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THE ROLE OF GP'S COMPENSATION SCHEMES IN DIABETES CARE: EVIDENCE FROM PANEL DATA

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The role of GP's compensation schemes in diabetes care: evidence from panel data.

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ABSTRACT

The design of incentive schemes that are effective in improving quality of care is a central policy issue for the health care sector. Nowadays we observe many pay-for-performance programs, where payment is contingent on meeting indicators of provider effort, but also other alternative financial strategies have been introduced, for example programs that reward physicians for participation in diseases management projects. Although it has been recognised that incentive-based remuneration schemes can have an impact on GP behaviour, there is still weak empirical evidence on the extent to which such programs influence healthcare outcomes. We investigate the impact of financial incentives in Regional and Local Health Authority contracts for primary care in the Italian Region Emilia Romagna for the years 2002-2005. At this scope, we focus on avoidable hospitalisations (Ambulatory Care Sensitive Conditions) for patients affected by type 2 diabetes mellitus, for which the assumption of responsibility and the adoption of clinical guidelines are specifically rewarded by specific economic incentives differentiated by health districts. We estimate a panel count data model using a Negative Binomial distribution to test the hypothesis that, other things equal, patients under the responsibility of GPs receiving a higher share of their income through these programs are less likely to experience avoidable hospitalisations. Our results support the hypothesis that financial transfers may contribute to improve quality of care, even when they are not based on the ex-post verification of performances and that programs aimed at stimulating GP assumption of responsibility in diabetic management significantly reduce the probability of avoidable admissions for their patients.

1. Introduction

In the last decade, financial incentives have been employed for improving performances of healthcare providers not only in insurance based systems but also in countries with a National Health Service (NHS). Probably, the best known example of this trend is the Payment by Results program adopted by British NHS for financing hospital trusts (Farrar et al., 2009). In addition to it, the UK has extended target payments to different areas such as primary care through the Quality and Outcomes framework (e.g. Campbell et al. 2009) . The British experience is not unique as proved by the implementation in the Italian NHS of programs that provide General Practitioners (GPs) with extra-payments exceeding standard capitation. These additional financial transfers are usually paid to GPs for meeting targets that are considered of general interest or for taking part in care improvement activities promoted by public authorities.

In NHS systems, the attention devoted by policymakers to the design of an effective governance of primary care has increased over the years as a consequence of the pivotal role attributed to GPs as direct providers of ambulatory care as well as gatekeepers for access to secondary care. Consequently, public interest focuses not only in improving quality of primary care per sé, but also in involving GPs in cost containment strategies conceived on a wider scale.

In a broad sense, the common purpose of these programs is to promote physicians' internalisation of policymaker's objectives and the range of activities potentially involved is extremely diversified. Special bonuses may be provided for meeting pre-specified targets that promote the alignment of GPs' referral and prescription decisions to general health policy goals, usually associated to a more appropriate use of resources (e.g. prescription rate of generic vis-a-vis branded drugs, patients' hospitalisation rate under pre-defined thresholds etc…). Nevertheless, financial incentives may reward also direct provision of treatments (e.g. immunisation uptake), assumption of responsibility for patient affected by diseases that require additional efforts on part of the physician (e.g. diabetes, hypertension), or the adoption of organisational routines aimed at improving cooperation among providers, such as participation in network organisation of GPs or adherence to evidence-based guidelines and clinical protocols.

Another important distinction concerns the degree of performance monitoring. Pay for performance schemes typically associate financial transfers to the achievement of targets agreed in advance. Alternative approaches may choose to reward participation in care improvement activities, without necessarily linking the provision of additional funds to the attainment of specific objectives defined in terms of financial or epidemiological indicators to be verified ex-post. On the one hand, the first approach has the advantage of introducing a more stringent incentive structure, thus increasing its capacity to influence GPs behaviour in the desired direction. On the other hand, the second approach is claimed to be less intrusive of physicians professional autonomy and therefore, there are institutional circumstances and areas where it may prove effective in encouraging and promoting cooperation between independent providers, such as GPs, and the different actors of the public system.

Given the variety of possible institutional arrangements, the research agenda has suggested a number of questions whose assessment is relevant for improving the policy design, especially at the micro level. First, are primary care physicians' influenced at all by "ad hoc" economic incentives in their referral and prescribing decisions? GPs' responses can be obtained only through large financial transfers or also with (relatively) small scale programs? To what extent are the results sensible to monitoring of performances? Should programs based on financial incentives span over wide areas of intervention or do they work effectively also when focused on disease specific objectives? Does the target of the program (e.g. cost containment vs. quality enhancement) affect its effectiveness? What is the impact on the quality of care? Do we observe systematic differences across countries? Can these differences be attributed to peculiar institutional characteristics of each system or are they associated to different practice style related to local clinical culture and habits?

The array of experiences developed around the world in recent years, each with its distinctive features, provides a rich and promising area of investigation for evaluating the effectiveness of different incentive schemes based on financial transfers to GPs that add up to standard capitation. Our work contributes to this empirical literature on program evaluation in primary care by analysing the case of diabetes in the Italian Region Emilia Romagna for the period 2002-2005. Emilia Romagna launched a Diabetes Project in 2003 for improving clinical appropriateness in disease management, through which GPs were assigned the home care responsibility of type II diabetic patients. In order to promote the

accomplishment by GPs of a number of activities expected to improve quality of diabetes care, local health authorities have been allowed to provide specific compensations to their GPs for activities such as the regular review of patients, the periodic measure of their glycosylated haemoglobin, participation and/or adherence to the local diabetes medical management program and in meetings that set clinical guidelines. The identification of the activities to be incentivated and the extent of the corresponding financial transfers has been bargained between health authorities and the representative organisations of GPs at the district level. As a consequence of it, wide differences across districts in the amount of economic incentives are observed in the period under consideration.

