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Can we update the Summary Hospital Mortality Index (SHMI) to make a useful measure of the quality of hospital care? An observational study

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ABSTRACT

Objective: To advance methods for the estimation of hospital performance based upon mortality ratios.
Design: Observational study estimating trust performance in a year derived according to comparative standards from a 3-year period, accounting for patient-level case-mix and overdispersion (unexplained variability).
Participants: 23 363 630 admissions to the English National Health Service (NHS) by NHS Trust.
Main outcome measures: Number of SDs (QUality and Outcomes Research Unit Measure, QUORUM banding) and comparative odds of hospital mortality difference from mean performance by trust compared for 2010/2011, 2008/2009 and 2009/2010, accounting for patient-level case-mix.
Results: The model was highly predictive of mortality (C statistic=0.93), and well calibrated by risk stratum. There was substantial overdispersion. No trusts were more than 3 SDs above the mean, and only one trust was more than 2 SDs above the mean for 2010/2011.
Conclusions: QUORUM is highly predictive of patient mortality in hospital or up to 30 days after admission. However, like the Summary Hospital Mortality Indicator (SHMI), QUORUM is subjected to considerable remaining legitimate but unexplained variation. It is unlikely that measures like QUORUM and SHMI will be useful beyond identifying a very small number of trusts as potential outliers.

ARTICLE SUMMARY

Article focus

- The Summary Hospital Mortality Indicator (SHMI) aims to identify poorly performing hospital trusts but is limited through unexplained variability between trusts.
- We aimed to develop a more efficient model with additional explanatory variables using more sophisticated statistical techniques to assess trust performance (QUality and Outcomes Research Unit Measure, QUORUM).
- We assessed the performance of QUORUM and compared QUORUM with SHMI.

Key messages

- QUORUM is well calibrated and strongly predicts patient mortality.
- Nonetheless, QUORUM is subject to considerable unexplained variation at the trust level and neither QUORUM nor SHMI convincingly identify poorly performing trusts.
- The National Health Service should investigate the usefulness of collecting more detailed clinically relevant data such as prescriptions, observations and assessments to enable improvement of the evaluation of quality of care and outcomes

Strengths and limitations of this study

- QUORUM has a very high predictive value for deaths.
- QUORUM, like SHMI, cannot convincingly identify poorly performing hospitals.
- Mortality at an aggregate is not a suitable surrogate measure of quality.

INTRODUCTION

Methods for assessing quality of care of hospitals in the National Health Service (NHS) have been a topic of debate for many years. There has been considerable focus on mortality as a surrogate marker of the quality of care that hospitals deliver. There have been attempts to predict appropriate levels of mortality and identify hospitals that are exceeding such limits. In the UK this has involved using data derived from Hospital Episode Statistics (HES). The Hospital Standardised Mortality Ratio (HSMR)[1] was used as an indicator of hospital assessment in the English NHS for several years. This measure calculated the ratio of the number of observed deaths and the number of deaths expected on the basis of a risk adjustment algorithm for each Acute Trust in England, using basic statistical methods developed in the 1980s.

The HSMR received considerable criticism, specifically about the application of death rates as a measure of overall quality of care,[2] the inconsistency of its findings[3 4] and the fact that the HSMR had been subject to little empirical evaluation.[5] Furthermore, HSMR methodology included only 78% of all inhospital deaths, did not consider all patients' comorbidities and did not take into account postdischarge outcomes and readmissions so that in many circumstances one patient death could be counted multiple times. This methodology was criticised as it lended itself to 'gaming' and more importantly there was dissatisfaction that HSMR was used commercially to judge NHS Hospitals' performance. As a result, the NHS Medical Director recently convened a group of interested parties to develop a methodology to create a new national death statistic based on HSMR.[6] This measure is known as the Summary Hospital Mortality Indicator (SHMI).[7]

The methods used to derive the SHMI are based upon those used for the HSMR. In order to derive the ratio of the observed-to-expected deaths, the SHMI method estimates the expected number of deaths by fitting a logistic regression model using data from each non-specialist acute NHS Trust in England, grouped by diagnostic group (using the Clinical Classification Software, CCS categories)[8] and adjusted for patient age, sex, Charlson comorbidity score[9] and for mode of admission (elective vs emergency). The expected number of deaths is calculated as a sum of the probability of death for all trusts based on the risk stratification algorithm and compared with the observed number of deaths for each trust. Any excess in observed versus expected deaths is taken as a marker to suggest a more in depth investigation of the hospitals quality of care delivery.

In its first iteration, the SHMI provided two different statistical indicators (PO and OD banding) to identify hospitals with performance warranting further investigation. The PO banding, based on Poisson distribution, inappropriately indicated too many trusts to be performing outside the expected range because the statistical methods did not account for the substantial unexplained variation in the statistical model, a phenomenon known as overdispersion.

Overdispersion in the SHMI is caused at least partly by inadequate case-mix adjustment where the characteristics not included in the statistical model exert an important influence on the outcome. It is well known that social deprivation affects outcome[10] and we may expect that trusts with patients experiencing below average deprivation will, everything else being equal, have better outcomes than those facing higher than average deprivation. Other factors such as ethnicity, previous urgent and complex hospital admissions, comorbidities not included in the Charlson index and the time of the year when admission occurs may also be associated with the risk of death among patients admitted to hospital.[11] The SHMI also does not take into account all the care information known about patients who are admitted to hospital. For example only information in the patients' current episode of care when admitted to hospital is considered. Patients' previous admissions and their complexity are not included, thus underestimating the risk profile. It is also subject to significant bias due to differing recording practices from hospital to hospital in the NHS, which because it is confounded with true performance (both offer competing and plausible reasons for apparently 'poor' performance) presents a particular challenge for the development of a standardised measure.

PO banding was abandoned in 2012, although still reported in the SHMI output, and replaced by OD banding. OD banding is based upon an approximate random effects model and makes a reasonable attempt to overcome the limitations of the error structure of the SHMI,[12] albeit acting indirectly. OD banding achieves a substantial adjustment for overdispersion, and the resulting measure does not find evidence of variation between trusts at the conventional 3 SD level, thus identifying no trusts that would be conventionally considered outliers based on mortality. The NHS Information Centre uses OD banding between 2 but less than 3 SDs to define trusts with death rate which is 'higher than expected'. However, using the threshold of less than 3 SDs will mean results reflect the natural variation (legitimate diversity caused by the play of chance) and these trusts would usually be understood to be performing within normal limits.

The aim of this study was to develop a measure of hospital mortality, QUality and Outcomes Research Unit Measure (QUORUM), which attempts to address some of the methodological limitations of the SHMI, specifically the potential inadequacies of case-mix adjustment and absence of directly estimated error structure and estimates of model uncertainty. In this manuscript we describe the development of the QUORUM measure and compare it with the SHMI. First, we develop a single statistical model of hospital mortality including a more complete set of explanatory variables to stratify risk associated with each admission, defined a priori, estimating directly the impact of hospital trust on outcome. Second, we apply robust methods to describe uncertainty associated with the estimate of performance of each trust in order to identify potential outliers (those trusts which warrant further investigation). Third we compare the output of our models with the SHMI.

METHODS

We developed a generalised linear model to estimate the relationship between hospital trust and patient outcome, accounting for patient case-mix, the QUORUM model. It includes diagnostic category and hospital trust as explanatory variables and, unlike the SHMI, considers all data on outcome in a single statistical model. Models were developed based upon a prespecified statistical analysis plan.

We accessed patient data for the financial years 2005/2006 to 2010/2011 and used the most recent 3 years that is, 2008/2009 to 2010/2011 (number of hospital spells n=25 414 697) to build the QUORUM model, estimating the death rate for each trust compared with the 3 year mean value (using the 'param=effect' option in SAS to define the factor comparison with the overall mean of the trust-year effects). We used the 3-year data set because of substantial and unexplained reduction in reported mortality over the 3-year period, which could not plausibly be due only to differences in actual death rates. In addition, using a 3-year period to estimate the trust level effects increases substantially the number of events and thus stability of the model. In supportive analyses we analysed data from the years 2007/2008 to 2009/2010 and 2006/2007 to 2008/2009, the two previous 3-year periods. In each of these (the main analysis and the two supportive analyses) we fitted the model to the full 3 year dataset, but examined the results at the level of the trust for the most recent year in each case. This approach mirrors that taken for the SHMI. The University Hospitals Birmingham NHS Foundation Trust (UHB) institutional review board approved the study.

