Quality of Disease Management and Risk of Mortality in English Primary Care Practices

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Objective. To investigate whether better management of chronic conditions by family practices reduces mortality risk.

Data. Two random samples of 5 million patients registered with over 8,000 English family practices followed up for 4 years (2004/5–2007/8). Measures of the quality of disease management for 10 conditions were constructed for each family practice for each year. The outcome measure was an indicator taking the value 1 if the patient died during a specified year, 0 otherwise.

Study Design. Cross-section and multilevel panel data multiple logistic regressions were estimated. Covariates included age, gender, morbidity, hospitalizations, attributed socio-economic characteristics, and local health care supply measures.

Principal Findings. Although a composite measure of the quality of disease management for all 10 conditions was significantly associated with lower mortality, only the quality of stroke care was significant when all 10 quality measures were entered in the regression.

Conclusions. The panel data results suggest that a 1 percent improvement in the quality of stroke care could reduce the annual number of deaths in England by 782 [95 percent CI: 423, 1140]. A longer study period may be necessary to detect any mortality impact of better management of other conditions.

Key Words. Disease management, chronic conditions, primary care, quality, mortality

Disease management in primary care involves finding, monitoring, and controlling chronic disease with the aim of improving health and reducing overall health care costs (Hofmarcher, Oxley, and Rusticelli 2007; Schoen et al. 2011). Policies to improve primary care disease management have been adopted in England, many other European countries, the United States, Taiwan, and Australia (McKee and Nolte 2004; Roland 2004; Scott et al. 2009;

Chen et al. 2010; Chang, Lin, and Aron 2012). Interventions have included subsidies for electronic record keeping and support systems, promulgation of guidelines for care of chronic diseases, self-management education for patients, and financial incentives for primary care professionals (Doran and Roland 2010; de Bruin, Baan, and Struijs 2011a). The evidence about the effect of better quality of disease management on health care costs and health outcomes is limited and generally inconclusive (Tsai et al. 2005; Mattke, Seid, and Ma 2007; de Bruin et al. 2011b).

The introduction in the United Kingdom in 2004 of an elaborate and extensive pay for performance scheme—the Quality and Outcomes Framework (QOF)—covering all family practices produced uniquely rich data on the quality of management of chronic diseases. Several studies have used the QOF data to examine the relationship between clinical quality indicators for practices and hospital admissions (Downing et al. 2007; Shohet et al. 2007; Bottle et al. 2008a,b; Kiran et al. 2010; Bankart et al. 2011; Calderón-Larañaga et al. 2011). They find that the association is weak at best, and usually statistically insignificant. This may be because of the use of data at an aggregate geographic level, or for a single year, or for a small sample of practices. Dusheiko et al. (2011a) used QOF data on the management of diabetes in 8,223 English practices from 2004/5 to 2006/7. They found that in an average family practice, a 10 percent increase in diabetic patients with good rather than poor control was associated with a 14 percent decrease in the rate of emergency admissions for diabetic complications. Dusheiko et al. (2011b) using data on 5 million patients in over 8,000 English family practices found that patients in practices with better stroke care had lower overall hospital costs, due mainly to reductions in emergency admissions and outpatient visits.

Other studies outside the United Kingdom have investigated the impact of disease management incentives for quality in primary care on hospital admissions and costs. Lee et al. (2010) reported that diabetes-related examinations and physician visits increased for patients enrolled in a disease management program in Taiwan compared with diabetic patients not enrolled, while the growth rate of inpatient admissions and diabetes-related hospitalizations

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and expenditure were 12 and 35 percent lower than the rate of growth for nonenrolled individuals. Chen et al. (2010) investigated the impact of a program for the management of diabetic patients in Hawaii. Patients who saw participating physicians were significantly more likely to receive better quality care compared with patients who saw nonparticipating physicians, and improvements in care were associated with significant reductions in hospitalization. A randomized control trial evaluating an Austrian diabetes disease management program found significant reductions in body mass index and cholesterol as well as improvements in quality of care but not in HbA1c control (Sönnichsen et al. 2010).