The sources for this study are a series of regional databanks that include detailed information on the different sources of GPs professional income and on the use of healthcare services (episodes of hospitalisation, prescription of drugs etc…) by all regional patients registered in the GPs' lists. Information on drug utilisation and access to specialised centres allows to identify patients suffering from diabetes type II. Then, the comprehensive information on economic incentives received by GPs permits us to investigate the relation between funds attributed to each GP for special programs related to diabetes care and quality of care received by their patients. It is well documented in the clinical literature on diabetes mellitus type II that timely and accurate ambulatory care should be able to prevent deterioration of the patient's health status that can ultimately lead to emergency hospitalisation (ADA, 2002; Booth and Fang, 2003; Ices 2003; Fleming 2004, RACGP, 2009) In particular, we choose to measure quality of diabetes care with the Ambulatory Care Sensitive Conditions (ACSCs) developed by Billings et al. (1993) for this chronic disease, internationally considered indicators of (low) quality in primary care.. According to the clinical literature based on ACSCs (Purdy et al., 2009), a high frequency of hospital admissions for such episodes is typically associated to deficiencies in disease management and inadequate patient supervision accurate. From this point of view, appropriate outpatient care should be effective in preventing complications and therefore hospital admission.[1]

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[1] For example, ACSCs include short-term complications of diabetes mellitus such as diabetic ketoacidosis, hyperosmolarity, and coma. These life-threatening emergencies arise when a patient experiences an excess of glucose (hyperglycemia) or insulin (hypoglycemia) but with timely and high-quality outpatient care hospitalization for these high-severity diabetic conditions are typically preventable.

The paper tests the hypothesis that, other things equal, the higher the fraction of professional income a GP receives from special payments for diabetes care, the lower the number of avoidable hospitalisations (i.e. diabetic ACSCs) experienced by his type-2 diabetic patients. By doing so, we verify whether physician respond to economic incentives by improving the quality of care and patient supervision, measured by a reduction in (avoidable) adverse outcomes.

Our work contributes on several dimensions to the existing literature on the role of financial incentives on physician behaviour. First of all, differently from most experiences analysed so far, the incentive scheme implemented in this case is designed at compensating participation in caring improvement activities, such as assumption of responsibility of patients, adherence to guidelines etc, rather than rewarding high level of performances.

A second important improvement is ensured by the use of a the large dataset that covers the entire regional population for four years. The initial study population amounts to 2618087 inhabitants aged 35 or more, from which 164574 diabetic patients are extracted. The use of longitudinal data allows a more precise identification than it was done in previous works (Lippi Bruni, Nobilio, Ugolini 2009) of the link between the relative amount of economic incentives and outcomes of care. In particular, by exploiting variation across time and GPs, the effect of financial transfers associated to diabetes care can be isolated from confounding factors such as generalised improvement in clinical practice (Gujarati, 2003) and endogeneity issues can be more appropriately controlled for.

2. The role of financial incentives for quality improvement

Financial incentives aimed at improving quality of healthcare services are increasingly adopted and usually designed as pay-for-performance programmes in which remuneration is conditional on achieving measurable targets, that reflect clearly identified policy goals.

Whereas empirical evidence suggests that physicians respond to changes in the compensation scheme, studies where quality measures are introduced explicitly to assess the impact of financial incentives are at early stage of development. Numerous evaluations have focused on the recent implementation of the Quality and Outcomes framework in UK using various methodologies including interviews, surveys and records review to assess

trends in quality care indicators before and after introduction of the pay-for-performance scheme in 2004. At this regards, Campbell, Reeves et al. (2009) find a positive improvements in quality for two of the three chronic conditions considered (diabetes and asthma but not for heart disease) in the short term but, once targets were reached, rates of quality improvement slowed considerably for all the three conditions, whereas continuity of care and the quality of care for conditions not linked to incentives declined significantly. In their conclusion, the pay-for-performance scheme introduced in the UK produced at the beginning significant improvements in measurable aspects of clinical performance for the three chronic conditions considered but the initial acceleration was not sustained over the subsequent years.

Focusing on diabetes care, Scott et al. (2009) evaluate a positive moderate impact on quality of care in diabetes management of the incentive program introduced in Australia in 1999, increasing the probability of ordering an HbA1c test for diabetic patients. Contrariwise, for the same chronic condition, Young et al. (2007) investigate the effect of a program conferring limited financial risk to primary care physicians in Rochester, US, between 1999 and 2004 and demonstrate no difference between the post- and pre-intervention trends indicating that the overall increase in performance was largely independent from the incentive program.

Some studies suggest that both organization-level and individual physician-level incentives have a measurable impact on quality improvement but also that financial incentives are more influential when based on individual physician's performance. When results reported that physicians are unresponsive to financial incentives, conclusions suggest that in these cases financial amounts might have been too small (Conrad and Perry, 2009). In a recent and comprehensive survey of the argument, Christianson, Sutherland and Leatherman (2009) conclude that studies with stronger research design reporting no impacts of financial incentives on quality of care and so the evidence base for justifying the growing use of pay-for-performance schemes is thin and inconclusive.

The empirical literature on payment arrangements for quality improvement encounters three main difficulties. First, incentives schemes are often complicated and nuanced, introduced on top of, or blended with, payment mechanisms aimed to pursue different scopes. This makes difficult to assess the independent effect of the financial scheme.

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Second, financial incentives could be manipulated owing to the incompleteness of many performance measures, leading for example to concentrate efforts only on the areas included in the performance indicator scheme. Third, paying for performance can diminish the intrinsic motivation and satisfaction to perform the task for its own sake. A precondition for crowding-out effects (Frey, 1993; Le Grand, 2003) is that individuals are sufficiently intrinsically motivated. The more important is the task for the agent — in the sense that it would have been performed independently of reward — the more likely they become. Such relationships are considered to be particularly relevant for non-repetitive jobs with high discretion, e.g. physicians motivated by ethics and professionalism. In these contexts, if financial incentives are perceived to trivialize the non-financial motivations, the use of incentives could be harmful. This could be especially true in national health care systems where monetary incentives could devalue providers altruistic motivation (Siciliani, 2009).[2] Indeed, there are contradictory theories on the power of incentives in the public sector as public organizations are endowed with a set of very unique characteristics - among others, the lack of markets for goods provided by public organizations and the non-monetary motivations of many public sector employees - that make it more difficult and less necessary to motivate public employees by paying them based on the value of their output (Andersen, 2009).

