Ownership, System of reimbursement and Mortality rate relationships[#]

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Abstract

The issue is the real e;ect of the hospital type on the mortality rate. The statistical results on the mortality rate by hospital type (ownership and system of reimbursement) can lead to tremendous misinterpretations. According to statistical results we could conclude that the incentive created by fee-for-service reimbursement allows on 4 point save on the mortality rate. In fact, this ranking on hospital quality is completely dependant of characteristics and illness severity of patients. The computation on mortality rate by age structure crossed with sex totally changes the ranking. To take into account this di>culty, we use a innovative duration model applied to panel data. We consider a duration model with two kinds of unobserved heterogeneity, patient unobserved heterogeneity and hospital unobserved heterogeneity. No assumption of distribution is done on the latter component. By taking into account the observable and unobservable patient heterogeneity, we control the fact that patients admitted in the private sector can be di;erent in term of disease gravity than patients admitted in the public one. We find that the hospital type e;ect on the instantaneous death probability depends more on the capacity to perform innovative procedure than on the system of reimbursement and/or the ownership. However, hospitals of the private sector both provide more innovative procedures and are more numerous to adopt innovation. Thereby, hospitals of the private sector provide a better quality of care, measured by the probability of dying. Nevertheless, heterogeneity within the type of hospital is bigger in the for-profit hospitals in comparison with the other types of hospital. It suggests that by choosing for-profit hospital, the patient of reference have in average, a lower of instantaneous probability of dying but are less sure about the quality of the hospital.

Key Words: Hospitals, Mortality, Duration Model

1 Introduction

This paper evaluates the e;ect of the di;erence in hospital reimbursement and ownership on the in-patient mortality. This question is tackled according to two aspects in the litterature: first, ownership and hospital performance and second, the way to determine a measure of the quality of care.

There is an ongoing debate about the e;ect of ownership on hospital performance. The idea is that a profit incentive may improve e>ciency and, perhaps, observable quality

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(Hansman, 1996). Theory predicts that the for-profit organizational form is efficient because of the high-powered incentives. In early work, Arrow (1963) observed that non-profit organizations might be a socially optimal response to incomplete markets. Other theorical work has shown that the non-profit form may be socially inferior or equivalent to the for-profit form, even if markets are incomplete (Newhouse, 1970 and, Pauly and Redish, 1973).

Many empirical studies have been carried out on the effects of hospital ownership on performance (Cutler and al., 1998; Goworisakaran and Town, 1999; McClellan and Staiger, 2000; Silverman and Skinner, 2001 and, Sloan and alii, 1999). Most of these conclude that hospital ownership has little or no effect on indicators of performance. Picone and alii (2002) analyse the effects of changes in hospital ownership from government or private non-profit status to for-profit status and vice versa. They conclude that no decline in quality is observed after hospitals switch from for-profit to government or private non-profit status. However, after conversion to for-profit status, the in-patient mortality increases while hospital profitability rises markedly and the staff decreases. Kessler and McClellan (2002) find that an area with a presence of for-profit hospitals have lower level (around 2.4%) of hospital expenditures but virtually the same patient health outcomes.

The incentive to maximise profit can be correlated with the hospital ownership. For-profit hospitals have a strong incentive to maximize profit. Setting output, quality, inputs and patient mix, at levels that achieve this objective, does this. It is why they compete with other hospitals for some patients. The literature on the effect of hospital competition is thinner. Kessler and McClellan (2000) find that increases in competition increase patient mortality from 1986 to 1989 but decreased patient mortality from 1991 to 1994. Goworisakaran and Town (2002) examine the effects on hospital quality of competition for patients with different types of insurance. Outcomes variables for hospital quality is the risk-adjusted hospital mortality rates on patients with Acute Myocardial Infarction or Pneumonia. Their findings imply different relationships between competition and hospital quality: an increase in the degree of competition decreases the risk-adjusted hospital mortality rate for HMO patients but, conversely increases mortality for Medicare patients. Shortell and Hughes (1998), Ho and Hamilton (2000) find no significant effect of hospital competition on quality. Finally, Propper, Burgess and Green (2002) find that increased competition between hospitals treating heart attack in Britain reduced mortality rates.

In France, hospital care can be provided by the public or the private sector. Patients have access to all hospitals working in or belonging to the public sector but private sector hospitals can select patients. In addition, the public sector is under a global budget system. Hospitals of the private sector are paid by fee-for-service. Therefore, these differences suggest that hospitals have different incentives to provide care to patients. Besides, there are four kinds of hospital ownerships : university hospitals, local hospitals, not-for-profit hospitals and for-profit hospitals.

The goal of this paper is to evaluate the effect of ownership and system of reimbursement on the hospital quality. Most of existing literature measure hospital quality through the mortality rate accounting for sorting of patients. In 1986, the US Health Care Financing Administration identified hospitals in which the actual death rate differed from the predicted rate, on the basis of diagnosis and demographic data. The mortality rate was obtained after adjustments for the severity of illness and this work was carried out on three pathologies: cerebrovascular accident, pneumonia and myocardial infarction (Dubois and alii, 1987). Many studies also use the mortality rate adjusted by the severity of illness to judge the quality of the hospital (Geweke and alii (2001), Hartz and alii (1989) and Allison

(2000)). One key limitation is that these studies do not take into account the possible correlation between mortality rate and length of stay (Hamilton and Hamilton, 1987). To address this limitation, we use a duration model with multiple destinations.

Other potential measures of the quality of care than mortality rate, can be used to assess hospital quality. One of them is the level of hospital investment. In this study, we assess not only the ownership, the system of reimbursement and the mortality relationship but also the level of hospital investment on the mortality during the admission. In the private sector, these investments depend, at least in part, on the return hospitals receive. In the public sector, the investment depends on the decision of the public regulator. In practice, the investment in innovative procedures is decided in priority, for government hospital. For this work, we use the rate of innovative procedure by hospital.

We used a panel data. The dataset contains all French hospitals of the private and public sectors. The level of observation is the patient, who is admitted in the hospital from her/his residence. Her/his discharge can be death or return to home. The pathology used in this study is Acute Myocardial Infarction (i.e. heart attack). By ownership, the mortality rate is almost 15% for local public hospitals and less than 7% for for-profit hospitals. We could conclude that the incentive created by ownership allows an 8 point save on the mortality rate, which seems huge! Our bottom line is that statistical results on the mortality rate by ownership or system of reimbursement can lead to tremendous misinterpretations. Indeed, this ranking on hospital quality is completely dependant on the selection of patients. When we focus on the mortality rate by age structure crossed with sex, the ranking is totally changed. Local public hospitals, that have the highest mortality rate on the whole sample, have one of the lowest rate for male patients aged of less than 80. It clearly shows the jeopardy to judge on the statistical mortality rate by hospital.

We have to resolve the issue of patient characteristic structure in order to have a measure of hospital ine>ciency. For this purpose, we used a duration model that accounts for observed and unobserved patient characteristics, and unobserved hospital e>ciency. In a first step, the estimation includes hospital specific dummy variables in the specification in order to control for fixed di;erences in hospital quality. In a second step, we use the coe>cient of hospital specification dummy variable to estimate a specification of hospital type-outcome relationship. Hospital types are established according to the system of reimbursement and ownership. Hence the estimated probabilities of mortality depend on the system of reimbursement and the ownership. Moreover, by a variance analysis in the second step, we identify the variance of quality ine>ciency between hospitals for di;erent systems of reimbursement and ownerships. This is a relatively novel approach to the problem.

The first feature of the empirical framework is that over 50% of the in-death rate variance is explained by the composition of patient by sex and age. Besides, we assess the e;ect of the system of reimbursement and the ownership on the probability of in-death. Under a private ownership, system of reimbursement by fee-for-service is associated with a lower conditional probability of in-death. For hospitals paid by global budget, the hospital ownership does not a;ect the conditional probability of in-death. To judge the e;ect of investment is really di>cult because of the high correlation between hospital ownership and innovative procedure rate. Moreover, a variance analysis shows that ine>ciency heterogeneity between for-profit hospitals is very stronger than in the other hospital ownerships. These results suggest that being admitted into a for-profit hospital has two consequences:- a lower risk of death, - a bigger uncertainty about the level of quality of the hospital.

In section 2, we describe our data and variables. Section 3 provides the first statistical results. In section 4 we discuss our empirical specification. Section 5 presents our results. Section 6 concludes.

