

Inequalities in access to coronary angiography and revascularisation: the association of deprivation and location of primary care services

JULIA HIPPISELEY-COX

MIKE PRINGLE

SUMMARY

Background. Coronary artery surgery reduces re-infarction rates and mortality in patients with ischaemic heart disease. This study examines inequality in relation to primary care services.

Aim. To determine the effect of primary care services on access to coronary angiography and revascularisation.

Method. A cross-sectional survey of all 180 Nottinghamshire practices in the Trent region that were in existence between 1993 and 1997. The numbers of coronary bypass grafts, angioplasties, and angiographies were determined from the regional National Health Service database and linked to a database of general practice characteristics. Poisson regression analysis was used to determine the relationship between the angiography and revascularisation rates and the following practice characteristics: deprivation score, distance from nearest secondary or tertiary referral centre, medical cardiology admission rate for ischaemic heart disease, fundholding status, and partnership size. Multiple linear regression analysis was used to determine the relationship between practice characteristics and the waiting times for revascularisation and angiography.

Results. Practices with high deprivation scores had significantly lower rates of utilisation of angiography and revascularisation procedures. Their patients also waited longer for angiography. Practices that were 20 km or further from a revascularisation centre had significantly lower angiography and revascularisation rates. On average, their patients had to wait more than twice as long for an angiography compared with patients from nearer practices. Fundholding practices had higher angiography rates but similar revascularisation rates compared with non-fundholding practices.

Conclusion. The results suggest that there may be some under-investigation and/or treatment of patients with ischaemic heart disease from 'deprived' practices and for those from practices far from a secondary or tertiary referral centre.

Keywords: coronary angiography; revascularisation; primary care; deprivation; inequalities.

Introduction

Our Healthier Nation aims to improve the health of the worst off in society and to narrow the health gap.¹ Doctors are specifically urged to identify those at high risk of heart disease

J Hippisley-Cox, MD, MCRGP, senior lecturer in general practice; and M Pringle, MD, FRCGP, professor of general practice, The Division of General Practice, The Medical School, Queen's Medical Centre, Nottingham.

Submitted: 11 August 1998; final acceptance: 23 June 1999.

© British Journal of General Practice, 2000, 50, 449-454.

and to provide high quality services. Coronary artery surgery has been shown to reduce re-infarction rates and mortality in patients with ischaemic heart disease,² and increased utilisation has been recommended.³

Studies investigating access to revascularisation services have produced conflicting results. Some have shown that residents of poorer areas have less access to services,^{4,5} while others have shown no difference⁶ or an increased access.⁷ In addition, there is little information on the effect of proximity to a secondary or tertiary referral centre, although this has been described as a confounding factor⁷ requiring more investigation.⁴

Although practices with high deprivation scores have higher medical referral rates,⁸ no studies have examined the effect of general practice characteristics — for example, fundholding, practice area, deprivation, partnership size, and proximity to a secondary or tertiary referral centre — on the utilisation of angiography and revascularisation. There is also limited data for the effect of these factors on hospital waiting times. These relationships are important given that much patient care is initiated and organised within general practice, and there is the potential to target resources to practices with high levels of unmet need.

We set out to (1) investigate the effect of general practice characteristics — deprivation score, fundholding status, partnership size, and distance from nearest secondary or tertiary referral centre — on admission rates for angiography and revascularisation; and (2) to investigate the effect of practice characteristics on waiting times. This is in view of recent reports stating that patients from fundholding practices have shorter waiting times.^{9,10}

Method

The study population

Approval for the study was obtained from the Local Ethics Committee and from the two Nottinghamshire Local Medical Committees. The study sample consisted of all admissions for cardiac coronary revascularisation procedures from all the 180 Nottinghamshire practices between 1 April 1993 and 31 March 1997. The admissions for cardiac procedures were identified from the Trent National Health Service (NHS) regional database by using the following Office for Population and Census Statistics (OPCS) procedure codes:

