Monitoring clinical outcomes with administrative data”

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Florence Nightingale
Uniform hospital statistics would:

• “Enable us to ascertain the relative mortality of different hospitals as well as of different diseases and injuries at the same and at different ages, the relative frequency of different diseases and injuries among the classes which enter hospitals in different countries, and in different districts of the same country”

_Nightingale 1863_
Key events

• Heart operations at the BRI
  “Inadequate care for one third of children”

• Harold Shipman
  Murdered more than 200 patients
Comparison of UK paediatric cardiac surgical survival with that of other centres

Summary

Background Reporting of high cardiac surgery mortality at the Bristol Royal Infirmary raised the question of whether or not Bristol's mortality was abnormal compared to other centres. To answer this question, analysis of mortality in the UK was performed.

Methods Data from the United Kingdom Paediatric Cardiac Surgery Register (UKPCSR) and Hospital Episode Statistics (HES) were obtained for all 12 major cardiac surgical centres. Analysis of mortality within 30 days of surgery was performed, with a sensitivity analysis of a model derived from the UKPCSR.

Findings For children, the highest mortality rate in the UK was found in Bristol, with a rate of 2.7% (95% CI 2.1% to 3.3%). For adults, the highest mortality rate was found in the UK, with a rate of 1.1% (95% CI 0.9% to 1.3%). In sensitivity analysis, the model derived from the UKPCSR showed similar results.

Interpretation An outlier, or systematic error, was detected in the Bristol Royal Infirmary, with a significantly higher mortality rate than other centres. This finding highlights the importance of continuous monitoring and improvement in cardiac surgical outcomes.

Figure 1: Mortality from open procedures by centre derived from Hospital Episode Statistics (HES) and Cardiac Surgical Register (CSR). Centre 1 = Bristol Royal Infirmary. HES mortality rates based on admissions with known outcome.

THE LANCET • Vol 358 • July 21, 2001
Comparison of mortality rates between UBHT and rest of the country - HES 1 April 1991 to 31 March 1995 - aged under 90 days

Note: Numbers of valid cases where outcome known at 30 days is given in italics. Groups 1-11 are open procedures, Groups 12&13 are closed procedures.
“Bristol was awash with data. There was enough information from the late 1980s onwards to cause questions about mortality rates to be raised both in Bristol and elsewhere had the mindset to do so existed.”

Ian Kennedy
Following Shipman: a pilot system for monitoring mortality rates in primary care

As part of the investigations into the crimes of Harold Shipman, it has become clear that there is little monitoring of deaths in general practice. By use of data on annual deaths at family physician and practice level for five English health authorities for 1993-95, we investigate whether the cumulative sum charts (a type of statistical process control chart) could be used to create a workable monitoring system. On such charts, thresholds for deaths can be set, which, if crossed, may indicate a potential problem. We chose thresholds based on empirical calculations of the probabilities of false and successful detection after allowing for multiple testing over physicians or practices. We also statistically adjusted the charts for extra-Poisson variation due to unmeasured causes. This, with 33 (including Shipman) crossed the alarm threshold designed to detect a 2 SD increase in standardized mortality rate, 97% of these alarm charts were associated with a false-alarm rate. Unfortunately, the number of deaths observed by these physicians in nursing homes or of the patients included in such charts provided a useful test for monitoring deaths in primary care. However, improved data quality is essential.

As part of the investigations into the crimes of Harold Shipman, a UK family physician who has been imprisoned for the murder of many of his patients, it has become clear that there is little formal monitoring of deaths in general practice. However, if an acceptable and workable method of monitoring mortality rates can be devised, implementation of such a system might be beneficial. Baker and colleagues have suggested that monitoring mortality in general practice should be able to detect illegal behaviour, but also could help to inform the quality of clinical care and maintain public trust.

We have assessed the feasibility of setting up a system for routine surveillance of mortality data as individual family physician and practice levels. We focused on statistical data quality issues involved, data requirements and statistical issues involved, especially small unmeasured factors, the net effect of data, many small unmeasured factors, and the difficulty of multiple testing over units and over time. We use data from a prospective pilot exercise, conducted by the Shipman Inquiry, to link national death registration records to lists of primary-care patients held in five health authority systems. Statistical process control (SPC) charts, which have been advocated for use in clinical governance, are discussed and applied to the data to illustrate the practical application of such techniques in this context.