Datasets were constructed using a 64-bit MS SQL server 2005 on a Dell PowerEdge R610 64-bit, 64 GB, 2x Intel (R) Xeon(R) 5550@2.67 GHz, 2660 MHz 4Core(s), 8 logical server. Principal analyses were conducted using the 64-bit version of SAS (SAS Institute, Cary, North Carolina, USA, V.9.2), on a Dell PowerEdge R610 64-bit, 64 GB, 2x Intel (R) Xeon(R) 5550@2.67 GHz, 2660 MHz 4Core(s), 8 logical server.

In line with the SHMI, we defined the response variable to be mortality in hospital or up to 30 days post-discharge, unless admitted to another acute provider, and applied the analysis to the basic data structure described for SHMI.[7] Mortality data were obtained from the Office of National Statistics. We fitted a generalised linear model with a logit link and binomial error, with an additive residual random effect to account for overdispersion. Explanatory variables for case-mix adjustment were selected a priori by the study group considering existing knowledge on items, and interactions, likely to be associated with mortality in admissions to the NHS, and based upon our previous experience.[11] We included the independent explanatory variables: age, seasonality (count of days from the beginning of the 3-year data period), deprivation score (Index of Multiple Deprivation, IMD),[13] total number of previous emergency admissions, total number of previous complex admissions, Charlson comorbidity score,[9] sex, ethnicity, admission method, admission source, diagnostic group (based on aggregated CCS category),[8] trust–year (identifying the patients admitted to each trust over each of the three included years), and the interaction terms age×deprivation score, age×admission source.

Missing categorical data were addressed in the model through the inclusion of an additional level for missing values. Missing continuous values were not imputed and observations with missing continuous data were not included in the analyses.

Age was centred by subtracting the median value. Non-linear variable seasonality was fitted using an 8 knot restricted cubic spline.[14] Total number of previous urgent or complex admissions were included using $\log_e(x+1)$, Charlson score was transformed using $\log_e(x+2)$. All non-linear transformations were identified on the basis of substantive improvement (≥4) in Akaike's Information Criterion (AIC)[15] from $\log_e$ transformation and then a restricted cubic spline sequentially, with only seasonality requiring a restricted cubic spline using this prespecified rubric. Overdispersion was included in the estimates of trust performance using the random effects method described in the appendix. Included explanatory variables for both the QUORUM and SHMI models are described in box 1.

In order to identify trusts with worse than average performance according to the QUORUM model we calculated the number of SEs departure from the overall case-mix adjusted trust average for each trust having accounted for overdispersion (Q band). We compared the Q band with OD banding calculated for SHMI.

The SHMI accounts indirectly for overdispersion derived from a random effects model, and applies a 10% trim from the best and worst performing trusts in an attempt to separate 'normal' variation from 'extreme' variation and thus avoid the situation where outlier trusts which should properly be considered as belonging to a different distribution contribute to the calculation of the SDs used for banding. However, truncating the distribution of trust performance in this way will provide SDs (and thus bandings) which are too small and risks (wrongly) identifying trusts as outliers. The appropriate course of action in these circumstances is to inflate the SD and thus bandings by an amount which represents what the SD *would have been* for the whole population of trusts if the top and bottom 10% trimmed observations followed the normal distribution described by 80% of trusts included. The choice of level of trim is somewhat arbitrary, although it should be derived from the expected number of extreme cases. Our advisory group believed ±5% to be more appropriate given the expected number of poorly performing trusts. We also considered it inappropriate to base the bandings only on the included trusts, and thus reflated the SEs as described above.[12]

RESULTS

Of the 25 414 697 patient episodes in the 2008/2009 to 2010/2011 admissions dataset 23 363 630 had complete information (8.1% missing). There were 822 805 deaths in hospital or within 30 days of discharge. For the year 2010/2011, the median trust mean Charlson index was 1.22 (range 1.15–1.29). Similarly, the median trust mean age was 44 (range 33–63). The median trust IMD was

Box 1 Explanatory Variables Included in SHMI and QUORUM Models

SHMI

Item	Coding
Age	In 5 year bands
Sex	Male, Female or Unknown
Charlson comorbidity score	Categorised into 3 groups
Admission method	Elective, acute or unknown

QUORUM Model

Item	Coding
Age	Continuous, centred on median age
Seasonality	Restricted cubic spline with 8 knots fitted to count of day from 1/7/2008
Sex	Male, Female or Unknown
Index of Multiple Deprivation	Untransformed continuous score
Number of previous emergency admissions	transformed using $log_e(x+1)$
Number of previous complex admissions	transformed using $log_e(x+1)$
Charlson comorbidity score	transformed using $log_e(x+2)$
Ethnicity	Categorised into Asian or Asian British, Black or Black British, Mixed, White, unknown, or other ethnic group
Admission method	Elective, acute or unknown
Admission source	Birth, home, transfer or unknown
Diagnostic group	CCS categories grouped into categories numbers as detailed in [Clinical Indicators Team 2011]
Trust year	Categorised into trust and year
Age*deprivation score	
Age*admission source	

22.74 (range 9.16–43.65). The median number of previous complex admissions per trust was 0.04 (range 0.02–0.12), and the median number of previous emergency admissions per trust was 0.66 (range 0.47–0.90). The trust with the lowest crude death rate was Chelsea and Westminster Hospital NHS Foundation Trust, with 11.6 deaths per 1000 admissions, while the trust with the highest crude death rate was Trafford Healthcare NHS Trust with 54.8 deaths/1000 admissions. The characteristics of the included trusts for the year 2010/2011 and their SHMI scores and bands are described in online supplementary table S1.

The 10 patient cohorts, defined by the CCS categories with the highest count of deaths collectively accounted for 44% of deaths, and were: septicaemia (except in labour) (2.6%); shock (2.6%); cancer of bronchus, lung (3.3%); acute myocardial infarction (2.7%); congestive heart failure, non-hypertensive (3.8%); acute cerebrovascular disease (6.9%); pneumonia (except that caused by tuberculosis or sexually transmitted disease) (13.1%); acute bronchitis (2.5%); chronic obstructive pulmonary disease and bronchiectasis (3.3%); urinary tract infections (3.2%) and fracture of neck of femur (hip) (2.5%).

Age, seasonality, deprivation score (IMD), total number of emergency admissions, total number of complex admissions, sex, ethnicity, admission method, admission source, diagnostic group (CCS category), trust–year and the interaction terms age (*deprivation score, age (*admission source were all highly statistically significant predictors of death within 30 days of admission to hospital or within 30 days of discharge albeit with interesting differences in the statistical strength of individual items (see table 1). In table 2, we present the observed versus expected number of deaths for the

Box 2 Outcome Measures Describing Hospital Related Mortality

PO Band	3 standard deviations (3SD) from the target, corresponding to a 99.8% control limit derived from an exact Poisson distribution, abandoned in 2012 but still reported[7]
OD Band	2 standard deviations (2SD) from the target, corresponding to a 95% control limit derived from a random effects model applying a 10% trim from the top and bottom of all providers[7]
Q Band	Number of standard errors from mean, accounting for overdispersion at the trust level, derived from QUORUM Model

Table 1 QUORUM Model

Effect	DF	χ^{2*}
Age†	1	622.0
Seasonality‡	7	1207.8
Index of multiple deprivation (IMD)	1	757.5
Number of previous emergency admissions§	1	307.3
Number of previous complex admissions§	1	8585.5
Charlson score¶	1	111796.0
Sex	2	231.9
Ethnicity	5	4226.8
Admission method	2	88638.7
Admission source	3	3348.6
Clinical Classification Category	139	605564.0
Trust–year	441	11072.6
Age×IMD	1	714.8
Age×admission source	3	2261.8

*All p<0.0001.
†Centred on median.
‡8 knot restricted cubic spline.
§$\log_e(x+1)$.
¶$\log_e(x+2)$.
DF, degrees of freedom.

QUORUM model by risk strata which demonstrates a high level of prediction of the model across the range of risk strata. In online supplementary table S4 we present Q banding for each of 146 trusts with available data for the financial year 2010/2011 (where the model was built on the 3-year period 2008/2009 to 2010/2011), and for the two prior 3-year periods. The C statistic for QUORUM is 0.93 for the 2008/2009 to 2010/2011 time period.

The QUORUM values (eg, see online supplementary table S4 QUORUM OR values×100) for each trust differ quite substantially from the SHMI (see online supplementary table S1), with a median ratio of ORs difference of 2.1%, range −12.5% to 34.1%, differences which may be attributable to the additional explanatory variables included in the model and the differing model structures.