K40–K47	coronary artery bypass graft
K49–K50.1	angioplasty
K63–K65	angiography

Admissions were included if the patients were registered with a Nottinghamshire general practice. Data for patients who received treatment outside Trent, but were nonetheless registered with a Nottinghamshire practice, were also included. Each record on the database represented one hospital admission. Duplicate entries were removed from the datafile. The admission rate for ischaemic heart disease (i.e. myocardial infarction and angina) was used as a proxy for the prevalence of severe ischaemic heart disease in each practice.⁶ These admissions were identified from the NHS Trent regional database by searching on the following

codes between 1 April 1993 and 31 March 1997:

ICD-9 codes 410 to 414
ICD-10 codes I20 to I24

Data collection

We constructed two databases:

1. A cardiology admission database, and
2. A general practice database.

The cardiology database contained the following variables: the relevant OPCS, ICD-9, or ICD-10 code; the date the decision was made to do the procedure; date of operation; whether the procedure was elective or not; and the unique code of the patients' registered general practice. The waiting times for elective angiography and revascularisations were calculated by subtracting the recorded 'decision' date from the date of the operation.

The general practice database was a database of general practices in Nottinghamshire and was constructed using the following variables: unique identifying general practice code, number of partners, total list size, number of male and female patients aged over 65 years, and the UPA(8) and Townsend score of the practice area according to the weighted average of the percentage of patients in each electoral ward. The UPA(8) score or Jarman score^{11,12} forms the basis for current 'deprivation' payments made to general practitioners (GPs) and includes the following variables according to data collected in the 1991 Census:

- unemployment,
- overcrowded households,
- unskilled,
- children under five years,
- lone parent families,
- pensioners living alone,
- moved house within the past year, and
- ethnic group.

The variables included in the Townsend score¹³ are:

- unemployment,
- overcrowding,
- lack of a car, and
- non-owner occupation.

Practices were categorised into those that had never been fundholding and those that were fundholding at any time between 1993 and 1997.

Patient level data from the cardiology admission database were then linked to the Nottinghamshire general practice database using the unique general practice code. Three rates (per 10 000 registered patients) were calculated for each practice.¹⁴ These were the annual admission rates for:

1. coronary angiography,
2. coronary revascularisation procedures, and
3. ischaemic heart disease.

Distance to referral centres

There are three centres that perform angiography and revascularisation procedures in Trent (Nottingham, Leicester, and Sheffield). There is a fourth centre in Nottingham that only undertakes angiography. The grid references related to postcodes were used to calculate (1) the distance from each practice's main surgery to the nearest centre providing angiography ('secondary referral centre'), and (2) the distance to the nearest centre providing revascularisation ('tertiary centre').

Statistical analysis

The univariate and multivariate associations for coronary angiography and revascularisation rates were determined using Poisson regression analysis.^{15,16} An explanation of Poisson regression can be found in Box 1.

Two multivariate models were fitted to the data, including all potentially important variables. The first model contained UPA(8) score, fundholding status, partnership size, the admission rate for ischaemic heart disease, and distance to the centre performing the relevant procedure. The second model consisted of the Townsend score and percentage of men and women aged over 65 years instead of the UPA(8) score.

A weighted mean waiting time for each type of procedure was calculated for each practice. Since these data satisfied the assumptions for normality, it was possible to perform a parametric analysis without transformation. A multiple linear regression model containing similar variables was fitted to the waiting time data for both angiographies and revascularisation procedures. A two-tailed significance level of 0.01 was used because of the number of analyses planned. All the data were analysed with either SPSS for Windows (version 6.0) or with STATA (version 5.0).¹⁷

Results

The study population

During the four-year study period (1 April 1993 to 31 March 1997), there were 28 558 cardiology admissions identified, of which 28 117 (98.5%) could be linked to a Nottinghamshire general practice. Of these, 7412 were for coronary artery surgical procedures: 1932 for a coronary artery bypass grafts, 1078 for an angioplasty, and 4402 for angiography. There were 64 surgical admissions to units outside Trent.