1.1 Data and preliminary evidence

The primary source of data for this study is the French national database from the PMSI (Programme de Médicalisation des Systèmes d'Informations). These data provide records for all patients discharged from any French acute-care hospital during the year 1997. That year is the first one to include both the public and private sectors (80% of exhaustivity for the latter). In the dataset, the patient is admitted in the hospital from her/his residence1 and her/his discharge can be death or return to home.

We limit our study to a single disease because there is evidence that the relation between mortality and covariates is disease specific (See Wray and alii, 1997). We choose acute myocardial infarction (heart attack) in particular for two reasons. First of all, this is an ischemic desease, first cause of mortality in France. Second, in-hospital death is a relatively frequent outcome for heart attack, which makes it an interesting disease to examine using hospital discharge records. Moreover, mortality from AMI has been widely used to assess the quality of care of hospitals in the US health market and was published as a measure of quality for UK hospitals for the first time in 1999 (Propper and alii, 2002).

The dataset is really suited to our purpose because it has a large base of patients (45,072 individual stays) and contains multiple hospitals in every size and ownership class (422 public and private hospitals for heart attack).

1.2 A process of patients elimination

The sample was selected through a process of eliminating patients. The first qualification for selection is that the ICD-10-CM disease codes specified in the discharge data is a code for hearth attack disease. There is substantial nonrandom variation across hospitals in the sequence of ICD-10 diagnosis kept. Furthermore, we use the French DRGs code to complete this selection. We keep only patients that are coded by a heart attack French DRG code. There are six codes: 3 surgical French DRGs (154, 155, 157) and 3 medical ones (178: complicated heart attack, 179: uncomplicated heart attack and 180: heart attack with death).

The second one is that the patient is over 35 at the time of admission and less than 100 years.

The third qualification for inclusion in the sample is that the patient should be admitted to a hospital with at least 30 admissions for heart attack in our dataset. This qualification is imposed for the validity of the econometric results. In principle, this qualification introduces a problem of biased sampling, but because only few patients were thereby eliminated we believe that this is a negligible di>culty.

The fourth qualification is that the length of stay of each patient must be in the interval: from one day to thirty days. Less than one day is considered as immediate transfer and more than thirty days, as a patient not anymore in hospital for heart attack care.

1.3 Variable construction

We have three kinds of variables: demographic variables, indicators of disease severity and information about hospitals[1].

The demographic variables are constructed from the discharge records. There are five age indicators (35-49, 50-59, 60-69, 70-79, 80 and older) crossed with an indicator for

[1] In this dataset, we do not have inpatients admitted in emergency.

female. As a proxy for the distance between the domicile and the in-hospital, we use the district code. The indicator of mortality (called ¥¦¤¦´) is set to 1 if the patient died in the hospital[2].

Indicators of disease severity are constructed from the information on diagnosis codes contained in the discharge records. We constructed nine diagnosis codes corresponding to: hypertension (i h d), rheumatism ischemic cardiopathy (c r), ischemic valvulopathy non rheumatism (v c), arrhythmia (t c), hypertension (m v), heart failure (i c), other heart disease (c°¦¶³), cerebro-vascular disease (c e r), peripheral arterial disease (a r), circulatory system problem (c i r), other diagnosis (oµ©¦³)[3]. Moreover, we have the procedures realized during the admission (catheterisation use, angioplasty, stent, surgery bypass). Concerning the French DRGs, we are not sure about the coding assigned to each patient. So, the only information on the kind of treatment (medical or chirurgical) will be used through the creation of an indicator for chirurgical French DRGs, called ¤©ª³¶³¨ª¤¢-.

There are four kinds of hospital ownership: university hospitals[4], local hospitals, not-for-profit hospitals and for-profit hospitals. Not-for-profit hospitals are private but work for the public sector. Moreover, they are regulated like a public one. In France, they are named PSPH (hôpitaux Participant au Service Public Hospitalier)[5].

There exist two types of reimbursement system. The university hospitals, the local hospitals and the not-for-profit hospitals are paid by global budget. There cannot have any profit. These hospitals are said belonging to the public sector. The for-profit hospitals are regulated by fee-for-service. These hospitals have no constraint on their profit. Graph 1 gives the percentage of patients for each type of hospital. First of all, we see that for this pathology, the majority of patients are admitted in the public sector. Secondly, almost 50% of patients are admitted in local public hospitals. Graph 2 shows the number of patient by hospital ownership, indicator of the acute care unit size. In the sample with all hospitals, we note that hospitals of the private sector have a smaller unit size than the public ones.

The heart attack is a strong ground of competition between the public and the private sector. Innovative procedures were and still are widely developed in the private sector. The public sector followed rapidly in spite of a non-incentive system of regulation. Indeed, the financial incentives are quite di;erent in these two sectors. Public sector hospital are financed by a global budget and their doctors are salaried. A deterrent to public sector use of innovative procedures is the financing of supplies from a global budget, which makes it di>cult for them to purchase expensive devices. The global budget system does not take costly procedures such as catheterization or angioplasty into account and therefore penalises the innovative hospitals which use them. On the opposite, most private hospitals are financed on the basis of a fee-for-service system. Supplies such as stents are reimbursed ex-post in addition to the fee-for-service payment. Moreover, physicians receive additional fees for performing these procedures.

Graph 1 gives the percentage of patients for each type of hospital. First of all, we see that for this pathology, the majority of patients are admitted in the public sector and, almost 50% of patients are admitted in local public hospitals. Graph 2 shows the number of patients by hospital ownership, indicator of the acute care unit size. In the sample with

[2] p³°¹ is an indicator for the equality between the two district codes (the district of domicile and the one of hospital of admission). When we estimated the di;erent models, this variable was never significant. So, we decided to present the results without this variable.

[3] After estimations of di;erent models, only a part of these variables was kept for estimations presented here.

[4] University hospitals are called "main regional hospitals" in this study.

[5] Within the local hospitals of the sample, the number of inpatient during the year (indicator of the acute care unit size) is strongly similar.

all hospitals, we note that hospitals of the private sector have a smaller unit size than the public ones.

1.4 Initial evidence

The more innovative a procedure is, the less it will be performed in a local hospital (graph 7). The incentive to perform innovative procedures is quite di;erent in the public and private sector, as said above. If the private sector is reimbursed ex-post for the supplies such as stents or angioplasties in addition of the fee-for-service, hospitals under global budget system do not receive any additional budget for performing these procedures.

Nevertheless, innovation (catheterisation use, angioplasty, stent) spreads in the public and private sectors even if the pace is di;erent (graph 7). Hence, physicians seem not to be strongly influenced by these rather di;erent incentives.

Moreover, the for-profit and university hospitals seem to perform coronary artery bypass graft surgery (CABG) in the same proportion. Therefore, in the public sector as well as the private one, some hospitals have the equipment to perform complex, expensive and/or innovative procedures.

Local public hospitals have the lowest rate of innovative procedure. However, investment in innovative/complex procedure is one determinant of quality. So, this lower rate of innovative procedure could have an e;ect on the level of quality.

We see that in average, female patients are older then males (graph 5 and graph 6). We distinguish now the distribution of inpatients by age and gender. The proportion of younger (until 70 years) and male inpatient is much more important in the for-profit and university hospitals. We observe a peak on the graph of distribution for the 60-70 years-male patient group.

One could have the intuition that the incentives to code diagnoses were bigger gor certain categories of hospital than for others. Yet, it does not seem to be the case (graph 8). We observe neither an absence of secondary coronary diagnosis of patients for a specific hospital ownership, nor a higher rate of every secondary coronary diagnosis for a specific hospital category. Therefore, secondary diagnoses are not a bad indicator of the illness severity because whatever the hospital ownership, hospitals appear to have the same behaviour of coding.

Besides, we observed some di;erences in the proportion of patients with a specific coronary diagnosis depending on hospital ownerships.

These results suggest a selection of patients linked to the type of hospital. In introduction, we explained that because of the system of reimbursement, private sector could select patients but not the public one. We expect that the rule of admission is the same within the private sector. Hence, the distribution of inpatients by age and gender or, by secondary diagnosis should be the same. De facto, statistical results show a strong heterogeneity within the private sector. However, we observe that the distribution of inpatients by age and gender between the for-profit and university hospital, is comparable. Moreover, both of them are composed of hospitals that can perform intensive and innovative procedures. If we control by level of ability to perform innovative procedures, we do not observe any di;erences in the composition of patient[6]. Therefore, it seems that the system of reimbursement do not have an e;ect on the selection of patients. The selection is based on the ability to performed intensive and innovative procedure.