Some studies have found that better disease management reduces mortality for patients with heart disease. Kiran et al. (2010) in a cross-section study of 1,531 family practices in London found that those with better QOF quality for coronary heart disease (CHD) had lower CHD mortality rates, especially for deprived patients. Hardoon et al. (2011) report that, for 10,352 patients in 218 U.K. family practices who had a myocardial infarction, better prescribing was associated with better longer term survival. Levene et al. (2010) used CHD mortality data from 152 English Primary Care Trusts (the administrative unit for NHS primary care) between 2006 and 2008, but they found no significant association between quality of hypertensive, CHD, and diabetic care measured by the QOF with mortality. A meta-analysis of randomized trials of disease management programs versus usual care for heart failure patients found that the programs reduced mortality and hospitalizations (Roccaforte et al. 2005).

There is evidence from randomized controlled trials that better performance on indicators of quality of disease management improves patient outcomes and many of these indicators were included in the QOF (McColl et al. 1998; Fleetcroft et al. 2010). However, although simulations of the effects of improvement in these indicators on health outcome suggest substantial reductions in population mortality (Fleetcroft and Cookson 2006; Fleetcroft et al. 2010), there have been no attempts to estimate their effects from using observations of family practice disease management quality and patient outcomes.

In this study, we use QOF data on disease management in all English family practices linked to those practices' patient registers to investigate whether patients in practices with better disease management have lower all-cause mortality. Note that we are not attempting to evaluate the specific effect of the QOF P4P scheme on either practice's disease management activities (as in Campbell et al. 2009) or on patient outcomes. Rather, we use the data produced by the QOF to investigate the effect of disease management quality on

outcomes. Our study contributes to the literature in several respects. We have large samples of patients (over 5 million) observed in over 8,000 practices over 4 years. We measure outcomes for individual patients from the general population and have detailed information on their past diagnoses obtained from their hospital records. We control for the socio-economic characteristics of the small areas in which patients live and for the local health care supply conditions.

Data

In the English National Health Service (NHS), patients who wish to obtain publicly funded NHS primary care services must register with a family practice. Registrations with family practice are recorded in the National Strategic Tracing Service (NSTS) database. For the cross-section analysis, we drew a 10 percent (5,170,588 individuals) random sample of patients registered on 1 April 2007 with English family practices with a list size of at least 1,000 patients. These patients were followed up for 1 year. For the panel data analysis, we drew another 10 percent random sample of 5,206,651 patients who were registered on 1 April 2004 and followed these patients until 31 March 2008. Detailed information about the sample and the construction of variables is in Dixon et al. (2011) and PBRA Team (2010).

From the NSTS database, we had information on each pseudonymised patient's age, gender, and their family practice at the start (1 April) of each financial year. For each patient and financial year, we constructed a dummy variable indicating if the patient died in the financial year. We also knew the small area—lower super output area (LSOA)—in which the patient lived at the start of each financial year. LSOAs have a mean population of 1,500 and are used by the Office for National Statistics to report, for example, data from the decennial population census. We also had information on each patient's inpatient and outpatient hospital episodes from Hospital Episode Statistics (<http://www.hsic.gov.uk/hes>).

Measures of the quality of practice disease management for different diseases in each year were constructed from QOF data extracted from electronic practice records by the NHS Information Centre. The clinical quality indicators included both processes (e.g., the proportion of eligible patients with diabetes whose HbA1c levels had been measured in the previous 15 months) and intermediate outcomes (e.g., the proportion of eligible patients with stroke diagnosis whose total cholesterol—measured in the last 15 months—is 5 mmol/l or less). Practices scored points for their achievement against each

indicator, with the maximum number of points available varying across indicators.

We measured quality for each indicator as the population achievement: the number of patients for whom an indicator was achieved divided by the number of patients with the relevant condition. We measured quality of disease management for each condition as a weighted average of the performance on each indicator for the condition. The weights applied were the maximum number of points the practice could earn for each indicator (as in Doran et al. 2006). We constructed quality measures for 10 disease domains that were incentivized throughout the study period (asthma, coronary heart disease, chronic kidney disease, chronic obstructive pulmonary disease, dementia, diabetes, hypertension, hypothyroidism, mental health, stroke) and also calculated an overall quality measure based on all the indicators in the 10 disease domains. Further details about the quality measures included in our summary measures together with more information about the points-based weighting system are in the Technical Appendix.

