

## Supplement 1: Indicators of quality of care

A range of indicators based on other sources were identified a-priori to examine their relationship to mortality alerts.

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### ***Acute bed occupancy data***

The bed availability and occupancy data are published quarterly by NHS England and identify the number of bed days, for each NHS health care provider, available for patients to have treatment or care.<sup>1</sup> We used the percentage of beds occupied over a three-month period (a quarter) in general and acute wards. We analysed data for the years 2011 to 2013, using the 4<sup>th</sup> quarter data from financial year 2010/11 and excluding the 4<sup>th</sup> quarter data from 2013/14.

### ***Nurse to bed ratio***

NHS workforce statistics are available from the Health and Social Care Information Centre (HSCIC).<sup>2</sup> The monthly publication is a summary of the validated data extracted from the NHS's HR and Payroll system. The data include full-time equivalent (FTE) figures for all NHS Hospital staff groups working in England. We used the mean number of FTE Qualified nursing staff (over a three-month period), as the numerator and quarterly bed availability as the denominator for each NHS trust. We analysed data for calendar years 2011 to 2013.

### ***Trust financial data***

Information on trust financial data was obtained and combined from two sources. Information on the consolidated accounts of NHS foundation trusts (hospital groups that have achieved a status which allows decisions to be made locally) was available publicly<sup>3</sup> and we used data for the financial years 2011/12 – 2013/14 from the United Kingdom (UK) government information website.<sup>4</sup> Data for other NHS trusts were accessed using a freedom of information request to the Department of Health (FOI ref: 1041857) for the same years. As the two datasets were compiled from different sources we could not directly combine the datasets. We therefore created a binary variable to determine whether a trust was in deficit in a given year. We used the value for 'surplus before impairments' to determine whether a foundation trust was in deficit. We analysed available data for the years 2011 to 2013 (calendar year) or 2011/2 – 2013/4 (financial year).

### ***GMC National Training Survey***

The GMC National Training Survey is carried out by the General Medical Council. The aim of the survey is to ensure medical education and training is meeting the standards set to support high quality medical care and patient safety across the UK. In 2012, 51,316 doctors in training completed the survey out of 54,035 who were eligible, giving a response rate of 95.0%. The survey data cover over 12 questions or indicators, within 100 specialities/departments, in all NHS trusts in England. Data are available at a trust level from 2012/3; we used 2012/3 and 2013/4 data. Mean percentage satisfaction scores were presented only if there were more than 3 trainee respondents for a specific specialty and question within a trust. We created a weighted trust score across all indicators and all departments for each trust by year. To weight the hospital score we needed to estimate the number of trainees (N) responding to a question. From the provided mean and 95% confidence interval, we could calculate the standard error of the mean (SE):

$$95\% \text{ LCI} = \text{mean} - (1.96 * \text{SE})$$

We were also provided with the standard deviation (SD) and using

$$\text{SE} = \text{SD} /$$

we could calculate the number of trainees as

$$N = (\text{SD} / \text{SE})^2$$

The weighted mean is the sum of the partial means, which was calculated as the mean x number of trainees (for a trust/specialty/question) / total number of trust trainees:

$$\text{Weighted trust } k$$

where k denotes a single question answered by trainees within a single specialty for each trust.

We carried out a sensitivity analysis on the unweighted satisfaction where missing data was ignored.

### ***NHS Litigation Authority***

The NHS Litigation Authority (NHS LA) is a not-for-profit part of the NHS which handles negligence and other claims against the NHS in England.<sup>5</sup> NHS LA conducts a risk management assessment for each hospital and awards a rating against a set of risk management standards. The highest risk management assessment a trust can achieve is a level 3. NHS LA has published factsheets on risk management assessment levels since 2002/3. The factsheets include data on the trust, the date of the last assessment and the level achieved. We used data from 2011/12 to 2013/4 and dichotomized

trusts risk assessment achievement into those that had a risk management assessment level 1 vs those with levels 2 or 3 for each quarter over the 3 years.

