Variation in HbA1c prescription for patients with diabetes in French general practice: an observational study prior to the implementation of a P4P programme

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Background: Prior to a large diffusion of a pay-for-performance programme (P4P) in primary care in France, it seemed of particular interest to identify, the doctors not performing optimally who could be the main target of this programme. Based on the example of HbA1c prescription for patients with diabetes, this study examined the impact of general practitioner's (GPs) characteristics on the variation of a P4P indicator for diabetes care, i.e. the percentage of patients undergoing three or four HbA1c tests during one year. **Methods:** We used a large database from the national health insurance fund for salaried workers in Brittany to select a cohort of patients with diabetes who had been attended to by their doctors for 1 year. In all, 2545 GPs attending to 41 453 patients with diabetes were included. A two-level hierarchical logistic model was used to analyse the data. **Results:** Thirty-six per cent (SD = 22.3) of patients with diabetes underwent three or four HbA1c tests during the year (the target objective was 65% in a patient list). There was a large variability between GPs, even after adjusting for patient characteristics. Doctors who were female, young, working in a group practice, participating in quality-control groups, and who had a lower patient load prescribed the three or four recommended tests more often. **Discussion:** The results indicate a target group of doctors which require attention. There is still room to improve the quality of care for patients with diabetes in general practice, notably by encouraging doctors to train better and practice in groups.
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Introduction

In recent years pay-for-performance (P4P) programmes for general practitioners (GPs) have increased substantially in numerous countries, as has the recognition of significant variations in the quality of health care. These programmes use performance incentives, including cash payments and public reports, to motivate clinicians, health practitioner groups and health care systems to achieve specific health care quality goals.[1] In France, an experimental programme of voluntary participation by GPs, a 'Contract for Improving Individual Practices' (CAPI: '*contrat d'amélioration des pratiques individuelles*') is being implemented.[2] This is a contract between the participating GP and the French national insurance plan (*l'assurance maladie*); in the programme, each practitioner receives an annual premium if he attains fixed objectives, particularly for the prescription rate of certain medications or tests to monitor chronic ailments. For the insurance plan, the development of this results-based payment system could lead to a diversification of remuneration practices for French GPs, which is currently dominated by payment per act, a system that is *ex post facto* judged to be inflationary.[3]

Diabetes is one of the disease areas within the clinical domain of the CAPI. Diabetes is among the leading chronic diseases in developed countries. Ensuring that patients with diabetes receive evidence-based care to control disease and reduce the risk of complications is a significant challenge; much evidence exists of the gap between optimal care and the actual care patients receive.[4] Many patients with diabetes are now managed solely or mainly in primary care. Since it is recommended internationally and by the *Haute*

Autorité de Santé (French National Authority for Health), the level of glycated haemoglobin (HbA1c) in patients suffering from diabetes must be tested three or four times a year.[5] There is good evidence that the risk of cardiovascular complications of diabetes can be reduced by careful control of blood glucose.[6] The CAPI's targeted objective has been established at 65%; no matter whether HbA1c is prescribed by the GP or other specialists, 65% of patients with diabetes in a patient list must be followed according to this recommendation, considering that the GP is responsible for treating and following the diabetes.

There is already an important body of research, particularly in the USA and the UK, studying the impact of P4P on the quality of health care. Surprisingly, there is little rigorous evidence to support or refute use of these programmes.[7] Prior to a large diffusion of the CAPI in France, it seemed of particular interest, because we had the opportunity to access a large database from the health insurance fund, to identify the doctors not performing optimally who could be the main target of this programme.[8] The objective of the present study was to assess, just before the P4P programme was to be implemented, the variability of HbA1c prescription rate between doctors and, depending on patient characteristics, to examine the impact of GP characteristics on the variation of the P4P indicator.