The covariates in the regression models are as follows:

1. Thirty-eight gender/5-year age band dummies based on age at the beginning of the financial year.
2. Individual morbidity as measured by 152 dummy variables for a classification of ICD10 diagnoses into 152 categories. The dummy for a morbidity category was set equal to 1 if the individual had one or more inpatient hospital spells in either of the previous 2 years with any diagnosis in the relevant subset of ICD10 diagnoses. These 152 categories are used by the Department of Health to group together broadly associated diagnosis codes (PBRA Team 2010; Dixon et al. 2011). Their definitions are based primarily on the first three digits of the diagnosis code (e.g., the first three groups comprise A00-A09 Intestinal infectious diseases, A15-A19 Tuberculosis, and A20-A49 Certain bacterial disease) and indicate the presence or absence (but not the severity) of a condition.
3. Four individual hospital encounter variables: (i) the number of inpatient episodes in the previous 2 years; (ii) the number of outpatient attendances in the previous 2 years; (iii) a dummy variable indicating whether the individual had a priority outpatient referral in the previous 2 years (normally GP referrals are offered outpatient appointments on a “first come, first served” basis, but the GP can make a “priority referral” so that the patient jumps the queue and is seen

more quickly); and (iv) a dummy variable indicating whether the individual received any treatment in the course of an outpatient attendance in the previous 2 years. These four encounter variables allow for the possibility that a patient with a given set of binary morbidity indicators is likely to be sicker if he or she has had several past hospital episodes or a more urgent referral. Only two of the encounter variables ((ii) and (iii)) are influenced by practice decisions: referrals to outpatient departments include those from both family doctors as well as by hospital doctors. All four of the variables are lagged (by up to 2 years) so that (ii) and (iii) will only be affected by past practice decisions. Similar variables have been used in models of risk adjustment (Beck, Trottmann, and Zweifel 2010).

4. Indicators for whether the patient had a private inpatient spell or a privately funded outpatient attendance in an NHS hospital in the previous 2 years. These allow for the fact that patients using private health care might have different characteristics and different propensity to be treated, given their underlying morbidity.

We also used 110 measures of small area population socio-economic characteristics that might plausibly be indicators of individual circumstances, and therefore potential predictors of ill health and mortality. These indicators were constructed from various sources including the 2001 Census of Population and the 2007 set of Indices of Multiple Deprivation (Department of Communities and Local Government 2008). These indicators included measures of ethnicity, marital status, economic activity, and benefit dependence. They were attributed to each individual via their LSOA of residence as at 1 April of each year.

We also had available estimates of the family practice prevalence rates for the diseases reported for the QOF. These prevalence rates were attributed to each individual via the practice with which they were registered as at the 1 April of each year. For 2007/8, these 18 prevalence rates were for asthma, hypertension, cancer, CHD, COPD, diabetes, epilepsy, LVD (left ventricle disease), mental health, stroke, hypothyroidism, atrial fibrillation, chronic kidney disease, dementia, heart failure, learning disability, obesity, and palliative care.

We had 55 local health system variables that might affect the probability of death. These included practice characteristics such as the number of patients per GP (Gravelle, Morris, and Sutton 2008) and measures of the accessibility of different types of health care facilities from the small area in

which the patient lives (e.g., inpatient beds per head of population). The supply variables also included measures of accessibility, such as distance to providers and waiting times at local hospitals. These variables were constructed from various sources, including the General Medical Statistics census and waiting time data published by the Department of Health. The variables were attributed to each individual via the practice with which they were registered on 1 April of each year.

Finally, we also use 151 dummy variables for the Primary Care Trust (PCT), the local administrative body responsible for funding and monitoring the family practice with which the individual is registered. The PCT dummies are intended to pick up the effects of unmeasured factors, such as environmental variables, local clinical policies, variations in funding, and characteristics of local hospitals including their quality and data coding.

