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Does better quality GP care reduce admissions for ambulatory care sensitive conditions?

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Abstract
Hospital admission rates for ambulatory care sensitive conditions (ACSCs) (also known as potentially avoidable hospital admissions) are widely used as an indicator of the quality of primary medical care. We investigate the validity of ACSCs as quality measures by estimating the effect of technical quality of care, measured from clinical audit of patient records, on hospital admission rates for 3 ACSCs (asthma, angina, and diabetes) using data on 42 GP practices in England for the years 1998 and 2003. We control for factors outside the control of the GP practice, such as disease prevalence, morbidity, demographic and socio-economic characteristics of patients registered with the GP practice.

Our preliminary analysis finds mixed results, and weak evidence supporting the hypothesis that better quality of primary care leads to a reduction in hospital admissions for angina, asthma and diabetes. A 10% increase in angina quality leads to a 4.5% (t-stat = 1.73) reduction in practice admission rates. For asthma there is little evidence of any quality effect. A 10% improvement in the quality of care for diabetes in GP practices leads to an 11.6% (t-stat = 2.61) increase in diabetes ACSC admissions. Most of the variation in admission rates is explained by morbidity, demographic and socio-economic characteristics and differences in the geographic location of GP practices. Caution is required when using ACSC hospital admission rates as a measure of the quality of care provided in GP practice.

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1 Introduction

Ambulatory care sensitive conditions are conditions where timely and effective outpatient intervention is likely to reduce the risk of hospitalization by 'preventing the onset of the illness or condition, controlling the acute episodic illness or condition, or managing the chronic disease or condition' (Billings et al., 1989). For example, effective drug therapy administered in an outpatient setting can prevent hospital admissions for angina. Patients with diabetes and asthma may be hospitalized for complications if not adequately treated, monitored and educated in primary care. Hospital admission rates for ACSCs have been commonly used as a measure of the accessibility and quality of primary care in the US, UK, AUS, NZ and Canada (AHRQ 2004; Giuffrida et al, 1999; Weissman 1992; Jackson and Tobias, 2001).

There are a number of concerns about the application of ACSCs admission rates as a performance indicator in general practice. A valid performance indicator should accurately reflect variations in actual performance that are under the control of the GP practice and related health care system and which improve health outcomes (Goddard et al, 2002; Giuffrida et al, 1999). Variations in ACSC admission rates, however, are influenced by many factors considered beyond the control of the primary care provider such as patient demographic and socio-economic characteristics, provision of secondary care, geographical and environmental factors and pure randomness. Hence using health outcome indicators such as ACSCs admissions as a direct measures of the quality of primary care may be misleading. They are an indication of the size of the medical problem in a population, but the extent to which crude admission rates directly measure quality needs to be assessed since the relationship is not immediate. Admission rates for ACSCs are rare events and may suffer form statistical instability, as a consequence, the indicators may not be applicable to individual GP practices with an average population size of 6,000 patients.

More direct measures of the quality of care provided in primary care can be derived from the assessment of patient medical records through clinical audit based on criteria derived from systematic review of high quality evidence on best practice and combined with expert opinion (Campbell et al, 2002a; Campbell et al, 2002b; Marshall et al, 2002). These measures of quality capture technical processes of care. They have the advantage of being readily attributable to the provider and easy to interpret without requiring adjustment so can give a clear answer as to whether or not a GP practice is providing adequate levels of care. By contrast, poor performance on an outcome measure gives no such indication (Goddard et al, 2002).

Data abstraction from records has been found to underestimate quality of care because what GPs record may not reflect what they actually do (Backer et al, 2000). Hence poor audit results can either reflect poor care or poor recording, however, there is evidence that better medical record keeping is associated with better quality of care (Solomon et al. (2000); Kosecoff et al. (1987)).

Clinical audit is resource-intensive, and sometimes impractical (Schreiber and Zielinski, 1997), whereas ACSCs admission rates are generally easily measured for the whole population of practices and over long time spans. If ACSCs are a good measure of quality they could provide useful information about the performance of individual practices and robust estimates of the factors affecting quality of care. They could, for example be used to assess the impact of the new GP contract with its financial incentives for quality.

To our knowledge few studies have examined the relationship between clinical indicators of quality in primary care and ACSC admission rates (Reid et al, 1999, AHRQ; 2004). In this paper we provide some new evidence on the relationship between ACSC admission rates and directly measured clinical indicators for a sample of English practices.