There were 20 705 medical cardiology admissions. Of these, 9213 were for myocardial infarction and 11 492 were for angina or other ischaemic heart disease. There were 133 medical admissions to units outside of Trent.

- This type of analysis, recommended by Moore *et al*¹⁶ for data with a Poisson distribution, has been used in other studies involving hospital admissions rates.^{23,24} The Poisson distribution (as distinct from the usual 'normal' distribution with the bell-shaped curve) describes fairly uncommon events occurring randomly in time.
- As cardiology admissions (i) arise independently of one another in the population, (ii) occur randomly in time, (iii) are fairly rare events for a individual patient, then the data are likely to fit a Poisson distribution, which means that Poisson regression needs to be used to analyse the data.
- The analysis estimates the 'rate ratios' — a rate ratio of 2.0 implies twice the admission rate, and a rate ratio of 0.5 implies half the admission rate. For example, if the variable 'fundholding/non-fundholding' has a rate ratio of 2.0 for admission rates, then a fundholding practice has twice the admission rate of a non-fundholding practice.
- An 'adjusted' rate ratio is that which results from a multivariate analysis where a number of variables are included in the analysis simultaneously. For example, if deprivation and fundholding are both included in the analysis, then the effect of deprivation score on admission rates has taken account of the presence of fundholding, and vice versa.
- The pseudo R² value is equivalent to the R² in linear regression. It tells us how much of the total variation is explained by the regression model.^{17,25} A pseudo R² of 90% means that the factors under consideration explain the data very well; one of only 2% is poor.

Box 1. A note on Poisson regression.

Waiting times for coronary revascularisation procedures were recorded for 84% (1615 out of 1932) of coronary artery bypass grafts, 44% (473 out of 1078) of angioplasties, and 80% (3540 out of 4402) of angiographies. The majority of angioplasties were done as emergency procedures, which is why only 44% had waiting time data.

The characteristics of the general practices

There were 180 Nottinghamshire general practices in existence for the whole four-year study period. Of these, 137 (76%) had never been fundholding. Fifty-three (29%) practices were single-handed. One hundred and fifty-one (84%) practices were within 20 km of a secondary or tertiary referral centre. Table 1 shows the cardiology admission rates for cardiac procedures and for ischaemic heart disease.

The relationship between practice characteristics and angiography rates

Table 2 shows the univariate and multivariate analyses for coronary angiography. There were two factors found to be significantly associated with lower angiography rates. First, practices with higher deprivation scores had lower angiography rates ($P<0.0001$) despite having a higher estimated prevalence of severe disease. For every 10 units of increase in UPA(8) score, the admission rate decreased by 9%. Secondly, practices that were further away from the nearest secondary referral centre also had lower angiography rates ($P<0.0001$). Both of these relationships persisted even when adjustments were made for the other practice characteristics.

Practices with high admission rates for ischaemic heart disease had high angiography rates as did fundholding practices ($P<0.0001$ for both).

The relationship between practice characteristics and revascularisation rates

Table 3 shows the effect of general practice characteristics on

admission rates for revascularisation procedures. Practices with high deprivation scores had lower revascularisation rates, as did practices further from a tertiary referral centre ($P<0.0001$ for both). These findings were despite adjustment for other practice characteristics.

The effect of distance on admission rates for cardiac procedures

Practices that were close to a secondary referral centre had higher angiography rates, despite adjustment for other practice characteristics (Table 4). For example, a practice within 20 km of a secondary referral centre had 1.6 times the angiography rate of a more distant practice ($P<0.0001$).

Although not presented, we tested for an association between revascularisation rates and proximity to a tertiary referral centre. The results were very similar to those in Table 4, with closer practices having significantly higher revascularisation rates ($P<0.0001$).