[6] Milcent (2000) obtained the same result on the public sector.

Controlling by the ability to perform incentive and innovative procedure, the distribution of DRG assignment by hospital type is quite similar. These results tend to show that for-profit hospitals do not upcode DRGs[7].

1.5 Mortality and length of stay

The general average length of stay is around 9 days for local public hospitals. It is about two days longer for the not-for-profit hospitals and 1 day shorter for the for-profit ones (graph 12). A very interesting feature is that when the patient died during her/his stay, the average length of stay (with death) is between 5 and 6 days whatever the type of hospital. For not-for-profit and for-profit hospitals, the average length of stay with discharge "return to home" is similar and more important than for the two other hospital ownerships.

For-profit hospitals have the lowest mortality rate (around 6.4%) whereas local public hospitals have the highest one: almost 15%! However, we have to be very careful with these results and not to conclude too quickly. The inpatient distribution is quite di;erent for these two groups. By taking into account the age group crossed with the gender, the results on mortality rate are strongly di;erent. Except for oldest patients (aged over 80), for-profit hospitals have one of the highest mortality rates whereas this group has the lowest one on the whole sample. Thus, the ranking on hospital quality (judged by mortality rate) is completely dependant on the composition of patient (see appendix, graph 10 and 11).

The illness severity explains the mortality rate. However, it is likely that ine>ciency within hospitals or within hospital types can explain a part of mortality rate. By an econometric approach, we could identify not only the e;ect of hospital ownership on mortality rate but also, the variance within hospital ownership of this e;ect i.e. the measurement of the ine>ciency heterogeneity within hospital type.

2 Empirical specification

2.1 A PH duration model

In this study, we use the duration model in order to take into account the possible correlation between mortality rate and length of stay. Most studies in the literature have estimated separate length of stay and inpatient mortality regressions, hence assuming that these events are independent. The problem is that it can lead to misinterpretation. For example, if we have the following case: patients admitted in a hospital of the private sector have shorter length of stay but this point has no e;ect on in-hospital mortality conditional upon length of stay. A separate regression of mortality on hospital type may yield a erroneous result. On one hand, patients admitted in private hospitals lead to shorter length of stay ; on the other hand, in-hospital deaths are less likely to be observed for patients with shorter length of stay when the outcomes are positively correlated. Thereby, we may obtain a significant e;ect whereas hospital type has no e;ect on the in-hospital mortality (Hamilton and Hamilton, 1997). Therefore, the length of stay and discharge destination are estimated in this study jointly using a duration model with multiple destinations[8].

To compare the model with a more conventional empirical framework we present the estimation of the AMI mortality rate as the dependant variable, too.

In the Proportional Hazard models, di;erences in independent variables imply a scaling of the common baseline survivor function. For the Accelerated Failure Time model, the

[7] It is not what Silverman and Skinner (2001) found for pneumonia in the US. However, the reimbursement of French hospitals is not based on French DRGs yet.

[8] The types of discharge are live or death

e;ect of the covariates is to change the time scale by a constant (survival time-invariant) scale factor (Allison, 1995). To decide which method is the most appropriate, we use the Wilcoxon-Beslow test. The test statistic results support a proportionnal relation. Thereby, we consider a PH model for this study.

Consider a PH model (Lancaster, 1990):

$$©(µ[x) = ©_0(µ)\,\exp(x^0.) \qquad (1)$$

µ : time or time's period

$©_0(µ)$: the baseline hazard function. It depends on µ (but not on x). It summarizes the pattern of "duration dependence" common to all persons.

$\exp(x^0.)$: a non-negative function of covariates x that does not depend on µ by construction.

x : independent observed variables composed of w and v such as

$$x^0_a. = v^0_a + + w^0_{©(a)} - \qquad (2)$$

a : the stay of inpatient, a R {1[ZZZ[¯} and ©(a) : the hospital © of the inpatient a, © R {1[ZZZ[h}

- v : observed variables of inpatient characteristics, sex, age, procedures received during the stay, secondary diagnosis noted during the stay.
- w : observed variables of hospital characteristics. In a first step[9], we focus only on indicator variables giving the hospital ownership (university hospitals, local hospitals, not-for-profit hospitals and for-profit hospitals).

Indicator variables of hospital ownership ° ¸ ¯ ¦ ³ °(©(a)) with °(©(a)) R [1; 4]	System of reimbursement	Sector
° ¸ ¯ ¦ ³ 1 : University (research, teaching, ...)	Global budget	Public
° ¸ ¯ ¦ ³ 2 : Local public[10]	Global budget	Public
° ¸ ¯ ¦ ³ 3 : Not-for-profit	Global budget	Private
° ¸ ¯ ¦ ³ 4 : For-profit	Fee-for-service	Private

For all µ = µ̄, and for two individuals a and « with characterictics vectors x_a and $x_«$,

$$\frac{©(\bar{µ}[x_a)}{©(\bar{µ}[x_«)} = \exp(x^0_a. \quad x^0_«.) \qquad (3)$$
$$= .\exp(x^0_a \quad x^0_«)$$

The right-hand side of this expression does not depend on survival time (by assumption), so the proportional di;erence result in hazards is constant.

2.2 Unobserved individual heterogeneity

We consider that the estimated model includes unobserved individual heterogeneity[11]. Thus, for the continuous time parametric model, we write the hazard rate for each observation as,

$$©(µ| x[\cdot) = ©(µ[x) Z \cdot \qquad (4)$$

[9] In the following, $w_{©(a)}$ corresponds to indicators for hospital ownership and indicators for technical hospitals, size, ...

[10] The groups "local public hospitals" is composed by hospitals of the public sector and, hospitals of the private sector that belong to the public sector (there are called PSPH). See section 2.2.

[11] In this paper, the unobserved individual heterogeneity is called individual frailty, too.

Thus, unobserved di;erences between observations are introduced via a multiplicative scaling factor, ·. This unobserved heterogeneity parameter takes positive values, with the mean normalized to one (for identification reason) and finite variance $;^2$. We suppose that · is distributed independently of x and µ. In principle, any continuous distribution with positive support mean one and finite variance is a suitable candidate to represent the distribution of the random variable. In this study, we used the two that have been commonly used: the Gamma and Inverse Gaussian distribution.

The frailty hazard rate can be written,

$$
\begin{aligned}
©(µ| x [\cdot) &= ©_0(µ) \exp(x^{0}.) z \cdot \\
&= ©_0(µ) \exp(x^{0}. + ¶) \quad \text{with } ¶ \; 1 \; \ln(\cdot)
\end{aligned}
\tag{5}
$$

In this study, we have no time varying covariate. Hence, the unobserved individual heterogeneity summarises both the impact of omitted variables on the hazard rate and the errors of measurement in recorded regressors (Lancaster, 1990).

Because of the choice of the pathology, the omitted variables that have an impact on the instantaneous probability of in-mortality are variables that give information on the health status of the in-patient. In this model, we have take into account di;erent variables given information on the health status of the in-patient (age, secondary diagnosis,). So, it is possible that we do not have omitted variables in the model. In this case, we will not observe any unobserved individual heterogeneity.

We suppose that the unobserved individual heterogeneity is not correlated to the observed independent variables.

2.3 Unobserved hospital heterogeneity

We consider now that the estimated model includes unobserved hospital heterogeneity noted $B_{©(^a)}$. Through this variable, we suppose that the unobserved ine>ciency of hospital explains a part of instantaneous mortality rate.