METHODS

We used multiple logistic regressions to test for an association between the mortality probability of individuals and measures of the quality of disease management in the family practices with which they are registered, allowing for previous patient morbidity, age, gender, socio-economic factors, and local health care supply factors (see the Technical Appendix for a fuller description). Because of the large number of potential explanatory variables, we selected a more parsimonious set using selective backward elimination. It was impracticable to do so using the panel dataset because of the long computation time (10 days) for each estimation. We therefore used the cross-section sample in two ways: first, to select a parsimonious set of variables that could be used for the panel data models and, second, to examine the robustness of the estimated effect of disease management quality to using lagged, rather than current quality, and to different sets of measures of disease management quality. The cross-section models are vulnerable to confounding by unobserved practice-level factors but, compared with panel data models, are reasonably fast to implement.

We produced the more parsimonious cross-section model by selective backward elimination of the attributed variables and practice disease quality measures. We started with the full model and estimated a cross-section logistic regression for 2007/8 dropping variables with $|z| < 0.2$, reestimating, and then dropping those variables with $|z| < 0.4$ and so on until all remaining variables were significant at the 1 percent level. Throughout the

process, individual- level age/gender groups, 152 morbidity markers, four hospital encounter variables, and the 151 higher level PCT dummies were forced into the model. The practice-level disease management quality measures and all the 200 plus attributed small area and practice variables were not forced into the model and so were potential candidates for elimination.

When we had selected the parsimonious set of attributed small area and practice characteristics using backward elimination on the cross-section sample, we used the panel data sample to estimate three models with practice effects to control for unobservable practice factors correlated with patient mortality, and we included year dummies to capture secular changes in mortality risk unrelated to disease management. The three panel models differ in the way they allow for unobserved practice factor affecting mortality. The first model uses practice fixed effects, which requires the assumption that any unobserved practice factors affecting mortality risk do not vary over time. The second model has random practice effects plus PCT fixed effects and requires the assumption that the unobserved practice factors are uncorrelated, within a PCT, with any of the observed explanatories. Our third, and preferred, panel data model is the same as the second except that it includes the baseline practice mortality rate for 2004/5. This specification has the advantage that the baseline mortality rate, like the practice fixed effect, will pick up unobservable time invariant practice characteristics, which are correlated with mortality but without the computational burden and loss of efficiency of the practice fixed effects specification.

RESULTS

Practice QOF achievement in 2007/8 was generally high (Table 1) and all measures of achievement were significantly positively correlated. Mortality risk was just under 1 percent (Table 2).

Cross-Section Models

In the final parsimonious cross-section model, only nine of the attributed small area and supply variables were significant (at 5 percent or better), and they made a very small contribution to the overall fit of the model. All 38 age/gender dummies were significant at 1 percent, and of the 152 morbidity categories, 58 were positive and significant and 12 were negative and significant. The Technical Appendix has the full results.

Table 1: Descriptive Statistics for Family Practice Disease Management Clinical Quality Measures 2007/8

QOF Disease Domains	Number of Indicators	Maximum Points	Number of Practices	Clinical Quality: Points Weighted Average Population Achievement; Rate (%)				Mean Practice Prevalence Rate (per 1,000 Patients)
				Mean	SD	Min	Max	
Asthma	2	35	8,289	76.38	9.11	0.00	100	56.78
Coronary heart disease	9	85	8,284	82.74	3.85	35.00	100	34.90
Chronic kidney disease	3	21	8,251	97.68	2.57	50.00	100	4.09
COPD	4	30	8,279	81.97	8.61	0.00	100	15.07
Dementia	1	15	8,200	75.44	17.48	0.00	100	28.22
Diabetes	15	87	8,290	87.42	5.57	9.38	100	49.65
Hypertension	2	77	8,292	91.28	4.11	14.87	100	128.39
Hypothyroidism	1	6	8,281	95.37	3.78	9.09	100	26.49
Mental health	5	35	8,284	74.73	13.66	0.00	100	7.68
Stroke	6	20	8,276	86.17	5.77	6.67	100	15.80
Overall quality	48	411	8,178	84.88	3.99	52.22	98.4	n/a

Notes: The population achievement for an indicator i in disease domain k is defined as N_{ik}/P_k , where N_{ik} is the number of patients for whom the indicator is achieved and P_k is the number of patients with the disease. The quality measure for a disease domain is a weighted average of population achievement on each indicator in the domain, where the weights are the maximum points available for the indicator.