Distance to the usual referral centres

It was apparent that not all patients were admitted to the nearest secondary or tertiary referral centre. This was probably owing to the historical use of services when there were only two centres performing revascularisation (Sheffield and Leicester). In order to account for this, the distance from each practice to the centre most frequently used was calculated and included in the multivariate analyses. This had no substantial impact on the findings: more distant practices still had lower rates of angiography and revascularisation ($P<0.0001$ for both).

The effect of practice characteristics on waiting times

Overall, practice characteristics explained 52% of the total variation in waiting times for angiography (Table 5). Distance alone accounted for 45% of the variation in angiography waiting time. Practices with high deprivation scores and those further from a secondary referral centre had longer waiting times, even when

Table 1. General practice cardiology admission rates per 10 000 registered patients.

	No. of practices with data	Median value	Interquartile range
Coronary angiography admission rate	180	10.6	7.6–14.2
CABG ^a and angioplasty admission rate	180	3.0	1.8–4.2
Medical cardiology admission rate ^b	180	51.2	40.5–63.5

^aCABG = coronary artery bypass graft; bincludes myocardial infarction, angina, other ischaemic heart disease (IHD).

Table 2. Poisson regression analysis for the effect of general practice characteristics on the admission rate for coronary angiography.

Variable	Pseudo R ² (%)	Rate ratio	95% CI	P-value
Univariate associations				
UPA(8) score	3.6	0.992	0.989–0.994	<0.0001
GP fundholder ^a	0.6	1.107	1.040–1.180	0.002
Single-handed GP ^b	0.3	0.891	0.810–0.980	0.02
Practice admission rate for ischaemic heart disease ^c	9.8	1.010	1.009–1.012	<0.0001
Distance (km) from nearest secondary referral centre	1.4	0.993	0.989–0.996	<0.0001
Multivariate associations				
		Adjusted rate ratio	95% CI	P-value
UPA(8) score		0.987	0.984–0.989	<0.0001
GP fundholder ^a		1.176	1.098–1.259	<0.0001
Single-handed GP ^b		0.895	0.811–0.987	0.03
Practice admission rate for ischaemic heart disease ^c		1.013	1.011–1.015	<0.0001
Distance (km) from nearest secondary referral centre (Pseudo R ² = 24.2 %)		0.979	0.975–0.982	<0.0001

^aRelative to a baseline of practice that had never been fundholding; ^brelative to a baseline of practices with more than one doctor; ^cincludes myocardial infarction, angina, other ischaemic heart disease.

other factors had been taken into account ($P = 0.002$ and $P < 0.0001$ respectively). Practices within 20km of the nearest centre performing angiography had significantly shorter waiting times compared with more distant practices (41 days versus 110 days; $P < 0.0001$). This was independent of other practice characteristics. Although there was a suggestion that fundholding was associated with longer angiography waiting times, this disappeared when all the other practice factors were taken into account.

On the other hand, practice characteristics did not seem to have an effect on waiting times for revascularisation (Table 5). In particular, there was no evidence that distance, deprivation, or fundholding status affected waiting times for revascularisation.

Comparison of the Townsend and UPA(8) scores

Each analysis was repeated with the Townsend score instead of the UPA(8) scores, adjusting for the percentage of men and women over the age of 65 years in each practice. There were no substantial differences in the results.

Discussion

This is the first study to examine the effect of primary care services, including geographical location, on admission rates for angiography and revascularisation. We have found that practices with high deprivation scores and those that are further from a sec-

ondary referral centre have lower rates of angiography. Practices further from a tertiary centre have lower revascularisation rates. These findings are despite higher admission rates for ischaemic heart disease in such practices. Patients from 'deprived' and distant practices had to wait longer for their operations.

Strengths and weaknesses

First, NHS hospital data quality can be limited by lack of accuracy and completeness.¹⁸ As our main outcome measure was a surgical procedure, the data are more likely to be accurate compared with more subjective medical diagnoses.

Secondly, we have used a proxy measure for the prevalence of severe ischaemic heart disease.⁶ We do not know how this correlates with the actual level of need within practices.