In using equations (5) and (2), the frailty hazard rate can be written,

$$
©(µ| w [v [¶ [B) = ©_0(µ) \exp(v_a^{0} + + w^{0}_{©(^a)} - + B_{©(^a)} + ¶_a) \tag{6}
$$

2.4 Estimation of the unobserved individual heterogeneity and unobserved hospital heterogeneity

The estimated model includes unobserved individual heterogeneity $¶_a$ and unobserved hospital heterogeneity noted $B_©$. The fact to account unobserved heterogeneity $¶_a$ allows to control of the di;erences in composition of patients between hospitals. Through the variable $B_©$[we assess the unobserved ine>cency of hospital. The issue is that we cannot identify both residuals $¶_a$ and $B_©$ directly from the equation (6).

$$
\begin{aligned}
©(µ| v [¶) &= ©_0(µ) \exp(v_a^{0} + + \,,_{©(^a)} + ¶_a) \qquad (7)\\
,_© &= w^{0}_{©} - + B_© \qquad (8)
\end{aligned}
$$

In the first step, the hospital fixed e;ects $,_©$ are included in the specification (equation (7)). $,_©$ represents the value of the hospital ine>ciency in the quality provided. This way, we obtain a consistent estimator of $,_©$: $\hat{,}_©$. In a second step, we estimate the equation (8) that allows to have an estimation of the observed and unobserved hospital heterogeneity.

However, a measurement error $0_©$ is produced because we have $\hat{,}_©$ and not $,_©$. So, we estimate,

$$
\hat{,}_© = w^{0}_{©} - + B_© + 0_© \tag{9}
$$

2.5 Ine>ciency heterogeneity within hospital ownership

One of the goals of this study is to measure the ine>ciency heterogeneity within hospital type. From this equation (9), we now can get the ine>ciency variance by hospital ownership, so a measurement of the ine>ciency heterogeneity within hospital type. It is what we explain now.

In vector form, the equation (9)can be written as

$$\hat{,} = w^0 - + B + 0 \tag{10}$$

with $, = (,_1[ZZZ[,_h)[B = (B_1[ZZZ[B_h)[0 = (0_1[ZZZ[0_h)$ and

$$0_© = \hat{,}_© \quad ,_©$$

From the equation (10), we estimate - by ordinary least squares (OLS),

$$\hat{-}_{mco} = (w^0 w)^{P1} w^0 \hat{,} = - + (w^0 w)^{P1} w^0 (B + 0)$$

By estimating the model (10) by OLS, we have a heteroskedasticity problem. To resolve this issue, we have to get an estimator unbiased and consistent of the variance-covariance matrix $v(B + 0)Z$

Under the assumptions,

$$\begin{aligned} ¤^{o33}(B[0) &= 0 \\ \text{and } v(B) &= ;^2 i \end{aligned}$$

we get,

$$v(\widehat{B+0}) = \hat{;}^2 i + \hat{v}(0) \tag{11}$$

an unbiased and consistent estimator $\hat{;}^2$ of $;^2$ is (see Gobillon, 2002),

$$;^2 = \frac{1}{µ^3(m_w)} \left[(\widehat{B+0})^0 (\widehat{B+0}) \quad µ^3 \left[m_w \hat{v}(0) \right] \right]$$

with,

$$\begin{aligned} m_w &= i \quad w(w^0 w)^{P1} w^0 \\ (\widehat{B+0}) &= \hat{,} \quad w \hat{-}_{mco} \\ v(0) &= v(\hat{,} \quad ,) = v(\hat{,}) \end{aligned}$$

and with $\hat{v}(0)$ is the asymptotic estimator of the variance-covariance matrix obtained from estimators of the first step.

Therefore, from (11), an consistent estimator of the variance of $-_{fgls}$ is given by[12] (Gobillon, 2002) :

$$v(\hat{-})_{fgls} = \left(w^0 \left(v(\widehat{B+0}) \right)^{P1} w \right)^{P1}$$

2.6 Advantage of a decomposition in two stages

To decompose in two steps has two great advantages. First of all, it allows measuring the heterogeneity within hospital type. Indeed, in a first step, we estimate hospital fixed e;ect. By this way, we can identify the variance of unobserved individual heterogeneity. Owing to the estimate of hospital fixed e;ect, we identify the e;ect of observed heterogeneity and we get the unobserved hospital heterogeneity $B_©$. Therefore, we are able to measure the variance of the heterogeneity component by type hospital. Secondly, the fact to estimate hospital fixed e;ect in a first step allows not to impose a parametric assumption on the unobserved hospital heterogeneity $B_©$.

[12] FGLS: Feasible Generalized Least Squares.

3 Findings

The patient of reference is a male patient, aged 35, with no secondary diagnosis. In the following, the term “patient” will define the inpatient of reference.

3.1 Estimation using Cox PH model and Piece-wise Constant Exponential model

We chose a PH model (see section 3.1). To estimate the equation (7), we use a Cox PH model. Thus, we obtain coe>cients of individual variables without restrictions on the shape of the baseline hazard. The estimator is a partial likelihood estimator that does not estimate the baseline hazard. This latter point is a drawback because we would like to get a baseline hazard. So, we use a Piece-wise Constant Exponential (PCE) model, which allows to fit a semi-parametric hazard. This way, we can estimate the coe>cients of individual variables and a baseline hazard. To be sure that the model is well specified, we can compare the coe>cients estimated by PCE (a more constraint model than Cox) with the coe>cients obtained with the Cox PH model. Moreover, using a PCE model rather than Cox model allows an easier introducing of an unobserved heterogeneity parameter (Horowitz, 1999).

All we need to estimate a PCE model is to generate variables, which allows the constant term in the hazard regression to di;er from interval to interval. In this study, we allow the baseline hazard to di;er over eight intervals: first day, second days, third days, fourth days, from 4 to 8 days, from 8 to 15 days, from 15 to 22 days and over 22 days. We call these dummies, µ« with « the number of the time interval. We chose the indicator corresponding to the interval from 4 to 8 days as reference. Choosing a reference and including the other indicators as covariate in the exponential regression model allow us to compare baseline hazard rates between intervals.

3.1.1 Robustness

In the appendix, table 1[13], we present results obtained by using a Cox PH model (column (1)) and PCE (column (2)) without unobserved heterogeneity. Results obtained by Cox PH model are really close to the ones obtained by PCE. So, we can conclude on the robustness of the model, the coe>cients obtained seem consistent.

3.1.2 Unobserved individual and hospital heterogeneity

In the table 1, column (2), we consider only unobserved hospital heterogeneity. In the column (3), we consider both unobserved individual heterogeneity and unobserved hospital heterogeneity. If we compare the results, we do not notice any di;erence. In both models, the unobserved individual heterogeneity appears to be not significant at 1%, 5% and 10%. So, we conclude that there is no parametric unobserved individual heterogeneity when we take into account the observed variables of individual heterogeneity.

3.1.3 Coe>cients

We compare the constant terms from interval to interval with the reference. We observe (see appendix, graph 13) that the baseline hazard rates are much higher for the first interval: one day, and the last one: over 22 days.

[13] Models are estimated with age structure crossed with sex indicator variables, too. We chose to present results with just two variables (sex and age) because of the number of coe>cients.

The output shows that there is a positive association between age and the hazard rate: a one-year rise in age is associated with 7 % higher probability of dying in hospital. By the same way, we find that female patients have a higher probability of in-death.

3.1.4 Hospitals ownerships

Hospital ine>ciency parameter can be explained not only by the hospital ownership but also by the fact that a hospital is able to performed innovative procedures. In this study, we work on heart attack and thus, the innovative procedure considered here is the percutaneous transluminal coronary angioplasty[14]. We called this indicator p t c a. Furthermore, we suppose that the rate of innovative procedures can also be an independent variable that explains the ine>ciency parameter. Another potential variable that explained the hospital ine>ciency is the unit care size of hospital. We use a proxy corresponding to the number of patients during the year.

In the following, results are presented in the appendix, table 2, column 1. A local public hospital is a public firm. The manager and the sta; are civil servants. A not-for-profit hospital is a private firm. The manager hires his sta; as a private firm does. However, both of them are paid by global budget. So, in comparing the ine>ciency of each of these hospitals ownership, we evaluate the e;ect of the hospital ownership for hospitals under the same system of reimbursement. We find that an hospital run by a private manager rather than a civil servant one does not have a significant change in outcomes. The ownership does not appear to reflect e>ciency di;erences. We obtained the same results by taking into account the ability to perform procedures, the rate of innovative procedure and/or the size of unit care (number of heart attack inpatients in the year).

Now, we evaluate the e;ect of the system of payment. Not-for-profit hospitals and for-profit hospitals are private firms. The formers are paid by global
budget whereas the latter are paid be fee-for-service. The result obtained shows that an admission in for-profit hospitals is associated with a lower conditional probability of death discharge from the hospital. Therefore, a fee-for-service reimbursement allows higher hospital e>ciency than a reimbursement by global budget. The di;erence in the hospital e>ciency is not significant at the level of 5% when we account for the ability to perform innovative procedures, the innovative procedure rate and/or the size of hospital care unit (appendix, table 2, column 1).