Contrariwise, financial incentives could also crowd "in" intrinsic motivation when agents perceive the external rewards as informative or supportive. Bénabou and Tirole (2003) formalize the distinction between intrinsic and extrinsic motivation indicating the importance of both while identifying the overall effect of external interventions on motivation. In their model the crowding out effect is more likely when the reward is offered to agents with limited ability and/or for unattractive tasks. In this case, the agent thinks the principal knows more about his abilities than he himself, so he takes the provision of incentives as a bad sign. In other words, rewards may be weak reinforcers in the short

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[2] As regards the Quality and Outcome framework, McDonald, Harrison et al (2008) reported that the financial incentives in the pay-for-performance program in England did not damage the internal motivation of GPs; while Campbell, McDonald et al (2008) noted that incentives had caused resentment on the part of some nurses about the distribution of practice bonus payments as they were given responsibility for achieving performance targets. Whalley, Gravelle et al (2008) conducted a longitudinal survey of UK physicians to assess changes in attitudes towards the pay-for-performance programme, finding improvements in satisfaction relating to hours worked and remuneration.

term but they could be counterproductive if they reduced the agent's motivation to undertake the tasks in the future and they become negative reinforcers when they are withdrawn. On the contrary, offering low-powered incentives or non-contingent payments the principal could signal his confidence in the agent's ability inducing stronger crowding-in effects. In this case the short-term effect of the principal's confidence-management motive would reduce the slope of the agent's compensation schedule and increase the his fixed salary but could strengthen the agent's intrinsic motivation in the long period. Striking a balance between wages, monetary rewards and monitoring in the design of compensation mechanisms is particularly important in the health sector, where production and delivery are both highly labor intensive. Indeed, worker motivation is the key determinant of health sector performance where resource availability and worker competencies are necessary but not sufficient to ensure desired worker performance. Worker performance depends, to a large degree, on workers' level of motivation stimulating them to apply themselves to their tasks.

In addition, theoretical work suggests that low-powered incentive contracts can be optimal when the agent allocates his effort across multiple tasks and some tasks are unobservable or observable only at a very high costs (Eggleston, 2005). These contracts usually combine an upfront payment (per patient or per unit of time) with a partial fee for service, trying to encourage the provision of aspects of care (such as quality) which are valuable for patients but are not easily observable to them and to the insurers (Dumont et a., 2008). For example, to improve primary care for patients with chronic illnesses, incentives designed to pay a fixed additional amount per chronic patient may help to reduce patients selection and contribute to align physicians' behaviour to the insurer's objectives.

For these reasons, although interest in pay-for-performance mechanisms continue to grow also in the healthcare sector, there are some doubts about the ultimate effectiveness of these scheme in the presence of intrinsic motivations and of multitasking. At this regards, an emerging literature further develops the general theory of economic incentives introducing concepts from the literature on Public Service Motivation (Andersen, 2009) such as identity with the organization goals, work ethic, non-pecuniary motivations and applying them to the health sector. Meanwhile, many countries such as US, Canada, Australia and New Zealand have been experimenting softer organisational drivers to improve performance, such as delegated autonomy (taking the form of decreased

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inspection and reporting requirements) and alternative incentive schemes for quality improvements that try to align the interests of the principal with those of the agent by means of a looser incentive structure with respect to pay-for-performance mechanism (Smith, 2002; Birkmeier & Birkmeier, 2006; Mannion et al., 2007). The potential advantages of this kind of incentive are providers adherence to evidence based protocols, helping patients with chronic illnesses to understand how to reduce their risk factors for developing complications, but also helping physicians to internalize the importance of being part of disease management programs, increasing cooperation and coordination. On the contrary, these incentive schemes could present shortcomings that should not be overlooked, since the lack of binding connections between individual results and financial transfers may strongly attenuate the influence on physicians behaviour. Systematic empirical literature on this topic is scarce but outlines that there are cases in which low-powered incentives may have a positive impact on the quality of care (Dumont et al., 2008; Lippi Bruni, Nobilio & Ugolini, 2009) than pay-for-performance mechanisms.

3. The organisation of diabetes care

In Italy, primary care physicians work as independent professionals contracted with the NHS and are on charge of delivering primary care services to the citizens registered with them. In addition to it, GPs are gatekeepers to NHS-funded specialist and hospital care. Local Health Authorities (LHAs) are divided into Healthcare Districts (HDs) that have the institutional responsibility of organising and coordinating outpatient specialist services, residential and primary care within their territory. The provision of primary care services is free of charge at the point of demand and each citizen chooses the GP with whom to register. Although the choice of the GP is reversible at any time, turnover rates are extremely limited and, in the large majority of cases, they are a consequence of a residence change of the patient. In 2000 it has been established a maximum allowed list size of 1500 registered patients. GPs exceeding the limit when the new regulation was approved, were allowed to keep their additional patients but they cannot add new ones until their list has fallen behind the threshold.

Over the last two decades, the Italian NHS has been characterised by a devolution of powers to regional governments which has opened to Regions new opportunities for

experimenting institutional innovations also in the area of primary care (Fiorentini, Lippi Bruni, Ugolini, 2008). In Emilia Romagna - a north eastern region with a population of around 4 millions inhabitants - interventions have been carried out in order to further coordination between GPs and LHAs that include also the introduction of economic incentives to complement the existing GPs' payment scheme based on capitation. In the policymaker's view these financial tools are aimed at promoting a closer alignment of GPs' decisions with health policy goals identified by the public authority. The objectives of these programs span from improvements in the quality and appropriateness of care, to the adoption of referral and prescribing decisions expected to back the public payer's effort for cost containment.

The main features of the GPs' remuneration scheme are defined every three years by a process of centralized collective bargaining with GPs' trade unions. An important economic dimension contracted at the central level is the capitation component of the remuneration, that represents the most relevant part of GPs' income paid by the NHS. Nevertheless, regions are now left with considerable autonomy in defining the additional part of GPs' professional income and geographical differences in this additional component are documented not only across but also within regions.