2. Literature review

There is little evidence on the extent to which effective treatment in an outpatient setting would reduce the incidence of hospitalisation for ACSCs. We have not found any studies that attempt to directly measure the effect of quality of care provided in a primary care setting on ACSC admission rates. A summary of the existing evidence, although mainly from the US is contained in The Agency for Healthcare Research and Quality's guide to Prevention Quality Indicators (2004). In one of the most relevant studies, Bindman et al (1995) found that self-reported "difficulty in receiving medical care when needed" was positively and significantly associated with 5 ACSC admission rates, controlling for condition prevalence, propensity to seek care, physician admitting style, and ecological measures of income, education, insurance, race, and gender. Komaromy et al. (1996) found that having a regular source of care and a lower primary care physician/population ratio to be independently associated with lower rates for avoidable hospitalisations. Laditka et al (2005) found that higher levels of primary care physician supply were associated with lower ACSH rates, although the evidence for the effect of density of primary care physician supply is mixed (Ricketts, 2001; Krakauer et al, 1996; Schreiber S. and Zielinski T, 1997; Parchman & Culler, 1994; Laditka, 2004). Several studies have shown ACSCs admissions to be higher amongst the poor, ethnic minorities, and the uninsured (Hayward et al, 1991; Weissman et el., 1992; Billing et al., 1993; Billings et al., 1996; Lambrew et al 1996; Scheiber & and Zielinski, 1997; Begley et al., 1994; Krakauer et al., 1996; Ricketts, 2001; Laditka et al., 2003; Dafny et al., 2005) which may reflect problems due to poor access to primary medical care or may be capturing the effects of confounding factors associated with increased risk of hospital admission. The influence of other factors such as condition prevalence, morbidity, health care-seeking behaviour, physician practice style, lifestyle and secondary care supply and reimbursement incentives on admissions has been document in previous studies (Giuffrida, 1999; Lambrew et al, 1996; Parchman & Culler 1994, Bindman et al, 1995; Brown et al, 1992; Dusheiko & Gravelle, 2005).

3.Data

The data is a panel of admission rates and quality scores for 42 GP practices over two time periods. Data on practice demographic and socio-economic characteristics and measures of rurality, geographic location and access to secondary care are attributed from a variety of sources including practice population surveys, census information and administrative data. The data come from five main sources: Hospital Episode Statistics, the Quality Assessment and Review Study (QUASAR) and General Practice Assessment Survey (GPAS), General Medical Statistics (GMS) GP census and the AREA project.

3.1 Ambulatory care sensitive admissions

Data on all hospital admissions by GP practice for angina, diabetes and asthma were obtained from Hospital Episode Statistics (http://www.hesonline.nhs.uk/) for the financial years 1997/98 – 2003/04. The data records patients who are formally admitted to a hospital bed for day case procedures, and those who are admitted for a longer period as inpatients. Only finished consultant spells (a spell of care can be made up of more than one finished consultant episode) were counted for both elective and emergency admissions and for patients of all ages. ICD-10 primary diagnosis codes were used to determine the main cause of admission. The criteria for classifying admissions were based on the prevention quality indicators from the Agency for Healthcare Research and Quality in the United States (AHRQ, 2004) and the Victorian Ambulatory Care Sensitive Conditions Study (2004)). We used a moving average of 1997/98, 1998/99 and 1999/2000 admission rates for the 1998/9 admission rates and a moving average of 2002/03 and 2003/04 admission rates for the 2003/04 admission (2004/05 data not yet available).

3.2 Outcomes data -clinical quality scores

Practice quality of care indicators for angina, asthma, and diabetes come from a sample of 42 practices in two years, 1998 and 2003. This was part of the QUASAR study of GP practice quality (Campbell et al, 2001; Campbell et al, 2003). At each practice a random sample of medical records (up to 20) for patients over 18 and diagnosed with the respective condition were obtained. These records were then assessed against a set a published quality criteria (see Table 1) (Marshall et al, 2002). A score was derived for each patient as a percentage of the indicators met. A practice quality score was estimated by the mean patient score and represents the average percentage of audited aspects of care met per patient.

3.3 Measures of practice disease prevalence, health status demographic and socio-economic status

The General Practice Assessment Questionnaire (http://www.gpaq.info/) is a measure of patient satisfaction and experience with their GP. It was modified to include detailed questions about patient health status, demographic and socio-economic characteristic. The GPAS survey undertook separate random samples of 200 patients over 18 for each GP practice in 1998 and 2003. Response rates to the survey were on average 38.5% (s.d. 23.30) in 1998 and 54.5% (s.d. 34.60) in 2003. The survey asked patients whether they had been diagnosed with asthma, angina and diabetes. Hence it was possible to estimate the prevalence of each disease in the practice's adult population. To improve the precision of the estimated prevalence, a weighted average for the two years was used. A number of health measures from the GPAS survey including long-standing limiting illness, self-assessed health (2003 only) and the SF-6D summary health state measure (Brazier et al. 2002) were included. Demographic and socio-economic characteristics of the practice population including ethnicity, number of children in household, marital status, number of cars, employment status, household income (1998 only), education (2003 only) and home ownership status. These variables were used to calculate practice level averages and proportions for characteristics of the practice population.

