

## Supplementary Appendix

This appendix has been provided by the authors to give readers additional information about their work.

Supplement to: Doran T, Fullwood C, Reeves D, Gravelle H, Roland M. Exclusion of patients from pay-for-performance targets by English physicians. *N Engl J Med* 2008;359:274-84.

## **Appendix 1. Statistical Methods**

### *The Quality and Outcomes Framework*

The U.K. Quality and Outcomes Framework consists of 146 quality indicators, of which 65 are for clinical activities. Exception reporting is only permitted for these clinical activities, and does not apply to the remaining quality indicators, which cover the maintenance of chronic disease registers, patients' experiences of care and aspects of practice organisation. For the clinical activity indicators, patients with the relevant chronic condition are either ineligible (i.e. do not meet the criteria for the indicator, for example because they are not in the specified age range), are exception reported by the practice (for one of the reasons given in **Box 1**), or are deemed appropriate for the particular indicator. For the latter patients, points are awarded for achieving the target on a sliding scale between a minimum threshold of 25 percent (i.e. the target must be achieved for at least 25 percent of patients) and a maximum threshold which varies from 50 to 90 percent according to the indicator. The maximum number of points attainable also varies by indicator (**Appendix 2**). In 2005/06 each point earned the average practice £125 (\$250).

### *Calculating exception reporting rates*

The national QMAS database system automatically extracts relevant performance data from practices clinical computing systems, including: list size, the number of patients with each condition on practices' registers ( $R_d$ ), the number of patients exception reported for each indicator ( $E_i$ ), the number of patients deemed appropriate by the practice for each indicator (denominator,  $D_i$ ) and the number for whom the indicator was met (numerator,  $N_i$ ). For each practice we calculated *rates of exception reporting*– the number of patients who were exception reported for each indicator as a proportion of the number of patients who were eligible for the target:

$$\text{Rate of exception reporting} = E_i / (E_i + D_i)$$

Summary outcome scores were constructed for each disease and each type of clinical activity using all indicators in the group (**Table 1**), effectively weighted according to the number of non-excluded patients:

$$\text{Summary outcome} = \sum E_i / \sum (E_i + D_i)$$

*Calculating financial gain from exception reporting*

We analysed the financial ‘gain’ from exception reporting, i.e. the number of points earned by practices which could be attributed to exception reporting. For each indicator this is calculated as:

$$\frac{\text{MIN}\{\text{Mx T}, \text{MAX}\{\text{Mn T}, \text{RA}\}\} - \text{MIN}\{\text{Mx T}, \text{MAX}\{\text{Mn T}, \text{PA}\}\}}{(\text{Mx T} - \text{Mn T})} \times \text{Points}$$

Where Mx T is the maximum threshold, Mn T the minimum threshold, RA is ‘reported achievement’ (i.e.  $N_i/D_i$ ), and PA is ‘population achievement’ (the number of points the practice would have earned if it had exception reported no patients):

$$\text{Population achievement} = N_i / (E_i + D_i)$$

#### *Explanation of variance in regression analyses*

The reported  $R^2$  value of 2.7% for the overall regression model in this paper was much lower than the figure of 20% reported in our analysis of the 2004-05 (Year 1) data [10]. Some explanation of this difference is warranted to avoid misinterpretation. Our regression analyses included two essentially different sets of variables: the socio-demographic predictors, and a set of ‘dummies’ to account for effects of missing

information (where the value for an indicator, or a register, was missing for a practice). Consequently only a part of the  $R^2$  value relates to the variance explained by the socio-demographic predictors themselves.

A large number of practices in the 2004-05 dataset had data missing for some indicators and in many cases we needed to use a denominator (rather than an actual register) to estimate the exception rate. These factors had systematic (i.e. non-random) effects on the exception rate estimates, adding extraneous error to the observed variation between practices. The dummies were included in the analysis to account for this. There were far fewer missing values on indicators in Year 2, and no missing registers.