In Emilia Romagna, the regional government sets priorities for primary care but LHAs and HDs benefit of considerable degrees of freedom in defining the activities to be incentivised through additional payments and the size of the financial incentives for each of these activities. As regards diabetes care, the Regional Health Authority started in 2003 a Diabetes Project that defines roles and responsibilities of LHAs, HDs and GPs for disease management, adopts clinical guidelines based on best practices and provides a general framework for introducing ad hoc financial incentives[3]. Nevertheless, it is through local agreements between GPs', LHAs and HDs that the details of the additional remuneration associated to diabetes care are specified. Each agreement involves all GPs operating in a particular district, it identifies the activities rewarded by public health authorities at the local level and the corresponding financial amount. According to the general set up of disease

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[3] Before 2003 LHAs had different behaviours in involving GPs in monitoring diabetes: there was no formal shared coordination between primary and secondary care but some districts have been experimented various forms of additional financial bonus for diabetes since the beginning of this century.

management outlined by the regional Diabetes Project, the activities that each district may choose to compensate range from adherence to clinical guidelines and protocols to the assumption of responsibility of diabetes patients[4] or participation in audit meeting,

The main purpose of these financial incentives is to compensate GPs for the costs in terms of additional time and effort that they face in order to care diabetes vis-a-vis non-diabetes patients. Moreover, such programs intend to promote improvement in the quality of care through a better coordination between GPs, health districts and (when necessary) also secondary care facilities for the delivery of appropriate and effective medical services. Local diabetes management plans introduce additional payments in a variety of different ways. In some cases, as for the assumption of responsibility of patients, GPs receive a financial transfer that increases capitation for each diabetes patient registered in their list. In other cases, as for attendance to audit meetings or contribution to dissemination of new protocols and guidelines, the additional transfers are associated to the specific activity promoted at the local level. Consequently, they are not related to the number of diabetes patients followed by each GP.

As a consequence of specific objectives pursued at the local level, the agreements signed in the different HDs display large variability in terms of remunerated activities and in the size of the incentives but their common purpose is to promote better diabetes management. For this reason we have grouped all payments received by GPs for the different activities aimed at incenting better diabetes care in a unique variable, labeled "financial incentives". [5]

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[4] As a consequence of assumption of responsibility, GPs must comply with a range of requirements that include the regular reviews of their diabetes patients, consolidating the patient's knowledge and skills regarding eating plan, physical activity, home blood glucose self-monitoring, foot care etc.,, reviewing medication usage (oral hypoglycaemic agents or insulin), the periodic measure of their blood pressure and glycosylated haemoglobin (HbA1c), the timely referral to community and hospital based specialists.

[5] In a related work (Lippi Bruni, Nobilio and Ugolini 2009), for which data only for a single year were available, we constructed two different variables for financial incentives according to whether the additional transfers were paid on per patient basis or not. Since in several districts the classification of the different items of GPs remuneration has not been fully consistent over time, we have preferred here to consider a unique indicator for financial incentives, that groups together all items associated to different local diabetes programs, in order to avoid possible distortions in the longitudinal analysis. This strategy is consistent with the objectives of the

Since our aim is to study the influence of this aggregated variable on the quality of diabetes care, we consider the number of diabetic ACSCs a measure of outcome that, for several reasons, represents a good summary indicator for the latter. First, since the most important avoidable admissions for diabetes are hyperglycaemic emergencies, a reduction in the frequency of these life threatening episodes ensures substantial health gains. Moreover, regular and accurate reviews of patient's conditions together with delivery of appropriate levels of care by GPs should be able to avoid such complication. Finally, a reduction in the frequency of diabetic ACSCs or diabetic comas is not explicitly contracted upon in any of the districts that we consider. This excludes that GPs operating in a particular district might pay more attention than their colleagues operating elsewhere to this specific indicator, simply because they receive specific financial transfers for it while the other GPs do not.

A final important distinguishing feature of diabetes-related incentives is that in Emilia Romagna, differently from what the Region does in other clinical areas, the additional payments are not linked to ex-post monitoring of performances, measured by clinical or economic indicators. The main justification for this approach relies in the attempt to limit possible drawbacks due to motivation crowding out and reduced willingness to cooperate with public authorities that strict monitoring may induce, if physicians perceive supervision by LHAs as intrusive of the patient-physician relationship. Such concern appears particularly relevant in a context where primary care physicians preserve a very large degree of professional autonomy in referral and prescribing. At the opposite, the major shortcoming of such payment schemes is that the associated incentive structure may be too weak to influence physicians behavior in the desired direction, failing to generate substantial improvements in terms of appropriateness of patterns of care with respect to what is obtained with standard capitation. Given these premises, it is a open issue whether programs with these characteristics can ensure health gains to the population of diabetes patients. For this reason a sound empirical evaluation of their impact in the case under consideration may prove particularly useful for the design of effective incentive-based programs also in different institutional contexts.

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empirical part of the paper, that benefits of the panel dimension of the dataset for obtaining a more precise identification than previously done of the relationship between financial incentives and health care outcomes.

4. Methods

Data

The study population consists of all regional patients affected by diabetes type 2 followed from 2002 to 2005. According to WHO criteria, patients are classified as having type 1 diabetes if they were below 35 years of age at the time of diagnosis and are currently taking insulin; patients are classified as having type 2 diabetes if they were aged 35 or more at the time of diagnosis or if they are not currently treated with insulin. Consequently, we include in our list of patients all individuals above 35 years who had at least one prescription for diabetes medications (oral agents or insulin) during the year 2002. As some diabetes patients who are being managed through a diet and exercise alone can be missed with this strategy, we also include individuals who had at least one outpatient visit to a diabetic centre during the 2002 or an hospital admission with a diabetic diagnostic code in the previous two years. During the period 2002-2005 the average number of GPs active each year amount to 2960 (std.dv. 136).

As outcome indicator we consider the Ambulatory Care Sensitive Conditions (ACSCs) developed by Billings et al. (1993) that refer to diabetes. Number of hospitalisations are identified from hospital records in which ICD-9 codes 250.1, 250.2, 250.3, 250.8, 250.9, 250.0, 251 are documented as primary or most responsible diagnosis. The total number of adverse outcomes in the four years period is 4357, averaging to 1089 (std.dv. 227) hospitalization per year. The dependent variable is measured as the total number of diabetic ACSCs referred to the patients list of each GP. Table 1 show the frequency distribution of our outcome. As expected, the sample has a non trivial fraction of zero outcomes: 71.18% zeros on the total amount of hospital admissions referred to our diabetic population.

INSERT TABLE1

Table 2 displays the descriptive statistics of the sample used in the analysis. For each GP we consider gender, years of seniority and a dummy signalling the presence of any postgraduate qualifications. We also control for the type of practice, with a dummy that distinguishes single-handed from group practice and practice location with a dummy

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variable for rural areas. As regards patients list, we consider size, average age and the number of diabetic patients. Other characteristics of the list are the number of insulin dependent patients and number of visits to a diabetic outpatient clinic (DOC), which are expected to capture severity of illness.