Thirdly, our data only cover treatment in NHS hospitals, although this is unlikely to have substantially affected our results. The vast majority of revascularisation procedures occur within NHS pay beds, the data for which were included in our analysis. If anything, we would expect the omission of private admissions to further exaggerate the effect of deprivation, since practices in more affluent areas tend to make more private referrals.

The effect of deprivation

Practices with high deprivation scores have lower rates of utilisation of angiography and revascularisation regardless of other practice characteristics. This is consistent with two other studies^{4,5} but is at variance with other work.^{6,7}

Table 3. Poisson regression analysis for the effect of general practice characteristics on the admission rate for CABG and angioplasty.

Variable	Pseudo R ² (%)	Rate ratio	95% CI	P-value
Univariate associations				
UPA(8) score	2.0	0.993	0.990–0.995	<0.0001
GP fundholder ^a	0.1	0.945	0.873–1.022	0.16
Single-handed GP ^b	0.1	0.921	0.822–1.032	0.16
Practice admission rate for ischaemic heart disease ^c	12.8	1.013	1.011–1.015	<0.0001
Distance (km) from nearest tertiary referral centre	0.0	1.000	0.996–1.004	0.99
Multivariate associations				
		Adjusted rate ratio ^d	95% CI	P-value
UPA(8) score		0.988	0.985–0.991	<0.0001
GP fundholder ^a		0.971	0.892–1.057	0.49
Single-handed GP ^b		0.910	0.809–1.023	0.11
Practice admission rate for ischaemic heart disease ^c		1.014	1.013–1.017	<0.0001
Distance (km) from nearest tertiary referral centre		0.987	0.982–0.992	<0.0001

^aRelative to a baseline of practice that had never been fundholding; ^brelative to a baseline of practices with more than one doctor; ^cincludes myocardial infarction, angina, other ischaemic heart disease; ^dadjusted for UPA(8) score, fundholding status, partnership size, and practice IHD admission rate.

Table 4. Poisson regression for the effect of distance to nearest secondary referral centre on the admission rate for coronary angiography.

Distance to nearest centre ^a	Number of practices (% of 180)	Adjusted rate ratio ^b	95% CI	P-value ^c
Within 4 km	68 (38%)	1.10	1.01–1.19	0.03
Within 8 km	104 (58%)	1.30	1.21–1.39	<0.0001
Within 12 km	117 (65%)	1.37	1.28–1.46	<0.0001
Within 16 km	130 (72%)	1.36	1.27–1.46	<0.0001
Within 20 km	151 (84%)	1.55	1.41–1.69	<0.0001
Within 24 km	155 (86%)	1.48	1.35–1.63	<0.0001
Within 28 km	170 (94%)	1.66	1.41–1.95	<0.0001
Within 32 km	172(96%)	1.66	1.40–1.97	<0.0001

^aCompared with more distant practices; ^badjusted for UPA(8) score, fundholding status, partnership size, and practice IHD admission rate; ^cthe P values need to be considered with caution as the analyses are not independent.

Table 5. Multiple regression analysis for the effect of general practice characteristics on weighted mean waiting times for angiography and revascularisation.

