Supplemental materials for:

Ricci-Cabello I, Stevens S, Kontopantelis E, Dalton AR, Griffiths RI, Campbell JL, Doran T, Valderas JM. Impact of the prevalence of concordant and discordant conditions on the quality of diabetes care in family practices in England. *Ann Fam Med*. 2015;13(6):514-522.

Supplemental Appendix 1. Empirical logit transformation and back transformation.

<u>A. Empirical logit transformation</u>

The logit transformation applied to the indicators is explained by way of an example using indicator DM02.

Let "Achieve02" denote the achievement rate for indicator 02 in % and "Count02" denote the denominator for indicator 02 (i.e. number of patients).

Then for practices with Achieve02 strictly between 0 and 1 the transformation applied was:

$$Logit02 = \ln\left(\frac{Achieve02}{1 - Achieve02}\right)$$

For practices with Score02 equal to 0 or 1, the transformation applied was:

$$Logit02 = \ln\left(\frac{Achieve02 + {0.5}/{Count02}}{1 - Achieve02 + {0.5}/{Count02}}\right)$$

<u>B. Methodology used for back-transformation from logit scores.</u>

Achievement in a practice on the logit scale is modeled as follows:

$$LogitA = \alpha + \beta_1 Prev_1 + \cdots + \beta_k Prev_k$$

Achievement on the logit scale for the same practice if one prevalence value increases by 1%:

$$LogitB = \alpha + \beta_1(Prev_1 + 1) + \cdots + \beta_k Prev_k$$

The difference gives of the change in achievement (on the logit scale) for a 1% increase in prevalence (our beta values currently from the model):

$$\rightarrow LogitB - LogitA = \beta_1$$

Achievement on the logit scale is related to a particular value of percentage achievement (as defined by our logit transformation):

$$LogitA = \ln\left(\frac{AchieveA}{1 - AchieveA}\right)$$

Similarly,

$$LogitB = \ln\left(\frac{AchieveB}{1 - AchieveB}\right)$$

To work backwards to get a change in percentage achievement, we assume that percentage achievement at prevalence "$Prev_1 + 1$" is equal to the percentage achievement at prevalence $Prev_1$" plus some constant X. This constant X is the change in percentage achievement per 1% increase in prevalence.

$$AchieveB = AchieveA + X$$

$$LogitB - LogitA = \ln\left(\frac{AchieveA + X}{1 - (AchieveA + X)}\right) - \ln\left(\frac{AchieveA}{1 - AchieveA}\right) = \beta_1$$

We need to solve the above for X, but this can only be done if we know AchieveA. It would be appropriate to take this as the average percentage achievement level across practices, e.g., 91.35%.

$$\ln\left(\frac{AchieveA + X}{1 - (AchieveA + X)}\right) = \beta_1 + \ln\left(\frac{AchieveA}{1 - AchieveA}\right)$$

$$\left(\frac{1 - (AchieveA + X)}{AchieveA + X}\right) = exp\left(-\beta_1 - \ln\left(\frac{AchieveA}{1 - AchieveA}\right)\right)$$

$$\frac{1}{AchieveA + X} = exp\left(-\beta_1 - \ln\left(\frac{AchieveA}{1 - AchieveA}\right)\right) + 1$$

$$X = \left[exp\left(-\beta_1 - \ln\left(\frac{AchieveA}{1 - AchieveA}\right)\right) + 1\right]^{-1} - AchieveA$$

Example – Diabetes:

In our first model (Table 3, all practices), the coefficient for diabetes before back-transformation was –0.0389 (95% CI -0.0513 to -0.0264).

Assume an anchor achievement rate of 91.35%

$$X = \left[exp\left(-(-0.0389) - \ln\left(\frac{0.9135}{1 - 0.9135}\right)\right) + 1\right]^{-1} - 0.9135$$

$$X = [exp(0.0389 - \ln(10.5607\ldots)) + 1]^{-1} - 0.9135$$

$$X = [exp(-2,3182\ldots) + 1]^{-1} - 0.9135$$

$$X = [1.0984\ldots]^{-1} - 0.9135$$

$$X = 0.9104\ldots - 0.9135$$

$$X = -0.0031$$

E.g., a 1% increase in diabetes prevalence is related to a 0.31% decrease in quality of care attainment (absolute difference).

Similarly, by using the limits of the CIs: -0.31% (95%CI: -0.41% to -0.21%).

The use of logit transformation implies that back transformed coefficients cannot be linearly extrapolated to calculate effects with different values of prevalence (see Figure below). Therefore, similarly to the calculation previously described, to assess the impact of a change in prevalence of 10%, replace β_1 with $10\beta_1$ in the equation: A 10% increase in diabetes prevalence is related to a 3.60% (95% CI: -5.01% to -2.33%) decrease is quality of care attainment (again, absolute difference).

