coefficients attached to the covariates, across all models, generally show the expected sign. Gender seems not to play a role for most of mortalities except for hip fracture where mortality and readmission rates are higher for male patients. Waiting time for knee replacement is also lower for male patients. Mortality tends to increase with age but this is not the case for readmissions and waiting times in most cases. The degree of hospital competition, as measured by the number of hospitals within a 30km radius, as well as the percentage of private providers in the same catchment area are generally insignificant. This result is in line with Berta et al. (2016), who find no significant effect of indices of competition on hospital quality.

5.3 Robustness checks

As a robustness check, we also re-estimated all models for mortality and readmission outcomes adopting a logistic regression, as well as instrumenting the dummy variable for private ownership with an IV logit approach. The results are reported in the Appendix, Table A1.

To allow for testing of multiple hypotheses, and the risk of false positives that arises from it, we can correct the critical significance level values. One option is to use the very conservative Bonferroni correction, which divides the critical value by the number of hypotheses. With a critical value of 5% and nine outcomes, the Bonferroni critical value is 0.56% (less than 1% significance level). The OLS results are not affected by this correction. This is because the coefficient on private hospitals is either not significant (for bypass and hip fracture mortality, and hip and knee readmissions) or significant at less than 0.1% level (AMI and stroke mortality, waiting times). In the IV regressions, the coefficient is already statistically insignificant for all but two indicators, while it is significant only at 5% level for AMI mortality and hip replacement readmission. Unsurprisingly, a more conservative critical value would make also these two coefficients insignificant.

6 Conclusions

We have investigated whether public and private providers differ in quality in a large Italian region where public and private providers compete for publicly-funded patients under a common fixed price DRG payment system. Using a large sample in 2012-14, we find, with few exceptions, that public and private providers generally do not differ in elective and emergency quality, neither in waiting times. The only exceptions are AMI for which mortality risk is lower in private providers, and hip replacement for which readmission risk is higher in private providers.

A key methodological concern is that, driven by their profit motive, private providers may have a stronger financial incentive to avoid costly patients, which could lead to biased quality measures in favour of the private providers. To control for different case-mix we have included a range of control variables, and to control for unobserved differences in casemix we have pursued an instrumental variable approach based on the distance between patient's residence and the closest public and private provider.

We indeed find that the distance to the closest private and public hospital are highly statistically significant determinants of whether the patient is treated by a private versus a public provider. One additional kilometer from patient residence to the closest public (private) hospital increases (reduces) the probability of being treated by a private provider by 1.2-1.3 (1.5-2.8) percentage points.

By comparing the OLS with the IV results, we have shown that unobserved factors are important. OLS results suggest that mortality rates are significantly lower (both statistically and economically) for *emergency* conditions in private hospitals, but this is not the case under our instrumental-variable approach except for AMI. This is also the case for our indicators of patient responsiveness: OLS suggests that waiting times are lower for private hospitals, while they are insignificant under the instrumental variable approach.

Overall, our results suggests that when public and private hospitals are subject to the same payment system, the evidence on whether private hospitals provide higher quality than public hospitals is mixed. Although several outcomes do not differ, AMI mortality risk is lower in private providers, and readmission risk for hip replacement is higher in private providers.

The result has policy implications for European countries who are moving towards expanding the role of private providers to treat publicly-funded patients and for which there is a lack of empirical evidence (in particular in relation to emergency conditions since private providers are only contracted elective treatments). Given that public and private providers are paid the same tariff for a given treatment, the cost to the purchaser of healthcare is the same and, as our analysis suggests, the (clinical and non-clinical) quality provided is also the same. Whether involvement of private provision should be expanded could then depend on capacity arguments but not on quality considerations. For example, if a purchaser of health services needs to expand capacity quickly to address higher needs, private providers may be able in the short run to absorb such additional demand. Our results also show that the proportion of private providers in a market does not affect the quality of public (or private) providers, which in turn suggests that competition by private providers in the health system does not impact on the ability to provide quality by public providers.

Finally, the analysis suggests that casemix adjustment based on observable covariates is not sufficient to make quality indicators comparable across public and private hospitals, but it is possible to correct for this through an instrumental variable approach based on distances between patients' address of residence and the closest hospitals, which is easily available to policymakers.

