International HSMRs – What they mean in Acute Medicine?

2nd International Conference
The Society For Acute Medicine
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Florence Nightingale (1820-1910), nurse

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”

Florence Nightingale 1863
Ernest Amory Codman
(1869–1940) a Boston surgeon
A founder of the American College of Surgeons
A founder of outcomes management in patient care

Noted
“calamities of surgery or those accidents and complications over which we have no known control. These should be acknowledged to ourselves and to the public and study directed to their prevention”

"I had made an error of skill of the most gross character and even (during the operation) failed to recognize that I had made it".

His reforming attempts
“brought him mostly ridicule, poverty and censure”
Adverse event studies (adapted from Charles Vincent)
Approx: 50% avoidable, 7% result in death, 6% in permanent disability
Total 210 hospitals involved, 100,429 admissions
Weighted (by no. admissions) mean adverse event rate = 6.6% of admissions

<table>
<thead>
<tr>
<th>Study</th>
<th>Number of hospitals</th>
<th>Date</th>
<th>Number of admissions</th>
<th>Adverse event rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>California Insurance Feasibility</td>
<td>23</td>
<td>1974</td>
<td>20,864</td>
<td>4.65</td>
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<tr>
<td>(The California study assessed 'potentially compensable' events)</td>
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<tr>
<td>Harvard Medical Practice</td>
<td>51</td>
<td>1984</td>
<td>30,195</td>
<td>3.7</td>
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<tr>
<td>Utah-Colorado (UTCOS)</td>
<td>28</td>
<td>1992</td>
<td>14,052</td>
<td>2.9</td>
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<tr>
<td>Quality in Australian Health Care</td>
<td>28</td>
<td>1992</td>
<td>14,179</td>
<td>16.6</td>
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<tr>
<td>Denmark</td>
<td>17</td>
<td>1998</td>
<td>1,097</td>
<td>9.0</td>
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<tr>
<td>New Zealand</td>
<td>13</td>
<td>1998</td>
<td>6,579</td>
<td>11.2</td>
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<td>United Kingdom</td>
<td>2</td>
<td>1999</td>
<td>1,014</td>
<td>10.8</td>
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<tr>
<td>Canada</td>
<td>20</td>
<td>2000</td>
<td>3,745</td>
<td>7.5</td>
</tr>
<tr>
<td>France (pilot only)</td>
<td>7</td>
<td>2002</td>
<td>778</td>
<td>14.5</td>
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<tr>
<td>Netherlands</td>
<td>21</td>
<td>2005-6</td>
<td>7,926</td>
<td>5.7</td>
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</table>
The Bristol Royal Infirmary Inquiry (1999-2001)

- Heart operations at the BRI
- “Inadequate care for one third of children”
Number of concerns expressed per year about Bristol Paediatric Cardiac Surgery yearly to 1994

In October 1986, Professor Andrew Henderson, then Professor Emeritus, University of Wales, distributed a letter at a meeting of the South Glamorgan Health Authority (SGHA) stating ‘it is no secret that their surgical service is regarded as being at the bottom of the UK league for quality’.

CMO Wales expressed concerns to Chief Medical Officer of England

New anaesthetist, Dr Bolsin, expressed repeated concerns - 1989 until 1995 both locally and nationally

SW Regional Cardiac Strategy Committee

16 June 1987 BBC Wales TV
‘Heart Surgery - the 2nd class Service’

‘Private Eye’ reports 14 February, 27 March, 8 May, 3 July, 9 October and 20 November 1992

External Inquiry
Mortality rate for paediatric cardiac surgery, all open operations, aged under 1 year, Hospital Episode Statistics April 1991 to March 1995

Dr Foster Unit, Imperial College, London, 2003
Mortality for paediatric cardiac surgery, 1991-Mar 95 for open operations for children aged under 1 year using Society of Cardio-Thoracic Surgeons’ (SCTS) data with 95% and 99.8% control limits based on the national average.
Bristol & England Paediatric Cardiac Surgery (under 1 year, open heart ops) – annual death rates

Bristol intervention 1995,
GMC trial 1998,
Inquiry 1998-2001

Bristol Rates
National Rate
Bristol (Kennedy) Inquiry Report
Data were available all the time

- “From the start of the 1990s a national database existed at the Department of Health (the Hospital Episode Statistics database) which among other things held information about deaths in hospital. It was not recognised as a valuable tool for analysing the performance of hospitals. It is now, belatedly.