Other changes in the regression models for Year 1 and Year 2 also have an effect on the  $R^2$ . For the Year 1 analysis we weighted exception reporting rates for the point values of the indicators, to reflect the relative importance of the indicators within the framework, and weighted the cases for variance heterogeneity. For the Year 2 analysis we did not weight, being more concerned with practice mean levels of exception reporting by disease type and type of activity. For the Year 2 data we also removed some of the highly correlated socio-economic variables, and highly correlated dummies, from the regression analyses.

To investigate further we ran analyses on both datasets using as similar a set of predictors, dummies, and outcome as possible (exact duplication was not possible due to changes in the indicator set and because of different patterns of missing values). We

performed unweighted analysis using the full set of predictors from the Year 1 analysis and the full set of dummies. The total variance explained in Year 1 dropped to 16.3%, a consequence of the removal of weighting, and that for Year 2 increased to 4.6%, due mainly to the inclusion of extra dummies (Table A1). The dummy variables accounted for the largest part of the explained variance in Year 1, and the socio-demographic predictors on their own explained 2.2% and 2.4% of the variance in each year respectively. Alternatively, removing the extraneous variance resulting from missing data (and estimated by the dummies) prior to examining the predictors, the predictors explained 2.6% and 2.3% of the remaining variance respectively. The results were virtually unchanged when we used adjusted  $R^2$  values.

Table A1. Analysis of 2004-05 (Year 1) and 2005-06 (Year 2) datasets using comparable sets of predictors, dummies, and outcome.

Variables in model	Variance explained ( $R^2$ )	
	2004-05	2005-06
Predictors and dummies	0.163	0.046
Dummies only	0.141	0.023
Predictors only	0.022	0.024

## Appendix 2. Exception Reporting Rates for Individual Indicators

Indicator	Points *	Payment range †	Exception Reporting Rate		
			Mean (SD)	Median (IQR)	Maximum rate ‡
ASTHMA 2. Diagnosis confirmed by spirometry or peak flow measurement (ages 8+)	0-15	25-70%	3.57 (4.62)	2.33 (0 – 5.08)	60.00
ASTHMA 3. Smoking status recorded (ages 14-19)	0-6	25-70%	2.54 (5.58)	0.0 (0 – 2.70)	66.67
ASTHMA 4. Smoking status recorded (ages 20+)	0-6	25-70%	1.28 (2.12)	0.54 (0 – 1.52)	29.09
ASTHMA 5. Smoking cessation advice offered (smokers)	0-6	25-70%	2.41 (4.40)	0.0 (0 – 3.03)	50.00
ASTHMA 6. Have had an asthma review	0-20	25-70%	4.33 (5.64)	2.22 (1.06 – 5.19)	55.11
ASTHMA 7. Received influenza immunisation (ages 16+)	0-12	25-70%	18.05 (10.71)	15.97 (10.00 – 23.96)	68.75
CANCER 2. Reviewed in practice (newly diagnosed patients)	0-6	25-90%	9.14 (8.90)	7.56 (2.91 – 12.73)	83.33
CHD 2. Referred for exercise testing and/or specialist assessment	0-7	25-90%	11.42 (12.40)	8.70 (0 – 16.67)	85.71
CHD 3. Smoking status recorded	0-7	25-90%	1.58 (1.81)	1.11 (0.28 – 2.22)	22.38
CHD 4. Smoking cessation advice offered (smokers)	0-4	25-90%	2.71 (4.63)	0.0 (0 – 4.17)	50.00
CHD 5. Blood pressure recorded	0-7	25-90%	1.25 (1.59)	0.79 (0 -1.76)	19.05
CHD 6. Blood pressure 150/90 mmHg or less	0-19	25-70%	4.05	3.28	43.48