Methods

Settings and participants

Our study used a database of workers reimbursed by the French national health insurance fund for salaried workers

(CNAMTS: *Caisse nationale de l'assurance maladie des travailleurs salariés*) in the Brittany region in northwestern France. Information was collected between 1 January and 31 December of 2008. This database routinely collects information from all patients affiliated with this fund for the reimbursement of their health care. The database also includes information regarding the characteristics of prescribing doctors. In France, National Health Insurance (*l'assurance maladie*) is mandatory; all salaried workers are registered with the CNAMTS. Since 2006, all those affiliated with the CNAMTS are required to select a referral doctor (*médecin traitant*), most often a doctor specializing in general medicine, to access other specialists or hospital treatments. Establishing this gate-keeping system has not changed the status of French GPs, who are still principally paid by the act whether practicing alone or in a group practice. All consultations, scans and biological tests, including HbA1c tests, reimbursed by the CNAMTS are recorded in this database and are potentially retrievable using the 'Common Classification of Medical Acts' (*Classification Commune des Actes Médicaux*) and the 'Nomenclature of Acts of Biological Medicine' (*Nomenclature des Actes de Biologie Médicale*) terms. Prescribed and reimbursed medications can be identified by their Anatomical Therapeutic Chemical (ATC) codes.

Our research was approved on 4 May 2009 by a representative of the French Data Protection Authority (*Commission Nationale Informatique et Libertés*) at the CNAMTS regional directorate for medical services.

Patients were included in the study if they had been prescribed at least one oral anti-diabetic drug and/or insulin during the last quarter of 2007, at least one in 2008 and at least one during the first quarter of 2009 and were registered with a referral doctor in 2008. Oral anti-diabetic drugs and insulin were included in the A10 medication class in the ATC classification system.[9] We excluded patients whose doctors initiated, modified or ceased their activity in 2008. Doctors included in the study were the diabetic patients' referral doctors.

Study variables

The doctor variables examined in this study included age (≤40 years/40–54 years/≥55 years), gender (male/female), type of practice (single doctor/group practice), participation in quality-control group (yes/no) and total number of patients registered with the GP (including patients affiliated with funds other than CNAMTS) (≤1375/>1375). It is noteworthy that working in group practice meant that doctors could work with one or more other specialists (in general practice or whatever) in the same surgery and/or with one or more other health care professionals (such as nurses, physiotherapists, etc.) in multidisciplinary care teams (maison de santé pluri-disciplinaire). We should also specify that participating in a quality-control group enabled GPs from the same geographical area to meet regularly, to discuss their practice and the problems they encounter and thus to break out of their isolation, to develop new forms of relationships and to form a professional group.

Due to their potential impact on doctor practices,[10,11] the following patient variables were used as adjustment factors: age (<65, 65–75, >75 years), gender (male/female), hospitalization in 2008 (non-hospitalized/hospitalized in endocrinology/hospitalized in other units), the number of vascular comorbidities (0/1/≥2) and the number of visits to the referral GP in 2008 (≤5, >5). We also considered whether the patient benefited from Universal Medical Coverage (*Couverture Médicale Universelle*: CMU), which is a proxy for patients' socioeconomic level because this coverage is for low-income beneficiaries (yes/no).

Statistical analyses

The variables were descriptively analysed. The dependent variable was whether or not a diabetic patient had three or four HbA1c tests during the year ('1' if the patient had 3 or 4 tests and '0' otherwise). The prescription for HbA1c tests can be identified in the database by the code 1577 of the Nomenclature of Acts of Biological Medicine.[12] For each doctor, the mean of this variable corresponded to the percentage of patients with diabetes in his/her patient list who were prescribed a HbA1c test three or four times a year (called 'diab'). The analysis was based on a multilevel approach using HLM software.[13]

Three models were specified. The first, the empty model, was designed to investigate whether there was a significant difference between doctors, with respect to the prescription of HbA1c tests. The second model allowed a between-doctor comparison of these prescriptions adjusted for the patient characteristics. The third model was designed to measure the impact of GP characteristics. The estimation method used was 'penalized quasi-likelihood,' which took overdispersion into account. The total variance of the dependant variable was considered in the measure of the intra-class correlation to be composed of the variance of the intercepts at the GP level, as well as the level-one residual variance for the logistic model.[14] The variables available at the two levels were retained and included in the model.