Variable	R ² (%)	b-coefficient	95% CI	P-value
Univariate associations for angiography				
UPA(8) score	0.4	-0.19	-0.49–0.11	0.21
GP fundholder ^a	6.9	15.83	7.46–24.20	0.0003
Single-handed GP ^b	0.5	-2.85	16.02–10.32	0.67
Practice admission rate for ischaemic heart disease ^c	0.2	-0.14	-0.38–0.09	0.23
Distance (km) to nearest secondary referral centre	44.9	2.04	1.70–2.38	<0.0001
Multivariate associations for angiography				
		Adjusted b-coefficient ^d	95% CI	P-value
UPA(8) score		0.37	0.14–0.59	0.002
GP fundholder ^a		7.73	1.37–14.09	0.02
Single-handed GP ^b		5.80	-3.42–15.02	0.22
Practice admission rate for ischaemic heart disease ^c		-0.15	-0.34–0.03	0.11
Distance (km) to nearest secondary referral centre		2.20	1.85–2.56	<0.0001
(Adjusted R ² = 52.0%; constant = 30.7; F = 36.7; d.f. = 5.159; P < 0.0001)				
Multivariate associations for revascularisation				
		Adjusted b-coefficient ^d	95% CI	P-value
UPA(8) score		0.42	-0.25–1.08	0.22
GP fundholder ^a		-11.48	-28.96–6.00	0.20
Single-handed GP ^b		-29.71	-54.10 to -5.33	0.02
Practice medical cardiology admission rate ^c		0.04	-0.47–0.55	0.88
Distance (km) to nearest tertiary referral centre		-0.74	-1.76–0.28	0.15
(Adjusted R ² = 4.9%; constant = 139.9; F = 2.67; d.f. = 5.159; P = 0.03)				

^aRelative to a baseline of practice that had never been fundholding; ^brelative to a baseline of practices with more than one doctor; ^cincludes myocardial infarction, angina, other ischaemic heart disease; ^dadjusted for UPA(8) score, fundholding status, partnership size, and practice IHD admission rate.

The effect of distance

We have been able to examine the effect of distance in more detail than before⁴ and have found that proximity to a referral centre is an important and independent factor. Practices that are further from a secondary referral centre have lower rates of angiography. Similarly, practices that are further away from a tertiary referral centre have lower revascularisation rates. The effect of distance was most marked for practices more than 20 km away from the nearest relevant referral centre, which had 1.6 times the angiography rate compared with more distant practices. These results were independent of other practice characteristics.

Possible reasons for the effect of deprivation and distance on operation rates

Why should practices with high deprivation scores and more distant practices have lower angiography and revascularisation rates? First, it is plausible that patients from deprived areas have different patterns of disease, different illness behaviour, and thresholds for consulting their GPs. For example, deprivation is associated with increased morbidity,^{5,19,20} increased prevalence of risk factors, and different illness behaviour.²¹ However, it is less likely that these factors explain the effects of distance on operation rates.

Secondly, part of the variation in operation rates could be a result of the referral behaviour of the GP or owing to differences in consultant thresholds for intervention. There is some evidence that unspecified non-medical factors influence the decision of hospital doctors to undertake such procedures.²²

The effect of practice characteristics on waiting times

None of these factors adequately explain why patients from more distant practices, and from more 'deprived' practices, had to wait longer for angiography but not for revascularisation procedures. A detailed audit of what happens when decisions are taken is needed in each hospital. It is possible that patients from closer practices are contacted by hospitals at short notice should a

vacancy on the angiography operating list arise.

There was no evidence that patients from fundholding practices have shorter waiting times than other practices.

Conclusion

The results suggest that there may be some under investigation and/or under-treatment of patients with ischaemic heart disease from 'deprived' practices and for those from practices far from a secondary or tertiary referral centre.

References

- Secretary of State. *Our Healthier Nation: A Contract for Health*. London: HMSO, 1998.
- RITA-2 trial participants. Coronary angioplasty versus medical therapy for angina: the second Randomised Intervention Treatment of Angina (RITA-2). *Lancet* 1997; **350**: 461-468.
- Working Group of the British Cardiac Society. A report of the working group of the BCS: cardiology in the district general hospital. *Br Heart J* 1994; **72**: 303-308.
- Ben-Shlomo Y, Chaturvedi N. Assessing equity in access to health care provision in the UK: does where you live affect your chances of getting a coronary artery bypass graft? *J Epidemiol Comm Health* 1995; **49**: 200-204.
- Payne N, Saul C. Variations in the use of cardiology services in a health authority: comparison of coronary artery revascularisation rates with prevalence of angina and coronary mortality. *BMJ* 1997; **314**: 257-261.
- Kee F, Gaffney B, Currie S, O'Reilly D. Access to coronary catheterisation: fair shares for all? *BMJ* 1993; **307**: 1305-1307.
- Black N, Langham S, Petticrew M. Coronary re-vascularisation: why do rates vary geographically in the UK? *J Epidemiol Comm Health* 1995; **49**: 408-412.
- Hippisley-Cox J, Hardy C, Pringle M, *et al*. The effect of deprivation on variations in general practitioners' referral rates: a cross sectional study of computerised data on new medical and surgical outpatient referrals in Nottinghamshire. *BMJ* 1997; **314**: 1458-1461.
- Kammerling RM, Kinnear A. The extent of the two tier service for fundholders. *BMJ* 1996; **312**: 1399-1401.
- Dowling B. Effect of fundholding on waiting times: database study. *BMJ* 1997; **315**: 290-292.