However, in spite of the added predictive variables, overdispersion (unexplained variation) remains a major feature, with the overdispersion corrected SE for the QUORUM model being on average 3.7 times the size of the uncorrected value (ie, the value not accounting for overdispersion).

No trusts were identified to be at least 3 QUORUM SEs (Q band) above the mean (see supplementary table S4), and only one trust was more than 2 SEs above the mean (Q band). In both of the previous 3-year periods analysed, only one trust (Basildon and Thurrock University Hospitals NHS Foundation Trust) was more than 3 SEs above the mean in overall mortality.

When we addressed the potential effect of outlier trusts on the width of the SEs of the model and thus the size of the Q band categories) through trimming excess mortality trusts at ±5%, and inflating the resulting SEs to allow for truncation of the normal distribution we found no qualitatively important difference in the number of trusts identified as outliers.

Table 2 Partition into tenths of observed versus expected deaths

Group	Total	Observed	Expected
1	2294980	108	74.63
2	2336156	162	171.87
3	2338189	746	1139.86
4	2335659	1522	2645.24
5	2336384	3497	5266.39
6	2336445	8123	10842.63
7	2336394	20523	24778.44
8	2336395	57770	58772
9	2336357	157250	143658.7
10	2376671	573104	575444.3

DISCUSSION

We have developed a new measure (QUORUM), which directly estimates the performance of hospital trusts using all-cause mortality (in hospital or within 30 days of hospital discharge), from individual patient data, as an alternative to the recently proposed SHMI. QUORUM undertakes a more complete adjustment for case-mix and avoids several of the pitfalls encountered by the SHMI. Our model is accurate and has a good calibration for different strata of risk. Direct comparison with SHMI was not possible due to differences in construction of this model. There are myriad potential modelling strategies, but QUORUM was developed from a prespecified statistical analysis plan developed by the multidisciplinary research team in order to avoid bias. Despite its accuracy, QUORUM does not identify hospitals with mortality outliers when using the conventional 3 SDs from the mean as a threshold. It is possible that once a robust case-mix adjustment is applied, such as the one used by QUORUM, there is little variation in hospital outcomes and the old HSMR methodology showed differences amplified by insufficient risk adjustment and inadequate handling of overdispersion (unexplained variation). However, we might reasonably expect to see some variation in outcomes in an organisation such as the UK NHS properly attributable to the performance of NHS Trusts, and if this is the case our findings question whether an approach using this methodology may be used to assess overall hospital quality of care.

Assessing hospital performance with a single surrogate of mortality has several limitations. A surrogate measure may be a composite of areas where an institution has poor performance and areas where the performance is excellent. The surrogate computation could show the institution performing within accepted limits, while masking clinical areas of poor performance. It may be more appropriate to focus on specific indicators of performance in important areas, such as that promoted by the NHS Quality

Outcomes Framework,[16] and not attempt an overall metric for performance in all clinical areas.

Furthermore, using overall hospital statistics does not provide information on the quality of the individual services, a measure possibly of more interest to patients, healthcare commissioners and regulators as findings relating to specific services may be more amenable to remedial action. Furthermore, while early mortality is an important outcome measure, modern healthcare systems should measure the effectiveness and complications of the health interventions that they provide. Finally, the outcomes of the provision of care in Acute Trusts should be put in the context of the out-of hospital primary and secondary care services and markers for whole pathways of care would be of considerable interest.

When first developed, the HSMR represented the limit of what was achievable computationally at that time.[1] The approach of fitting separate models for each diagnostic category and estimating the effects of hospital trusts was a practical solution to this circumstance. However, this approach has a range of substantive limitations as we discussed previously. Progress in computational power has enabled these significant limitations to be addressed making possible direct estimation of the effects of hospital trusts and the appropriate estimation of uncertainty and thus identification of outliers.

The simple statistical model fitted for the SHMI, which includes only age, clinical group, type of admission method and comorbidity index, does not account for many potentially important determinants of patient outcome. Variation in these measures is thus attributed to the trust contributing to the observed variation in scores between trusts and the unexplained differences (overdispersion). Thus, in the SHMI, the trust facing the lowest social deprivation, Frimley Park Hospital NHS Foundation Trust with an average IMD[13] score for patients admitted during the 3 years 2008/2009 to 2010/2011 of 9.2 is implicitly judged by the same standards as the trust with the most deprived caseload, the Royal Liverpool and Broadgreen University Hospitals NHS Trust with an average IMD score of 43.7 for patients admitted in the same time period.

The OD banding calculated for the SHMI represents a serious attempt to overcome the limitations of the modelling approach to provide a valid estimate of uncertainty and thus appropriate identification of outliers. However, it is hampered by the inadequate case-mix adjustment included in SHMI, and the trimming of the SE distribution without reflation according to normal distribution which leads to SEs which are too small. Including a more coherent model structure and additional case-mix adjustment in the QUORUM, while achieving a very high C statistic (0.93), did not result in the identification of outlier NHS Trusts. There was, however, substantial overdispersion in this model at the trust level. We believe that the additive random effects model that we included in QUORUM represents a methodological advance on the SHMI, incorporating the unexplained variability at the trust level in the SEs in a manner somewhat analogous to that used by random effects meta-analysis. However, this advance is also the key to the major limitation of the QUORUM approach. When unexplained, extra binomial, between trust variability is appropriately accounted for since there are no remaining differences between trusts for the outcome. In other words, QUORUM is overwhelmed by variability that it simply cannot explain.

We observed a substantial change in mortality among patients who had been admitted to hospital over the periods included in our study. In the 3 years from 2007/2008 to 2010/2011 we observed a 9% reduction in all-cause mortality among patients who had been admitted to hospital, a difference of a magnitude which cannot wholly be explained by improvements in patient care. We are aware that during this period some trusts have made changes to patient pathways and to the way data are acquired. In particular, where trusts moved activity for emergency ambulatory care from inpatient to outpatient activity this will have led to reduction in apparent mortality among outpatients as deaths occurring in emergency ambulatory care will not now be included in our analyses. Such changes may have a substantial effect upon reported death rates regardless of any actual changes in patient outcome. Clearly, changes like these can mask the true relationship between trusts and outcome, particularly where they occur at different time periods, and there is no guarantee that one will be aware of all such effects in a complex dataset such as HES. This possibility goes some way to explaining the residual variation in our current model, while any future ‘hidden’ differences of a similar nature will result in additional overdispersion, adding uncertainty to the effects of trust and making true differences yet more difficult to identify.

Both SHMI and the QUORUM measures have evolved the development of mortality measures by measuring outcomes within a hospital and within the community. This method of linking data at the patient level allows the indicator to have more of a robust overview and is not reliant on a single type of data submitted by hospitals for payment purposes. In order to improve the accuracy of calculation of quality of care in hospitals and associated outcomes for patients, much greater variety and depth of data are required to be collected in a formal, standardised way, by all sections of care provision. This should be made uniformly available for use and assessment. Types of relevant data include electronic prescription, laboratory test outputs, general practice record data and incidents linked to peripheral electronic health records. Linkage of these information sources will allow clinicians, researchers and service members a more refined view of inequality of outcomes. Furthermore, future research should focus on developing measures for the individual clinical services offered by the individual trusts and measures of whole care pathways for individual health economies.

CONCLUSION

We have developed QUORUM to estimate excess mortality at the trust level. QUORUM is highly predictive of patient mortality in hospital or up to 30 days after admission. QUORUM accounts directly for overdispersion (otherwise unexplained variation in patient outcome) and provides estimates of trust performance over a 3-year period. However, the overdispersion that remains after fitting our sophisticated statistical model is substantial and overwhelming. In the financial year 2010–2011 no trusts were found to be outliers at the conventional level of statistical significance, and in the previous two periods, only one trust was observed to be an outlier. Owing to legitimate but unexplained variation, it is unlikely that measures like QUORUM and SHMI will be useful beyond identifying a very small number of trusts as potential outliers for a period with values more than 3 SDs above the mean. Like the SHMI, our attempts to advance the methodology remain challenged by substantial overdispersion which, when accounted for in the mixed effects model, result in no trusts being identified as outliers in 2010/2011. There is no sound methodological basis for the use of values between 2 and 3 SDs of the overall mean as markers of poor performance. In our view future developments should concentrate upon driving healthcare providers to collect more clinically relevant data centrally, for example Scottish Early Warning System (SEWS) (early warning scores), and prescribing and the derivation of much more detailed linked patient datasets. This may then be used to explore quality within focused clinical areas rather than averaging across multifarious service provision.