A Hosmer–Lemeshow test with a grouping strategy based on percentiles of the estimated probabilities was performed and the area under the Receiver Operating Characteristic (ROC) curve was calculated to evaluate the goodness-of-fit of the model.[15]

Results

A total of 41 453 patients treated by 2545 GPs were included in this study. Patients' and doctors' characteristics are summarized in table 1. The mean diab per doctor was 35.8% (SD = 22.3). Table 2 presents the mean diab (SD) according to doctors' characteristics. Table 3 presents the percentage of patients having three or four HbA1c tests per year according to patients' characteristics.

The estimations of the logit specification introduced in Equation 1 are reported in table 4.

In the patient model, older patients, patients who did not benefit from CMU, patients who had not been hospitalized and patients who had more than five visits during the course of the year were significantly more likely to be prescribed HbA1c as recommended. There were strong interactions between the number of vascular comorbidities and the number of visits to the referral GP. More patients had comorbidities, more they were followed as recommended, but only when the number of visits to the referral GP was higher than five per year.

Between-doctor variability: after controlling for patient characteristics, the probability for a GP to prescribe at least three or four HbA1c per year was 33.6% with a range of 9%–77.1%.

The doctor model integrated the variables observed at the doctor level into the explanation of the between-doctor variability of prescription of HbA1c tests. We observed, after adjusting for patient characteristics, that female doctors, doctors who were younger, working in a group practice, participating in quality-control groups and who had a number of patients registered ≤1375 (third quartile) more often prescribed the three or four recommended tests. Although significantly decreased in the doctor model, the between-doctor residual variance remains significant.

The value of the Hosmer–Lemeshow goodness-of-fit was 6.49 and the corresponding *P*-value was 0.59. The area under the ROC curve was 0.58.

Discussion

These study results on medical practice variation (MPV) are of particular interest when analysed from the perspective of implementing a P4P programme. They show a great variability between practices without a complete explanation neither with patient

Table 1 Patients' and doctors' characteristics in frequency unless stated otherwise

Variables	
Patients (_n_ = 41 453)	
Sex	
Male	53.0
Age (years)	
<65	44.7
65–74	28.8
≥75	26.4
Beneficiary of the CMU	
Yes	2.3
Associated vascular co-morbidities	
0	76.3
1	19.6
≥2	4.1
Hospitalization	
Not hospitalized	81.3
Hospitalized in an endocrinology unit	4.7
Hospitalized in another unit	14.0
Number of visits to the referral GP during the year 2008	
Five visits or less	30.7
More than five visits	68.9
Mean number (SD) of visits to the referral GP during the year 2008	8.4 (5.2)
Dependent variable: Whether or not a patient had 3 or 4 HbA1c tests/year	
Yes[a]	36.0
Mean number (SD) of HbA1C test per patient during the year 2008	2.20 (1.4)
Vascular comorbidities:	
Hypertension	13.6
Ischaemic heart disease	7.6
Stroke	4.3
Peripheral arterial disease	3.3
GPs (_n_ = 2545)	
Sex	76.0
Male	
Age (years)	17.5
≤40	61.4
40–54	21.1
≥55	
Group practice	
Yes	57.3
Participation in a quality-control group	
Yes	16.9
Total number of registered patients (all insurance plans)	1100 (844–1375)[b]

a: 4.4% of patients had 5 or more HbA1C tests/year.
b: Median (Q1–Q3).

characteristics nor GP characteristics. They demonstrate that there is still room to improve further the quality of care for patients with diabetes in general practice and to intervene by encouraging doctors to better train and/or practice in group.