- “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.”
Bristol (Kennedy) Inquiry Report

Informing patients and the public

- “Patients and the public are entitled to be involved wherever decisions are taken about care in the NHS.
- “The involvement of patients and the public must be embedded in the structures of the NHS and permeate all aspects of healthcare.
- “The public and patients should have access to relevant information.
- “Healthcare professionals must be partners in the process of involving the public.”
Hospital Episode Statistics UK 
administrative data

- Electronic record of every inpatient or day case admission in every NHS (public) hospital
- 14 million records a year
- ICD10 data available from 1996 to near real time eg Oct 2007
- HSMRs & SMRs available to hospitals on web in UK and Netherlands
- HSMRs published and some SMRs, but not data on individual clinicians
- All patient admissions linked from 1996: deaths linked to census deaths
- 300 fields of information including
  - Patient details such as age, sex, post-code
  - Diagnosis using ICD10 and Procedures codes
  - Admission method, Discharge method
- **Similar data available in other countries** eg US, Canada, Netherlands, Sweden, Australia, Wales, Singapore (Scotland, Denmark, Italy, France)
HSMRs cover top 80% deaths

Model uses the 56 diagnoses’ SMRs, which adjust for:

- Age*
- Sex*
- emergency status*
- socio-economic deprivation
- CCS diagnosis group (56 groups, accounting for 80% of all in hospital deaths)*
- diagnosis subgroup (3 digit ICD10)
- co-morbidity – Charlson index
- number of prior emergency admissions
- palliative care
- year
- month of admission (for some respiratory diseases)
US HSMRs (Medicare data) uses binary logistic regression to adjust for:

- Age-group
- Sex
- Admission type (emergency, urgent, elective etc)
- Admission source (physician refer, ER, transfer etc)
- Length of stay
- Each of above within each diagnosis of the diagnoses leading to 80% all deaths
- Note that these ‘top-down’ HSMRs differ from ‘bottom-up’ HSMRs, using model for each SMR, by 2-3% in England
UK highest correlations with HSMR (sig <0.001) (more of each associated with lower HSMRs)

- Doctors per bed (average of 5 years values)
- Total doctors 5 years/total beds 5 years
- Being a university teaching hospital
- NHS facilities per 100,000 population (from census)
- Achievement of the financial position shown in the 2002/3 Plan without the need of unplanned financial support.

In National Survey of NHS Patients:

- ‘If you had any anxieties or fears about your condition or treatment, did a doctor discuss them with you?’
- ‘If your family or someone else close to you wanted to talk to a doctor, did they have enough opportunity to do so?’
- ‘Did a member of staff explain the purpose of the medicines you were to take at home in a way you could understand?’
- ‘Did a member of staff tell you about medication side effects to watch for when you went home?’
- ‘Would you recommend this hospital to your family and friends?’
USA HSMRs
(using year 2000 as reference)

Institute of Medicine reports 2000, 2001
HSMRs first sent to hospitals early 2002
USA (Medicare) HSMRs using year 2000 as reference
English HSMRs using year April 2000-March 2001 as reference
HSMRs USA (Medicare) and England - both using national data for year 2000 as reference base
Dutch HSMRs vs year
(using year 2003 as the reference)
Swedish HSMRs
(using 2000 as the reference)
International Comparison a Driver for Change

Hospital Standardised Mortality Rates

- Imperial College Healthcare NHS Trust
- Royal Free Hampstead NHS Trust
- University College London Hospitals NHS Foundation Trust
- Cambridge University Hospitals NHS Foundation Trust
- University Hospital of South Manchester NHS Foundation Trust
- Oxford Radcliffe Hospitals NHS Trust
- Southampton University Hospitals NHS Trust

Source: intelligence
US Academic Medical Centers’ HSMRs

HSMRs (95% CIs)
Years for which we have calculated HSMRs

Green = monthly  red = published with hospital names

discussions with Finland, France, Italy, & Denmark

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<td>US Medicare</td>
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<td>x</td>
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<td>Australia NSW</td>
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<td>Wales</td>
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Calculation of international HSMRs

• The same key variables are recorded in most western countries
• Care needs to be taken with definitions eg length of stay for day 1
• With the countries listed above plus Japan and France if they agree we could calculate an international HSMR, using which all the hospitals could be compared.
Main queries raised about the results

- Accuracy of coding – ability to change incorrect diagnoses etc later
- Patients discharged to hospices and other forms of intermediate care
- Admission rate effect: differences of management locally
- The effect of social factors
- Severity of illness adjustments eg cancers
- Depth of coding (number of secondary diagnoses)
- Should we use clinical databases
- Inter-hospital transfers
- Patients admitted to hospital to die
- 30 day mortality
- Consistency of results from year to year
- Sensitivity analyses to test variations (eg exclude cancer)
- Zero-day LOS removed but only for AMIs
- Can hospitals use the data to reduce their mortalities?
RTM V7 HSMRs (Observed/Expected) with 95% and 99.8% control limits

West Midlands trusts in blue

100 = baseline risk
HSMRs based on last spell of patient (Observed/Expected) with 95% and 99.8% control limits