Statistical Issues
A monitoring system must be designed to quickly detect variations in the underlying mortality rate in any data used. Such a system requires that expected and observed counts are defined, corresponding to control limits.

Key features of SPC charts

Test statistic calculated for the unit at each time point
This statistic is typically a function of the difference between the observed outcome at a given time and that expected under the in-control distribution. The statistic may also depend on previous values of these residuals, leading to a cumulative sum.

Predefined alarm threshold
If the test statistic exceeds the threshold at some time, a warning or alarm is triggered and the chart is said to signal that the process being monitored has become out of control.

Some measure of the performance of the chart
This is a measure that is designed to detect when the underlying process is no longer in control. Such charts must be measured. Such charts cannot be measured. Such charts are not necessarily in control.
CUSUM for 3 West Pennine GPs signalling at any time between 1993 and 2000. 58 West Pennine GPs were monitored in total. Charts are designed to detect an increase of two standard deviations in standardised excess mortality (K=2) using an alarm threshold of h=3 (h=5 is also shown)
Report: Figure 5.11
The Mid Staffordshire NHS Foundation Trust Public Inquiry

On 9 June 2010 the Secretary of State for Health, Andrew Lansley MP, announced a full public inquiry into the role of the commissioning, supervisory and regulatory bodies in the monitoring of Mid Staffordshire Foundation NHS Trust.

The Inquiry is established under the Inquiries Act 2005 and is chaired by Robert Francis QC, who will make recommendations to the Secretary of State based on the lessons learnt from Mid Staffordshire. It will build on the work of his earlier independent inquiry into the care provided by Mid Staffordshire NHS Foundation Trust between January 2005 and March 2009.

Latest updates

Inquiry hearings - transcript for day two  (NEWS)  
The transcript for the second day of the Inquiry’s hearings is now available.

Inquiry hearings - first day  (NEWS)  
The Inquiry began its main hearings today, with opening statements from the Inquiry Chairman and Counsel to the Inquiry.

Appointment of assessors  (NEWS)  
Robert Francis QC today announced that four assessors had been appointed to the Inquiry. Further detail is set out in the assessor biographies, which are available under ‘key documents’.
Hospital Episode Statistics - HES

Electronic record of every inpatient or day case episode of patient care in every NHS (public) hospital in England
14 million records a year
300 fields of information including
  • Patient details such as age, sex, address
  • Diagnosis using ICD10
  • Procedures using OPCS4
  • Admission method
  • Discharge method
Why use Hospital Episode Statistics

- Comprehensive – collected by all NHS trusts across country on all patients
- Coding of data separate from clinician
- Access
- Current (we receive monthly updates)
Case mix adjustment

Limited within HES?

• Age
• Sex
• Emergency/Elective
Use of administrative data or clinical databases as predictors of risk of death in hospital: comparison of models

Paul Aynin, clinical senior lecturer,1 Alex Bottle, lecturer, Azeen Majeed, professor of primary care and social medicine2

Abstract
Objective To compare risk prediction models for death in hospital based on an administrative database with published results based on data derived from three national clinical databases: the national cardiac surgical database, the national vascular database, and the colorectal cancer study.

Design Analysis of inpatient hospital episode statistics. Predictive model developed using multiple logistic regression.

Setting NHS hospital trusts in England.

Patients All patients admitted to an NHS hospital within England for isolated coronary artery bypass graft (CABG), repair of abdominal aortic aneurysm, and colorectal excision for cancer from 1996-7 to 2003-4.

Main outcome measures Deaths in hospital. Performance of models assessed with receiver operating characteristic (ROC) curve scores measuring discrimination (0.7=poor, 0.7-0.8=reasonable, >0.8=good) and both Hosmer-Lemeshow statistics and standardised residuals measuring goodness of fit.