Of the 10 practice disease quality measures included in the initial full model, only 2007/8 stroke quality was significant in the final parsimonious cross-section model for 2007/8. Its coefficient is given in Table 3 (column 1). We reestimated this parsimonious model, replacing the stroke QOF score for 2007/8 with the stroke QOF score for 2006/7 (column 2), then with the score for 2005/6 (column 3), and finally with the score for 2004/5 (column 4). The coefficient on stroke quality remained significant but longer lags had smaller coefficients, suggesting that current mortality risk depends more on current disease management quality than past quality. A 1 percent increase in stroke quality in 2007/8 is associated with a reduction in the log odds ratio of death of 0.0066. This implies that the average reduction in the probability of death in the sample is 0.000048 against an average probability of 0.0091. The number of lives saved in a year for a population of 51.1 million (the English population in 2007) with the same average characteristics as the sample is 2,437 (95 percent CI: 1,548–3,327).

Table 2: Mortality in 2004/5–2007/8 Panel and 2007/8 Samples

Sample	Year	Patients			Analysis Sample Practice Mortality Rates (%)				
		Patients at 1 April	Deaths in Year	Mortality Rate (%)	Practices	Mean	SD	Min	Max
Panel	2004/5	5,131,161	46,217	0.901	8,042	0.893	0.562	0.000	4.739
	2005/6	5,084,944	44,979	0.885	8,053	0.881	0.560	0.000	4.306
	2006/7	5,039,965	44,854	0.890	8,046	0.896	0.577	0.000	4.955
	2007/8	4,995,111	44,406	0.889	8,015	0.900	0.561	0.000	5.263
Cross-section	2007/8	5,206,651	44,692	0.858	7,937	0.851	0.540	0.000	5.820

Note: Year is financial year 1 April to 31 March. The panel sample is a 10% random sample of patients registered on 1 April 2004 in practices with lists of at least 1,000 patients. The cross-section sample is a separate 10% random sample of patients registered on 1 April 2007 in practices with lists of at least 1,000 patients. Practice mortality rates are the percent of patients in the sample alive and registered in the practice at 1 April who die in the following year. Practice summary statistics are unweighted.

We reestimated the parsimonious model having added the nine QOF quality measures that were excluded from it, and the coefficients on these variables are shown in column 1 of Table 4. The stroke score again had a larger negative and significant coefficient though the hypertension quality score had a significant and positive coefficient. This is possibly because of collinearity: the two scores are positively correlated ($r = 0.48$, $p < .000$). In the full model containing all the explanatories and the 10 disease management quality measures, only the coefficient on stroke quality was significant. The magnitude (-0.0059) of the stroke coefficient in the full model was similar to that in the final parsimonious model (-0.0066) though its standard error was slightly larger (0.0021 vs. 0.0020).

When the model is reestimated with the composite measure of the 10 disease domain scores, the coefficient on the composite is negative and significant when it is included in the parsimonious model as the only QOF quality measure (column 2), though its coefficient is much smaller than that on the stroke score.

We also estimated 10 separate cross-section models for mortality, in turn forcing one of the 10 quality measures into the model. The coefficients on the quality measures from these 10 separate estimations are shown in column 3 of Table 4. Four quality measures (for coronary heart disease, chronic kidney disease, COPD, and diabetes) are separately significantly negatively associated with the log odds ratio of death, but their coefficients are smaller and/or

Table 3: Results from Cross-Section Multiple Logistic Models of Individual 2007/8 Mortality Probability: Associations with Current and Lagged General Practice Stroke Management Quality

	1	2	3	4
Stroke 2007/8	−0.0066*** [0.0012]			
Stroke 2006/7		−0.0059*** [0.0013]		
Stroke 2005/6			−0.0034*** [0.0011]	
Stroke 2004/5				−0.0021** [0.0008]
Average marginal effect of stroke score on the probability of dying	−0.0000477*** [−0.0000651, −0.0000303]	−0.0000428*** [−0.0000608, −0.0000249]	−0.0000247*** [−0.0000397, −0.0000097]	−0.0000154*** [−0.0000264, −0.00000442]
Implied number of lives saved nationally from a 1% point increase in the stroke QOF score	2,437 [1,548, 3,327]	2,187 [1,272, 3,107]	1,262 [496, 2,029]	787 [226, 1,349]
Observations	5,170,588	5,170,588	5,170,588	5,166,968
McFadden's R^2	0.349	0.349	0.349	0.349