Weaknesses of our study

The main limitations of our research are related to shortcomings in the health insurance databases. Firstly, part of the medical activities performed still eludes this information system, particularly in regard to patients with diabetes who are not yet receiving oral anti-diabetic treatment or insulin. These patients hence were absent from our data. It is, however, reasonable to hypothesize that they represent a small percentage relative to those in the database. Nevertheless, it may limit the generalizability of the findings. Secondly, this database only includes HbA1c tests presented for reimbursement, which does not accurately reflect the activities of practitioners since patients are not necessarily compliant. This can lead to an under-estimation of the number of tests prescribed. We cannot assess to what extent this phenomenon exists for patients with diabetes in this database. Finally, while this might have influenced the delivery of care, we did not have access to patients' socioeconomic status (educational or income levels). Nevertheless, until now, these databases were one

of the only sources of large-scale medico-economic data in France, and their role implies that there is relatively little missing data. Moreover, these same data are used today to calculate P4P indicators. Another limitation of the study, which is not related to shortcomings in the database, is linked to the fact that the study focuses on only one P4P indicator for only one disease area (diabetes care). This limits the scope of our results to diabetes care. However, our discussion on monetary incentives in combination with P4P might be applicable to other domains of care.

Comparisons with other studies

Our results were, most of the time, consistent with those already published. We found that younger GPs prescribed the tests more often. This result goes along with those of Choudhry et al.[16] who systematically reviewed data relating experience and age to physician performance across different medical specialties and found that 70% of studies demonstrated a negative association between length of time in practice and several measures of good physician performance. There are many possible explanations for these findings, and perhaps most plausible, write the researchers, is that doctors' 'toolkits' are created during training and may not be updated regularly. Older physicians seem less likely to adopt newly proven therapies and may be less receptive to new standards of care.

Concerning the effect of gender on the performance of care, Bensing *et al.*[17] showed that besides the expected differences in female-specific problems, there is a clear GP-gender effect in the presence of 'social' and 'metabolic' problems in the female GP's consultations in general practice. More recently, Kim *et al.*[18] showed that patients of female physicians were slightly more likely to have their lipid and HbA1c levels measured over 12 months than patients of male physicians. It is also what we found in our study.

We found a negative significant association between the number of patients registered with the GP and glycemic control. Without any clear explanation why, our results were not consistent with those of Holmboe *et al.*[19] They found that Medicare fee-for-service patients with diabetes cared for by physicians with greater numbers of diabetic Medicare patients in their practice were more likely to

receive important diabetes processes of care. However, our results were closer to those of Millett *et al.*[20] who found that the performance of small practices was broadly similar to larger practices in achievement of intermediate outcome targets for HbA1c, blood pressure and cholesterol.

Finally, doctors who worked in a group practice and who participated in quality-control groups more often prescribed the three or four recommended tests. These results were consistent with those of a systematic review of controlled trials evaluating the effectiveness of interventions targeted at health care professionals and aimed at improving the process of care or patient outcomes for patients with diabetes in primary care, outpatient and community settings.[21] In the studies in which the interventions were targeted at health care professionals only, postgraduate education combined with local consensus procedures, reminders, audit and/or feedback improved the provision of diabetes care in all studies that did not demonstrate a good standard of care at baseline. In the studies in which multidisciplinary teams were implemented in combination with arrangements for follow-up and patient education, glycemic control and cholesterol improved significantly. Very recently in France, a case-control study that used HbA1c tests as an indicator of quality of care in general practice was performed to compare the effectiveness and costs of experimental teamwork involving doctors and nurses working together to the usual model of doctors working in a single-doctor practice. After 11 months of follow-up, the authors concluded that working in a team was more cost-effective.[22]

Non-monetary incentives in combination with P4P

Thus, returning to the question of P4P, we aimed to identify a target group of doctors which require attention; the doctors not performing optimally, who could change their follow-up of diabetic patients if their reimbursement were changed.[23,24] It has been shown that English family practices attained high levels of achievement in the first year of the new P4P contract and that achievement was higher in practices with doctors under the age of 50 years and in smaller practices.[25,26] Our data show that doctors practicing alone were not performing optimally. Although we believe

Table 2 Comparison of the mean percentage of patients with diabetes in doctors' patient lists having three or four HbA1C tests per year according to doctors' characteristics