Results During the study period 152 523 cases of isolated CABG with 3247 deaths in hospital (2.1%), 12 781 repairs of ruptured abdominal aortic aneurysm (5987 deaths, 46.8%), 31 705 repairs of unruptured abdominal aortic aneurysm (3246 deaths, 10.2%), and 144 370 colorectal resections for cancer (10 424 deaths, 7.2%) were recorded. The power of the complex predictive model was comparable with that of models based on clinical databases with ROC curve scores of 0.77 (v. 0.78 from clinical database) for isolated CABG, 0.66 (v. 0.65) and 0.66 (v. 0.69) for repair of ruptured and unruptured aneurysms respectively, and 0.66 (v. 0.68) for colorectal surgery.

Introduction
Routine administrative databases are increasingly being used for performance monitoring in healthcare in the United Kingdom (such as www.hospitalscommission.org.uk and www.drfoster.co.uk), United States (such as www.ihi.org/III/Programs/Campaign/), and elsewhere.1 In comparisons of performance between clinicians or organisations it is essential to adjust for several parameters including comorbidity and severity of disease (case mix). Routine data, however, might contain insufficient information for adequate adjustment. Clinical databases, run by various bodies including professional societies, could potentially record more detailed clinical information and might permit better adjustment for case mix. A survey of 105 multicentre clinical databases (which included hospital episode statistics, the administrative database available within England) found that their distribution was uneven and that their scope and the quality of the data was variable.2 The report from the public inquiry into deaths at a paediatric cardiac unit at Bristol criticised this “dual” system as “wasteful and anarchistic.”3 It is also suggested that hospital episode statistics should be supported as a major national resource and used to undertake monitoring of a range of healthcare outcomes.

We examined mortality for three index procedures (coronary artery bypass graft, abdominal aortic aneurysm repair, and colectomy for bowel cancer) used in three large clinical datasets (the national adult cardiac surgical database, the national vascular database, and the colorectal cancer study) and two administrative datasets (the national hospital episode statistics and the central death registration database) and compared the results.

Cite this article as: BMJ, vol 335, bmj:39168.6366.55 (published 23 April 2007)
ROC curve areas comparing ‘simple’, ‘intermediate’ and ‘complex’ models derived from HES with models derived from clinical databases for four index procedures.

Aylin P; Bottle A; Majeed A. Use of administrative data or clinical databases as predictors of risk of death in hospital: comparison of models. BMJ 2007;334: 1044
Comparison of HES vs clinical databases

Vascular surgery

- HES = 32,242
- National Vascular Database = 8,462


Bowel resection for colorectal cancer

- HES 2001/2 = 16,346
- ACPGBI 2001/2 = 7,635
- ACPGBI database: 43% of patients had missing data for the risk factor(s)

Our work

• All 259 diagnosis groups
• 128 procedures
• 100% admissions
• Outcomes
  • In-hospital mortality
  • Emergency readmissions
  • Length of Stay
Current casemix adjustment model for each diagnosis and procedure group

Adjusts for

• age
• sex
• elective status
• socio-economic deprivation (Carstairs)
• Diagnosis subgroups (3 digit ICD10) or procedure subgroups
• co-morbidity – Charlson index
• number of prior emergency admissions
• palliative care
• year
• month of admission
• Source of admission
Other considerations

• Trends

• Transfers
  • Transfers linked. All spells (admissions) linked into superspells
  • For diagnosis, outcome based on discharge method at end of superspell

• Diagnosis on admission
  • No diagnosis on admission exists within HES/SUS
  • We use primary diagnosis given on completion of first episode, unless a “vague symptoms and signs” diagnosis, in which case we examine subsequent episode

• Co-morbidity

• Palliative care
  • If treatment specialty in any episode in the admission coded to palliative care or includes ICD10 code Z515, accounted for in risk model
Charlson co-morbidity index

Comparison of regular HSMR and HSMR without adjustment for Charlson

English Acute Trusts 2008/9

\[ y = 0.9994x \]

\[ R^2 = 0.8768 \]
Coding of comorbidities

Guidance already exists around the definition of a primary diagnosis, on page 2 of the ICD-10 Clinical Coding Instruction Manual (Version 2.0) and the coding of certain comorbidities, on page 3 of the ICD-10 Clinical Coding Instruction Manual (Version 2.0), and the specific sequencing guidance in the Coding Clinic, Volume 6 Issue 3, October 2009.