Local public hospitals and university hospitals are paid by global budget. Furthermore, these hospitals are public firms. Nevertheless, we can distinguish them by their status. On one hand, local hospitals are hospitals with little or medium size care units, they are numerous and they are dispatched widely throughout the territory. On the other hand, each French region has only between one and two of university hospitals. So ine>ciency di;erences reflect the e;ect of assignment on the e>ciency. We observe no significant di;erence between hospital ine>ciency whatever the independent variables of the model (appendix, table 2, column 4).

It appears that the hospital ability to perform complex or innovative procedure does not explain the ine>ciency parameter (table 2). One explanation is the high correlation between the hospital ownership and the hospital ability to perform complex or innovative procedures (the correlation is equal to 0.36, significant at 5%).

[14] A cardiologist inserts a catheter with a deflated balloon at its tip onto the artery.

3.2 Variance analysis

3.2.1 Ine>ciency variance

We find that hospital ownership explained only 3.4% of the total variance. We saw that ine>ciency parameter can be explained not only by hospital ownership but also by the hospital ability to perform innovative procedures, the rate of innovative procedure and the care unit size. By taking into account these independent variables, we find that the share of explained variance is 4%.

Moreover, if the gender in not significant, the age of inpatient has a positive e;ect on the quality ine>cency. However, the share of explained variance is very low, too (appendix, table 2, column 5).

These results raise another question: what are the other determinants of the hospital ine>ciency?

3.2.2 The in-death rate and the composition of patients by age and sex

The composition of the patient group by age and sex varies according to the hospital. Therefore, to evaluate the consistency of the hospital ranking by in-death rate, we have to compute the share of variance explained by the composition of patients by age and sex (see the appendix, table 3). We find that 51% of the in-death rate variance is explained by the composition of patients by age and sex. This result raises the issue of the consistency of the hospital ranking by in-death rate.

3.2.3 Variance within hospital ownerships

First of all, the variance within hospital ownership does not depend on the hospital ability to perform complex or/and innovative procedures. Secondly, we consider the variance of ine>ciency between-hospital, by hospital ownership (appendix, table 4). The hospital ine>ciency variance depends highly on the hospital ownership. The standard deviation is twenty times more important for for-profit hospitals than government hospitals. Another element is the homogeneity of quality level[15] for not-for-profit hospital. These results are not modified when we account for the hospital ability to perform innovative procedure, the rate of innovative procedure and the care unit size.

4 Conclusion

The ranking of hospitals by mortality rate can be completely biased by the composition of inpatient. Statistical results show that if we considered the whole sample, for profit hospitals would have the lowest mortality rate but, for male patient aged between 50 and 60, the highest mortality rate is observed for for-profit hospitals. These results are due to the selection. Patients that need to receive innovative or complex procedures are lead to hospitals that are able to perform them.

To take into account this selection, we use a duration model which accounts for observed and unobserved (by the researcher) variables. The originality of this study is that we consider unobserved inpatient heterogeneity and unobserved hospital heterogeneity. So, we propose a duration model with two types of residuals. Moreover, none distribution assumption is done on the unobserved hospital heterogeneity residuals.

Owing to this specification, we evaluate the heterogeneity between hospitals for di;erent ownerships: university hospitals, local public hospitals, not-for-profit hospitals and for-profit hospitals, by controling the observed and unobserved patient characteristics.

[15] The quality level is measured by the conditional probability of in-death.

Heterogeneity between for-profit hospitals is greater than between university hospitals (the variance of the estimated coe>cients is almost four hundred times bigger). These results suggest that being admitted into a for-profit hospital has two consequences:- a lower risk of death, - a bigger uncertainty about the level of quality of the hospital, quality measured in terms of instantaneous probability of death. It raises a question: what covers the notion of quality? the average quality level? the value of the variance of quality level? Nowadays, a standard like ISO 9002 standard defines a product by the homogeneity of his level of quality. Should we use the same concept for hospitals?

Hospitals of the public sector are more homogeneous than in the private one. These results suggest that increasing the ability to adopt innovative procedures would allow a greater quality of care by keeping a homogeneity in the quality of care provided by these hospitals. In setting up the budget constraint, the regulator has to bear in mind that it may have consequences on the ability of the public sector to perform innovative procedures and insofar on the quality of care.

In this study, we have adopted a parametric approach for the residual, although a non parametric approach like the one suggested by Heckman and Singer (1984) could be chosen, too.

We considered that patient characteristic structure reflect the needs of patients to receive more complex or innovative procedures. However, it can be due to a choice of the patient for some kind of hospitals. A socio-economic information on patients would allow to model the choice of the patient (for a hospital or/and a hospital type).

In order to obtain consistent estimation, we have to eliminate all patiens with less than 30 admissions for heart attack in our dataset. Such a elimination process can be lead to bias selection. Nevertheless, the cardiologist center considers that an angioplasty must be performed on at least 30 patients to classify the unit care as cardiology unit.

The investment in innovative procedures di;ers according to the system of reimbursement. Hospitals of the private sector can have benefit by performing innovative procedure and hospitals of the public sector do not. So, if innovative procedures have an impact on the long-term mortality rate, the system of reimbursement could, too. To answer this acute question, we need to have a longitudinal dataset on survival inpatients.

5 References

Allison, J.J., Kiefe, C.I., Weissman N.W. (2000) "Relationship of Hospital Teaching Status with Quality of Care and Mrtality for Patients with Acute MI" Journal of American Medical Association, 284, 1256-1262.

Allison, P. (1995) Survival Analysis Using SAS System: A Practical Guide, SAS Institute, Gary NC.

Arrow, K.J. (1963) "Uncertainty and the Welfare Economics of Medical Care", American Economic Review, 53, 941-973.

Cutler, D.M., Horwitz, J.R. (1998). Converting Hospitals from Not-for-Profit to For-Profit States: Why and What E;ects? National Bureau of Economic Research Working Paper No. 6672.

Dubois R.W., Rogers W.H., Moxley J.H., Draper D., and Brook R.H. "Hospital inpatient mortality. Is it a predictor of quality?" the New England Journal of Medecine, 317 (26),1674-1680.

Geweke J., Goworisakaran G. and Town R. (2001) "Inferring hospital quality from patient discharge using a Bayesian selection model", NBER working paper. (Under third review stage at Econometrica)

Gobillon, L. (2002) Ph.D. dissertation.

Goworisakaran G. and Town R. (1999) "Estimating quality of Care in Hospitals Using Instrumental Varaibles", Journal of Health Economics, 18, 747-67.

Goworisakaran G. and Town R. (2002) "Competition, Payers, and Hospital Quality", NBER working paper

Kessler and McClellan (2000) "Is hospital competition socially wasteful?", Quaterly Journal of Economics, 115(2), 577-615.

Kessler D. and McClellan M. (2002) "The e;ects of hospital ownership on medical productivity", RAND Journal of Economics, 33 (3), 488-506.

Hamilton and Hamilton V. (1997) "Estimating surgical volume_outcome relationships applying survival models: accounting for frailty and hospital fixed e;ects", Health Economics, 6, 383-395.

Hansman, H.B. (1996) The ownership of Enterprise, Cambridge, Mass.: Havard University Press.

Hartz A.J., Krakauer H., Kuhn E.M. (1989) "Hospital Characteristics and Mortality Rates". New England Journal of Medecine, 321, 1720-1725.

Heckman, J. and Singer, B. (1984) "A method for minimizing the impact of distributional asumptions in econometrics models for duration data", Econometrica, 52, 271-320.

Ho, V. (2002) "Learning and the evolution of medical technologies: the di;usion of coronary angioplasty", Journal of Health Economics, 21, 373-885.

Ho V. and Hamilton B. (2000) "Hospital mergers and acquisitions: Does market consolidation hrm patients?" Journal of Health Economics, 19(5), 767-791.

Lancaster, T. (1990), The econometric Analysis of Transition Data, Cambridge University Press.

McClellan and Staiger D.O. (2000) "Comparing Hospital Quality at For-Profit and Not-for-Profit Hospitals". In D.M. Cutler, ed., The Changing Hospital Industry: Comparing Not-for-Profit and For-Profit Institutions. Chicago: University of Chicago Press, 2000.