Our analysis is limited to the comparison of the average mortality and readmission rates across public and private hospitals. There may be significant heterogeneity both within public hospitals and within private hospitals. Future research could further investigate the distribution of health outcomes across the two sectors.

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Table 1a. Descriptive statistics by quality measure and hospital ownership

Variable	AMI		Bypass		Ischaemic stroke		Haemorragic stroke	
	Private	Public	Private	Public	Private	Public	Private	Public
N. patients	18031	41377	3314	4154	11375	27887	5532	13716
N. hospitals	91	81	10	10	85	92	83	93
30-day mortality	0.066	0.094	0.012	0.013	0.107	0.140	0.180	0.246
Teaching hospital	0.247	0.207	0.427	0.477	0.322	0.215	0.190	0.309
Male	0.640	0.638	0.815	0.812	0.496	0.486	0.535	0.522
Age group 40-60	0.212	0.216	0.202	0.220	0.108	0.104	0.145	0.161
Age group 60-70	0.211	0.214	0.342	0.338	0.161	0.160	0.169	0.163
Age group 70-80	0.283	0.276	0.382	0.364	0.318	0.317	0.309	0.311
Age over 80	0.281	0.282	0.069	0.072	0.400	0.403	0.345	0.331
Elixhauser comorb.	0.4228	0.4824	0.3742	0.3953	0.6174	0.5704	0.4219	0.4348
std err	(0.7153)	(0.7395)	(0.7138)	(0.7411)	(0.7787)	(0.7755)	(0.6668)	(0.6968)
N. of procedures	4.4430	4.1651	4.00780	3.7932	3.5189	3.2287	3.3838	2.9258
std err	(1.5177)	(1.8041)	(1.4015)	(1.4883)	1.8640	(1.8881)	(1.8370)	(1.8802)
Distance to nearest hosp. (km)	10.315	4.767	24.628	15.043	9.156	4.469	9.502	4.310
N. hosp. in catch.	43.544	34.743	8.879	7.388	44.838	37.061	45.869	37.941
% priv. hospitals in catch.	0.309	0.278	0.433	0.302	0.333	0.293	0.322	0.287

Notes: Standard deviations are provided in round brackets.

Table 1b. Descriptive statistics by quality measure and hospital ownership

Variable	Hip fracture		Hip replacement		Knee replacement	
	Private	Public	Private	Public	Private	Public
N. patients	12760	31928	15327	10379	17125	8089
N. hospitals	79	84	46	64	46	63
30-day mortality	0.051	0.058	-	-	-	-
Readmission	-	-	0.040	0.038	0.036	0.037
Teaching hospital	0.182	0.293	0.258	0.293	0.211	0.297
Male	0.248	0.252	0.442	0.462	0.317	0.325
Age group 40-60	0.044	0.046	0.194	0.174	0.124	0.106
Age group 60-70	0.074	0.075	0.301	0.279	0.331	0.323
Age group 70-80	0.247	0.257	0.381	0.409	0.451	0.483
Age over 80	0.626	0.613	0.106	0.117	0.088	0.083
Elixhauser comorb.	0.2905	0.2985	0.023	0.116	0.030	0.135
std err	(0.6249)	(0.6263)	(0.177)	(0.386)	(0.204)	(0.421)
N. of procedures	3.1260	2.5913	2.284	2.406	1.811	2.063
std err	(1.8144)	(1.5737)	(1.250)	(1.382)	(1.367)	(1.493)
Distance to nearest hosp. (km)	8.405	4.021	11.716	5.536	11.285	5.518
N. hosp. in catch.	45.407	38.881	25.902	23.293	25.484	23.453
% priv. hospitals in catch.	0.347	0.313	0.305	0.298	0.311	0.303
Waiting times			81.960	103.334	81.308	111.072
std err			(67.054)	(76.539)	(67.783)	(76.512)

Notes: Standard deviations are provided in round brackets.