Current guidance states that comorbidities are conditions that exist in conjunction with another disease. Any comorbidity that affects the management of the patient and contributes to an accurate clinical picture within the current episode of care must be recorded. Conditions that relate to an earlier episode that have no bearing on the current episode should not be recorded.

The problems facing the clinical coding community have arisen due to absence of a clear indication in the patient record of which of the listed comorbidities would affect the management of the patient in the episode of care.

With the advent of the Audit Commission (AC) Payment by Results (PbR) audits, it had become clear that updated and more specific guidance was required for clinical coders and auditors. As a result the NHS Classifications Service (NCS) established a clinical working group to review and update the current guidance. It was clear that the interpretation of a medical condition as being relevant to record in the episode of care would require clinical input, which was ultimately strongly endorsed by the clinical working group members. The working group chair is the Clinical Director of the UK Terminology Centre at NHS Connecting For Health (NHS CFH) and membership includes clinical experts from the Department of Health (DH) Clinical Advisory Panel (CAP), the chair of all the NHS Information Centre (NHS IC) Expert Working Groups, representatives of the DH PbR team, representative from the NHS IC Coaximix Service and classification specialists from NCS at NHS CFH.

It was agreed that for the first stage of the review a list of common comorbidities must be developed, which would always be clinically relevant to be selected for coding regardless of specialty, when mentioned in the clinical record. For example, would an entry identifying...
Palliative care – lack of adjustment

Comparison of regular HSMR and HSMR without adjustment for palliative care
English Acute Trusts 2008/9

\[ y = 0.9979x \]

\[ R^2 = 0.8426 \]
Medical and Information Technology

Intelligent Information: A National System for Monitoring Clinical Performance

Alex Bottle and Paul Aylin

Objective. To use statistical process control charts to monitor in-hospital outcomes at the hospital level for a wide range of procedures and diagnoses.

Data Sources. Routine English hospital admissions data.

Study Design. Retrospective analysis using risk-adjusted log-likelihood cumulative sum (CUSUM) charts, comparing each hospital with the national average and its peers for in-hospital mortality, length of stay, and emergency readmission within 28 days.

Data Collection. Data were derived from the Department of Health administrative hospital admissions database, with monthly uploads from the clearing service.

Principal Findings. The tool is currently being used by nearly 100 hospitals and also a number of primary care trusts responsible for purchasing hospital care. It monitors around 80 percent of admissions and in-hospital deaths. Case-mix adjustment gives values for the area under the receiver operating characteristic curve between 0.60 and 0.86 for mortality, but the values were poorer for readmission.

Conclusions. CUSUMs are a promising management tool for managers and clinicians for driving improvement in hospital performance for a range of outcomes, and interactive presentation via a web-based front end has been well received by users. Our methods act as a focus for intelligently directed clinical audit with the real potential to improve outcomes, but wider availability and prospective monitoring are required to fully assess the method's utility.
Dr Foster Unit reports and methodology papers

Patient Safety Indicators

Adaptation of patient safety indicators from work originally commissioned by the Agency for Healthcare Research and Quality in the US. These have been incorporated into the RTM tool.

- [PSI specifications Jan 08](#)

Patient Safety Indicators Literature Review

Patient Safety Indicators (PSIs) have been specifically designed to screen for potential patient safety problems using administrative data. PSI sets are still in their very early stages of development, with a number of methodological concerns yet to be addressed. This literature review provides a comprehensive guide to PSI research to date and aims to determine the application of PSIs within the secondary care setting.

Attention has been placed on identifying which PSIs are being applied, who they are being used by and how they are utilised.

- [PSI report CT](#)

Hospital Standardised Mortality Ratios

- [HSMR Methodology](#)

Monitoring Hospital Mortality

The critical report on Mid Staffordshire's failings in its delivery of emergency care came about partly as a result of the mortality alerts sent out from the unit. These in turn have evolved from the Real-Time Monitoring tool, developed in collaboration with Dr Foster Intelligence. During the same period this investigation was going on, a group from the University of Birmingham published both a report commissioned by the West Midlands SHA and a paper in the BMJ, both highly critical of HSMRs. The unit pulled together a robust response in the form of a stand-alone report and a published letter in the BMJ. There was a considerable amount of analysis carried out to support these responses with good evidence.