INSERT TABLE 2

Figure 1 shows the distribution of the incentive mechanism across local areas in percentage terms on GPs annual income. This mechanism includes direct financial incentives for each diabetic patients assumption of responsibility and financial bonus for participation in improvement activities and for compliance with regional and local guidelines of care.

INSERT FIGURE 1

Statistical analysis

In our study the count variable – the number of diabetic ACSCs recorded in GP's list (denoted by y) has two fundamental statistical properties that are shown in Figure 2: to be non-negative and to follow a positively skewed distribution of the nonzero realizations.

INSERT FIGURE 2

For these count data structure we consider Poisson and Negative binomial regressions. The Poisson distribution is determined by one parameter, λ, that is equal to the mean and the variance. It is convenient to specify λ as a log-linear function of the explanatory variables x_i that account for observed sample heterogeneity: $E\left(y_i \middle| x_i\right) = \lambda_i = \exp(\beta_0 + \sum_j x_{ij}\beta_j) = \exp(\mathbf{x'}_i \boldsymbol{\beta}) > 0$. In this way, λ_i remains positive for all possible combinations of parameters and explanatory variables. Therefore, Poisson regression assumes that the dependent variable (*y*), e.g. the number of occurrence of an event, has a Poisson distribution given an independent variable vector:

$$f(y \mid \mathbf{x}) = P(y = k) = \frac{e^{-\lambda}\lambda^k}{k!}.$$

Assuming an independent sample, the parameters of the model can be estimated by the maximum likelihood method. Although the first-order condition is nonlinear and this not

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solvable in closed form, iterative algorithms can be used to find the maximum which is unique as the log-likelihood function is globally concave. The condition of equality of mean and variance in the Poisson distribution is very restrictive. When it is doubtful whether the strict requirements of *equidispersion* are satisfied the negative binomial regression (Hilbe, 2007) is the most commonly used alternative to the Poisson model. The extended model is (Hilbe and Greene, 2008):

$$E(y|x_i) = \exp(\mathbf{x'}_i \, \boldsymbol{\beta} + \varepsilon_i), \qquad\qquad Cov[\mathbf{x}, \varepsilon] = \mathbf{0}$$

where the unmeasured ε is a dispersion parameter measuring the extent of *overdispersion* (unmeasured heterogeneity). How the model evolves from here depends on what assumed about the distribution of ε. In the standard negative binomial model (Greene, 2008) $h_i = \exp(\varepsilon_i)$ is assumed to have a one parameter gamma distribution $G(\theta, \theta)$ with mean 1 and variance $1/\theta$:

$$f(h_i) = \frac{\theta^{\theta} \exp(-\theta \, h_i) h_i^{\theta-1}}{\Gamma(\theta)}, h_i \geq 0, \theta > 0$$

The marginal distribution of y is a Poisson-gamma mixture with a closed form and the marginal negative binomial (NB) distribution $NB(\lambda, \theta)$ is:

$$f(y_i \mid \mathbf{x}_i) = \frac{\Gamma(\theta + y_i)}{\Gamma(\theta)\Gamma(y_i + 1)} \left(\frac{\theta}{\lambda_i + \theta}\right)^{\theta} \left(\frac{\lambda_i}{\lambda_i + \theta}\right)^{y_i}$$

where $\Gamma(.)$ denotes the gamma integral that brings to an integer argument. The moments are $E(y_i \mid \mathbf{x}_i) = \lambda_i$ and $Var(y_i \mid \mathbf{x}_i) = \lambda_i + \frac{1}{\theta}\lambda_i^2$, where $\frac{1}{\theta}$ is a dispersion parameter measuring the extent of *overdispersion.* Therefore the conditional variance is always greater than the conditional mean: the negative binomial model is a model for overdispersion. The negative binomial model in previous equation is labeled the NEGBIN2 (Hilbe, 2007) in reference to the appearance of quadratic term for λ_i in the conditional variance function. Assuming an independent sample, the log-likelihood function of the Negative binomial (NB2) model is given by

$$\log L(\boldsymbol{\beta}) = \sum_{i=1}^{n}\left[\left(\sum_{j=1}^{y_i}\ln(1/\theta + j - 1)\right) - \ln y_i! - (y_i + 1/\theta)\ln\left(1 + \theta\exp(\mathbf{x}'_i\,\boldsymbol{\beta})\right) + y_i\ln\theta + y_i\mathbf{x}'_i\,\boldsymbol{\beta}\right]$$

Since the standard Poisson model does not allow the presence of overdispersion, we employ likelihood ratio (LR) test of overdispersion parameter $1/\theta$ to examine the validity of the Poisson specification against the negative binomial model ($H_0 : 1/\theta = 0$). This test is explained afterwards in the specification tests. After having chosen the model to employ, we observe the individual in time series. Panel data models are constructed in order to control for all for the stable predictors in the model and to account for correlation resulting from observation being associated within panel. The general approaches to nonlinear panel models are similar to those for linear models such as pooling, fixed effects, random effects.

The first approach to modelling panel data is simply to ignore the panel dependence that might be present. The result of this approach is called a pooled regression model since the data are simply pooled together. The resulting estimated coefficient vector is consistent, but it is not efficient. As a result, the estimated (naive) standard errors will not be a reliable measure for testing purposes. To address the standard errors, we may use a panel-robust estimate of variance that correct standard errors for any dependence over time for a given individual. Potential efficiency gains can occur if estimation accounts for the dependence over time that is inherent in panel data.

Other approaches assume that the dependent variable y_{it} varies over individuals ($i = 1,...,n$) and over time ($t = 1,...,T_i$).

The fixed effect (FE) model incorporate individual heterogeneity with an individual-specific intercept term.

$$\log \lambda_{it} = \alpha_i + \boldsymbol{\beta}'\mathbf{x}_{it} + \varepsilon_{it}$$

where α_i can be interpreted as the coefficient on a binary variable which indicates membership in the i-th group.

The alternative is called random effect (RE) model that can be written by:

$$\log \lambda_{it} = \boldsymbol{\beta}'\mathbf{x}_{it} + u_i$$

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where u_i is a random effect for the *i*-th group distributed as gamma with parameters $G(\theta_i, \theta_i)$. It is assumed that $\theta_i /(1+\theta_i)$ is distributed as Beta (a, b), which layers the random group effect onto the NB model. The random effect is added to the NB model by assuming that overdispersion parameter is randomly distributed across groups.