Milcent, C. (2001) Ph.D. dissertation.

Newhouse, J. (1970) "Toward a Theory of Nonprofit Institution". American Economic Review, 60, 64-74.

Pauly M.V. and Redish M. (1973) "The Not-for-Profit Hospital as a Physicians' cooperative", American Economic Review, 63, 87-99.

Picone G., Shin-Yi C., and Sloan, F. (2002) "Are for-profit hospital conversions harmful to patients and to Medicare ?", RAND Journal of Economics, 33 (3), 507-523.

Propper, C. and Burgess S. and Green K. (2002) "Does competition between hospitals improve the quality of care? Hospital death rate and the NHS internal market", mimeo.

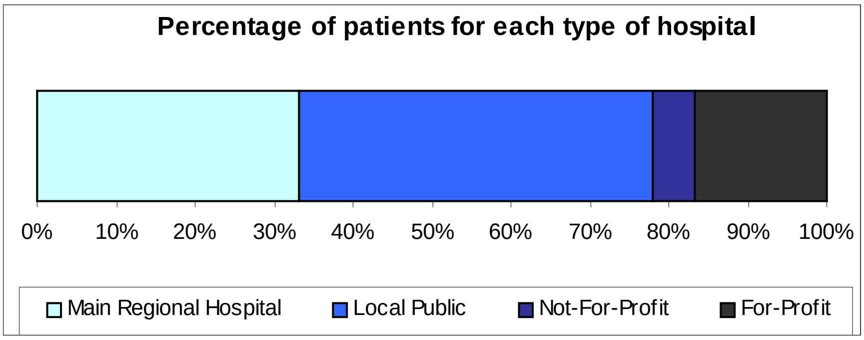
Silverman E.M.and Skinner J.S. (2001) "Are For-Profit Hospitaks Reallt di;erent? Medicare Upcoding and Market Structure", NBER working paper.

Shortell S.M. and Highes E.F.X. (1998) "The e;ects of Regulation, Competition, and Ownership on Mortality Rates Among Hospital Inpatients", New England Journal of Medecine, 318, 1100-1107.

Frank A. Sloan, Gabriel A. Picone, Donald H. Taylor, Shin-Yi Chou (1999), "Hospital Ownership and Cost and Quality of Care: Is There a Dime's Worth of Di;erence?", Working Paper.

Wray N. J., Hollinghsworth, N. Petersen, and C. Ashton (1997), "Case-Mix Adjustement Using Administrative Databases: A Paradigm to Guide Future Research", Medical Care Research and Review, 54, 326-356.

Graph 1:



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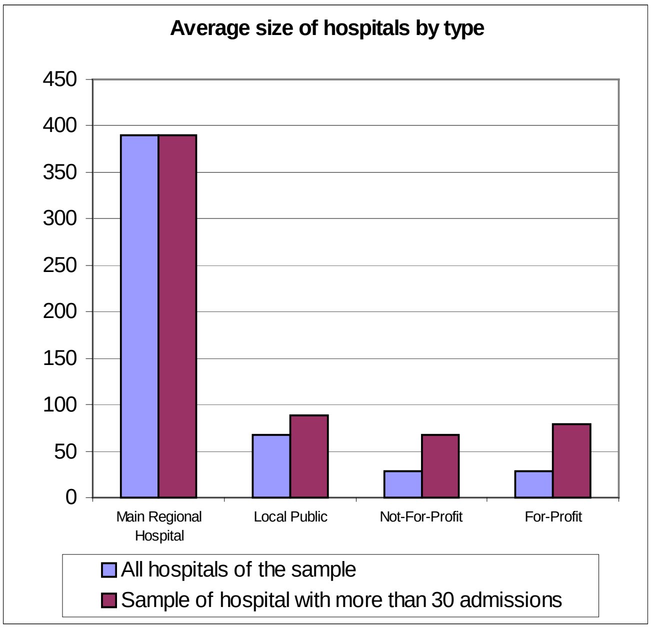

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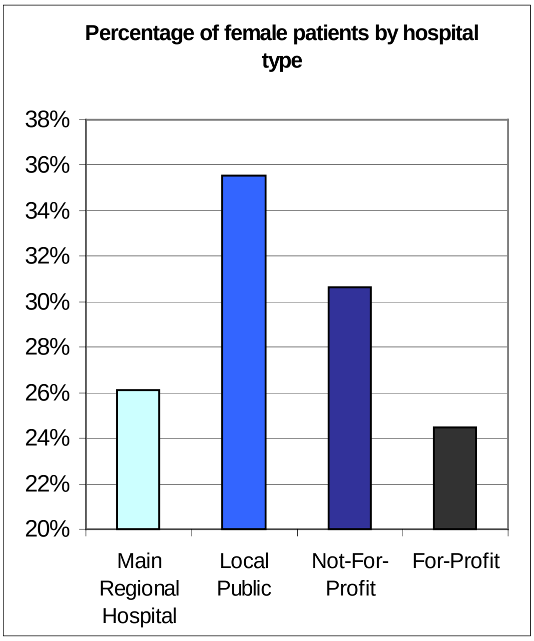

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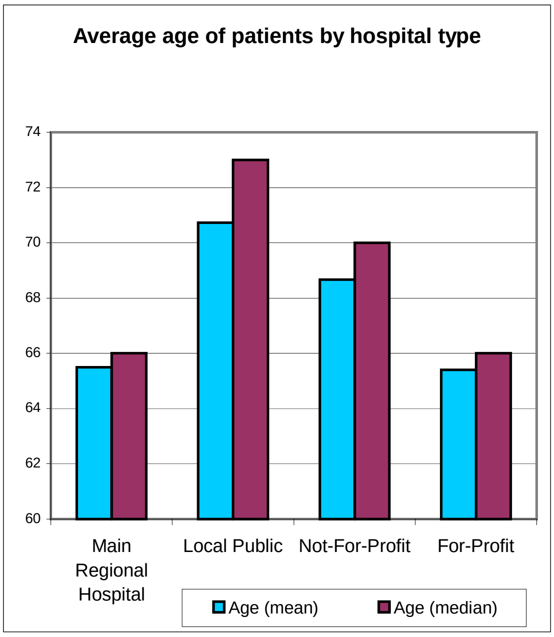

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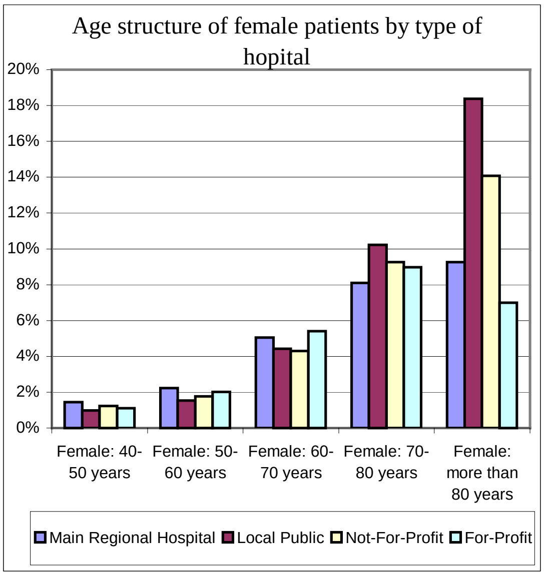

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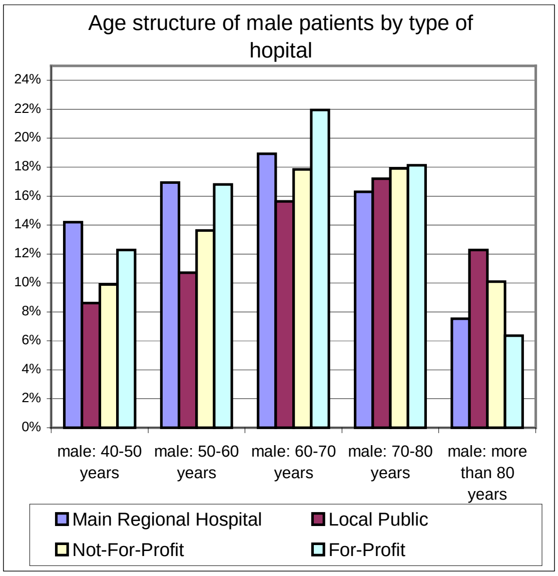