Note: The results are from four separate models for 2007/8 individual patient mortality with the quality of stroke care measured in different years. The reported coefficients are the effect of a one unit (1% point) increase in the clinical population achievement rate for a patient's practice on the patient's log odds of dying ($\log(p/(1-p))$, where p is the probability of dying in 2007/8). The average marginal effect is the effect of a one unit (1% point) increase in the clinical population achievement rate for a patient's practice on the patient's probability of dying in 2007/8. The calculation of the implied number of lives saved assumes a population of the same size as England in 2007 (51.1 million) with the same characteristics as the sample. Robust standard errors with clustering by PCT are in brackets. All models also contain 37 age/gender bands, 152 ICD10 patient morbidity dummies for 2006/7 and 2005/6, 4 hospital encounter variables for 2006/7 and 2005/6, a dummy for the patient having a private outpatient appointment in an NHS hospital in 2006/7 or 2005/6, 9 attributed needs/supply variables, and 151 PCT dummies. Full results for column 1 are in the Appendix and those for columns 2, 3, and 4 are available from the authors.

*** $p < .01$, ** $p < .05$.

Table 4: Association of 2007/8 Family Practice Disease Management Clinical Quality Measures with the Log Odds Ratio of Dying in 2007/8

	1	2	3
	<i>All Quality Measures in Single Regression</i>	<i>Overall Quality</i>	<i>Quality Measures Entered in Separate Regressions</i>
Asthma	0.0000 [0.0008]		−0.0008 [0.0006]
Coronary heart disease	−0.0005 [0.0030]		−0.0063*** [0.0018]
Chronic kidney disease	−0.0041 [0.0026]		−0.0066*** [0.0023]
COPD	−0.0003 [0.0012]		−0.0021** [0.0009]
Dementia	−0.0003 [0.0004]		−0.0006 [0.00004]
Diabetes	−0.0004 [0.0018]		−0.0035*** [0.0014]
Hypertension	0.0054** [0.0021]		−0.0007 [0.0017]
Hypothyroidism	0.0003 [0.0023]		−0.0029* [0.0019]
Mental health	0.0004 [0.0005]		−0.0002 [0.0004]
Stroke	−0.0075*** [0.0020]		−0.0066*** [0.0012]
Overall quality		−0.0045*** [0.0016]	
Observations	5,170,588	5,170,588	5,170,588
McFadden's R^2	0.349	0.349	

Note: The dependent variable in all models is the log odds ratio of a patient dying in 2007/8. The reported coefficients are the effect of a one unit (1% point) increase in the clinical population achievement rate for a patient's practice on the patient's log odds of dying ($\log(p/(1-p))$ where p is the probability of dying). Robust standard errors with clustering by PCT are in brackets. All models are cross-section and also contain 37 age/gender bands, 152 ICD10 morbidity dummies for 2006/7 and 2005/6, 4 hospital encounter variables for 2006/7, 2005/6, a private patient measure for 2006/7 and 2005/6, 9 attributed needs/supply variables, and 151 PCT dummies. All 10 models reported in column 3 had the same McFadden's R^2 of 0.349.

*** $p < .01$, ** $p < .05$, * $p < .1$.

less precise than those associated with the stroke care quality variable. We also reestimated the parsimonious model replacing the stroke population achievement rate with the reported achievement rate (i.e., the rate incorporating exception reporting). This reduced the coefficient on the stroke score to −0.0041, but it remained significant at the 1 percent level.

We interpret these cross-section sensitivity tests as suggesting that we use the parsimonious model with stroke disease management quality as the only disease management measure when estimating the computationally more demanding panel data models.