Effect of logit-transformation of the estimation of the coefficients[1].
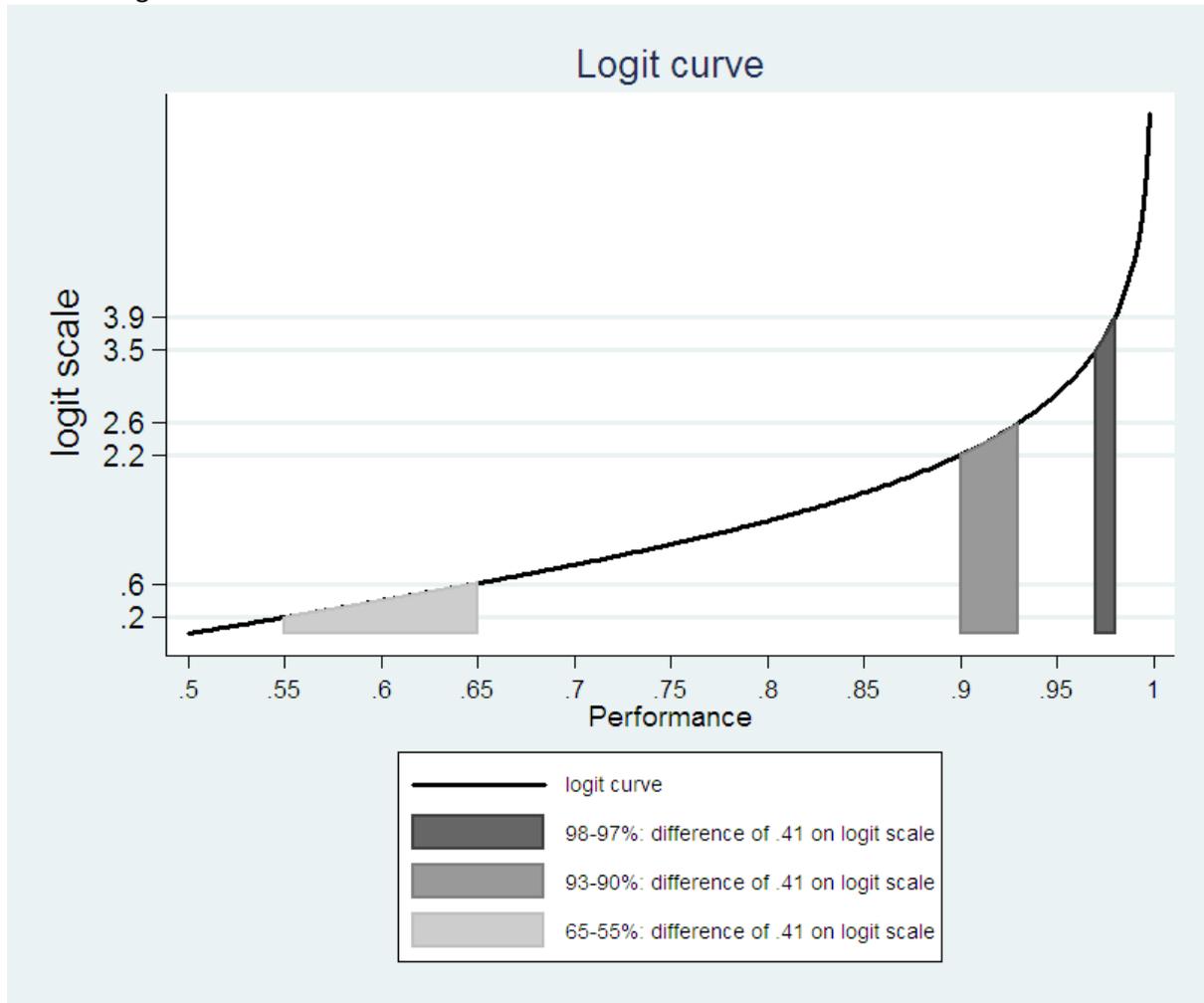
[1] This figure demonstrates how, as practices' achievement rates approach the ceiling, the size of percentage differences that correspond to the same level of achievement on the logit scale (transformed) becomes smaller.