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APPENDIX: EXTRA BINOMIAL VARIABILITY

In binomial models the assumption of independence of each subject in the model can be violated, where subjects sharing common characteristics are clustered within hierarchical structures. Failing to account for this extra binomial variability, or overdispersion, will lead to SEs, which are too small and thus corresponding CIs that are too narrow. Quasi-likelihood methods, which inflate the SEs from the model by a scale factor, represent one possible solution. However, where there are unequal numbers of observations within a cluster across the stratum of interest, and the additional component of variance is most naturally regarded as additive rather than multiplicative, the adjustment they make is inappropriate. For such a situation the methods described by Williams[17] should work well, and these have been implemented in SAS (SAS V.9.2, SAS Institute, Cary, North Carolina, USA) for data in events/trials format. We have extended this approach to enable the use of individual subject data in the large sample size situation, using the asymptotic distribution of differences in the deviance as the basis for estimation of overdispersion. (Here we are using the term 'deviance' in the common sense to mean −2 times the log likelihood ratio of the current model compared with the saturated model.) Specifically, we assessed the level of extra binomial variability or overdispersion in our model due to trust and year by examining the difference in the deviance for the full model and the model with trust–year omitted. If D_1 is the deviance for the full model, D_2 is the deviance for the model with trust–year omitted, K is the number of levels for trust–year and W is the average overall trust–year combinations of the reciprocals of binomial variance (in other words, W is the average of the fixed-effects weights) then the overdispersion parameter φ is estimated by

$$\{((D_1 - D_2)/(K-1)) - 1\}/W$$

There is a slight complication here in that the variance due to binomial sampling variation at the level of the trust and year is affected by the fact that the risks for individual patients vary. However, this variation—referred to below as γ—is easily estimated using the variance of the fitted values from the model, and an approximate adjustment is also simple:

Suppose R is the total number of events observed in N Bernoulli trials, where the average probability (overall N trials) of an event is π, but where the individual probabilities—$\{p_i\}$ say—vary over trials (due here to case-mix within provider) with variance γ. Then we have directly

$$\mathrm{var}(R) = \sum p_i(1-p_i)$$

and also

$$N\gamma = \sum p_i^2 - N\pi^2$$

therefore

$$\mathrm{var}(R) = N(\pi - \gamma - \pi^2)$$

furthermore, (remembering that we are working on the logit scale, and approximating this through a Taylor expansion in R), the following holds:

$$\mathrm{var}(\mathrm{logit}(R/N)) \approx \{1/[N\pi(1-\pi)]^2\}\mathrm{var}(R)$$

so finally

$$\mathrm{var}(\mathrm{logit}(R/N)) \approx \{\pi(1-\pi) - \gamma\}/\{[\pi(1-\pi)]^2 N\}$$

The reciprocal of this gives the set of weights w_i (where i indexes the set of trust–year combinations) and the mean of w_i gives W in the first formula above.

Strictly speaking, a more accurate formula for estimating ϕ is given by replacing W with

$$\left[\sum w_i - \frac{\sum w_i^2}{\sum w_i}\right]/(K-1)$$

However, in practice, the difference is very small.

Finally, an adjusted SE for trust is obtained by calculating

$$\sqrt{se^2 + \hat{\varphi}}.$$

 Freemantle N, Richardson M, Wood J, *et al.* *BMJ Open* 2013;**3**:e002018. doi:10.1136/bmjopen-2012-002018

Trust	Trust_Name	Admissions	Deaths	SHMI	Age	Charlson	Complex Admissions	Emergency Admissions	IMD	OD BANDING
REM	AINTREE UNIVERSITY HOSPITALS NHS	43101	2007	110.6	58	1.26	0.05	0.88	40.41	2
RCF	AIREDALE NHS FOUNDATION TRUST	32571	951	92.9	43	1.21	0.05	0.63	22.92	2
RTK	ASHFORD AND ST PETER'S HOSPITALS	49750	1614	90.5	45	1.21	0.06	0.56	11.55	2
RF4	BARKING HAVERING AND REDBRIDGE	84771	3033	96.4	44	1.22	0.05	0.68	24.37	2
RVL	BARNET AND CHASE FARM	74295	2303	88.8	43	1.21	0.06	0.71	19.94	2
RFF	BARNSLEY HOSPITAL NHS	40744	1410	106.4	43	1.21	0.05	0.67	30.10	2
RNJ	BARTS AND THE LONDON NHS TRUST	68656	1311	69.1	41	1.22	0.03	0.74	36.04	3
RDD	BASILDON AND THURROCK UNIVERSITY HOSPITALS NHS	48522	1923	114.8	45	1.23	0.06	0.58	21.41	1
RN5	BASINGSTOKE AND NORTH	33692	963	113.7	40	1.18	0.03	0.62	11.76	2
RC1	BEDFORD HOSPITAL NHS TRUST	28062	1121	99.9	45	1.23	0.05	0.61	16.66	2
RXL	BLACKPOOL TEACHING HOSPITALS	53958	2371	116.7	51	1.25	0.05	0.74	30.80	1
RMC	BOLTON NHS FOUNDATION TRUST	54266	1753	105.0	38	1.20	0.04	0.66	34.39	2
RAE	BRADFORD TEACHING HOSPITALS	73484	1846	94.5	41	1.21	0.05	0.69	38.19	2
RXH	BRIGHTON AND SUSSEX UNIVERSITY	67771	2368	101.3	47	1.21	0.04	0.69	21.33	2
RXQ	BUCKINGHAMSHIRE HEALTHCARE	52249	1658	111.7	40	1.19	0.03	0.56	12.09	2
RJF	BURTON HOSPITALS NHS	39668	1257	112.1	42	1.20	0.04	0.59	19.05	2
RWY	CALDERDALE AND HUDDERSFIELD	77554	2309	102.6	43	1.21	0.04	0.63	26.20	2
RGT	CAMBRIDGE UNIVERSITY HOSPITALS	70225	1893	78.4	45	1.23	0.03	0.63	12.87	3
RW3	CENTRAL MANCHESTER UNIVERSITY	83686	1334	103.2	33	1.19	0.02	0.66	37.22	2
RQM	CHELSEA AND WESTMINSTER	49277	571	78.4	34	1.15	0.02	0.47	22.71	3
RFS	CHESTERFIELD ROYAL HOSPITAL NHS	44229	1632	104.0	46	1.22	0.05	0.67	23.06	2
RLN	CITY HOSPITALS SUNDERLAND NHS	61302	2136	106.9	46	1.24	0.06	0.69	32.32	2
RDE	COLCHESTER HOSPITAL UNIVERSITY	49865	2179	113.1	47	1.22	0.04	0.63	20.38	2
RJR	COUNTESS OF CHESTER HOSPITAL	48012	1376	110.8	42	1.19	0.03	0.62	21.52	2
RXP	COUNTY DURHAM AND DARLINGTON	87143	2788	95.6	43	1.22	0.05	0.71	27.85	2
RJ6	CROYDON HEALTH SERVICES NHS	43910	1307	104.6	41	1.21	0.04	0.65	24.88	2