The panel data results are in Table 5. The first panel data model (column 1) uses fixed practice effects to control for unobservable practice-level effects correlated with both quality and mortality. It relies on variation in QOF scores within practices over time to identify the impact of quality on mortality. The

Table 5: Multiple Regression Logistic Panel Data Models for Individual Mortality 2004/5–2007/8

	1	2	3
	<i>Fixed Practice Effects</i>	<i>Random Practice Effects</i>	<i>Random Practice Effects with Baseline Practice Death Rate</i>
Stroke QOF score coefficient (SE)	−0.00060 (0.00076)	−0.00305*** (0.00049)	−0.00199*** (0.00047)
Baseline practice mortality rate coefficient (SE)			24.598*** (0.55546)
Observations	19,624,830	19,673,261	19,673,261
Individuals	5,109,238	5,119,437	5,119,437
Average marginal effect of stroke score on probability of dying	−0.0000941	−0.0000234***	−0.0000153***
[95% CI]	[−0.0003269, 0.0001386]	[−0.0000309, −0.000016]	[−0.0000223, −0.0000083]
Implied number of lives saved in population of 51.1 million from a 1% point increase in stroke QOF score	4,809	1,196	782
[95% CI]	[−708, 16,705]	[818, 1,579]	[423, 1,140]

Note: The average marginal effect of the stroke QOF score is the effect of a one unit (1% point) increase in the clinical population achievement rate for a patient's practice on the patient's probability of dying. The calculation of the implied number of lives saved assumes a population the same size as England in 2007 (51.1 million) with the same characteristics as the sample. Model 1 has fixed practice effects. Model 2 has random practice effects but includes PCT dummies. Model 3 is the same as model 2 with the addition of the baseline (2004/5) practice mortality rate. All models also contain 37 age/gender bands, 152 ICD10 patient morbidity dummies for the previous 2 years, 4 hospital encounter variables for the previous 2 years, a dummy for the patient having a private outpatient appointment in an NHS hospital in the previous 2 years, 9 attributed needs/supply variables, and 3 year dummies. Full results are in the Appendix.

*** $p < .01$.

coefficient on the stroke QOF score is negative (-0.0006), but it is smaller than the corresponding coefficient in the one period cross-sectional model (-0.0066) and it is not significant. This may be because fixed effects estimation is less efficient than random effects, but it may also indicate unobserved heterogeneity across practices. The second panel data model (column 2) uses random effects to control for unobservable practice factors. The coefficient on the stroke QOF score (-0.00305) is about one-half of the size of the cross-section estimate, but it is significant at the 1 percent level. Our preferred specification is the third panel data model (column 3), which adds the baseline 2004/5 practice mortality rate to the random effects model in column 2 to control for unobserved practice-level factors. The coefficient on the stroke QOF score is smaller in absolute value (-0.00199), but it is still significant at the 1 percent level. These random effects panel data results are consistent with those from the cross-section model, which was estimated on a different sample of patients.

The average marginal effect of the stroke QOF score in the third panel data model (random practice effects with baseline practice mortality) is -0.0000153 and, with a population of 51.1 million with the same characteristics as the sample, this implies that a one unit (1 percent point) increase in the stroke QOF achievement rate would be associated with 782 fewer deaths per year (95 percent CI: 423–1,140).

DISCUSSION

Although it can be plausibly argued that better management of chronic disease in family practice should improve patient health, there is little evidence to date for or against this hypothesis. We tested it using panel data on the quality of disease management in all English practices and on all-cause mortality for a random sample of 5 million patients from the general population followed up for 4 years from 2004/5 to 2007/8. After allowing for patient age, gender, morbidity over the previous 2 years, and socio-economic characteristics, we found that patients in practices with better quality of stroke management had a lower risk of death. We estimate that a 1 percent improvement in the quality measure is associated with a reduction in 782 deaths. On average, the stroke disease management score in English general practices improved by 10 percent points between 2004/5 and 2007/8.

Our panel data models use a 10 percent sample of patients from every practice as at 1 April 2004 and who were followed without replacement for 4 years. This risks two types of attrition bias. First, a small proportion of

patients (less than 1 percent) die in each of the study years and, as these patients are not replaced, this will leave a nonrepresentative sample of healthier individuals over time. In the absence of information on patient morbidity, this would tend to bias the impact of quality on mortality toward zero because the proportion of sicker patients will diminish through the study period, and it is this group that is most likely to be affected by practice disease management quality. However, if our rich set of morbidity indicators for patients adequately captures their morbidity, then our model allows for the changing morbidity of sample as some patients die and are not replaced.