Supplemental Appendix 2. Association between quality of diabetes care (process) and the prevalence of diabetes and of diabetes concordant and discordant conditions (sensitivity analysis based on QOF scores instead of achievement rates)[1]

Prevalence	<3,000 patients (N = 1,376)		3,000–6,000 patients (N = 2,466)		6,001–10,000 patients (N = 2,354)		>10,000 patients (N = 1,688)		All Practices (N = 7,884)	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Diabetes	0.36	[0.13; 0.58]†	0.19	[0.19; 0.55]†	0.08	[-0.02; 0.18]	0.02	[-0.09; 0.12]	0.22	[0.16; 0.28]†
Diabetes-concordant										
Obesity	0.28	[0.21; 0.35]†	0.12	[0.17; 0.30]†	0.19	[0.15; 0.22]†	0.09	[0.05; 0.12]†	0.14	[0.12; 0.16]†
Hypertension	-0.07	[-0.20; 0.05]	-0.02	[-0.15; 0.06]	-0.04	[-0.09; 0.02]	0.03	[-0.03; 0.08]	-0.05	[-0.08; -0.01]
CHD	0.03	[-0.42; 0.44]	-0.26	[-0.93; -0.12]†	-0.19	[-0.41; -0.01]†	-0.24	[-0.48; -0.03]†	-0.18	[-0.31; -0.06]†
CKD	0.26	[0.10; 0.40]†	0.14	[0.15; 0.40]†	0.04	[-0.02; 0.09]	0.10	[0.05; 0.15]†	0.14	[0.10; 0.18]†
Stroke & TIA	0.37	[-0.41; 1.04]	-0.11	[-0.97; 0.45]	0.29	[-0.03; 0.57]	0.03	[-0.37; 0.35]	0.21	[0.00; 0.41]†
Atrial fibrillation	-0.27	[-1.21; 0.53]	0.44	[0.23; 1.40]†	0.71	[0.46; 0.93]†	0.34	[0.03; 0.57]†	0.55	[0.37; 0.72]†
Heart Failure	0.62	[-1.37; 1.44]	0.23	[-0.37; 1.16]	0.18	[-0.24; 0.52]	0.22	[-0.20; 0.54]	0.24	[-0.01; 0.47]
Diabetes-discordant										
Asthma	-0.03	[-0.24; 0.18]	0.16	[0.14; 0.47]†	0.00	[-0.09; 0.08]	0.13	[0.05; 0.21]†	0.08	[0.03; 0.14]†
Cancer	1.10	[0.59; 1.55]†	0.43	[0.39; 1.23]†	-0.05	[-0.31; 0.18]	0.25	[0.06; 0.41]†	0.44	[0.31; 0.57]†
COPD	0.19	[-0.24; 0.59]	0.20	[0.04; 0.71]†	0.05	[-0.14; 0.23]	0.16	[-0.04; 0.33]	0.11	[-0.01; 0.22]
Dementia	0.10	[-0.61; 0.72]	0.14	[-0.32; 0.78]	-0.01	[-0.42; 0.33]	-0.34	[-0.85; 0.07]	-0.06	[-0.28; -0.13]†
Depression	-0.03	[-0.13; 0.06]	-0.02	[-0.12; 0.03]	-0.01	[-0.05; 0.02]	0.02	[-0.02; 0.05]	-0.01	[-0.04; 0.01]
Epilepsy	0.15	[-0.89; 1.01]	-0.11	[-1.26; 0.67]	-0.25	[-0.89; 0.24]	-0.14	[-0.82; 0.33]	-0.06	[-0.37; 0.23]
Hypothyroidism	0.10	[-0.23; 0.42]	0.11	[-0.06; 0.48]	0.03	[-0.11; 0.17]	-0.04	[-0.18; 0.09]	0.04	[-0.05; 0.13]
Severe Mental Health Disorder	-0.73	[-1.33; -0.19]†	-0.45	[-1.59; -0.22]†	-0.15	[-0.51; 0.16]	-0.01	[-0.39; 0.30]	-0.54	[-0.74; -0.35]†

[1]Multivariable linear regression analysis. Dependent variable is the logit-transformed proportion of QOF scores archived from processes of care indicators. Independent variables are the prevalence of diabetes and conditions concordant and discordant to diabetes. Analysis adjusted for age, sex, ethnicity, deprivation, number of GPs, Carr-Hill list size, and exception rate. Coefficients have been back-transformed to percentages from logit-transformed proportion of QOF scores. β is the fully adjusted, absolute percentage change in the proportion of QOF scores archived from processes of care indicators, per 1% change in prevalence. †$P < 0.05$.

CHD, coronary heart disease; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; QOF, Quality and Outcomes Framework; TIA, transient ischemic attack.