West Midlands trusts in blue

100 = baseline risk
HSMRs based on all 30 day deaths and last spell of patient (Observed/Expected) with 95% and 99.8% control limits

West Midlands trusts in blue

100 = baseline risk
English HSMRs 2007-8 calculated with and without adjustment for Charlson index of secondary diagnoses (Dr Foster Unit, Imperial College, 2008)

\[ y = 0.99x + 1.4207 \]

\[ R^2 = 0.937 \quad R=0.97 \]
Comparison of HES vs clinical databases

**Isolated CABG**
- HES around 10% fewer cases compared to National Cardiac Surgical Database

**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, 39% of patients had missing data for the risk factors
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
Calibration plots for ‘complex’ HES-based risk prediction models for four index procedures showing observed number of deaths against predicted based on validation set.

Surgery for isolated CABG

Surgery for colorectal cancer

Surgery for ruptured AAA

Surgery for unruptured AAA

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
HSMRs for US Medicare hospitals with good quality data 2004-6 with 95% and 99.8% control limits (US Medicare 21004-6=80.85, green line)
HSMRs for US Medicare hospitals with good quality data 2004-6 with 95% and 99.8% control limits
(US Medicare 2004-6=80.85, green line) - States
NB: some of the factors affecting HSMRs include coding, risk adjustment & quality of care
HSMRs 2004 (regression adjusted) vs Directly standardised Reimbursements 2000
US Medicare data for 1594 non-specialist hospitals with good quality data
US HSMRs 2006 vs Volume of cases 2006 (for average hospitals with good quality data and >50 deaths per year)
Beth Israel Deaconess Medical Center annual HSMR vs USA HSMR – Oct 1997 to Sep 2007
(from dataset of 765 US hospitals for which monthly HSMRs calculated)
Beth Israel Deaconess Medical Center annual
HSMR vs USA HSMR – Oct 1997 to Sep 2007
BETH ISRAEL DEACONESS MEDICAL CUSUM
Observed - Expected HSMR deaths from Sep 1997 to Mar 2007 (adjusted for US HSMR change)
Massachusetts hospitals with good quality data:
HSMRs 2005 vs standardised Medicare reimbursement 2000
Regression adjustment to allow for mainly community factors for BIDMC: net effect on HSMR = +14.1

(sign in brackets shows the direction of change of the hospital HSMR if the local value of the factor is greater than the USA value)

<table>
<thead>
<tr>
<th>Adjustment factor</th>
<th>Ratio to US average</th>
<th>Effect on HSMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Medicare deaths occurring in hospitals in HAS (+)</td>
<td>1.012</td>
<td>-0.71</td>
</tr>
<tr>
<td>All Medical Discharges per 1,000 Medicare enrollees in HAS (-)</td>
<td>1.095</td>
<td>3.70</td>
</tr>
<tr>
<td>Specialist + Generalist physicians per 100,000 residents (-)</td>
<td>1.403</td>
<td>4.66</td>
</tr>
<tr>
<td>Hip Fracture Repair/1,000 Medicare Enrollees (2001) at HRR level (-)</td>
<td>0.902</td>
<td>1.79</td>
</tr>
<tr>
<td>% Diabetic Enrollees Receiving One or More Blood Lipids Tests + Eye Examination (+)</td>
<td>1.062</td>
<td>0.91</td>
</tr>
<tr>
<td>% Discharged to short-term hospital + % discharged to home health service, 2000 (-)</td>
<td>1.254</td>
<td>0.94</td>
</tr>
<tr>
<td>% Cases (in top 80% deaths diags) with 1st sec diag: Malig neopl liver spec as sec, Sec malign neopl bone/bone marrow, Malig neoplasm unspec bronchus/lung, Chronic ulcer skin decubitus, Unspec protein-calorie malnutrition, Type 1 diabetes, 2000 (+)</td>
<td>0.590</td>
<td>2.10</td>
</tr>
<tr>
<td>Procedures Per Surgery Patient 2000-2001 (-)</td>
<td>1.024</td>
<td>-0.14</td>
</tr>
<tr>
<td>Fraction below 125% poverty level by State (+)</td>
<td>0.786</td>
<td>0.85</td>
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Massachusetts hospitals with good quality data: regression-adjusted HSMRs 2005 vs standardised Medicare reimbursement 2000
Massachusetts hospitals with good quality data: HSMRs 2005 without & with regression adjustment vs standardised Medicare reimbursement 2000
Beth Israel and Deaconess Medical Center
annual regression-adjusted HSMR vs USA
HSMR – Oct 1997 to Sep 2007
Use of HSMRs for planning hospital services for London
HSMRs - London hospitals vs non-London hospitals
(HSMR all England year 2005-6=100)