RN7	DARTFORD AND GRAVESHAM NHS	37399	1413	109.4	43	1.20	0.05	0.63	19.30	2
RTG	DERBY HOSPITALS NHS FOUNDATION	83787	2673	106.2	45	1.21	0.04	0.66	22.30	2
RP5	DONCASTER AND BASSETLAW	73234	2724	102.0	44	1.24	0.04	0.68	30.91	2
RBD	DORSET COUNTY HOSPITAL NHS	29316	1024	102.5	49	1.22	0.04	0.61	19.17	2
RC3	EALING HOSPITAL NHS TRUST	31490	721	86.6	41	1.20	0.05	0.70	28.04	3
RWH	EAST AND NORTH HERTFORDSHIRE	67467	2546	118.4	44	1.21	0.04	0.60	13.24	1
RJN	EAST CHESHIRE NHS TRUST	24679	929	96.0	46	1.22	0.06	0.72	14.81	2
RVV	EAST KENT HOSPITALS UNIVERSITY	98736	3900	95.5	50	1.25	0.07	0.69	22.74	2
RXR	EAST LANCASHIRE HOSPITALS NHS	79689	2596	113.9	41	1.23	0.04	0.73	35.71	1
RXC	EAST SUSSEX HEALTHCARE NHS	60857	2754	109.0	50	1.23	0.05	0.69	24.20	2
RVR	EPSOM AND ST HELIER UNIVERSITY	57226	1912	91.0	48	1.23	0.06	0.68	14.17	2
RDU	FRIMLEY PARK HOSPITAL NHS	49928	1404	89.6	45	1.22	0.05	0.62	9.16	2
RR7	GATESHEAD HEALTH NHS	34276	1445	99.5	48	1.26	0.07	0.77	30.74	2
RLT	GEORGE ELIOT HOSPITAL NHS TRUST	24157	1023	121.4	45	1.21	0.05	0.63	22.24	1
RTE	GLOUCESTERSHIRE HOSPITALS NHS	82575	2754	97.7	46	1.21	0.04	0.61	16.43	2
RN3	GREAT WESTERN HOSPITALS NHS	46972	1496	100.0	44	1.21	0.05	0.64	15.75	2
RJ1	GUY'S AND ST THOMAS' NHS	84928	1444	90.9	41	1.17	0.02	0.58	27.66	2
RCD	HARROGATE AND DISTRICT NHS	24054	895	94.4	46	1.23	0.05	0.63	12.09	2
RR1	HEART OF ENGLAND NHS	148776	4314	103.6	42	1.20	0.04	0.68	33.40	2
RD7	HEATHERWOOD AND WEXHAM PARK HOSPITALS NHS FOUNDATION TRUST	50200	1388	100.2	41	1.20	0.04	0.63	16.70	2
RQQ	HINCHINGBROOKE HEALTH CARE NHS	21535	667	90.1	47	1.23	0.04	0.54	12.58	2
RQX	HOMERTON UNIVERSITY HOSPITAL	37565	609	95.4	33	1.16	0.03	0.60	42.12	2
RWA	HULL AND EAST YORKSHIRE	92194	3266	114.6	47	1.21	0.04	0.66	29.33	1
RYJ	IMPERIAL COLLEGE HEALTHCARE NHS	108713	2231	74.9	44	1.22	0.04	0.60	27.00	3
RGQ	IPSWICH HOSPITAL NHS TRUST	49467	1873	101.1	47	1.23	0.05	0.64	17.91	2
RGP	JAMES PAGET UNIVERSITY HOSPITALS	32097	1446	86.1	49	1.26	0.06	0.69	26.08	3
RNQ	KETTERING GENERAL HOSPITAL NHS	44572	1517	107.8	43	1.20	0.04	0.64	20.92	2
RJZ	KING'S COLLEGE HOSPITAL NHS	65526	1358	92.0	40	1.20	0.03	0.55	28.33	2
RAX	KINGSTON HOSPITAL NHS TRUST	48304	1307	85.7	40	1.19	0.05	0.50	12.22	3

RXN	LANCASHIRE TEACHING HOSPITALS	77029	2277	98.1	42	1.22	0.04	0.69	24.37	2
RR8	LEEDS TEACHING HOSPITALS NHS	156748	4115	93.8	43	1.21	0.04	0.70	29.83	2
RJ2	LEWISHAM HEALTHCARE NHS TRUST	35854	945	94.8	39	1.19	0.05	0.72	30.61	2
RC9	LUTON AND DUNSTABLE HOSPITAL	54997	1541	108.5	38	1.20	0.04	0.55	22.13	2
RWF	MAIDSTONE AND TUNBRIDGE WELLS	64939	2261	104.0	45	1.20	0.04	0.64	13.56	2
RPA	MEDWAY NHS FOUNDATION TRUST	51539	1743	115.8	40	1.20	0.04	0.65	23.41	1
RBT	MID CHESHIRE HOSPITALS NHS	45865	1507	110.5	44	1.21	0.04	0.76	19.64	2
RQ8	MID ESSEX HOSPITAL SERVICES NHS	57960	1640	107.1	44	1.20	0.03	0.55	14.24	2
RJD	MID STAFFORDSHIRE NHS	32791	962	98.5	42	1.20	0.04	0.68	18.19	2
RXF	MID YORKSHIRE HOSPITALS NHS	95657	3095	105.7	43	1.19	0.04	0.66	28.29	2
RD8	MILTON KEYNES HOSPITAL NHS	42698	1110	103.4	39	1.19	0.03	0.68	17.12	2
RNH	NEWHAM UNIVERSITY HOSPITAL NHS	46331	648	79.8	33	1.17	0.04	0.52	41.28	3
RM1	NORFOLK AND NORWICH UNIVERSITY HOSPITALS NHS	84176	3046	99.1	47	1.22	0.04	0.62	17.77	2
RVJ	NORTH BRISTOL NHS TRUST	72517	2152	97.8	46	1.22	0.03	0.54	18.19	2
RNL	NORTH CUMBRIA UNIVERSITY	44552	1728	112.4	46	1.22	0.04	0.65	23.90	2
RAP	NORTH MIDDLESEX UNIVERSITY	25931	831	94.1	39	1.22	0.06	0.66	38.24	2
RVW	NORTH TEES AND HARTLEPOOL NHS	57550	1829	102.6	44	1.22	0.04	0.75	33.32	2
RV8	NORTH WEST LONDON HOSPITALS	66781	1739	83.5	42	1.22	0.04	0.66	23.33	3
RNS	NORTHAMPTON GENERAL HOSPITAL	53668	1546	114.0	39	1.20	0.03	0.60	20.25	1
RBZ	NORTHERN DEVON HEALTHCARE NHS	25804	972	93.0	48	1.23	0.05	0.62	21.18	2
RJL	NORTHERN LINCOLNSHIRE AND GOOLE HOSPITALS NHS FOUNDATION	57610	2263	114.8	45	1.22	0.03	0.61	27.29	1
RTF	NORTHUMBRIA HEALTHCARE NHS	74023	3027	99.6	51	1.24	0.06	0.83	24.62	2
RX1	NOTTINGHAM UNIVERSITY	134220	4284	96.7	45	1.23	0.05	0.66	24.56	2
RTH	OXFORD RADCLIFFE HOSPITALS NHS	100244	3053	101.8	43	1.20	0.03	0.62	13.58	2
RW6	PENNINE ACUTE HOSPITALS NHS	139603	4410	106.4	42	1.22	0.05	0.72	36.16	2
RGN	PETERBOROUGH AND STAMFORD	48721	1541	104.6	42	1.22	0.04	0.61	21.02	2
RK9	PLYMOUTH HOSPITALS NHS TRUST	76870	2429	94.1	46	1.24	0.05	0.66	23.56	2
RD3	POOLE HOSPITAL NHS FOUNDATION	53657	1479	92.4	40	1.20	0.04	0.61	18.01	2

RHU	PORTSMOUTH HOSPITALS NHS	87474	2892	98.8	46	1.22	0.05	0.70	21.34	2
RHW	ROYAL BERKSHIRE NHS FOUNDATION	58566	2060	109.5	41	1.20	0.03	0.56	13.68	2
REF	ROYAL CORNWALL HOSPITALS NHS	69098	2161	101.3	45	1.22	0.04	0.63	24.03	2
RH8	ROYAL DEVON AND EXETER NHS	61391	1766	92.1	47	1.21	0.03	0.59	17.99	2
RAL	ROYAL FREE HAMPSTEAD NHS TRUST	55530	1189	77.5	49	1.20	0.05	0.72	24.31	3
RQ6	ROYAL LIVERPOOL AND	48890	1915	100.3	56	1.27	0.06	0.90	43.65	2
RA2	ROYAL SURREY COUNTY HOSPITAL	43839	1347	91.0	48	1.25	0.04	0.57	9.57	2
RD1	ROYAL UNITED HOSPITAL BATH NHS	41020	1925	93.9	54	1.26	0.06	0.84	13.96	2
RM3	SALFORD ROYAL NHS FOUNDATION	57160	1621	94.6	44	1.22	0.05	0.65	34.31	2
RNZ	SALISBURY NHS FOUNDATION TRUST	35773	1074	95.8	45	1.21	0.04	0.60	13.90	2
RXK	SANDWELL AND WEST BIRMINGHAM	78513	2359	101.3	43	1.23	0.06	0.72	40.20	2
RCC	SCARBOROUGH AND NORTH EAST	24811	1168	112.2	47	1.23	0.05	0.67	26.61	2
RHQ	SHEFFIELD TEACHING HOSPITALS NHS	104505	3585	85.5	51	1.24	0.05	0.68	29.33	3
RK5	SHERWOOD FOREST HOSPITALS NHS	50267	1835	103.0	45	1.22	0.05	0.69	28.34	2
RXW	SHREWSBURY AND TELFORD	61651	2423	111.7	44	1.22	0.03	0.66	21.04	2
RA9	SOUTH DEVON HEALTHCARE NHS	39087	1617	97.3	50	1.24	0.05	0.70	23.19	2
RYQ	SOUTH LONDON HEALTHCARE NHS	102471	3020	90.4	43	1.20	0.05	0.58	22.10	2
RTR	SOUTH TEES HOSPITALS NHS	94025	2650	98.0	45	1.23	0.04	0.67	29.93	2
RE9	SOUTH TYNESIDE NHS FOUNDATION	22584	1067	99.9	47	1.25	0.07	0.80	31.15	2
RJC	SOUTH WARWICKSHIRE NHS	32439	1079	107.7	44	1.20	0.03	0.57	11.88	2
RHM	SOUTHAMPTON UNIVERSITY	84978	2506	96.3	43	1.20	0.03	0.67	18.69	2
RAJ	SOUTHEND UNIVERSITY HOSPITAL	49764	2215	105.7	50	1.25	0.07	0.63	19.57	2
RVY	SOUTHPORT AND ORMSKIRK	35785	1370	109.5	46	1.22	0.04	0.71	21.57	2
RJ7	ST GEORGE'S HEALTHCARE NHS	72434	1619	77.8	43	1.22	0.04	0.65	19.78	3
RBN	ST HELENS AND KNOWSLEY	60713	1881	100.1	45	1.22	0.06	0.76	36.02	2
RWJ	STOCKPORT NHS FOUNDATION	59999	1637	90.7	44	1.21	0.05	0.71	22.13	2
RTP	SURREY AND SUSSEX HEALTHCARE	49448	1597	96.2	42	1.20	0.05	0.69	12.81	2
RMP	TAMESIDE HOSPITAL NHS	34849	1463	116.6	43	1.22	0.05	0.70	32.62	1
RBA	TAUNTON AND SOMERSET NHS	53740	1526	94.5	45	1.22	0.04	0.59	19.23	2
RNA	THE DUDLEY GROUP OF HOSPITALS	69838	2134	109.0	42	1.20	0.04	0.59	27.40	2