Deriving the probability and the log-likelihood function results in the following forms of the function

$$
\begin{aligned}
L(\boldsymbol{\beta}; y_{it}, a, b) = &\sum_{i=1}^{n_i} \ln \Gamma(a+b) + \ln \Gamma \left(a + \sum_{k=1}^{n_k} (\exp(\mathbf{x'}_{ik}\, \boldsymbol{\beta})) \right) \\
&+ \ln \Gamma \left(b + \sum_{k=1}^{n_k} y_{ik} \right) - \ln \Gamma(a) - \ln \Gamma(b) \\
&+ \ln \Gamma \left(a + b + \sum_{k=1}^{n_k} (\exp(\mathbf{x'}_{ik}\, \boldsymbol{\beta})) + \sum_{k=1}^{n_k} y_{ik} \right) \\
&+ \sum_{t=1}^{n_t} \left(\ln \Gamma((\exp(\mathbf{x'}_{ik}\, \boldsymbol{\beta})) + y_{it}) \right) \\
&- \ln \Gamma(y_{it}+1) - \ln \Gamma(\exp(\mathbf{x'}_{ik}\, \boldsymbol{\beta}))
\end{aligned}
$$

These models, FE and RE, can be fit by a conditional maximum likelihood or by a direct maximization of the full log-likelihood function (unconditional estimator). The conditional estimator derive from HHGs specification (Hausman et al, 1984). The fixed effect (dummy variable) coefficients appear directly in the distribution of the latent heterogeneity variable, not in the regression function. In general we prefer the HHG approach because the full unconditional maximum likelihood estimator of model that contain fixed effects is usually inconsistent - the estimator is consistent in T, but T is usually taken be fixed and small.

Random effects estimator is more efficient than fixed-effects estimator when the data come from within a larger population of observations, as well as when there are more panels in the data. Data coming from a smaller complete data set, with relatively few panels, prefer the fixed-effects estimator.

We use a likelihood ratio (LR) test of panel structure to examine the validity of the Pooled with robust error specification against the Panel model (fixed effect or random effect indifferently). After having detected the panel structure we use a Hausman test to decide whether the fixed or random effects model should be used (Hausman, 1984).

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Specification tests

For verifying the hypothesis that a modified count model with overdispersion is the adequate specification for our analysis we implement a likelihood ratio test for overdispersion parameter in the negative binomial specification against the Poisson model specification.

A formal test of the null hypothesis of equidispersion against the alternative of overdispersion could be formalized by this equation $V(y \mid x) = E(y \mid x) + a[E(y \mid x)]^2$. The outcome indicates the presence of significant overdispersion. The LR test is that if H_0 is valid, then imposing the restrictions in estimation of the parameters should make little difference to the maximized value of the likelihood function. The LR statistic is $LR = -2\{\ln L_{NB} - \ln L_{POIS}\} \xrightarrow{a} \chi^2(h)$. The LR statistic displayed in Table 3 reject the Poisson specification in favour of the Negative binomial specification.

For testing the presence of effects we use a likelihood ratio test in the random effect against the pooled with robust error. The LR statistic displayed at the bottom of Table 3 reject the pooled specification in favour of the effects' specification.

<div align="center">INSERT TABLE 3</div>

An important assumption of the random effects model is that the effects are uncorrelated with the errors. A Hausman test compares two estimators. Under the null hypothesis, both are consistent, but one is more efficient; under the alternative hypothesis, the more efficient of two becomes inconsistent but the less efficient remains consistent. Thus if the null hypothesis is verified, the two estimators should be similar; divergence indicates rejection of the null. The statistic is:

$$H = (\hat{\boldsymbol{\beta}}_{FE} - \hat{\boldsymbol{\beta}}_{RE})' [V\hat{a}r(\hat{\boldsymbol{\beta}}_{FE}) - V\hat{a}r(\hat{\boldsymbol{\beta}}_{RE})]^{-1} (\hat{\boldsymbol{\beta}}_{FE} - \hat{\boldsymbol{\beta}}_{RE})$$

For completeness, the statistic has χ^2 distribution with *K* df (degree of freedom), where *K* is the number of elements of the parameter's vector. Applying this computation to the models in Table 4 produces a χ^2 statistic of 35.77. The critical value from the table with 14

degrees of freedom is lower than 0.001. The hypothesis of the fixed effects model is rejected in favour of the Random effects model.

INSERT TABLE 4

Results

In Table 5 and 6 we report estimates for the different negative binomial model specification previously discussed. In particular, Table 5 reports the standard coefficients for (panel) count data models whereas Table 6 displays re-transformations of the standard coefficients in exponential forms to interpret them more directly as elasticities (incident-rate ratios).

INSERT TABLE 5 -6 ABOUT HERE

Estimation results are fairly consistent across specifications, with the only (partial) exception of the fixed effect (FE) model that displays some peculiar features. This is not surprising, if one consider that the FE specification includes an additive individual component whereas is the Negative Binomial implies a non linear specification of the unobservable component. Interestingly, the differences between FE and the other specifications only marginally affect the most relevant variables in a policy perspective, i.e. those related to financial incentives.

Given the results of the Hausman test (Table 3) that confronts the RE against the FE specification and provides support for the former, we focus our comment in particular on the results of the RE estimates. Individual characteristics of the GP, such as gender, specialisation and seniority are in general poorly significant.

On the contrary, we obtain statistically significant effects when we consider the characteristics of the list of patients falling under the responsibility of each GP. List size as well as number of diabetic and insulin dependent patients, they all positively contribute to record an increase in the number of diabetic ACSCs among GP's patients.

Our evidence indicates also that accessibility to primary and secondary care services plays an important role. For instance, rural location of a GP increases the risk of avoidable

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admissions among its patients, whereas a high frequency of visits to diabetic specialised wards reduces the numbers of adverse events. Quite interestingly the institutional arrangement of the practice has a limited impact, with patients followed by GPs operating in single handed practices displaying a higher frequency of diabetic ACSCs, once we control for the other covariates. Yet, this effect is only poorly significant (only at the 10% level).

An interesting insight is provided also by year dummies. The baseline case is year 2002, and all the year dummies display a negative sign, indicating that, other things equal, the number of adverse events has fallen over time. A more detailed check of the relative size of the coefficients suggests that a major improvement in the reduction of avoidable episodes was achieved between 2003 and 2004 and between 2004-2005, while no significant differences is observed between 2002 -2003.