Doctors' characteristics	Percentage of patients with three or four HbA1C tests per year [mean (SD)]	P-value*
Sex		
Female	40.3 (24.5)	$<10^{-4}$
Male	34.3 (21.3)	
Age (years)		
<40	43.4 (24.5)	$<10^{-4}$
40–54	35.3 (21.8)	
≥55	30.1 (19.5)	
Group practice		
Yes	37.2 (21.5)	$<10^{-3}$
No	33.8 (23.1)	
Participation in a quality-control group		
Yes	39.9 (21.4)	$<10^{-4}$
No	34.9 (22.3)	
Patient list (patients)		
>1375	33.9 (19.9)	10^{-2}
≤1375	36.3 (22.9)	

*Fisher test.

Table 3 Comparison of the distribution of patients with diabetes on whether or not they had three or four HbA1C tests per year according to patients' characteristics

Patient characteristics	Having three or four HbA1C tests per year	Having less or more than three or four HbA1C tests per year	P-value*
Sex			
Male	7786	14 198	0.0125
Female	7125	12 344	
Age (years)			
<65	6180	12 365	<0.0001
65–74	4615	7338	
≥75	4116	6839	
Beneficiary of the CMU			
Yes	274	661	<0.0001
No	14 637	25 881	
Associated vascular co-morbidities			
0	11 318	20 296	0.2411
1	2952	5185	
≥2	641	1061	
Hospitalization:			
Not hospitalized	12 279	21 410	<0.0001
Hospitalized in an endocrinology unit	600	1344	
Hospitalized in another unit	2032	3788	
Number of visits to the referral GP during the year 2008			
Five visits or less	3924	8785	<0.0001
More than five visits	10 950	17 629	

*Chi-squared test.

Table 4 Multilevel model of the probability of having three or four HbA1c tests during the year

Explanatory variables	Empty model		Patient model		Patient/doctor model	
Fixed effects	**Coeff. (SE)**	**P-value**	**Coeff. (SE)**	**P-value**	**Coeff. (SE)**	**P-value**
Constant	−0.62 (0.02)	****	−0.93 (0.03)	****	−0.50 (0.07)	***
Patient-level ($n = 41\,453$)						
Age (ref.: <65 years)						
65–74 years			0.19 (0.03)	****	0.20 (0.03)	****
≥75 years			0.11 (0.03)	***	0.11 (0.03)	****
Sex (ref.: female)			−0.01 (0.02)		−0.01 (0.02)	
Beneficiary of CMU (ref.: no)			−0.31 (0.08)	****	−0.32 (0.08)	****
Hospitalization (ref.: none)						
In endocrinology			−0.23 (0.06)	****	−0.24 (0.06)	****
In other unit			−0.12 (0.03)	****	−0.12 (0.03)	****
Interaction comorbidities* number of						
visits (ref.: co-morbidity = 0 at number of visits≤5)						
Comorbidity = 0						
—Nb visits >5			0.39 (0.03)	****	0.39 (0.03)	****
Comorbidity = 1						
—Nb visits ≤5			−0.03 (0.06)		−0.04 (0.06)	
—Nb visits >5			0.33 (0.04)	****	0.33 (0.04)	****
Comorbidities ≥2						
—Nb visits ≤5			−0.14 (0.12)		−0.14 (0.12)	
—Nb visits >5			0.43 (0.06)	****	0.43 (0.06)	****
Doctor level ($n = 2545$)						
Sex (ref.: female)					−0.20 (0.05)	****
Age (ref.: <40 years)						
40–54					−0.34 (0.05)	****
≥55					−0.57 (0.06)	****
Group practice (ref.: no)					0.09 (0.04)	**
Participation in a quality-control group (ref.: no)					0.21 (0.05)	****
Patient list (quartiles) (ref.: <Q1–Q3)					−0.11 (0.04)	***
Random effects						
Variance components Doctor level	0.57 (0.76)	****	0.59 (0.77)	***	0.54 (0.73)	****
Intra-class correlation coefficient	0.15		0.15		0.13	