RAS	THE HILLINGDON HOSPITALS NHS	38352	951	88.3	41	1.21	0.04	0.67	21.66	2
RTD	THE NEWCASTLE UPON TYNE	105636	2662	94.3	43	1.22	0.03	0.69	28.49	2
RQW	THE PRINCESS ALEXANDRA HOSPITAL	36247	1384	99.3	46	1.23	0.07	0.64	17.04	2
RCX	THE QUEEN ELIZABETH HOSPITAL	37565	1474	97.0	47	1.24	0.06	0.71	23.36	2
RFR	THE ROTHERHAM NHS FOUNDATION	47896	1453	102.3	43	1.21	0.04	0.73	31.81	2
RDZ	THE ROYAL BOURNEMOUTH AND CHRISTCHURCH HOSPITALS NHS	42990	2065	101.0	63	1.25	0.06	0.76	17.61	2
RL4	THE ROYAL WOLVERHAMPTON	60233	2199	111.4	43	1.22	0.04	0.65	32.12	2
RKE	THE WHITTINGTON HOSPITAL NHS	34679	575	67.3	38	1.19	0.04	0.61	33.19	3
RM4	TRAFFORD HEALTHCARE NHS TRUST	10180	558	106.3	60	1.29	0.12	0.83	21.72	2
RWD	UNITED LINCOLNSHIRE HOSPITALS	93977	3604	110.7	46	1.22	0.05	0.64	21.54	2
RRV	UNIVERSITY COLLEGE LONDON	61866	1022	71.8	42	1.20	0.02	0.51	26.64	3
RJE	UNIVERSITY HOSPITAL OF NORTH	86014	3063	103.2	44	1.21	0.05	0.76	29.17	2
RM2	UNIVERSITY HOSPITAL OF SOUTH	58944	1682	88.4	47	1.23	0.04	0.67	27.44	2
RRK	UNIVERSITY HOSPITALS	57141	2247	100.8	55	1.25	0.04	0.80	30.98	2
RA7	UNIVERSITY HOSPITALS BRISTOL NHS	76810	1653	92.3	39	1.20	0.03	0.61	23.72	2
RKB	UNIVERSITY HOSPITALS COVENTRY	82080	2670	105.6	44	1.22	0.04	0.62	25.90	2
RWE	UNIVERSITY HOSPITALS OF LEICESTER	154795	4549	105.8	42	1.21	0.04	0.67	22.97	2
RTX	UNIVERSITY HOSPITALS OF	53234	2047	113.7	47	1.22	0.04	0.71	23.05	1
RBK	WALSALL HEALTHCARE NHS TRUST	37387	1476	106.3	42	1.24	0.06	0.64	34.82	2
RWW	WARRINGTON AND HALTON	52219	1636	101.6	45	1.22	0.05	0.77	26.51	2
RWG	WEST HERTFORDSHIRE HOSPITALS	50993	1774	106.7	43	1.21	0.05	0.55	13.09	2
RFW	WEST MIDDLESEX UNIVERSITY	32719	897	88.0	41	1.20	0.06	0.63	20.46	2
RGR	WEST SUFFOLK HOSPITALS NHS	34138	1232	91.1	47	1.24	0.05	0.67	14.41	2
RYR	WESTERN SUSSEX HOSPITALS NHS	76060	3148	113.3	50	1.23	0.05	0.70	17.54	1
RA3	WESTON AREA HEALTH NHS TRUST	18906	1021	112.4	53	1.24	0.06	0.66	21.34	2
RGC	WHIPPS CROSS UNIVERSITY	53218	1452	91.8	42	1.21	0.06	0.67	30.89	2
RN1	WINCHESTER AND EASTLEIGH	26472	927	97.6	44	1.21	0.05	0.61	10.83	2
RBL	WIRRAL UNIVERSITY TEACHING	64796	2180	102.8	46	1.20	0.04	0.73	30.50	2
RWP	WORCESTERSHIRE ACUTE HOSPITALS	75995	2682	109.8	45	1.22	0.05	0.64	18.97	2

RRF	WRIGHTINGTON WIGAN AND LEIGH	48111	1714	106.1	48	1.24	0.06	0.68	28.63	2
RLQ	WYE VALLEY NHS TRUST	26305	985	108.0	43	1.22	0.05	0.58	19.43	2
RA4	YEOVIL DISTRICT HOSPITAL NHS	22995	909	107.9	49	1.22	0.04	0.68	15.43	2
RCB	YORK TEACHING HOSPITAL NHS	35680	1402	115.0	47	1.22	0.04	0.62	14.10	1

OD Banding Interpretation

1 – where the trust's mortality rate is 'higher than expected'

2 – where the trust's mortality rate is 'as expected'

3 – where the trust's mortality rate is 'lower than expected'