The major policy issue discussed in the paper concerns the effectiveness of economic incentive in improving outcomes of diabetic care. More specifically, coefficients associated to financial incentives are highly significant in all specifications. Moving from FE to RE model, the size of the coefficients substantially increases in size, although inspection of Table 6 suggests that elasticity is fairly stable and reaches values that are just below one.

Overall, the empirical results on financial incentive indicate that they may be effective tools for improving outcomes in primary care. In particular, after controlling for a set of relevant factors such as GP individual characteristics and composition of the GP's list, an increase in the share of additional payments that a GP receives significantly reduces the expected number of avoidable hospitalisations experienced by patients included in its list.

Conclusions

In the present paper we have analysed the influence of economic incentives on the quality of primary care. We have focused on diabetes type II and we have considered financial transfers provided to GPs with the specific purpose of improving quality of treatment for such disease.

Our dataset spans over 4 years (2002-2005) and covers the population of diabetic patients and GPs operating in the Italian region Emilia Romagna. Thanks to a comprehensive dataset that links hospital records, pharmaceuticals prescriptions and provides details on GPs remuneration schemes, we have been able to associate the performance of each GP in terms outcomes of its diabetic patients to the share of money he/she receives for participating in health improvement activities in the area of diabetes care.

According to a well established epidemilogical literature (Billings et al. 1993), our outcome indicator is expressed as number of avoidable hospitalisations per year for ICD-9CM codes recognized as diabetic Ambulatory Care Sensitive Conditions. As . timely and good quality of treatment in a primary care setting should be able to prevent such hospitalisations, we take this adverse event as indicator of poor quality of primary care.

We estimate a series of panel count data models, where the dependent variable consists of the number of diabetic ACSCs recorded in the list of each GP. We control for a set of covariates aimed at capturing differences in size and composition of the list, as well as in individual characteristics of the GP. The results are fairly consistent across specification, with the partial exception of the fixed effect model, which is rejected in favour of a random effect specification.

The present work extends previous analysis to a more general setting, thanks to the availability of longitudinal data which allow to control for time-varying effects. We confirm and extend previous findings (Lippi Bruni et. al. 2009) on the role of economic incentives in the Italian primary care system, and in particular in diabetes management. The panel structure of the dataset guarantees a more precise identification of the causal relationship between financial transfers and outcomes of care and provides more accurate estimations of the impact of the former on disease management. Our results stress the importance of the size and of the incentive structure induced by the different sets of programs in order to exert a positive influence on patient outcome: financial incentives are consistently negative and significant across specifications, thus implying that patients being followed by GPs that receive a higher share of their wage through the programs have a lower probability to experience an avoidable hospitalisation.

Future research should be devoted to test similar hypothesis in different clinical areas and institutional settings, in order to support policymakers with a more general and robust spectrum of evidence for the design of effective incentives schemes able to improve referral and caring activities of primary care physicians.

Acknowledgements

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Table 1 - **Frequency distribution of the adverse outcome (diabetic ACSCs in GP's list)**

Number of adverse outcome	Freq.	Percent	Cum.
0	8428	71.18	71.18
1	2674	22.58	93.77
2	591	4.99	98.76
3	108	0.91	99.67
4	30	0.25	99.92
5	3	0.03	99.95
6	2	0.02	99.97
7	3	0.03	99.99
9	1	0.01	100
Total	**11,840**	**100**	

Table 2 - **Descriptive Statistics, GP characteristics year 2002-2005**

Variable	Coding	Mean	Std. Dev.	Min	Max
Adverse outcome	continuos	0.37	0.67	0	9
Postgraduate qualification	(if yes=1)	0.05	0.22		
GP gender	Male=1	0.77	0.42		
Practice rural location	(if yes=1)	0.06	0.23		
Practice type	Associated	0.68	0.46		
GP seniority	continuos (yrs)	18	8	0	47
List average age	continuos (yrs)	47	5	12	76
List size	continuos (nr. of patients)	1162	383	10	1941
List diabetics size	continuos (nr. of patients)	53	23	1	137
Insulin patients	continuos (nr. of patients)	8	5	0	29
Specialist visits	continuos (nr. of patients)	48	40	0	255
Financial incentives	continuos (% annual income)	0.67	1.31	0	14

Figure 1 - **Financial incentives in % GP annual income. LHAs, years 2002-2005**
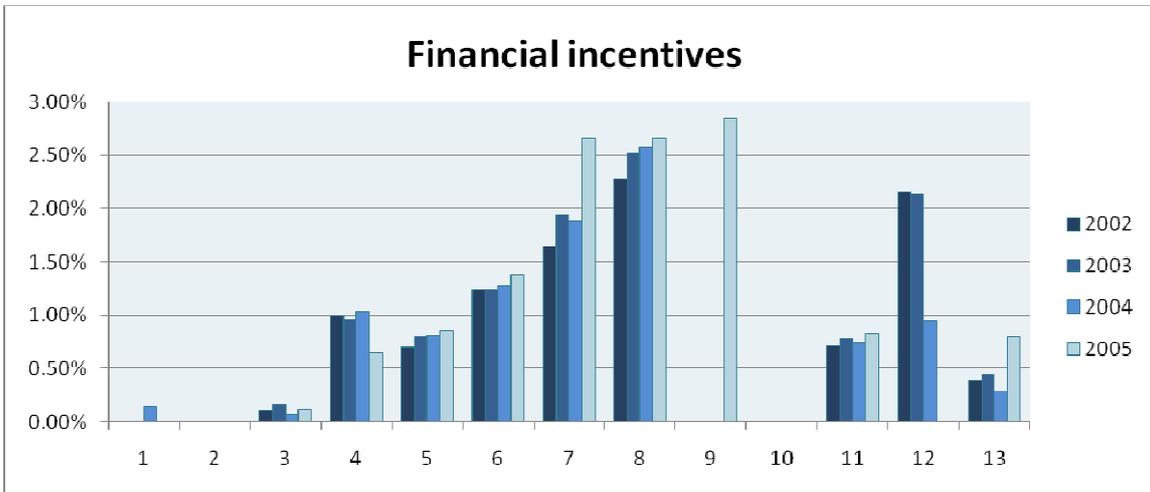
Figure 2 **- Density histogram of dependent variable with normal line. Years 2002-2005**
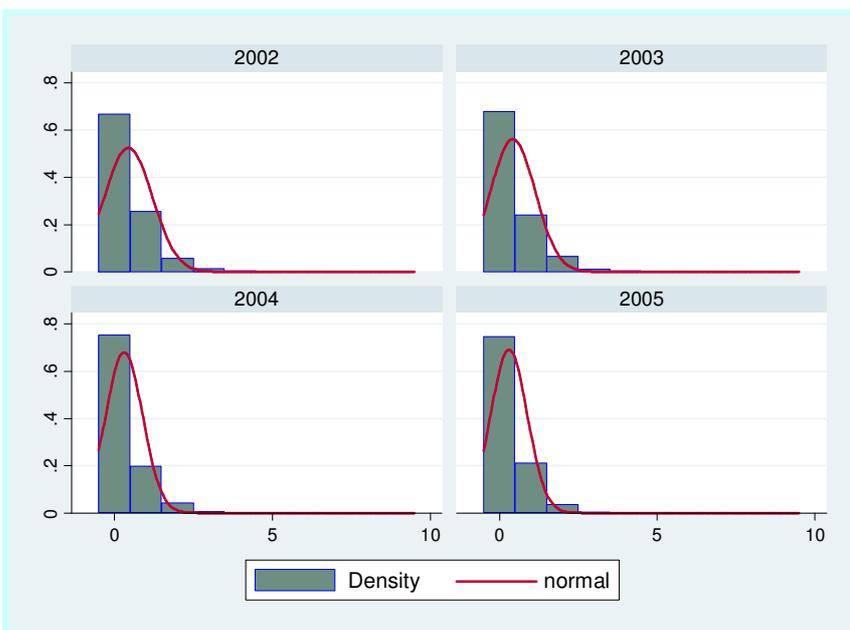
Table 3 – **Likelihood-ratio test**