## **Process**

### ***Myocardial Ischaemia National Audit Project (MINAP)***

MINAP is the national clinical audit of the management of heart attack. MINAP captures information on all patients with a heart attack directly after treatment. All providers audited have common definitions of clinical important variables and common standards of good quality. In our analysis we focused on percutaneous coronary interventions (PCI). National and international guidance recommend that in the emergency treatment of patients with ST-elevation myocardial infarction, a blockage in one of the heart's major arteries, primary PCI should be performed within 90 minutes of arrival at the heart attack centre. Not all hospitals have the facility to perform primary PCI. We were unable to obtain information on which trusts provide PCI (independent of MINAP); we therefore included all trusts that provided primary PCI data in our analysis and assumed the data were complete. We focused on the quality indicator: 'Proportion of all patients who received primary PCI within 90 minutes from arrival at the heart attack centre'. We analysed data for years 2011/12 and 2012/13.

## **Outcomes**

### ***National Inpatient Survey***

The NHS Patient Survey Programme is run by Picker Institute Europe on behalf of the Care Quality Commission. The views of patients about the care they have recently received from all NHS Health Care Providers in England have been systematically gathered since 2005. Eligible patients for the survey were aged 16 years or older, had at least one overnight stay, and were in hospital between June and August of the collection year. The questions cover 4 specific areas on access and waiting; on safe, high quality co-ordinated care; on better information and more choice; and on building closer relationships. All questions are collated to give an overall patient experience score. We used annual National Inpatient Survey data for years 2011 and 2012.

### ***NHS Safety Thermometer***

The NHS Safety Thermometer is a tool designed to support patient safety and improvement. The tool focuses on four harms where there is clinical consensus that the harms are largely preventable through good quality patient care. These harms are: Pressure ulcers; Falls; Urinary Tract Infections in patients with a catheter; and new venous thromboembolisms. The prevalence of patient harms is recorded within each health care setting, with the aim to provide information for performance

monitoring.<sup>6</sup> NHS Safety Thermometer data are supplied by HSCIC and is available, as monthly reports, from April 2012. For our analysis we included all harms within an acute hospital ward setting, using data for financial years 2012/13– 2013/14.

### **Summary Hospital Mortality Index (SHMI)**

SHMI data were supplied by HSCIC. These annual standardised mortality statistics are generated using HES provider spells linked to the Office for National Statistics (ONS) mortality data. The SHMI is a ratio of the observed number of deaths (the total number of finished provider spells for the trust which resulted in a death either in hospital or within 30 days (inclusive) of discharge from the trust) to the expected number of deaths for a trust adjusting for patient case-mix. The SHMI risk model adjusts for age, gender, admission method, year index, Charlson Comorbidity Index and diagnosis grouping.<sup>33</sup> We used data for financial years 2011/12 to 2013/14. There were no SHMI data for specialist trusts such as Birmingham Women's Health Care NHS Trust.

### **Hospital Standardised Mortality Ratio (HSMR)**

HSMR data were accessed from Dr Foster Hospital Guides.<sup>34</sup> These annual standardised mortality statistics were generated using HES provider spells by Dr Foster Intelligence. The HSMR is a ratio of the observed number of deaths (the total number of finished provider spells for the trust which resulted in a death) to the expected number of deaths for a trust calculated from a risk-adjusted model, multiplied by 100. The risk model adjusted for various factors as in Error: Reference source not found.<sup>25</sup> Data were available at an annual trust level for financial 2011/12 and 2012/13.

1. NHS England. *Statistics*. URL: <https://www.england.nhs.uk/statistics/> (Accessed 1st Nov 2018)).
2. Health and Social Care Information Centre. *NHS Workforce - Monthly Workforce Statistics*. In:
3. Monitor. *NHS foundation trusts: consolidated accounts 2013/14*. 2014. URL: [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/331166/Consolidated\\_Accounts\\_2013-14.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/331166/Consolidated_Accounts_2013-14.pdf) (Accessed 1st Nov 2018)).
4. GOV.UK. URL: <https://www.gov.uk/> (Accessed 1st Nov 2018)).
5. Jones HE, Spiegelhalter DJ. Accounting for regression-to-the-mean in tests for recent changes in institutional performance: Analysis and power. *Statistics in Medicine* 2009;**28**:1645-67. <http://dx.doi.org/10.1002/sim.3583>
6. Health and Social Care Information Centre. *NHS Safety Thermometer: Annual Publication, Patient Harms and Harm Free Care, England April 2012- March 2014, Official Statistics*. 2014. URL: <http://digital.nhs.uk/catalogue/PUB14502/nhs-safe-ann-rep-apr-2012-mar-2014.pdf> (Accessed 1st Nov 2018)).