Table 1c. Balance test

	AMI			Bypass		
	(a): Diff. dist.<0	(b): Diff. dist.>0	(a) - (b)	(a): Diff. dist.<0	(b): Diff. dist.>0	(a) - (b)
Male	0.637	0.639	-0.002	0.822	0.807	0.015
Age	70.922	71.185	-0.263	67.735	67.908	-0.173
Elix. comorb.	0.46	0.466	-0.006	0.423	0.36	0.063
N. of interv.	4.438	4.189	0.249	3.819	3.938	-0.119
	(a): Low diff. dist.	(b): High diff. dist.	(a) - (b)	(a): Low diff. dist.	(b): High diff. dist.	(a) - (b)
Male	0.635	0.642	-0.007	0.82	0.808	0.012
Age	71.345	70.911	0.434	67.768	67.89	-0.122
Elix. comorb.	0.48	0.449	0.031	0.413	0.364	0.049
N. of interv.	4.31	4.193	0.117	3.827	3.938	-0.111
	Hischaemic stroke			Haemorragic stroke		
	(a): Diff. dist.<0	(b): Diff. dist.>0	(a) - (b)	(a): Diff. dist.<0	(b): Diff. dist.>0	(a) - (b)
Male	0.491	0.488	0.003	0.524	0.526	-0.002
Age	75.088	75.712	-0.624	71.805	72.576	-0.771
Elix. comorb.	0.583	0.584	-0.001	0.419	0.435	-0.016
N. of interv.	3.657	3.204	0.453	3.255	3	0.255
	(a): Low diff. dist.	(b): High diff. dist.	(a) - (b)	(a): Low diff. dist.	(b): High diff. dist.	(a) - (b)
Male	0.484	0.495	-0.011	0.521	0.53	-0.009
Age	75.92	75.179	0.741	72.826	71.969	0.857
Elix. comorb.	0.624	0.541	0.083	0.437	0.425	0.012
N. of interv.	3.292	3.335	-0.043	3.118	2.995	0.123

Notes: (*): Differential distance is defined as the difference between the closest private hospital and the closest public hospital for each patient. Diffential distance is defined as low when it is below the median differential distance, and is high when it is above the median.

Table 1c (continued). Balance test

	Hip fracture			Hip replacement			Knee replacement		
	(a): Diff. dist.<0	(b): Diff. dist.>0	(a) - (b)	(a): Diff. dist.<0	(b): Diff. dist.>0	(a) - (b)	(a): Diff. dist.<0	(b): Diff. dist.>0	(a) - (b)
Male	0.247	0.251	-0.004	0.452	0.45	0.002	0.319	0.32	-0.001
Age	80.487	80.948	-0.461	68.254	68.645	-0.391	70.126	70.268	-0.142
Elix. comorb.	0.279	0.301	-0.022	0.053	0.063	-0.01	0.055	0.067	-0.012
N. of interv.	2.791	2.731	0.06	2.383	2.319	0.064	1.976	1.867	0.109
	(a): Low diff. dist.	(b): High diff. dist.	(a) - (b)	(a): Low diff. dist.	(b): High diff. dist.	(a) - (b)	(a): Low diff. dist.	(b): High diff. dist.	(a) - (b)
Male	0.253	0.248	0.005	0.43	0.466	-0.036	0.295	0.341	-0.046
Age	81.084	80.555	0.529	68.624	68.499	0.125	70.634	69.884	0.75
Elix. comorb.	0.267	0.333	-0.066	0.055	0.066	-0.011	0.054	0.073	-0.019
N. of interv.	2.779	2.7	0.079	2.44	2.245	0.195	1.909	1.877	0.032

Table 2. First-stage regression. Probability of choosing a private hospital (OLS)