For the vast majority of the initial sample who do not die, attrition will only occur if the patient emigrates or deregisters from one practice and fails to register with another practice. As we know which practice a patient is registered with and the date on which he or she changes practice registrations, we do not lose patients who move between practices. Patients who (temporarily or permanently) move overseas are lost from the sample but, as emigrants tend to be relatively young and healthy, we would not expect their loss to bias the results because care quality is unlikely to affect this group's probability of death.

In an observational study, we cannot rule out the risk of confounding by unobserved factors. It is possible that practices with better disease management attract more educated or knowledgeable patients who are also healthier. We had information on a large number of socio-economic and supply-side factors that might influence mortality. Although we did not have information on individual patient health from practice records, we did have information on practice disease prevalence rates. We also had detailed data on the past morbidity of individual patients from their hospital records. The use of panel data methods, especially the inclusion of the baseline practice mortality rate in the random effects specification, also reduced the risk of confounding. The fixed effects estimates also suggest that improvements in stroke disease management within a practice reduce mortality, though the effects are much less precisely estimated, perhaps because we employ a fairly short panel.

Stroke patients are a small proportion of practice patients (1.6 percent), and other QOF diseases, such as CHD (3.5 percent) and asthma (5.7 percent), have larger prevalences (Health and Social Care Information Centre [HSCIC] 2008). Thus, the fact that, of all the disease areas studied, only stroke management quality was associated with reduced mortality risk is at first sight surprising. However, postdischarge stroke patients are at much higher mortality risk than the general population (Brønnum-Hansen, Michael Davidsen, and Thorvaldsen 2001) and there is evidence from trials that control of blood

pressure and cholesterol (which are incentivised QOF indicators) significantly reduces risk of subsequent stroke and mortality (Collins et al. 1990; Heart Protection Study Collaborative Group 2002).

We did not have data on cause of death and so we were unable to test if the quality of management of particular diseases was associated with reductions in mortality for related causes. But by using all-cause mortality for the general population, we were able to overcome the concern that, although QOF might lead to improved quality in some areas of care, this improvement might come at the expense of quality in other areas that are not monitored as part of QOF.

The absence of an effect of the quality of disease management other than for stroke does not necessarily imply that primary care management of other diseases has no impact on population health. It may be that the indicators of disease management in these disease areas were not sensitive enough to capture all the variations in clinical management, and there may be certain population subgroups for whom family practice performance did have an important influence on mortality. Moreover, we would expect mortality of high-risk patients to be most affected by improvements in quality of care over time. However, according to the clinical QOF scores, the level of performance was already high at around 75 percent even in the first year of QOF. Thus, the scope for improvement was limited. This does not, of course, negate the value of good quality care, but it will make its impact more difficult to detect.

Furthermore, it is possible that some of the benefits from disease management in primary care arise in the form of improvements in health-related quality of life rather than reduced mortality. But perhaps most important, our modeling framework implicitly assumes that, conditioning on patient, practice, and environmental factors, better disease management will be associated with lower mortality in the same year. For some disease areas, it is plausible that better management will be associated with an immediate decline in mortality. However, for other conditions, the impact on mortality is likely to be in the medium to long term. With only 4 years of data, however, we cannot examine the more distant impact of better disease management; at the moment we can only test for an immediate impact on mortality. This distinction—between the short- and medium- to long-term impact of better disease management—might well explain why we find that the quality of care for patients who have already had a stroke is associated with an immediate impact on mortality, and yet the QOF scores for other disease areas such as hyperten-

sion (which might be expected to prevent strokes) appear to have no (immediate) association with mortality.

Caution is required in drawing policy conclusions about the cost-effectiveness of specific policies to improve disease management. We could find little support for any immediate health benefits of improvements in many types of disease management. However, our results suggest that better stroke disease management in family practices is associated with a modest but immediate reduction in mortality risk. Further work, in particular using cause-specific mortality data over a longer time period, and using individual-level measures of quality of disease management, is required to clarify the extent to which such associations are evidence of a causal effect, and hence to improve the focus of future disease management policy.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

- Appendix SA1: Author Matrix.
- Data S1: Technical Appendix.