Supplemental Appendix 3. Association between quality of diabetes care (intermediate outcomes) and the prevalence of diabetes and diabetes-concordant and diabetes-discordant conditions (sensitivity analysis based on QOF scores instead of achievement rates)[1]

Prevalence	<3,000 patients (N = 1,376)		3,000–6,000 patients (N = 2,466)		6,001–10,000 patients (N = 2,354)		>10,000 patients (N = 1,688)		All Practices (N = 7,884)	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Diabetes	0.82	[0.56; 1.07]†	0.37	[0.23; 0.51]†	0.23	[0.09; 0.36]†	0.42	[0.26; 0.57]†	0.52	[0.44; 0.60]†
Diabetes-concordant										
Obesity	0.20	[0.08; 0.32]†	0.12	[0.07; 0.17]†	0.13	[0.08; 0.17]†	0.04	[-0.02; 0.10]	0.07	[0.04; 0.10] †
Hypertension	-0.15	[-0.31; 0.00] †	-0.08	[-0.16; 0.00]	-0.09	[-0.17; -0.01]†	-0.02	[-0.11; 0.07]	-0.12	[-0.17; -0.07]†
CHD	-0.21	[-0.78; 0.32]	-0.34	[-0.66; -0.04]†	-0.12	[-0.41; 0.15]	-0.13	[-0.49; 0.19]	-0.22	[-0.40; -0.04]†
CKD	0.26	[0.07; 0.44]†	0.18	[0.08; 0.27]†	0.07	[-0.01; 0.14]	0.06	[-0.03; 0.15]	0.17	[0.11; 0.22]†
Stroke & TIA	0.42	[-0.54; 1.24]	0.25	[-0.28; 0.72]	0.05	[-0.47; 0.51]	0.13	[-0.52; 0.66]	0.38	[0.10; 0.65]†
Atrial fibrillation	-0.46	[-1.65; 0.54]	0.55	[0.05; 0.99]†	0.93	[0.55; 1.26]†	0.48	[-0.05; 0.93]	0.67	[0.40; 0.92]†
Heart Failure	0.20	[-1.14; 1.29]	0.23	[-0.43; 0.79]	0.28	[-0.30; 0.77]	0.25	[-0.48; 0.83]	0.26	[-0.11; 0.59]
Diabetes-discordant										
Asthma	-0.21	[-0.48; 0.05]	0.04	[-0.09; 0.18]	-0.02	[-0.15; 0.10]	0.02	[-0.13; 0.17]	-0.04	[-0.12; 0.04]
Cancer	0.95	[0.28; 1.53]†	0.71	[0.38; 1.01]†	0.11	[-0.23; 0.42]	0.03	[-0.34; 0.36]	0.58	[0.39; 0.76]†
COPD	0.79	[0.32; 1.22]†	0.31	[0.04; 0.56]†	0.36	[0.11; 0.59]†	0.21	[-0.13; 0.51]	0.34	[0.18; 0.49]†
Dementia	0.42	[-0.41; 1.14]	-0.19	[-0.68; 0.25]	0.24	[-0.29; 0.69]	-0.11	[-0.82; 0.47]	-0.11	[-0.40; 0.17]
Depression	-0.06	[-0.18; 0.06]	-0.02	[-0.08; 0.03]	0.03	[-0.02; 0.08]	0.06	[0.00; 0.11] †	-0.01	[-0.05; 0.02]
Epilepsy	0.42	[-0.81; 1.42]	-0.61	[-1.51; 0.14]	-0.50	[-1.42; 0.23]	-0.10	[-1.13; 0.68]	-0.15	[-0.61; 0.25]
Hypothyroidism	0.25	[-0.16; 0.62]	0.16	[-0.06; 0.36]	-0.01	[-0.22; 0.18]	0.12	[-0.10; 0.32]	0.11	[-0.01; 0.23]
Severe Mental Health Disorder	-0.93	[-1.67; -0.25]†	-0.16	[-0.66; 0.29]	0.32	[-0.10; 0.69]	-0.26	[-0.94; 0.31]	-0.66	[-0.94; -0.40]†

[1]Multivariable linear regression analysis. Dependent variable is the logit-transformed proportion of QOF scores archived from intermediate outcomes indicators. Independent variables are the prevalence of diabetes and conditions concordant and discordant to diabetes. Analysis adjusted for age, sex, ethnicity, deprivation, number of GPs, Carr-Hill list size, and exception rate. Coefficients have been back-transformed to percentages from logit-transformed proportion of QOF scores. β is the fully adjusted, absolute percentage change in the proportion of QOF scores archived from intermediate outcomes indicators, per 1% change in prevalence. †$P < 0.05$. CHD, coronary heart disease; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; QOF, Quality and Outcomes Framework; TIA, transient ischemic attack.