11. Jarman B. Identification of underprivileged areas. *BMJ* 1983; **286**: 1705-1709.
12. Jarman B. Underprivileged areas: validation and distribution of scores. *BMJ* 1984; **289**: 1587-1592.
13. Townsend P, Davidson N (eds). *The Black report*. London: Penguin, 1982.
14. Roland MO, Bartholomew J, Morrell DC, *et al*. Understanding hospital referral rates: a users guide. *BMJ* 1990; **301**: 98-102.
15. Armitage P, Berry G. *Statistical methods in medical research*. [3rd edn.] Oxford: Blackwell Scientific Publications, 1994.
16. Moore AT, Roland MO. How much variation in referral rates among general practitioners is due to chance? *BMJ* 1989; **298**: 500-502.
17. Computing Resources Centre. *STATA reference manual*. [5th edn, v. 3.] California: Computing Resources Centre, 1992.
18. Rees JL. Accuracy of hospital activity data in estimating the incidence of proximal femoral fractures. *BMJ* 1982; **284**: 1856-1857.
19. Crombie IK, Kenicer MB, Smith WCS, Tunstall-Pedoe H. Unemployment, socioenvironmental factors and coronary heart disease in Scotland. *Br Heart J* 1989; **61**: 172-177.
20. Crombie IK, Smith WCS, Tavendale R, Tunstall-Pedoe H. Geographical clustering of risk factors and lifestyle for coronary disease in the Scottish heart health study. *Br Heart J* 1990; **64**: 199-203.
21. Davis BS, McWhirter MF, Gordon DS. Where needs and demands diverge: health promotion in primary care. *Public Health* 1996; **110**: 95-101.
22. Gray D, Hampton JR, Bernstein SJ, *et al*. Audit of coronary angiography and bypass surgery. *Lancet* 1990; **335**: 1317-1320.
23. Griffiths C, Sturdy P, Naish J, *et al*. Hospital admissions for asthma in East London: associations with characteristics of local general practices, prescribing, and population. *BMJ* 1997; **314**: 482-486.
24. Bonneux L, Looman CWN, Barendregt JJ, van der Maas PJ. Regression analysis of recent changes in cardiovascular morbidity and mortality in the Netherlands. *BMJ* 1997; **314**: 789-792.
25. Glassman AH. Cardiovascular effects of antidepressant drugs: *J Clin Psychiatry* 1998; **59**(Suppl 15): 13-18.

Acknowledgements

JHC conceived the idea, designed the study, collected, analysed, and interpreted the data, and drafted the paper. MP contributed to the study design and interpretation.

Our thanks are due to the late Dr Dave Ebdon for providing the grid references, Mr Andy Nicholson for extracting the cardiology data, and Ms Pat Ward for constructing the practice characteristics database. Thanks to Ms April McCambridge for collecting the references for the literature review, and Professor Clair Chilvers and Ms Lindsay Groom for making constructive comments on late drafts of the article.

Address for correspondence

Julia Hippisley-Cox, The Division of General Practice, The Medical School, Queen's Medical Centre, Nottingham NG7 2UH. E-mail: julia.hippisley-cox@nottingham.ac.uk