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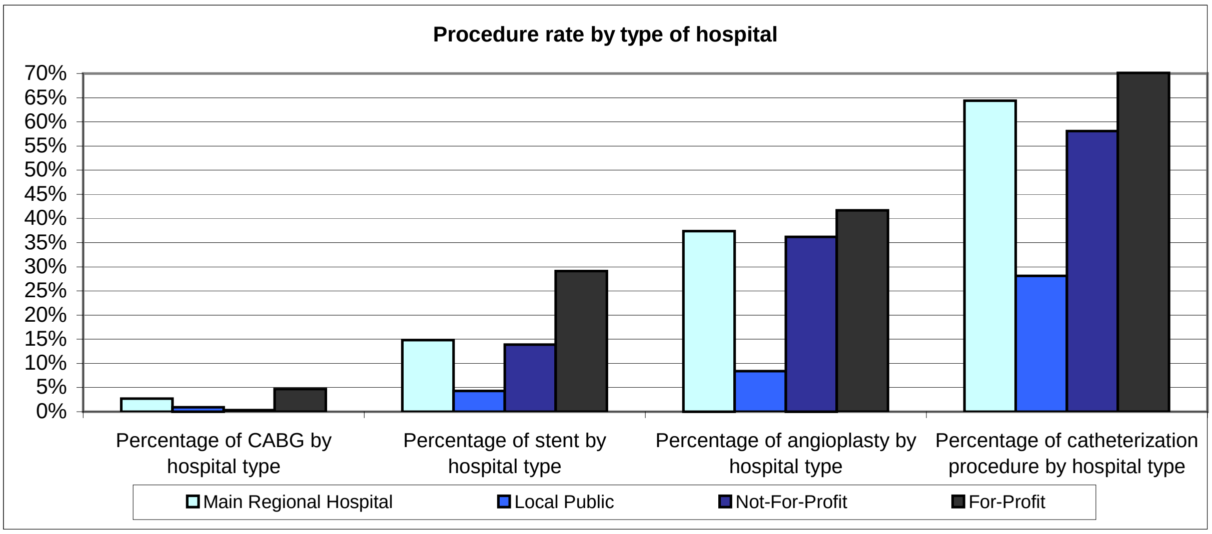

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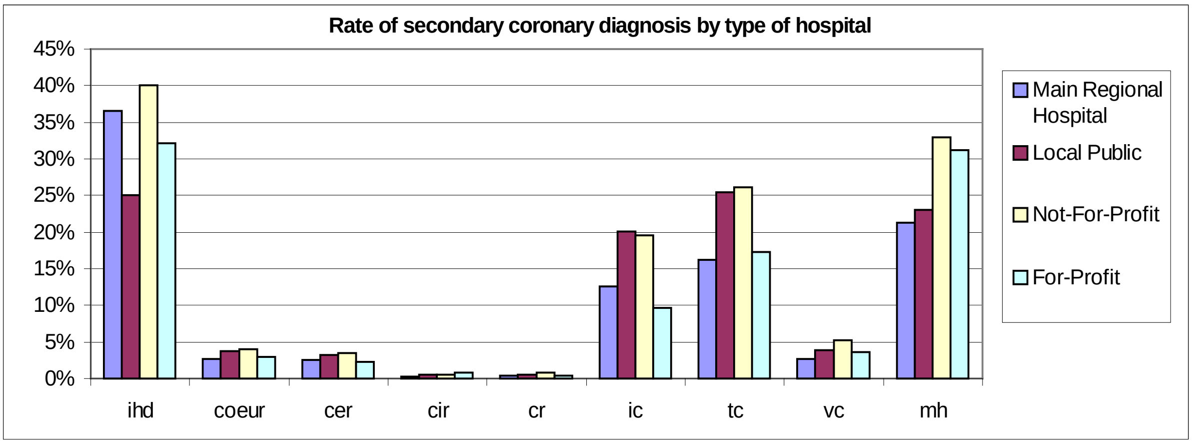

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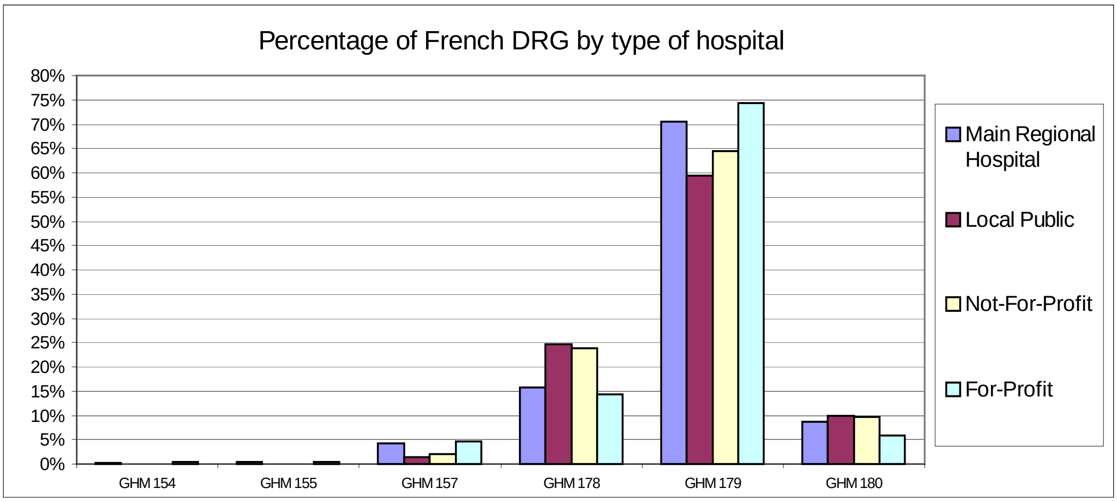

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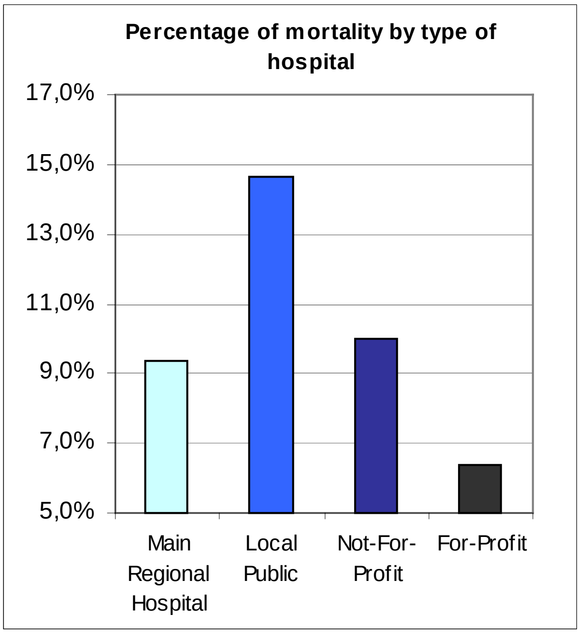

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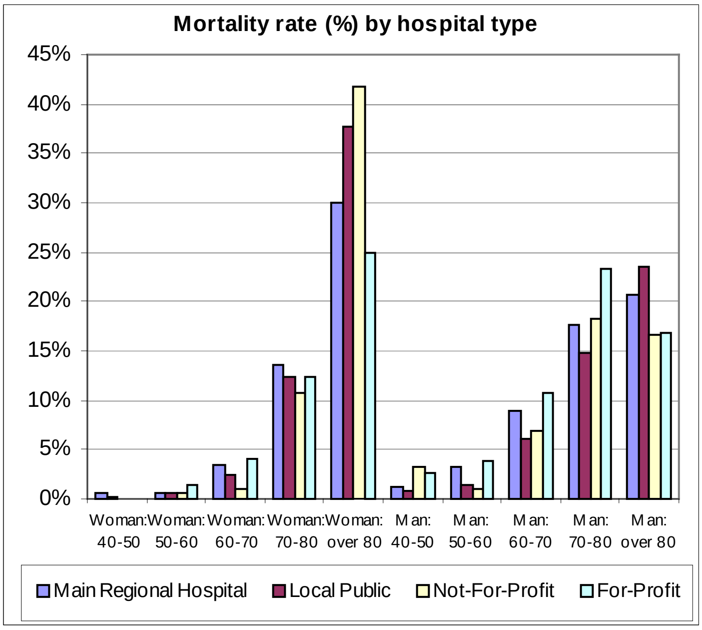