3.4 AREA project data

From the AREA project (Sutton, et al., 2002) additional attributed measures of socio-economic characteristics of the GP practice and detailed information about access to secondary care and primary care were obtained. Data from the 1991 census and the Indices of Multiple Deprivation were assigned and supply characteristics including the average distance to and average number of beds at the practice's 5 nearest hospitals. There are also measures of the accessibility of the GP practices.

3.5 General Medical Services Statistics

Data on practice characteristics come from General Medical Service statistics for 1996 – 2003. It contains data relating to practice patients, the practice partnership and services provided. These include the size and demographic characteristics of the GP practice's patient list. A two year moving average of the practice list size was used to smooth the effects of measurement error in the list size and to align the data better with the financial years used by HES. The GMS data also included details of the number of GPs in the practice, the age of the GPs, the gender of the GPs, the qualifications of the GPs and the services provided by the practice.

4 Methods

4.1 Descriptive analysis

We investigate the distribution of admission rates and quality scores and the change in admissions and quality over time using histograms, normal plots and box plots. We identify a suitable transformation for normality, such as the logarithm using the *ladder* command in STATA version 8.2 to implement skewness and kurtosis tests for normality as well as graphical examination. Box plots showing the difference between the quartiles, the median and extreme values were used to compare distributions of admissions and quality scores over time and to identify outliers. Mean comparison tests were performed to test for significant changes in practice admission rates and quality over time. We looked at the crude relationship between practice quality and admissions for each condition, pooling all observations over time, by plotting the two against each other and fitting a regression line.

4.2 Regression Analysis

The intention of the analysis is to estimate the direct effect of practice quality on hospital admissions, controlling for potential confounding factors that have a direct effect on hospital admissions and which may be associated with GP quality. We specify the following structural model for practice hospital admission rates:

$$y_{it}^{c} = \beta_0^c + \beta_1^c t_t + \beta_2^c q_{it}^c + \beta_k^c x_{kit} + \alpha_i + \varepsilon_{it}^c \qquad (1)$$

$$q_{it}^{c} = \gamma_0^c + \gamma_{1j}^c z_{jit} + \gamma_{2k}^c x_{kit} + \upsilon_{it}^c \qquad (2)$$

where $i = 1,...,42;\ t = 1998, 2003;\ \text{c = angina, asthma, diabetes}$. y_{it}^c is the admission rate for practice i in period t for condition c (asthma, angina or diabetes), t_t is a time trend dummy variable, q_{it}^c the measure of practice quality, and x_{kit} is a vector of k covariates (both time varying and time invariant) thought to have a direct effect on admission rates and potentially practice quality, but uncontrollable by the GP practice such as the disease prevalence, level of morbidity, age, gender, ethnic composition and the socio-economic characteristics of the practice. z_{jit} is a vector of j GP practice characteristics thought to have a direct effect on the quality of care q_{it}^c, for example the number of GPs, nurses and patients; the age, experience and competence of the GPs and nurses; the opening hours and accessibility of the practice etc. We assume that conditional on q_{it}^c, the z_{jit}^c do not have a direct effect on hospital admissions y_{it}^c, hence we do not include the z_{jit}^c variables in (1). We do control for x_{kit}^c in the y_{it}^c equation as these are potential confounding variables that may influence quality and have a direct effect on admissions. We assume that q_{it}^c has no direct influence on the set of x_{kit}^c variables. α_i captures unobserved heterogeneity across GP practices thought to affect admissions, ε_{it}^c is a practice and time specific error term for the admission rate model and υ_{it}^c an idiosyncratic error term influencing quality which is assumed independent of ε_{it}^c .

4.3 Model estimation and variable selection

The aim of this paper is to estimate β_2^c the direct effects of quality on admission rates, therefore, we estimate only the 'outcome' models (1) separately for angina, asthma and diabetes using pooled cross sectional and fixed effects (within group) panel data estimators. Both are estimated using ordinary least squares (OLS) with robust (Huber/White) standard errors and allowing for within practice correlation in the residuals using the *cluster* option. Pooled cross sectional OLS estimation does not allow for unobserved heterogeneity across practices α_i, and treats the data as one large cross section. Parameter estimates take account of only the between practice correlation, and may be biased if there is correlation between α_i and q_{it}^c. The fixed effects estimator includes practice intercept parameters for α_i and therefore uses only the within practice variation in the dependent and explanatory variables. The fixed effects estimates of β_2^c will not be biased by correlation between α_i and q_{it}^c. The standard errors will be consistent but less efficient than the pooled OLS estimator.