Based upon 2 SD Threshold

Trust	Trust Name	Quorum O(	Q Band 20(	Q Band 20(	Q Band 2006/7 to 2008/9
REM	AINTREE UNIVERSITY HOSPITALS NHS FOUNDATION TRUST	1.042	0.392	-0.769	-0.775
RCF	AIREDALE NHS FOUNDATION TRUST	0.879	-1.187	-0.449	-0.321
RTK	ASHFORD AND ST PETER'S HOSPITALS NHS FOUNDATION TRUST	0.839	-1.650	-1.925	-1.795
RF4	BARKING HAVERING AND REDBRIDGE UNIVERSITY HOSPITALS NHS TRUST	0.958	-0.410	0.954	0.580
RVL	BARNET AND CHASE FARM HOSPITALS NHS TRUST	0.778	-2.376	-1.745	-0.926
RFF	BARNSLEY HOSPITAL NHS FOUNDATION TRUST	1.068	0.618	0.030	0.150
RNJ	BARTS AND THE LONDON NHS TRUST	0.604	-4.712	-2.257	-1.483
RDD	BASILDON AND THURROCK UNIVERSITY HOSPITALS NHS FOUNDATION TRUST	1.128	1.138	3.244	3.567
RN5	BASINGSTOKE AND NORTH HAMPSHIRE NHS FOUNDATION TRUST	1.182	1.533	0.844	0.582
RC1	BEDFORD HOSPITAL NHS TRUST	0.984	-0.145	0.645	0.159
RXL	BLACKPOOL TEACHING HOSPITALS NHS FOUNDATION TRUST	1.214	1.842	2.868	2.755
RMC	BOLTON NHS FOUNDATION TRUST	0.988	-0.115	1.970	1.827
RAE	BRADFORD TEACHING HOSPITALS NHS FOUNDATION TRUST	0.858	-1.448	-1.836	-1.358
RXH	BRIGHTON AND SUSSEX UNIVERSITY HOSPITALS NHS TRUST	1.026	0.240	-0.964	-1.288
RXQ	BUCKINGHAMSHIRE HEALTHCARE NHS TRUST	1.134	1.183	0.601	-0.208
RJF	BURTON HOSPITALS NHS FOUNDATION TRUST	1.087	0.779	0.822	1.262
RWY	CALDERDALE AND HUDDERSFIELD NHS FOUNDATION TRUST	1.022	0.207	1.592	1.482
RGT	CAMBRIDGE UNIVERSITY HOSPITALS NHS FOUNDATION TRUST	0.734	-2.922	-2.554	-2.667
RW3	CENTRAL MANCHESTER UNIVERSITY HOSPITALS NHS FOUNDATION TRUST	1.021	0.197	1.797	2.062
RQM	CHELSEA AND WESTMINSTER HOSPITAL NHS FOUNDATION TRUST	0.782	-2.177	-2.282	-2.020
RFS	CHESTERFIELD ROYAL HOSPITAL NHS FOUNDATION TRUST	1.031	0.283	0.994	1.160
RLN	CITY HOSPITALS SUNDERLAND NHS FOUNDATION TRUST	0.974	-0.248	0.461	-0.159
RDE	COLCHESTER HOSPITAL UNIVERSITY NHS FOUNDATION TRUST	1.190	1.647	2.250	1.979
RJR	COUNTESS OF CHESTER HOSPITAL NHS FOUNDATION TRUST	1.130	1.129	1.511	1.294
RXP	COUNTY DURHAM AND DARLINGTON NHS FOUNDATION TRUST	0.885	-1.166	-0.486	-0.439
RJ6	CROYDON HEALTH SERVICES NHS TRUST	1.065	0.586	0.887	0.856
RN7	DARTFORD AND GRAVESHAM NHS TRUST	1.087	0.780	2.266	1.941
RTG	DERBY HOSPITALS NHS FOUNDATION TRUST	1.081	0.744	0.552	0.526
RP5	DONCASTER AND BASSETLAW HOSPITALS NHS FOUNDATION TRUST	0.986	-0.133	-0.993	-1.651
RBD	DORSET COUNTY HOSPITAL NHS FOUNDATION TRUST	1.027	0.248	0.109	-0.207
RC3	EALING HOSPITAL NHS TRUST	0.852	-1.438	-1.630	-1.599
RWH	EAST AND NORTH HERTFORDSHIRE NHS TRUST	1.308	2.556	2.074	1.761
RJN	EAST CHESHIRE NHS TRUST	0.918	-0.784	-0.238	-0.211

RVV	EAST KENT HOSPITALS UNIVERSITY NHS FOUNDATION TRUST	0.877	-1.263	-0.793	-0.438
RXR	EAST LANCASHIRE HOSPITALS NHS TRUST	1.150	1.333	1.360	1.334
RXC	EAST SUSSEX HEALTHCARE NHS TRUST	1.116	1.043	0.611	-0.209
RVR	EPSOM AND ST HELIER UNIVERSITY HOSPITALS NHS TRUST	0.831	-1.748	-0.777	-0.031
RDU	FRIMLEY PARK HOSPITAL NHS FOUNDATION TRUST	0.851	-1.506	-0.658	-0.522
RR7	GATESHEAD HEALTH NHS FOUNDATION TRUST	0.954	-0.439	-1.309	-1.611
RLT	GEORGE ELIOT HOSPITAL NHS TRUST	1.228	1.883	1.688	2.051
RTE	GLOUCESTERSHIRE HOSPITALS NHS FOUNDATION TRUST	0.995	-0.045	0.167	0.485
RN3	GREAT WESTERN HOSPITALS NHS FOUNDATION TRUST	0.992	-0.071	1.158	1.584
RJ1	GUY'S AND ST THOMAS' NHS FOUNDATION TRUST	0.924	-0.741	-1.163	-2.074
RCD	HARROGATE AND DISTRICT NHS FOUNDATION TRUST	0.918	-0.784	0.141	0.081
RR1	HEART OF ENGLAND NHS FOUNDATION TRUST	1.031	0.289	0.790	1.217
RD7	HEATHERWOOD AND WEXHAM PARK HOSPITALS NHS FOUNDATION TRUST	0.956	-0.421	0.078	0.150
RQQ	HINCHINGBROOKE HEALTH CARE NHS TRUST	0.864	-1.312	-0.432	-0.887
RQX	HOMERTON UNIVERSITY HOSPITAL NHS FOUNDATION TRUST	0.786	-2.141	-1.755	-1.192
RWA	HULL AND EAST YORKSHIRE HOSPITALS NHS TRUST	1.184	1.616	1.891	0.995
RYJ	IMPERIAL COLLEGE HEALTHCARE NHS TRUST	0.695	-3.452	-3.091	-3.214
RGQ	IPSWICH HOSPITAL NHS TRUST	0.959	-0.392	-1.215	-1.573
RGP	JAMES PAGET UNIVERSITY HOSPITALS NHS FOUNDATION TRUST	0.785	-2.260	-1.066	-0.226
RNQ	KETTERING GENERAL HOSPITAL NHS FOUNDATION TRUST	1.098	0.878	1.626	2.039
RJZ	KING'S COLLEGE HOSPITAL NHS FOUNDATION TRUST	0.900	-0.988	0.692	0.909
RAX	KINGSTON HOSPITAL NHS TRUST	0.536	-5.699	-1.282	-1.297
RXN	LANCASHIRE TEACHING HOSPITALS NHS FOUNDATION TRUST	0.901	-0.988	-1.634	-1.632
RR8	LEEDS TEACHING HOSPITALS NHS TRUST	0.920	-0.797	-0.590	-0.610
RJ2	LEWISHAM HEALTHCARE NHS TRUST	0.909	-0.872	-0.481	-0.313
RC9	LUTON AND DUNSTABLE HOSPITAL NHS FOUNDATION TRUST	1.034	0.310	0.375	0.193
RWF	MAIDSTONE AND TUNBRIDGE WELLS NHS TRUST	1.070	0.643	-1.343	-1.625
RPA	MEDWAY NHS FOUNDATION TRUST	1.207	1.768	2.147	2.668
RBT	MID CHESHIRE HOSPITALS NHS FOUNDATION TRUST	1.123	1.091	2.131	1.898
RQ8	MID ESSEX HOSPITAL SERVICES NHS TRUST	1.055	0.503	0.134	-0.230
RJD	MID STAFFORDSHIRE NHS FOUNDATION TRUST	0.962	-0.358	1.411	2.536
RXF	MID YORKSHIRE HOSPITALS NHS TRUST	1.078	0.720	1.737	1.320
RD8	MILTON KEYNES HOSPITAL NHS FOUNDATION TRUST	1.003	0.028	0.144	0.248