****$P < 0.001$; ***$P < 0.01$; **$P < 0.05$; *$P < 0.1$.

that caution is needed if we want to draw conclusions from the studies undertaken in the UK to predict the chances of P4P in France, their results lead to the hope that the P4P might be successful in France in this target group of doctors practicing alone. In terms of doctors' ages, the conclusions that we could draw are different. In our study, doctors over the age of 50 years were not performing optimally. Since they are less sensitive to P4P, according to the British studies cited above, the fact that the doctors in our sample worked more often in solo practice and participated less in quality-control groups strengthens the idea that they could benefit from incentives other than financial ones. Of course, these doctors' characteristics only explain a small part of doctors' compliance in our model, however it can be suggested that educational incentives or organizational changes combined with P4P could allow to hope for better results.[7,8] The addition of postgraduate education (including quality improvement programme) might be important in providing practitioners with the skills and knowledge to improve their performance, but they must be convinced of the importance of changing their practice and must be motivated to carry it out. In addition to the skills, knowledge and motivations of individual care providers, organizational barriers can impede the implementation of change by care providers and must therefore be addressed.[21] The question is how to complete this task. The development of group practice inside multidisciplinary care teams has recently been encouraged by the French legal framework. On their own initiative, health care professionals can sign co-operation protocols after consultation with the French National Authority for Health, and following authorization by the Regional Health Agency. Their object is to transfer activities or care or to arrange intervention procedures for patients (such as therapeutic education programmes) that draw upon different health care professionals according to their respective knowledge and experience. Henceforth, the question of doctors' motivations to commit themselves becomes essential.

Intrinsic motivation refers to engaging in an activity for no reason other than the enjoyment and satisfaction of the activity itself. Numerous research studies outside the scope of this article have recently broached this theme. Intrinsic motivations may be especially relevant in social services, particularly in teaching and health care, both of which have been traditionally described as vocations.[27] It is probably only after focusing on these questions, specifically in the field of health care, that one will find the information needed to answer the question of the success of these P4P programmes.

Acknowledgements

Key points

- There is little rigorous evidence to support or refute the use of pay for performance (P4P) incentive in the UK and United States. Prior to the implementation of a primary care P4P programme in France, it seemed of particular interest to identify the GPs who could be the target of this programme.
- We showed that much remains to be done to improve the quality of diabetes care in general practice since only 36% (±22.3) of patients with diabetes in the GP patient list underwent three or four HbA1c tests during the year (target objective of the P4P programme is 65%).
- We observed, after adjusting for patient characteristics, that female doctors, doctors who were younger, working in a group practice, participating in quality-control groups, and who had a number of patients registered ≤1375 (third quartile) more often prescribed the three or four recommended tests.
- The results indicate a target group of doctors that require attention and suggest there is still room to improve the quality of care for patients with diabetes in general practice, notably by encouraging doctors to train better and/or practice in groups.

References

1 Rosenthal MB, Frank RG, Li Z, Epstein AM. Early experience with pay-for-performance: from concept to practice. *JAMA* 2005;294:1788–93.

2 Journal officiel de la République française (JORF) [French Republic Official Journal (Official laws and settlement Journal of the French Republic)]. n°0093 du 21 avril 2009 page 6839, texte n° 34.

3 Shafrin J. Operating on commission: analyzing how physician financial incentives affect surgery rates. *Health Economics* 2010;19:502–80.

4 McGlynn EA, Asch SM, Adams J, et al. The quality of health care delivered to adults in the United States. *N Engl J Med* 2003;348:2635–45.

5 AFSSAPS-HAS. Recommandation Professionnelle. Traitement médicamenteux du diabète de type 2 (Actualisation). Novembre 2006. Recommandation de Bonne Pratique (Synthèse et Recommandations). *Diabetes Metab* 2007;33:1S1–1S105. www.has-sante.fr. Mise à jour 29/11/2011. [AFSSAPS-HAS. Professional Guidelines. Type 2 Diabetes medication (Update). November 2006. Guidelines (Summary and recommandations). Diabetes Metab 2007;33:1S1–1S105. www.has-sante.fr.] (29 November 2011, date last accessed).