We first estimate equation (1) excluding all x_{kit} by pooled OLS, but include the time trend t. We then compare these estimates with those of the fixed effects to infer the extent of confounding bias due to unobserved time invariant characteristics.

To test whether quality scores remain independently associated with preventable hospitalization rates after controlling for factors outside the control of GPs we include the set of control variables x_{kit}. Due to the small sample size, we use a general to specific stepwise selection procedure to exclude insignificant covariates (10% significance level) in order to increase the precision of our estimates by increasing the number of degrees of freedom and reducing collinearity between variables. We selected the set of control variables x_{kit} by drawing on the existing theory and evidence on factors that influence admissions for angina, asthma and diabetes and by conducting preliminary bivariate analysis to identify highly correlated variables. We included disease prevalence, proportion with limiting long-standing illness, the SF-6D general health state measure, age bands, gender, income, education, ethnicity, number of cars, housing, children, marital status, distance to nearest 5 acute providers, number of beds at the nearest 5 providers, and to capture environmental and geographic characteristics dummy variables for the health authority (a geographic administrative health area) in which the practice is located.

4.4 Expected effects of covariates

We expect to observe negative effects of practice quality on admissions by definition of ACSC admissions. Higher prevalence of disease and morbidity of the population would be expected to increase admissions. Demographic variables would be expected to capture prevalence of the disease and possibly also differences in behaviour. One would expect practices with better socio-economic characteristics to have lower admission rates. Finally, health authority dummy variables and measures of access to and supply of secondary care are likely to capture geographical and environmental factors that influence admissions.

4.5 Tests for model specification

Ramsey's RESET test and added variable plots are estimated to check model specification. Variance Inflation Factors are calculated to detect collinearity between covariates. Diagnostic tests for normality of residuals are performed, and Cook's distances computed to identify outliers. An F-test on all the excluded variables is performed after stepwise regressions to assess the validity of the restricted model (Fox, 1997).

5 Results

5.1 Effects of GP practice on quality on hospital admission rates

Table 2 provides descriptive statistics for all the variables used in the analysis. Table 2 shows a comparison of mean practice quality scores and admission rates for asthma, angina and diabetes over time. There is a significant increase in quality between 1998 and 2003, the largest increase being for angina. Log admission rates also decrease significantly for asthma and diabetes. Figure 1 shows a scatter plot with fitted regression line for practice admission rates against quality scores for 1998 and 2003 combined. There is a negative relationship between angina (elasticity = -0.54%, t-stat = -2.05, Adj R^2 = 0.03) and asthma admission rates (elasticity = -0.53, t-stat = 1.79, Adj R^2 = 0.04) and their respective practice quality scores. For diabetes the scatter plot indicates a positive relationship (elasticity = 0.49%, t-stat = 1.05, Adj R^2 = 0.01).

Table 4 compares the estimated coefficients β_2^c and associated elasticity estimates for the effects of quality on the log of admission rate for each condition for three different models: a pooled cross-sectional model for the effect of practice quality on log admission rates controlling only for a common time trend; a fixed effects model with trend; a stepwise pooled cross sectional regression conditioning on confounding factors thought to have a direct effect on the relationship between quality and admissions and to be beyond the control of the GP practice. The simple pooled cross sectional model (column 1 for each condition) for diabetes has a positive association between quality and admission rates. A 1% increase in practice quality scores leads to a 0.79% increase in practice admissions. For asthma and angina there is a negative, but insignificant association (elasticities of -0.38% and -0.45%

respectively). The relationship between practice quality and admission rates for asthma and diabetes is confounded by a common downward trend in admissions. The simple pooled OLS with trend explains 3%, 4% and 2% of the variation in diabetes, asthma and angina admission rates respectively. Fixed effects estimates (column 2 for each condition) for diabetes show that on average the effect of quality on diabetes is still positive and larger than in our simple pooled cross-sectional regressions (elasticity = 1.15%). The effect for asthma, however, is now positive (elasticity = 0.23%). For angina the effect of quality remains negative and the effect is somewhat larger than in our simple pooled cross sectional model (elasticity = -1.10%). Again, none of the estimated effects of quality are significant at the 10% significance level. After controlling for practice characteristics in a pooled cross sectional regression (column 3 for each condition), we find the effect of diabetes quality on log admission rates to be positive and statistically significant at the 5% significance level with an estimated elasticity of 1.16%. There is no statistically significant effect of asthma quality on admissions with a small negative elasticity of -0.11% . For angina we find a significant (at the 10% level) negative effect. A 1% increase in quality leads to a -0.45% decrease in admission rates.