			(3.40)	(1.82 – 5.34)	
CHD 7. Total cholesterol recorded	0-7	25-90%	3.38 (3.19)	2.52 (1.18 – 4.67)	30.30
CHD 8. Total cholesterol 193 mg/dL (5 mmol/l) or less	0-16	25-60%	10.06 (5.84)	9.05 (5.94 – 13.08)	64.44
CHD 9. Taking aspirin or alternative anti-platelet/anti-coagulant	0-7	25-90%	3.54 (3.12)	2.82 (1.33 – 4.94)	28.57
CHD 10. Taking beta blocker	0-7	25-50%	25.27 (13.08)	24.65 (15.56 – 33.93)	82.12
CHD 11. Taking ACE inhibitor (history of MI)	0-7	25-70%	7.30 (9.40)	4.76 (0 – 10.94)	75.00
CHD 12. Received influenza vaccination	0-7	25-85%	10.71 (5.71)	9.80 (6.84 – 13.54)	51.02
CHD/LVD 2. Diagnosis confirmed by echocardiogram	0-6	25-90%	10.34 (14.71)	0.00 (0 – 16.67)	80.00
CHD/LVD 3. Taking ACE inhibitors or A2 antagonists	0-10	25-70%	7.59 (9.94)	4.35 (0 – 11.36)	83.33
COPD 2. Spirometry & reversibility testing (newly diagnosed patients)	0-5	25-90%	9.36 (10.57)	6.67 (1.52 – 13.33)	85.71
COPD 3. Spirometry & reversibility testing (all patients)	0-5	25-90%	8.37 (8.20)	6.32 (2.78 – 11.67)	90.91
COPD 4. Smoking status recorded	0-6	25-90%	2.30 (3.14)	1.35 (0 – 3.37)	57.14
COPD 5. Smoking cessation advice offered (smokers)	0-6	25-90%	2.47 (4.98)	0.0 (0 – 3.39)	66.67
COPD 6. FeV1 recorded	0-6	25-70%	9.09 (8.79)	6.90 (2.97 – 12.50)	83.33
COPD 7. Inhaler technique checked	0-6	25-90%	5.44 (5.84)	4.17 (1.20 – 7.82)	95.24
COPD 8. Received influenza immunisation	0-6	25-85%	11.00 (6.96)	10.00 (6.45 – 14.29)	66.67

DIABETES 2. BMI recorded	0-3	25-90%	3.53 (3.23)	2.74 (1.32 – 4.85)	46.39
DIABETES 3. Smoking status recorded	0-3	25-90%	1.70 (1.76)	1.27 (0.51 – 2.37)	22.68
DIABETES 4. Smoking cessation advice offered (smokers)	0-5	25-90%	3.17 (4.65)	1.36 (0 – 5.00)	66.67
DIABETES 5. HbA <sub>1c</sub> recorded	0-3	25-90%	3.29 (2.71)	2.72 (1.45 – 4.40)	42.86
DIABETES 6. HbA <sub>1c</sub> 7.4% or less	0-16	25-50%	12.57 (8.13)	10.58 (7.14 – 15.53)	64.36
DIABETES 7. HbA <sub>1c</sub> 10% or less	0-11	25-85%	6.37 (4.17)	5.51 (3.57 – 8.09)	47.62
DIABETES 8. Retinal screening recorded	0-5	25-90%	6.42 (6.11)	5.23 (3.19 – 8.06)	98.28
DIABETES 9. Peripheral pulses recorded	0-3	25-90%	6.21 (4.89)	5.14 (3.00 – 8.05)	90.63
DIABETES 10. Neuropathy testing recorded	0-3	25-90%	6.36 (4.91)	5.24 (3.08 – 8.28)	74.80
DIABETES 11. Blood pressure recorded	0-3	25-90%	1.55 (1.81)	1.09 (0.33 – 2.16)	36.84
DIABETES 12. Blood pressure 145/85 mmHg or less	0-17	25-55%	7.97 (5.09)	6.94 (4.61 – 10.04)	58.49
DIABETES 13. Micro-albuminuria testing recorded	0-3	25-90%	7.55 (9.75)	5.53 (3.29 – 8.73)	98.95
DIABETES 14. Serum creatinine recorded	0-3	25-90%	2.54 (2.60)	1.87 (0.88 – 3.42)	47.62
DIABETES 15. Taking ACE inhibitors/A2 antagonists (proteinuria or micro-albuminuria)	0-3	25-70%	5.33 (10.03)	0.0 (0 – 6.67)	80.00
DIABETES 16. Total cholesterol recorded	0-3	25-90%	2.88 (2.69)	2.23 (1.11 – 3.85)	42.86
DIABETES 17. Total cholesterol 193 mg/dL (5 mmol/l) or less	0-6	25-60%	10.51 (5.34)	9.62 (6.92 – 13.08)	61.90
DIABETES 18. Received influenza immunisation	0-3	25-85%	13.17	12.38	53.39