Dependent variable: patient is treated in a private hospital							
Sample used:	AMI	Bypass	Isc. stroke	Hem. stroke	Hip fracture	Hip repl.	Knee repl.
Dist. nearest public	0.0174	0.0172	0.0201	0.0142	0.0233	0.0183	0.0123
	[0.0001]	[0.0001]	[0.0011]	[0.0106]	[0.0005]	[0.0001]	[0.0008]
Dist. nearest public^2	-0.0001	-0.0001	-0.0004	-0.0003	-0.0006	-0.0004	-0.0001
	[0.2007]	[0.0270]	[0.1987]	[0.2893]	[0.0716]	[0.0220]	[0.3819]
Dist. nearest private	-0.0218	-0.0173	-0.0249	-0.0187	-0.0279	-0.0153	-0.0172
	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]
Dist. nearest private^2	0.0002	0.0001	0.0002	0.0001	0.0003	0.0001	0.0002
	[0.0001]	[0.0207]	[0.0001]	[0.0001]	[0.0001]	[0.0008]	[0.0001]
Male	-0.0018	-0.0084	0.0044	0.0155	-0.0056	-0.0197	-0.0082
	[0.7232]	[0.5096]	[0.3420]	[0.0286]	[0.3721]	[0.0017]	[0.1820]
Age group 40-60	-0.0229	0.0424	0.0434	-0.0106	0.0137	0.0564	0.0476
	[0.1647]	[0.4947]	[0.0312]	[0.7330]	[0.6105]	[0.0318]	[0.4698]
Age group 60-70	-0.0116	0.0700	0.0382	0.0212	0.0168	0.0494	0.0157
	[0.4890]	[0.2689]	[0.0761]	[0.5162]	[0.5649]	[0.1060]	[0.8189]
Age group 70-80	0.0026	0.0778	0.0411	0.0154	0.0087	0.0221	-0.0014
	[0.8807]	[0.2067]	[0.0761]	[0.6699]	[0.7626]	[0.5248]	[0.9842]
Age over 80	0.0087	0.0650	0.0429	0.0298	0.0173	0.0143	0.0192
	[0.6417]	[0.2886]	[0.1207]	[0.4431]	[0.5516]	[0.7035]	[0.7903]
Elixhauser comorb.	-0.0141	-0.0324	-0.0020	-0.0209	-0.0222	-0.2483	-0.2179
	[0.3639]	[0.2865]	[0.8957]	[0.1080]	[0.2084]	[0.0001]	[0.0001]
N. of interv.	0.0225	0.0405	0.0076	0.0276	0.0475	-0.0021	-0.0096
	[0.0022]	[0.0728]	[0.5044]	[0.0022]	[0.0001]	[0.9032]	[0.5809]
n. hospitals	0.0003	-0.0018	0.0005	-0.0012	0.0000	0.0003	0.0008
	[0.8104]	[0.0236]	[0.6525]	[0.2177]	[0.9912]	[0.8161]	[0.4956]
F-test$^+$	784.1	468.4	166.3	895.5	179.2	176.4	186.9
	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]

Notes: includes province fixed effects; p-values are provided in square brackets.

($^+$): Stock and Yogo (2005) F statistic.

Table 3a. Estimation results for 30-day mortality.

Quality measure:	30-day mortality				
	AMI	Bypass	Isc. stroke	Hem. stroke	Hip fracture
	(A) OLS estimation				
Private	-0.0277	-0.0047	-0.0299	-0.0677	-0.0072
	[0.0001]	[0.2959]	[0.0001]	[0.0001]	[0.0502]
	(B): IV estimation				
Private	-0.035	-0.006	-0.010	0.058	0.004
	[0.012]	[0.651]	[0.566]	[0.170]	[0.710]
	Other covariates (IV estimation)				
Teaching	0.014	-0.001	-0.007	0.002	-0.006
	[0.016]	[0.835]	[0.361]	[0.848]	[0.078]
Male	-0.005	-0.004	-0.001	-0.006	0.054
	[0.061]	[0.265]	[0.851]	[0.253]	[0.000]
Age group 40-60	0.003	0.003	0.024	0.047	0.017
	[0.602]	[0.342]	[0.000]	[0.000]	[0.000]
Age group 60-70	0.021	0.006	0.044	0.085	0.036
	[0.000]	[0.110]	[0.000]	[0.000]	[0.000]
Age group 70-80	0.055	0.016	0.084	0.142	0.050
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Age over 80	0.154	0.034	0.200	0.243	0.095
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Elixhauser comorb.	-0.004	0.005	-0.004	-0.005	0.031
	[0.122]	[0.200]	[0.138]	[0.369]	[0.000]
N. of procedures	-0.009	0.009	-0.009	-0.004	-0.003
	[0.000]	[0.000]	[0.000]	[0.252]	[0.004]
% private hosp. in the catchment	0.014	-0.021	-0.018	0.035	-0.027
	[0.508]	[0.022]	[0.609]	[0.565]	[0.169]
n. hospitals in the catchment	0.001	0.001	0.001	0.001	0.001
	[0.338]	[0.265]	[0.057]	[0.831]	[0.070]
N	59,407	7,468	39,262	19,248	44,688

Notes: includes province fixed effects; p-values are provided in square brackets.