5.2 Effects of potential confounding factors on practice admission rates

Table 5 shows the full set of results from the stepwise pooled cross-sectional model which includes the set of x_{kit}^{c} variables found to be individually or jointly significant. For diabetes (column 1) the proportion of patients reporting a limiting long standing illness (elasticity = 1.36%) and the proportion of patients without A-Level education (elasticity = 1.06%) are associated with higher admission rates. An increase in the proportion of white people (elasticity = -0.39%), and patients aged under 5 (elasticity = -1.49%), aged 45-64 (elasticity = -0.68%) and aged over 65 (elasticity = -0.87%) are associated with a decrease in admission rates. A 1% increase in the proportion of individuals in households with income over £20K leads to a significant decrease in admissions of 0.59%. There is significant variation in practice admission rates between health authorities. The model explains 51% of the sample variation in log admission rates.

For asthma (column 2) a 1% increase in the proportion of patients reporting limiting long-standing illness increases admission rates by 0.32%. An increase in the proportion of white people (elasticity = 0.99%), in the proportion aged under 5 (elasticity = 0.64%) and in the proportion aged 45-64 (elasticity = 1.08%) increases practice admission rates. A 1% increase in the average number of cars available to households within the practice decreases admission rates by 0.92%. We also find significant differences between health authorities. The percentage of the sample variation in log admission rates explained by the model is 65%.

For angina admission, we find a small positive effect of self-reported prevalence (elasticity = 0.17%). An increase in the proportion of female patients (elasticity = 5.01%), white patients (elasticity = 0.64%), and the proportion aged 45-64 (0.42%) and over 65 (0.20%) is associated with a significant increase in admission rates. A 1% increase in the proportion of economically active or in education is associated with a 0.65% decrease in admissions. A greater average distance from the GP practice to its 5 nearest providers leads to a decrease in the admission rates (elasticity = 0.26%). There was no significant variation between health authorities. The percentage of the sample variation in log angina admission rates explained by the model is 40%.

6. Discussion

There is weak evidence that better quality of care reduces hospital admissions for angina, but no effect of quality on admissions for asthma. There is a significant but counter-intuitive positive effect for diabetes. The majority of variation in admission rates is explained by factors beyond the control of the GP practice. For diabetes and asthma a higher proportion of patients with limiting long-standing illness are associated with higher admission rates. For angina and asthma the effects of age and gender reflect the prevalence of the disease in the population and for diabetes more responsible glycaemic control. There is evidence of socio-economic inequalities in hospital admissions. Practices with on average higher incomes and better educated populations have lower admission rates for diabetes complications. A higher average number of cars owned by households in the practice is associated with lower asthma admission rates and for angina admissions are lower in practices with a higher proportion of employed patients. We find that asthma and angina admissions increase with the proportion of white patients. This result is somewhat unexpected, and could be the result of survey non-response bias.

Our estimates are for a small number of practices, with rare event outcome data and a measure of quality based on a small sample of patients within each practice. Therefore the study may be sensitive to outlier observations and have low power. We do, however, find statistically significant effects for diabetes and angina quality in the pooled cross-sectional model as well as significant and highly plausible effects for confounding factors. The data is aggregated at practice level and not patient specific data. Hence we are unable to capture the complexity of the GP and patient interaction and to control for confounding factors. We are assuming that our measure of quality captures all dimensions of care important in the prevention of hospital admission. The quality scores used in our analysis, however, capture mainly the clinical aspect of the care, and may not measure other important dimensions of quality.

The significant positive effect of practice quality on diabetes admissions does put into question the ACSC paradigm. Tighter glycaemic control can lead to an increase in admissions for hypoglycaemic emergencies, but reducce admissions for longer term complications due to poor glycaemic control. This suggests that it may be important to discriminate between different types of admissions for diabetes. The counter-intuitive result may also indicate that there is a limit to what GP practices can do to prevent patients developing diabetes complications, and that the extent of 'unmet need' in terms of undiagnosed patients who require hospital treatment may be greater in poor quality practices.