Monitoring Hospital Mortality: the response to the University of Birmingham

[Monitoring hospital mortality document](#)
“Even if all surgeons are equally good, about half will have below average results, one will have the worst results, and the worst results will be a long way below average”

- *Poloniecki J. BMJ* 1998;316:1734-1736
HSMR 2007/8 with 99.8% control limits “funnel plots”
Funnel plots

No ranking
Visual relationship with volume
Takes account of increased variability of smaller centres

…. but not as useful for continuous surveillance and less sensitive to sudden increases in mortality
Tools -
Calculating PH measures

Standardised Rates
- Improved batch calculation of directly standardised rates
- Spreadsheet tool for crude rate, DSR and ISR/SMR
- DSRs - Web Tool *

Confidence Intervals
- 95% CIs for proportions

Funnel Plots
- Funnel plot for Proportions (binomial) - Web Tool *
- Funnel plot template for count data
- Funnel plot template for proportions and percentages
- Template for SMRs
• Based on log-likelihood CUSUM to detect a predetermined increase in risk of interest
• Taken from Steiner et al (2000); pre-op risks derived from logistic regression of national data
• The CUSUM statistic is the log-likelihood test statistic for binomial data based on the predicted risk of outcome and the actual outcome
• Model uses administrative data and adjusts for age, sex, emergency status, socio-economic deprivation etc.
Monitoring surgical performance using risk-adjusted cumulative sum charts

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shsteine@uwaterloo.ca

VERN T. FAREWELL
Department of Statistical Sciences, University College London, UK

TOM TREASURE
St. George’s Hospital Medical School London, UK

\[
W_t = \begin{cases} 
\log \left[ \frac{(1 - p_t + R_0 p_t) R_A}{(1 - p_t + R_A p_t) R_0} \right] & \text{if } y_t = 1 \\
\log \left[ \frac{1 - p_t + R_0 p_t}{1 - p_t + R_A p_t} \right] & \text{if } y_t = 0
\end{cases}
\]
CUSUM

Query Summary

- **Baskct**: Diagnoses: All
- **Benchmarks**: Data Year
- **Outcome**: Mortality (in-hospital)
- **Chapter**: Circulatory
- **Diagnosis Group**: Acute cerebrovascular
- **Department**: All
- **Team**: All
- **Admission Type**: All
- **Sex**: All
- **Deprivation**: All
- **Age Range**: All
- Drilldown 1: Mid Staffordshire NHS...
- Drilldown 2: Provider

- **Spells**: 691
- **Superspells**: 684 (669 / 15)
- **First / Last**: Feb-07 / Jan-09
- **Deaths**: 229 (33.3%)
- **Expected**: 180.1 (27.3%)
- **Relative Risks**: 121.2 (105.0 - 138.0)
- **E-Statistic**: 0.71

(Average) **Lost**: 23.3 / 26.5
**Alerts**: 1 (Feb-08)
**FAR / SDR**: 0.7% / 99.1%

Mortality (in-hospital) | Diagnoses | Acute cerebrovascular
## Performance Summary (Feb-08 to Most Recent)

### Criteria selection

- **Time Period**: 12 Months
- **Level**: Trust
- **Display**: All Alerts

### Peers - My current group - HSMR Basket of 56 Diagnoses Groups

<table>
<thead>
<tr>
<th>Diagnoses</th>
<th>Mortality</th>
<th>Length of Stay</th>
<th>Day Case Rate</th>
<th>Readmissions</th>
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<tr>
<td>Abdominal pain</td>
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<td>Acute bronchitis</td>
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<tr>
<td>Acute cerebrovascular disease</td>
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<tr>
<td>Acute myocardial infarction</td>
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<tr>
<td>Alcohol-related mental disorders</td>
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<tr>
<td>Anxiety, somatoform, dissociative, and personality disorders</td>
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<td>Cancer of breast</td>
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<td>Cancer of bronchus, lung</td>
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<tr>
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</table>
How do you investigate a signal?
• Look at alerts generated at 0.1% statistical False Alarm Rate (default in Real Time Monitoring is 1%)
• Write to trusts with doubling of odds of death over previous 12 months
MORTALITY OUTLIERS

We are writing to share with you in confidence higher than average mortality rates for CA hospital trust (Appendix 1).