Graph 12:

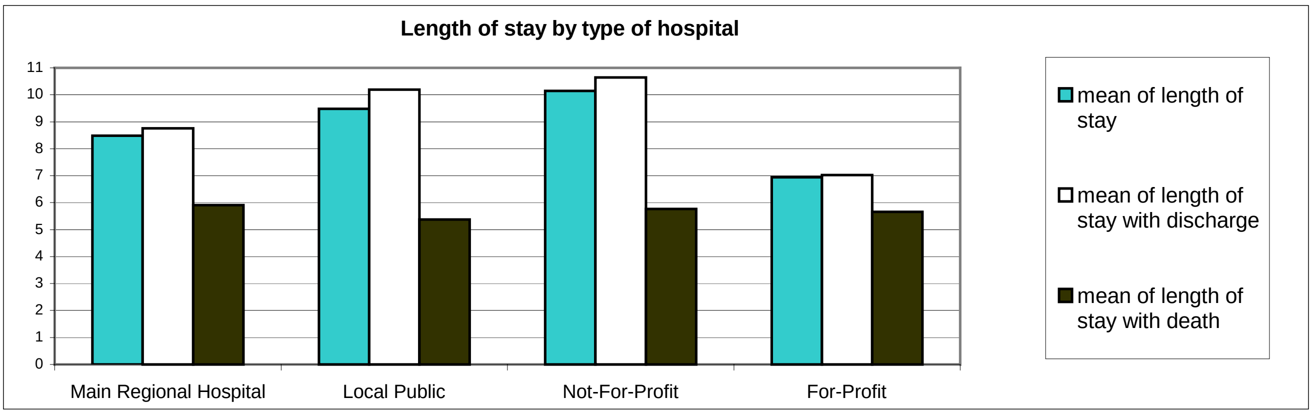

Table 1:

	PH Cox (1)	PCE without heterogeneity (2)	PCE with heterogeneity (2)
Patient characteristics			
Age	0.066***	0.066***	0.066***
	[0.002]	[0.002]	[0.002]
Female	0.179***	0.179***	0.179***
	[0.038]	[0.038]	[0.038]
Severity disease			
Number of secondary diagnostic	0.049***	0.049***	0.049***
	[0.014]	[0.014]	[0.014]
Chirurgical French DRGs	0.636***	0.638***	0.638***
	[0.115]	[0.115]	[0.115]
ihd	-0.154***	-0.154***	-0.154***
	[0.036]	[0.036]	[0.036]
coeur	-0,123	-0,123	-0,123
	[0.090]	[0.090]	[0.090]
cer	0.405***	0.407***	0.407***
	[0.067]	[0.067]	[0.067]
cir	-0.634**	-0.635**	-0.635**
	[0.305]	[0.304]	[0.305]
cr	-0,094	-0,095	-0,095
	[0.201]	[0.201]	[0.201]
ic	0.198***	0.199***	0.199***
	[0.039]	[0.039]	[0.039]
Interval			
interval= first day		1.396***	1.397***
		[0.059]	[0.059]
interval= second day		0.812***	0.812***
		[0.068]	[0.068]
interval=third day		0.632***	0.632***
		[0.073]	[0.073]
interval=fourth day		0.459***	0.459***
		[0.078]	[0.078]
interval=from 4 to 8 days		0.205***	0.205***
		[0.061]	[0.061]
interval=from 8 to 15 days		Reference	Reference
interval=from 15 to 22 days		0.433***	0.433***
		[0.091]	[0.091]
interval= over 22 days		1.074***	1.074***
		[0.137]	[0.137]
Constant		-9.965***	-9.965***
		[0.175]	[0.175]
			(b)
Variance of Gamma parameter			7.72e-07
			[0.0001451]
Hospital fixed effects have been estimated but they are not shown because of too many coefficients			
log likelihood	-29690,63	-11295,02	-11295,02

Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

(b): Likelihood ratio test of theta=0: chibar2(01) = 3.6e-05 Prob>=chibar2 = 0.498

Graph 13:

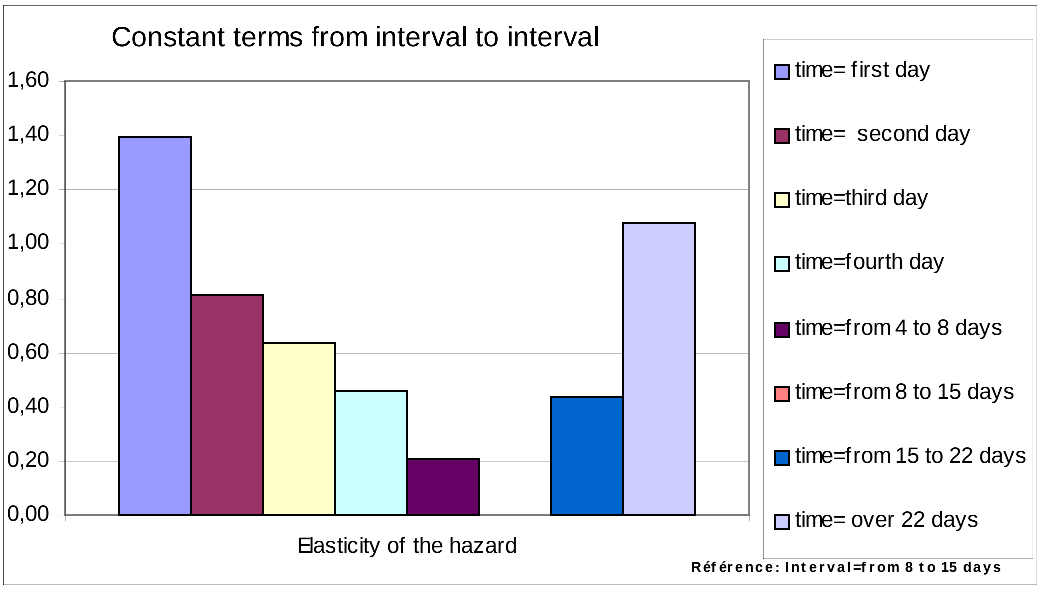

Table 2:

Independent variables	Coefficients				
	(1)	(2)	(3)	(4)	(5)
Main regional hospital	0.280** [0.119]	0.264 [0.207]	-0.069 [0.326]	-	-
Local public	0.068 [0.247]	0.0920 [0.309]	0.068 [0.361]	-0.212 [0.225]	-
Not-for-profit	-	-	-	-0.280** [0.122]	-
For-profit	-1.546* [0.786]	-1.551* [0.792]	-1.572* [0.812]	-1.826** [0.779]	-
Hospital ability to perform innovative procedures	-	0.050 [.540]	-0.101 [0.462]	-	-
Innovative procedure's rate	-	-	0.257 [0.759]	-	-
Care unit size	-	-	0.002 [0.001]	-	-
Average age of inpatients	-	-	-	-	0.151** [0.595]
Gender	-	-	-	-	-0.308 [2.059]
Intercept	-10.344*** [0.111]	-10.377*** [0.371]	-10.455*** [0.387]	-10.064*** [0.044]	-21.049*** [4.291]
Prob > F	0.0107	0.0243	0.1190	0.0107	0.0411
R-squared	0.0340	0.0341	0.0355	0.0340	0.0408

Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3:

Dependent variable: in-death rate

Independent variables	Coefficients
Average age by hospital	0.0113*** [0.001]
Proportion of male patient by hospital	0.013 [0.048]
Intercept	-0.658 [0.062]
Prob > F	0.0000
R-squared	0.5106

Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4:

	Variance between-hospital by hospital ownership: inefficiency heterogeneity			
Independent variables	(1)	(2)	(3)	(4)
Main regional hospital	0.25	0.26	0.29	0.68
Local public	2.85	2.86	2.86	2.86
Not-for-profit	0.54	0.56	0.54	0.58
For-profit	6.23	6.23	6.24	6.23

(1): Hospital ownership.
(2): Hospital ownership, hospital ability to perform complex or/and innovative procedures.
(3): Hospital ownership, hospital ability to perform complex or/and innovative procedures and the rate of innovative procedure.
(4): Hospital ownership, hospital ability to perform complex or/and innovative procedures, the rate of innovative procedure and the care unit size.