7. Conclusions

Our preliminary analysis provides mixed evidence on whether better quality GP care reduces hospital admission rates for ambulatory care sensitive conditions. We find weak evidence that improved quality of angina care reduces hospital admissions. A 10% increase in quality decreases admissions by -4.5% in the pooled OLS and by -11% in the fixed effects model but the estimates are not significant at the 5% level. There was no effect of asthma quality on admission rates. For diabetes there is evidence that better quality significantly increases admissions rates. A 10% increase in practice quality increases practice admission rates by 11.5%. The majority of variation in admission rates is explained by factors beyond the control of the GP practice. It confirms that crude admission rates are an inaccurate quality indicator for primary care and suggests considerable caution is required when applying admission rates as a proxy of quality in primary care.

In future we hope to increase the power of our study by incorporating additional observations from a related study on different GP practices. We also hope to improve the reliability of our estimates by investigating overly influential observations and to use another year of hospital admissions data. We intend to estimate a model that allows other observable practice characteristics that may capture other dimensions of quality and effectiveness. We will also explore different classifications of diabetes admissions that discriminate between short and long-term complications and hypo and hyperglycaemic admissions. We are interested to explore other econometric methods and approaches to test the robustness of our results.

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Appendix

Table 1: List of criteria used in quality assessment for angina, asthma e diabetes2

Angina		**Asthma**		**Diabetes**	
Past 14 month record	Past 5 year record	Past 14 month record	Past 5 years record	Past 14 month record	Past 5 years, record of:
Blood pressure Prescribed or advised to take aspirin unless record of contraindication or intolerance Prescribed ß blocker as maintenance therapy if sole therapy Frequency or pattern of angina attacks Action taken on blood pressure if systolic blood pressure >160, or >140 if cholesterol level >5.5 mmol/l Exercise capacity	Smoking status Smoking advice to smokers Cholesterol Weight advice if overweight Dietary advice Action taken if cholesterol >5.5 mmol/ Referred for specialist assessment Referred for an exercise ECG	Record of daily, nocturnal or activity limiting symptoms	Speech rate, Pulse rate or respiratory rate during a consultation for an exacerbation of asthma if immediate bronchodilator therapy was used Oral steroids prescribed if peak flow <60% of normal/predicted Smoking status Normal or predicted peak flow or record of difficulty using a peak flow meter Peak flow during a consultation for an exacerbation of asthma Action taken if patient experiencing nocturnal symptoms Smoking advice to smokers Referral to a respiratory physician where oral steroids are used in maintenance treatment Action taken if patient experiencing activity limiting symptoms Inhaler technique For patients with recorded exercise induced bronchospasm, short acting bronchodilators prescribed for use before exercise Self-management plan for those on high dose steroids or who have had inpatient treatment for asthma	Blood pressure HbA1c Weight Serum creatinine Examination of fundi or visual acuity Urine proteinuria Recording of peripheral pulses or record of vibration sense Visual examination of the feet Record of hypoglycaemia symptoms if patient on sulphonylurea	Smoking status Documentation of education about diabetes if diagnosed <5 years Serum cholesterol Advice given to smokers Blood pressure: (criteria developed before publication of UKPDS trial38) Under 80 years: Offered treatment if average of last 3 readings shows diastolic >100 or systolic >150 and diastolic >90 Treatment (criteria developed before publication of UKPDS trial38) Referral to a specialist where serum creatinine is >200 mmol/l For patients under 70, where the last HbA1c was >9, patient offered a therapeutic intervention aimed at improving glycaemic control For patients over 70, where the last HbA1c was >10, patient offered a therapeutic intervention aimed at improving glycaemic control If patient is being treated for hypertension and has proteinuria (macro- but not micro-albuminuria), the patient is on an ACE inhibitor

Table 2. Descriptive statistics for dependent and explanatory variables (obs=84)

Variable	Mean	Std. Dev.	Min	Max
Diabetes admission rate /10, 000	11.19	7.97	1.66	38.81
Asthma admission rate / 10, 000	14.47	11.74	1.32	63.47
Angina admission rate /10, 000	17.56	9.22	4.09	55.94
Diabetes quality score	74.13	12.80	35.0	94.61
Asthma quality score	65.02	16.56	20.61	97.19
Angina quality score	69.57	13.21	37.36	94.54
Diabetes prevalence	0.06	0.04	0.014	0.22
Asthma prevalence	0.14	0.03	0.091	0.23
Anginaprevalence	0.06	0.03	0.009	0.12
Limiting longstanding illness (lli)	0.30	0.08	0.118	0.51
SF-6D health status	0.81	0.03	0.663	0.86
Ethnicity (white)	0.88	0.23	0.000	1.00
Female population	0.49	0.02	0.455	0.57
Population aged 0-4	0.13	0.03	0.087	0.24
Population aged 25-44	0.23	0.05	0.079	0.31
Population aged 45-64	0.15	0.04	0.077	0.29
Population aged 65 +	0.15	0.05	0.033	0.26
Married	0.69	0.09	0.273	0.88
Number of children	0.66	0.32	0.244	2.10
Below A-level education	0.90	0.11	0.585	1.06
Household income ≥ £20, 000	0.29	0.13	0.000	0.53
Household car number	1.01	0.22	0.391	1.40
Employed or in education/training	0.65	0.09	0.473	0.84
Housing (own/mortgage)	0.76	0.14	0.304	0.95
Rural patients	0.08	0.19	0.00	0.76
Average distance to 5 nearest hospitals	23.83	9.64	13.7	47.45