The Dr Foster Unit at Imperial College (DFU) and Secondary Uses Service (SUS) data file and risk-adjusted mortality rates for hospitals. Risk-adjusted mortality rates in various trusts signifies the profile of the relevant patients.

There are a number of possible reasons for the figures: however, as clinicians we

We therefore piloted a system of feedback. As a result of the pilot system, we have limited the alert system, as we wish to maintain the integrity of the figures. However, as clinicians we

Third, we have decided to shout of the trusts we consulted in confidence as part of the work. The trusts did request clarity as to what we would expect trusts to take: we assured them that a single day's work was conducted regularly in the circumstances of the patient, but this was considered in the light of the data input. We have not had any feedback from trusts. We have not had any feedback from trusts.
What to do with a signal

Screening tool

• Check the data
• Difference in casemix
• Examine organisational or procedural differences
• Only then consider quality of care
Acknowledgements

• Dr Alex Bottle
• Steve Middleton (Dr Foster Intelligence)
• Professor Sir Brian Jarman
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Summary Hospital-level Mortality Indicator (SHMI)
Summary Hospital-level Mortality Indicator (SHMI)

- Ideas developed from DH HSMR Technical Working Group
- Dependent on further modelling
- Should have been finalised by April 2011
- “Final” specifications v1.7 published in October 2011
SHMI vs. HSMR

• 100% of admissions vs. 80%
  • …but excludes still births
• No adjustment for palliative care
• 30 day post discharge deaths vs. in-hospital
• Attributes death to final spell in acute non-specialist trust vs. all providers in continuous inpatient spell
• Cruder case-mix adjustment model (>over dispersion)
• Quarterly and up to 8 months behind vs. monthly and 2-3 months
• Still in development and untested
Comparison of HSMR calculated using 56 diagnoses compared with all 259 diagnoses English Acute Trusts 2008/9

- 56 diagnosis group HSMR vs. all diagnosis
- \( y = 0.9743x + 2.2451 \)
- \( R^2 = 0.9666 \)

- 100% match
- 10% more than standard HSMR
- 10% less than standard HSMR
- 25% more than standard HSMR
- 25% less than standard HSMR

Linear (Trusts)
Out of hospital deaths

Comparison of HSMR calculated using 30 day in-hospital deaths with HSMR using all 30 day deaths
English Acute Trusts 2004/5

Bradford Teaching Hospitals NHS Foundation Trust
Process vs. Outcome

- Debate simmering!!
The case FOR measuring outcomes

- It’s what really matters to the patient
- Common endpoint in RCTs etc for assessing treatments
- A ‘hard’ i.e. objective measure
- Often readily available in routinely collected data
And the case AGAINST

- Casemix adjustment is needed for fair comparison and is difficult
- Can be affected by artefact, e.g. deaths post discharge (or by transfers)
- All-cause mortality is not the same thing as preventable mortality
- Attribution
The case FOR measuring process

• Easily interpreted
• Little or no casemix adjustment required
• Sample size: compared to outcome indicators, process indicators can identify significant deficiencies with much smaller sample sizes.
• Indicators for action
And the case AGAINST

- Can often only capture a small aspect of quality; composite process measures are problematic (Jacobs 2005)
- Not always related to specific outcomes
- Salience, may have little meaning to the patient
- Adverse behaviour
Process vs. Outcome

- Review of relation between quality of care and death rates (36 studies):
  - 26/51 processes: good care -> low rates
  - 16/51 processes: no relation found
  - 9/51 processes: good care -> high rates…

Pitches D, Mohammed MA, Lilford R. What is the empirical evidence that hospitals with higher-risk adjusted mortality rates provide poorer quality of care? A systematic review of the literature. BMC Health Serv. Res 2007;7:91