6 Stratton IM, Adler AI, Neil HA, et al. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. *BMJ* 2000;321:405–12.

7 Serumaga B, Ross-Degnan D, Avery AJ. Effect of pay for performance on the management and outcomes of hypertension in the United Kingdom: interrupted time series study. *BMJ* 2011;342:d108.

8 Chaix-Couturier C, Durand-Zaleski I, Jolly D, Durieux P. Effects on financial incentives on medical practice: results from a systematic review of the literature and methodological issues. *Int J Qual Health Care* 2000;12:133–42.

9 World Health Organisation. Guidelines for ATC classification and DDD assignment. NorskMedisinaldepot, Oslo, 1996.

10 Omar RZ, O'Sullivan C, Petersen I, et al. A model based on age, sex, and morbidity to explain variation in UK general practice prescribing: cohort study. *BMJ* 2008;337:a238.

11 Jotkowitz A, Rabinowitz G, Segal A, et al. Do patients with diabetes and low socioeconomic status receive less care and have worse outcomes? A national study. *Am J Med* 2006;119:665–9.

12 Caisse Nationale de l'Assurance Maladie. Table Nationale de Biologie. Mise à jour du 07/03/2011 [National Health insurance Fund. National Biology Table. Update]. http://www.ameli.fr/professionnels-de-sante/directeurs-d-etablissements-de-sante/-codage/codage-des-actes-biologiques-nabm.php (7 March 2011, date last accessed).

13 Raudenbush S, Bryk A, Yuk FC, et al. Hierarchical linear and nonlinear modelling. Lincolnwood: Scientific Software International, 2000.

14 Snijders T, Bosker R. An introduction to basic and advanced multilevel modelling. London: Sage Publications, 1999.

15 Hosmer DW, Lemeshow S.Applied logistic regression. A Wiley series in probability and statistics, 2000.

16 Choudhry NK, Fletcher RH, Soumerai SB. Systematic review: the relationship between clinical experience and quality of health care. *Ann Intern Med* 2005;142:260–7.

17 Bensing JM, Van Den Brink-Muinen A, De Bakker DH. Gender differences in practice style: a Dutch study of general practitioners. *Med Care* 1993;31:219–29.

18 Kim C, McEwen LN, Gerzoff RB, et al. Is Physician gender associated with the quality of diabetes care? *Diabetes Care* 2005;28:1594–8.

19 Holmboe ES, Wang Y, Tate JP, Meehan TP. The effects of patient volume on the quality of diabetic care for Medicare beneficiaries. *Med Care* 2006;44:1073–7.

20 Millett C, Car J, Eldred D, et al. Diabetes prevalence, process of care and outcomes in relation to practice size, caseload and deprivation: national cross-sectional study in primary care. *J R Soc Med* 2007;100:275–83.

21 Renders CM, Valk GD, Griffin SJ, et al. Interventions to improve the management of diabetes in primary care, outpatient, and community settings. *Diabetes Care* 2001;24:1821–33.

22 Mousquès J, Bourgueil Y, Le Fur P, Yilmaz E. Effect of a French experiment of team work between general practitioners and nurses on efficacy and cost of type 2 diabetes patients' care. *Health Policy* 2010;98:131–43.

23 Shen Y. Selection incentives in a performance-based contracting system. *Health Serv Res* 2003;38:535–52.

24 Campbell S, Reeves D, Kontopantelis E, et al. Quality of primary care in England with the introduction of pay for performance. *N Engl J Med* 2007;375:181–90.

25 Doran T, Fullwood C, Reeves D, et al. Exclusion of patients from pay-for-performance targets by English physicians. *N Engl J Med* 2006;355:375–84.

26 Tahrani AA, McCarthy M, Godson J, et al. Impact of practice size on delivery of diabetes care before and after the Quality and Outcomes Framework implementation. *Br J Gen Pract* 2008;58:576–9.

27 Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol* 2000;55:68–78.