Table 3. Change in the average quality scores and ACSC admission rates (1998 to 2003)

ACSC and year	Mean (SD)	Mean difference†	Range
Angina quality score			
1998˜	60.52 (9.68)	18.27	37.36-75-67
2003	78.79 (9.56)	(10.69)*	47.39-94.50
Asthma quality score			
1998	60.61 (16.47)	9.83	20.61-85.5
2003	69.63 (15.29)	(3.46)*	40.05-97.19
Diabetes quality score			
1998	69.81 (13.74)	8.65	35.00-88.85
2003	78.46 (10.23)	(4.74)*	50.10-94.61
Angina admission rate (logs)			
1998	2.81 (0.42)	-0.14	1.84-3.74
2003	2.67 (0.59)	(1.57)	1.41-4.02
Asthma admission rate (logs)			
1998	2.57 (0.64)	-0.31	1.18-4.15
2003	2.26 (0.75)	(3.57)***	0.28-4.10
Diabetes admission rate (logs)			
1998	2.27 (0.68)	-0.21	0.73-3.38
2003	2.06 (0.78)	(1.81)*	0.51-3.66

† absolute value of t-statistic in brackets ˜ only 41 practices

Figure 1. Scatterplots of log admission rates against quality scores

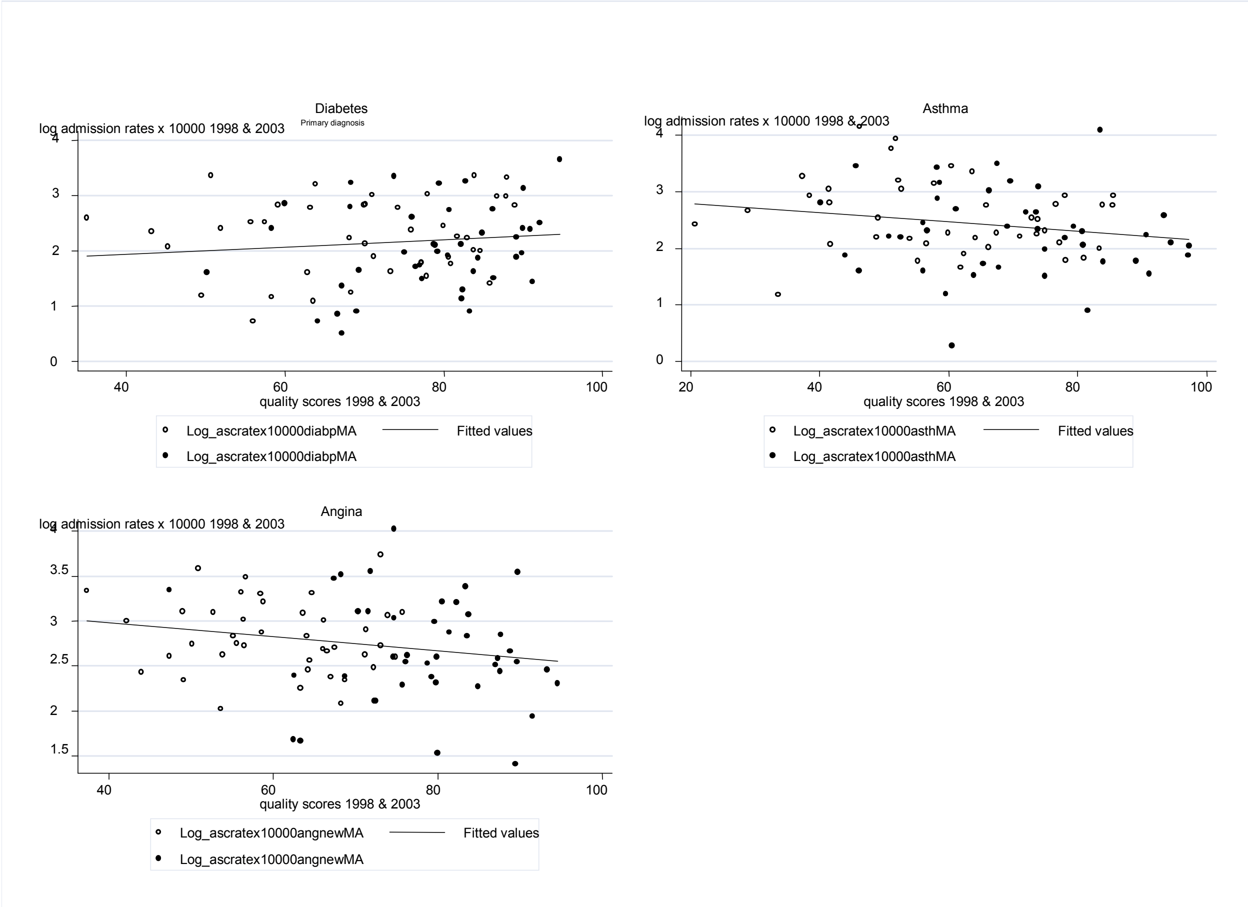

Table 4. Pooled cross sectional and fixed effects OLS regressions of admission rates on quality scores with time trend

	Diabetes admission rate (logs)			Asthma admission rate (logs)			Angina admission rate (logs)		
	Pooled	Fixed effects	Pooled Cond	Pooled	Fixed effects	Pooled Cond.	Pooled	Fixed effects	Pooled Cond.
quality score	0.011	0.016	0.016	-0.006	0.004	-0.002	-0.007	-0.016	-0.006
	(1.55)	(1.12)	(2.61) **	(1.25)	(0.63)	(0.60)	(1.17)	(1.44)	(1.73)*
year	-0.301	-0.343	-0.369	-0.248	-0.340	(-0.18)	-0.048	0.149	
	(2.47)**	(2.29)**	(2.77)***	(2.74)***	(3.04)***	(1.98)*	(0.35)	(0.73)	
constant	1.524	1.184	2.996	2.923	2.359	0.428	3.228	3.776	7.328
	(2.91)***	(1.17)	(2.97)***	(8.66)***	(6.42)***	(0.62)	(9.18)***	(5.51)***	(4.35)***