RNH	NEWHAM UNIVERSITY HOSPITAL NHS TRUST	0.673	-3.547	-1.242	-0.713
RM1	NORFOLK AND NORWICH UNIVERSITY HOSPITALS NHS FOUNDATION TRUST	0.976	-0.236	0.282	0.030
RVJ	NORTH BRISTOL NHS TRUST	0.933	-0.660	-0.666	-1.164
RNL	NORTH CUMBRIA UNIVERSITY HOSPITALS NHS TRUST	1.169	1.470	0.613	0.404
RAP	NORTH MIDDLESEX UNIVERSITY HOSPITAL NHS TRUST	0.900	-0.955	0.725	1.509
RVW	NORTH TEES AND HARTLEPOOL NHS FOUNDATION TRUST	1.016	0.149	1.256	1.405
RV8	NORTH WEST LONDON HOSPITALS NHS TRUST	0.814	-1.941	-1.942	-1.469
RNS	NORTHAMPTON GENERAL HOSPITAL NHS TRUST	1.192	1.647	1.153	1.052
RBZ	NORTHERN DEVON HEALTHCARE NHS TRUST	0.889	-1.080	-2.469	-2.524
RJL	NORTHERN LINCOLNSHIRE AND GOOLE HOSPITALS NHS FOUNDATION TRUST	1.231	1.970	1.839	1.547
RTF	NORTHUMBRIA HEALTHCARE NHS FOUNDATION TRUST	0.946	-0.533	-0.243	-0.255
RX1	NOTTINGHAM UNIVERSITY HOSPITALS NHS TRUST	0.927	-0.726	-0.741	-1.017
RTH	OXFORD RADCLIFFE HOSPITALS NHS TRUST	1.033	0.306	0.664	0.499
RW6	PENNINE ACUTE HOSPITALS NHS TRUST	1.038	0.361	1.155	1.286
RGN	PETERBOROUGH AND STAMFORD HOSPITALS NHS FOUNDATION TRUST	1.049	0.447	0.364	0.611
RK9	PLYMOUTH HOSPITALS NHS TRUST	0.842	-1.630	-0.618	-0.061
RD3	POOLE HOSPITAL NHS FOUNDATION TRUST	0.889	-1.097	-1.449	-1.984
RHU	PORTSMOUTH HOSPITALS NHS TRUST	0.925	-0.746	-0.758	-0.826
RHW	ROYAL BERKSHIRE NHS FOUNDATION TRUST	1.129	1.145	1.349	1.153
REF	ROYAL CORNWALL HOSPITALS NHS TRUST	1.000	0.004	-0.869	-0.806
RH8	ROYAL DEVON AND EXETER NHS FOUNDATION TRUST	0.883	-1.169	-0.604	-1.177
RAL	ROYAL FREE HAMPSTEAD NHS TRUST	0.579	-5.037	-3.079	-2.309
RQ6	ROYAL LIVERPOOL AND BROADGREEN UNIVERSITY HOSPITALS NHS TRUST	0.958	-0.406	-0.641	-1.202
RA2	ROYAL SURREY COUNTY HOSPITAL NHS FOUNDATION TRUST	0.908	-0.898	-0.790	-1.254
RD1	ROYAL UNITED HOSPITAL BATH NHS TRUST	0.928	-0.709	-0.435	-0.798
RM3	SALFORD ROYAL NHS FOUNDATION TRUST	0.848	-1.548	-1.778	-1.508
RNZ	SALISBURY NHS FOUNDATION TRUST	0.956	-0.417	1.219	0.913
RXK	SANDWELL AND WEST BIRMINGHAM HOSPITALS NHS TRUST	0.966	-0.325	-1.632	-2.075
RCC	SCARBOROUGH AND NORTH EAST YORKSHIRE HEALTH CARE NHS TRUST	1.149	1.280	0.777	0.750
RHQ	SHEFFIELD TEACHING HOSPITALS NHS FOUNDATION TRUST	0.779	-2.390	-1.661	-1.349
RK5	SHERWOOD FOREST HOSPITALS NHS FOUNDATION TRUST	0.999	-0.008	-0.496	-0.552
RXW	SHREWSBURY AND TELFORD HOSPITAL NHS TRUST	1.174	1.516	1.661	0.608
RA9	SOUTH DEVON HEALTHCARE NHS FOUNDATION TRUST	0.959	-0.389	-0.568	-1.043

RYQ	SOUTH LONDON HEALTHCARE NHS TRUST	0.861	-1.427	0.862	0.397
RTR	SOUTH TEES HOSPITALS NHS FOUNDATION TRUST	0.955	-0.436	-0.509	-0.867
RE9	SOUTH TYNESIDE NHS FOUNDATION TRUST	0.958	-0.390	0.640	0.778
RJC	SOUTH WARWICKSHIRE NHS FOUNDATION TRUST	1.129	1.119	2.008	1.565
RHM	SOUTHAMPTON UNIVERSITY HOSPITALS NHS TRUST	0.983	-0.167	1.148	1.516
RAJ	SOUTHEND UNIVERSITY HOSPITAL NHS FOUNDATION TRUST	1.007	0.067	-0.429	-0.146
RVY	SOUTHPORT AND ORMSKIRK HOSPITAL NHS TRUST	1.109	0.962	1.296	0.998
RJ7	ST GEORGE'S HEALTHCARE NHS TRUST	0.437	-7.624	-2.275	-1.714
RBN	ST HELENS AND KNOWSLEY HOSPITALS NHS TRUST	0.940	-0.584	0.893	1.030
RWJ	STOCKPORT NHS FOUNDATION TRUST	0.816	-1.907	-0.519	-0.234
RTP	SURREY AND SUSSEX HEALTHCARE NHS TRUST	0.865	-1.362	-0.337	0.308
RMP	TAMESIDE HOSPITAL NHS FOUNDATION TRUST	1.174	1.502	1.961	1.875
RBA	TAUNTON AND SOMERSET NHS FOUNDATION TRUST	0.906	-0.922	-1.083	-1.046
RNA	THE DUDLEY GROUP OF HOSPITALS NHS FOUNDATION TRUST	1.098	0.889	1.308	1.604
RAS	THE HILLINGDON HOSPITALS NHS FOUNDATION TRUST	0.862	-1.357	-0.633	-0.154
RTD	THE NEWCASTLE UPON TYNE HOSPITALS NHS FOUNDATION TRUST	0.895	-1.054	-2.292	-2.596
RQW	THE PRINCESS ALEXANDRA HOSPITAL NHS TRUST	0.901	-0.977	-0.049	-0.057
RCX	THE QUEEN ELIZABETH HOSPITAL KING'S LYNN. NHS FOUNDATION TRUST	0.943	-0.545	-0.012	0.198
RFR	THE ROTHERHAM NHS FOUNDATION TRUST	1.027	0.248	0.257	-0.216
RDZ	THE ROYAL BOURNEMOUTH AND CHRISTCHURCH HOSPITALS NHS FOUNDATION TR	1.002	0.022	0.698	1.044
RL4	THE ROYAL WOLVERHAMPTON HOSPITALS NHS TRUST	1.178	1.549	1.473	1.347
RKE	THE WHITTINGTON HOSPITAL NHS TRUST	0.596	-4.602	-5.330	-4.486
RM4	TRAFFORD HEALTHCARE NHS TRUST	0.983	-0.151	-0.469	0.409
RWD	UNITED LINCOLNSHIRE HOSPITALS NHS TRUST	1.122	1.100	1.716	1.526
RRV	UNIVERSITY COLLEGE LONDON HOSPITALS NHS FOUNDATION TRUST	0.652	-3.944	-2.695	-2.077
RJE	UNIVERSITY HOSPITAL OF NORTH STAFFORDSHIRE NHS TRUST	1.019	0.183	1.804	1.357
RM2	UNIVERSITY HOSPITAL OF SOUTH MANCHESTER NHS FOUNDATION TRUST	0.805	-2.036	-1.313	-1.607
RRK	UNIVERSITY HOSPITALS BIRMINGHAM NHS FOUNDATION TRUST	1.061	0.559	0.725	0.492
RA7	UNIVERSITY HOSPITALS BRISTOL NHS FOUNDATION TRUST	0.901	-0.980	-1.047	-0.761
RKB	UNIVERSITY HOSPITALS COVENTRY AND WARWICKSHIRE NHS TRUST	1.076	0.698	1.363	2.112
RWE	UNIVERSITY HOSPITALS OF LEICESTER NHS TRUST	1.073	0.673	-0.186	0.139
RTX	UNIVERSITY HOSPITALS OF MORECAMBE BAY NHS FOUNDATION TRUST	1.176	1.532	-0.530	-1.936
RBK	WALSALL HEALTHCARE NHS TRUST	1.023	0.208	0.337	0.880

RWW	WARRINGTON AND HALTON HOSPITALS NHS FOUNDATION TRUST	0.947	-0.510	-0.263	0.169
RWG	WEST HERTFORDSHIRE HOSPITALS NHS TRUST	1.050	0.460	0.207	0.627
RFW	WEST MIDDLESEX UNIVERSITY HOSPITAL NHS TRUST	0.821	-1.802	-1.104	-0.590
RGR	WEST SUFFOLK HOSPITALS NHS TRUST	0.855	-1.452	-0.575	-0.664
RYR	WESTERN SUSSEX HOSPITALS NHS TRUST	1.124	1.121	0.128	-0.004
RA3	WESTON AREA HEALTH NHS TRUST	1.030	0.271	-0.484	-0.618
RGC	WHIPPS CROSS UNIVERSITY HOSPITAL NHS TRUST	0.871	-1.292	0.025	-0.153
RN1	WINCHESTER AND EASTLEIGH HEALTHCARE NHS TRUST	0.841	-1.574	-1.507	-1.340
RBL	WIRRAL UNIVERSITY TEACHING HOSPITAL NHS FOUNDATION TRUST	1.007	0.063	-0.179	-0.773
RWP	WORCESTERSHIRE ACUTE HOSPITALS NHS TRUST	1.122	1.099	0.156	0.176
RRF	WRIGHTINGTON WIGAN AND LEIGH NHS FOUNDATION TRUST	1.018	0.172	0.528	1.141
RLQ	WYE VALLEY NHS TRUST	0.998	-0.018	-0.017	0.144
RA4	YEOVIL DISTRICT HOSPITAL NHS FOUNDATION TRUST	1.139	1.186	1.265	0.693
RCB	YORK TEACHING HOSPITAL NHS FOUNDATION TRUST	1.158	1.368	0.389	0.314