			(6.33)	(8.81 – 16.38)	
EPILEPSY 2. Seizure frequency recorded (ages 16+)	0-4	25-90%	3.54 (5.49)	1.52 (0 – 5.08)	75.78
EPILEPSY 3. Medication reviewed (ages 16+)	0-4	25-90%	3.46 (5.37)	1.48 (0 – 5.00)	75.78
EPILEPSY 4. Convulsion-free for 12 months (ages 16+)	0-6	25-70%	17.38 (15.25)	13.79 (5.88 – 25.00)	95.65
HYPERTENSION 2. Smoking status recorded	0-10	25-90%	1.53 (1.35)	1.28 (0.79 – 1.93)	26.42
HYPERTENSION 3. Smoking cessation advice offered (smokers)	0-10	25-90%	0.67 (1.37)	0.0 (0 – 0.96)	28.57
HYPERTENSION 4. Blood pressure recorded	0-20	25-90%	1.00 (1.51)	0.49 (0.16 – 1.21)	20.39
HYPERTENSION 5. Blood pressure 150/90 mmHg or less	0-56	25-70%	5.39 (3.93)	4.41 (2.99 – 6.64)	54.39
HYPOTHYROID 2. Thyroid function tests recorded	0-6	25-90%	0.71 (1.40)	0.0 (0 – 0.93)	31.58
MENTAL HEALTH 2. Reviewed in practice	0-23	25-90%	4.90 (8.67)	1.06 (0 – 6.25)	93.33
MENTAL HEALTH 3. Lithium levels recorded (on lithium therapy)	0-3	25-90%	4.25 (9.70)	0.0 (0 – 0)	80.00
MENTAL HEALTH 4. Serum creatinine and TSH recorded (on lithium therapy)	0-3	25-90%	3.37 (8.70)	0.0 (0 – 0)	75.00
MENTAL HEALTH 5. Lithium levels in the therapeutic range (on lithium therapy)	0-5	25-70%	8.13 (13.42)	0.0 (0 – 12.50)	80.00
STROKE 2. Referred for CT or MRI scan	0-2	25-80%	10.79 (11.95)	8.33 (0 – 16.52)	85.71

STROKE 3. Smoking status recorded	0-3	25-90%	2.79 (3.41)	1.89 (0 – 4.04)	54.55
STROKE 4. Smoking cessation advice offered (smokers)	0-2	25-70%	3.47 (7.05)	0.0 (0 – 4.76)	66.67
STROKE 5. Blood pressure recorded	0-2	25-90%	2.23 (3.10)	1.30 (0 – 3.30)	50.00
STROKE 6. Blood pressure 150/90 mmHg or less	0-5	25-70%	6.72 (6.28)	5.41 (2.90 – 8.90)	82.14
STROKE 7. Total cholesterol recorded	0-2	25-90%	6.18 (6.16)	4.59 (1.72 – 8.82)	50.00
STROKE 8. Total cholesterol 193 mg/dL (5 mmol/l) or less	0-5	25-60%	14.61 (9.02)	13.17 (8.33 – 19.35)	77.14
STROKE 9. Taking aspirin, or alternative anti-platelet/anti-coagulant (non-haemorrhagic)	0-4	25-90%	4.90 (5.43)	3.67 (0 – 7.14)	50.00
STROKE 10. Received influenza immunisation	0-2	25-85%	13.39 (7.86)	12.41 (8.15 – 17.39)	60.00

\* Number of points which can be awarded for the indicator. Each point earns the average practice £125 (\$250). Total points for all indicators = 492.

† Points are awarded within the stated range. For example: for ASTHMA 7 the practice must immunise at least 25 percent of asthma patients (over the age of 15) to earn any points, and must immunise 70 percent or more to earn the maximum 12 points.

‡ The minimum rate for all indicators is 0.