Elasticity	0.79	1.15	1.16	-0.38	0.23	-0.11	-0.45	-1.10	-0.45
Obs	84	84	84	84	84	84	83	83	83
Adjusted R-squared	0.03	0.76	0.51	0.04	0.85	0.65	0.02	0.70	0.40

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5. Stepwise pooled cross sectional OLS for admission rates (log)

	Diabetes	Elasticity	Asthma	Elasticity	Angina	Elasticity
quality score	0.016	1.16	-0.002	-0.11	-0.006	-0.45
	(2.61)**		(0.60)		(-1.73)*	
year	-0.369		-0.178			
	(2.77)***		(1.98)*			
prevalence					2.80	0.17
					(1.28)	
lli	4.571	1.36	1.072	0.32		
	(6.14)***		(1.45)			
ethnicity	-0.446	-0.39	1.129	0.99	0.719	0.64
	(0.78)		(3.22)***		(2.12)**	
female					-9.711	-5.01
					(-3.04)***	
age 0-4	-11.368	-1.49	4.909	0.64		
	(2.68)**		(1.74)*			
age 25-44	-3.569	-0.82				
	(1.56)					
age 45-64	-4.665	-0.68	7.387	1.08	3.828	0.42
	(2.13)**		(4.02)***		(2.58)**	
age 65+	-5.752	-0.87			1.29	0.20
	(2.53)**				(0.82)+	
income ≥ £20K	-2.006	-0.59				
	(2.91)***					
> A-level education	1.169	1.06				
	(1.87)*					
health authority QAY	0.583		-0.188			
	(2.46)**		(0.78)			
health authority QC9	0.775		0.465			
	(4.10)***		(2.58)**			
health authority QCT	0.478		0.327			
	(1.87)*		(1.78)*			
health authority QD5	0.453		-0.095			
	(1.83)*		(0.70)			
health authority QD8	1.364		-0.119			
	(6.76)***		(0.95)			
number of Cars			-0.920	-0.92		
			(3.37)***			
employment					-1.01	-0.65
					(-1.40) +	
distance to hospital					-.011	-0.26
					(1.78)*	
constant	2.996		0.428		7.328	
	(2.97)***		(0.62)		(4.35)***	
Observations	84		84		83	
Adjusted R-squared	0.51		0.65		0.40	

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

+ Jointly significant (employment and age 65+) F(2, 41) = 3.98**