Likelihood-ratio test LR					chi2(1)=	64.98
(Assumption: POISSON nested in NB)					Prob>chi2=	0.0000
Model	*Obs*	*ll(null)*	*ll(model)*	*df*	*AIC*	*BIC*
POISSON	11840	-9477	-9014	15	18058	18169
NB	11840	-9392	-8982	16	17995	18113

Likelihood-ratio test LR					chi2(1)=	99.49
(Assumption: POOLED nested in RANDOM EFFECTS)					Prob>chi2=	0.0000
Model	*Obs*	*ll(null)*	*ll(model)*	*df*	*AIC*	*BIC*
NB_POOLED	11840	-9392	-8982	16	17995	18113
NB_RE	11840	.	-8932	17	17898	18023

Table 4 **- Hausman test**

	COEFFICIENTS			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	NB_FE	NB_RE	Difference	S.E.
Postgraduate qualification	-0.400	0.023	-0.423	0.145
GP gender	-0.060	0.046	-0.105	0.076
GP seniority	0.000	0.000	0.000	0.014
List average age	-0.161	0.004	-0.165	0.208
List size	0.000	0.000	0.000	0.000
List diabetics size	0.012	0.010	0.002	0.005
Insulin patients	0.056	0.047	0.010	0.021
Specialist visits	0.000	-0.002	0.003	0.004
Practice rural location	-0.160	0.253	-0.413	0.192
Practice type	-0.209	-0.070	-0.138	0.072
Financial incentives	**-0.053**	**-0.046**	**-0.007**	**0.026**
year(2003)	0.084	-0.065	0.149	0.210
year(2004)	-0.067	-0.385	0.318	0.420
year(2005)	-0.300	-0.302	0.002	0.044

b=consistent under Ho obtained from xtn_fe

B =inconsistent under Ha obtained from xtn_re

Test: Ho: differences in coefficients is not systematic

chi2(14) = (b-B)'[(V_b-V_B)^(-1)](b-B)=35.77
Prob>chi2 =0.001

Table 5 – **Count data estimations**

Dependent variable: number of diabetic ACSCs in GP's list. Year 2002-2005.

Variable	NB_Pool_Rob	NB_FE	NB_RE
Postgraduate qualification	0.0649	-0.4000**	0.0233
GP gender	0.0575	-0.06	0.0455
GP seniority	0.0002	0.0003	0.0001
List average age	0.0036	-0.1614	0.0036
List size	0.0002***	0.0001	0.0002***
List diabetics size	0.0099***	0.0120**	0.0104***
Insulin patients	0.0449***	0.0564**	0.0465***
Specialist visits	-0.0022***	0.0004	-0.0022***
Practice rural location	0.2671***	-0.1598	0.2534***
Practice type	-0.0585	-0.2087**	-0.0704*
Financial incentives	**-0.0478*****	**-0.0527*****	**-0.0459*****
year(2003)	-0.0652	0.0842	-0.0651
year(2004)	-0.3879***	-0.0674	-0.3853***
year(2005)	-0.3106***	-0.3002***	-0.3023***
Constant	-2.1486***	11.147	1.5770***
ln_alpha	-1.3184***		
ln_r			5.2608***
ln_s			1.5216***
STATISTICS			
N	11840	7863	11840
ll	-8982	-4182	-8932
aic	17995	8395	17898
bic	18113	8499	18023

*Legend: * p<.1; ** p<.05; *** p<.01*

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Table 6 - **Count data estimations**

Dependent variable: Number of diabetic ACSCs in GP's list. Year 2002-2005. Coefficients in exponentiated form.

Variable	NB_Pool_Rob	NB_FE	NB_RE
Postgraduate qualification	1.0670	0.6703**	1.0236
GP gender	1.0592	0.9418	1.0466
Seniority	1.0002	1.0003	1.0000
List average age	1.0037	0.8510	1.0036
List size	1.0002***	1.0000	1.0002***
List diabetics size	1.0099***	1.0121**	1.0105***
Insulin patients	1.0459***	1.0580**	1.0476***
Specialist visits	0.9978***	1.0004	0.9978***
Practice rural location	1.3062***	0.8524	1.2884***
Practice type	0.9432	0.8117**	0.9320*
Financial incentives	**0.9534***	**0.9487***	**0.9552***
year(2003)	0.9369	1.0879	0.9369
year(2004)	0.6785***	0.9348	0.6802***
year(2005)	0.7330***	0.7407***	0.7391***
Constant	0.1166***	69000	4.8403***

Legend: * p<.1; ** p<.05; *** p<.01