Table 3b. Estimation results for 30-day readmission and (log of) waiting times.

Quality measure:	30-day readmission		Waiting times	
	Hip repl.	Knee repl.	Hip repl.	Knee repl.
	(A) OLS estimation			
Private	0.0024	-0.0006	-0.2488	-0.3530
	[0.4015]	[0.8252]	[0.0001]	[0.0000]
	(B): IV estimation			
Private	0.036	-0.009	0.256	0.216
	[0.032]	[0.585]	[0.118]	[0.168]
	Other covariates (IV estimation)			
Teaching	-0.003	-0.002	0.279	0.286
	[0.450]	[0.658]	[0.001]	[0.001]
Male	0.001	0.007	-0.010	-0.031
	[0.797]	[0.009]	[0.385]	[0.009]
Age group 40-60	-0.002	-0.010	0.065	0.212
	[0.854]	[0.649]	[0.150]	[0.045]
Age group 60-70	-0.004	-0.025	0.022	0.321
	[0.624]	[0.273]	[0.651]	[0.003]
Age group 70-80	0.005	-0.028	-0.012	0.333
	[0.572]	[0.221]	[0.805]	[0.002]
Age over 80	0.003	-0.026	-0.145	0.250
	[0.715]	[0.251]	[0.004]	[0.019]
Elixhauser comorb.	0.008	0.003	0.052	0.020
	[0.184]	[0.679]	[0.414]	[0.692]
N. of procedures	0.005	0.002	-0.072	-0.016
	[0.000]	[0.119]	[0.000]	[0.434]
% private hosp. in the catchment	-0.018	-0.017	0.122	0.183
	[0.300]	[0.300]	[0.352]	[0.201]
n. hospitals in the catchment	0.001	0.001	-0.003	-0.002
	[0.162]	[0.755]	[0.068]	[0.218]
N	25,706	25,214	25,706	25,214

Notes: p-values are provided in square brackets. Waiting times are in log.

7 APPENDIX

Table A1: Estimation results for mortality and readmissions. Logit.

Quality measure:	30-day mortality					30-day readmission	
	AMI	Bypass	Isc. stroke	Hem. stroke	Hip fracture	Hip repl.	Knee repl.
	Logit estimation						
Private	-0.3912	-0.5021	-0.2903	-0.4179	-0.1460	0.0620	-0.0207
	[0.0000]	[0.2420]	[0.0001]	[0.0001]	[0.0502]	[0.4220]	[0.8014]
	IV estimation (Logit + Logit)						
Private	-0.417	-0.958	-0.056	-0.308	0.107	0.966	-0.403
	[0.0343]	[0.3522]	[0.7183]	[0.2233]	[0.5906]	[0.0326]	[0.3828]

Notes: p-values are provided in square brackets.

ICD-9-CM codes by quality indicator

1) AMI: diagnosis codes 410.xx;

2) Coronary bypass: procedure codes 36.10-36.19, excluding procedure codes 33.5, 33.6, 35, 36.9, 37.10, 37.11, 37.31, 37.32, 37.33, 37.4, 37.5, 38.04, 38.05, 38.14, 38.15, 38.34, 38.35, 38.45, 38.65, 38.85, 39.21, 39.22, 39.23, 39.54 in any procedure field;

3) Ischaemic stroke: diagnosis codes 433.x1, 434.x1, 436, excluding codes 430, 431, 432.X in any diagnosis field;

4) Haemorragic stroke: diagnosis code 430, excluding codes 439 - 455 in any diagnosis field;

5) Hip fracture: diagnosis codes 820.0-820.9;

6) Hip replacement: intervention code 81.51, excluding codes 800 - 959.9 in any diagnosis field;

7) Knee replacement: intervention code 81.54, excluding codes 800 - 959.9 in any diagnosis field.