Source: B. Jarman, Dr Foster Unit, Faculty of Medicine, Imperial College London. Based on HES data – analysis 1 April 2007

*St Mary's, St George's, King's College Hosp, Guy's & St Thomas', Royal Free, UCL  Barts & The London, Chelsea & Westminster, Hammersmith Hosp
HSMRs St Mary’s compared with England (baseline 2005-6)

![Bar chart showing HSMR trends over years for St Mary's and England.](chart.png)
London Teaching Hospital Trusts* - circulatory diseases SMRs
(England = 100 each year)
Source: B. Jarman, Dr Foster Unit, Faculty of Medicine, Imperial College London. Based on HES data

*St Mary's, St George's, King's College Hosp, Guy's & St Thomas', Royal Free, UCL, Barts & The London, Chelsea & Westminster, Hammersmith
London Teaching hospitals*, Circulatory diseases

Observed - Expected circulatory disease deaths from 1996 to Mar 2007

Comparison with expected deaths based on England overall as norm

Source: B. Jarman, Dr Foster Unit, Faculty of Medicine, Imperial College London. Based on HES data

*St Mary's, St George's, King's College Hosp, Guy's & St Thomas', Royal Free, UCL, Barts & The London, Chelsea & Westminster, Hammersmith
London Teaching hospitals*, Circulatory diseases
CUSUM Observed - Expected deaths from 1996 to 2007
Comparison with expected deaths based on England overall as norm

Source: B. Jarman, Dr Foster Unit, Faculty of Medicine, Imperial College London. Based on HES data

* St Mary's, St George's, King's College Hosp, Guy's & St Thomas', Royal Free, UCL, Barts & The London, Chelsea & Westminster, Hammersmith
CUSUM observed – expected deaths: hypertension & heart failure

(US hospital, 250 admissions over 2 years)
Risk-adjusted Log-likelihood CUSUM charts

• STEP 1: estimate pre-op risk for each patient, given their age, sex etc. This may be national average or other benchmark

• STEP 2: Order patients chronologically by date of operation

• STEP 3: Choose chart threshold of acceptable “sensitivity” and “specificity” (via simulation)

• STEP 4: Plot function of patient’s actual outcome vs pre-op risk for every patient, and see if – and why – threshold is crossed
CUSUM charts

- 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
- Models can adjusts for age, sex, emergency status, etc.
Monitoring surgical performance using risk-adjusted cumulative sum charts

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TOM TREASURE
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\[ W_t = \begin{cases} 
\log \left[ \frac{(1 - p_t + R_0 p_t) R_A}{(1 - p_t + R_A p_t) R_0} \right] & \text{if } y_t = 1 \\
\log \left[ \frac{1 - p_t + R_0 p_t}{1 - p_t + R_A p_t} \right] & \text{if } y_t = 0
\end{cases} \]
CUSUM statistic (log likelihood of odds ratio): hypertension & heart failure
(US hospital, 250 admissions over 2 years)

CUSUM of patient statistic (log likelihood of odds ratio) score set to detect odds ratio of 2
(based on Steiner et al)

Trigger value = 5
Position of Owensboro in
distribution of US HSMRs 2002

- **US 2002**
- **OWENSBORO 2002 (HSMR=118.9)**

**Graph Details:**
- X-axis: HSMRs
- Y-axis: Number of hospitals in HSMR range of 2 units

The graph shows the distribution of HSMRs for the US in 2002, with Owensboro highlighted at an HSMR value of 118.9.
Owensboro medical Health System, Owensboro, KY

![Graph showing Improvement actions over years with USA Medicare HSMRs, lower 95% CI, upper 95% CI, and OWENSBORO HSMR indicated.]
Observed-Expected deaths: Owensboro medical Health System, Owensboro, KY
Position of Owensboro in distribution of US HSMRs 2006

HSMRs

Number of hospitals in HSMR range of 2 units

US 2006

OWENSBORO 2006 (HSMR=62.7)
Walsall hospital - CUSUM Real-Time Monitoring - 150,000 admissions over 9 years
The Clinical Governance Structure

Trust Board

Clinical Governance Assurance Committee

Clinical Governance Committee

Clinical Governance Teams

Clinical Governance Groups

- Clinical Audit
- Clinical Effectiveness
- Education & Training
- Information
- Risk Management
- Staffing & Staff Management
- Patient & Public Involvement
- Surgery
- Obs & Gynae
- Paeds
- Elderly Care
- General Medicine
- Theatre, Critical Care, A&E, OPD
- Professional Clinical Services

Top Management Team
(one member chairs each of the 7 CG committees)
Walsall (England) change of HSMR

Observed – expected deaths (for top 80% all deaths) by 10 September 2005
= a reduction of 284 deaths (355 annually if scaled to 100% deaths)

First publication of HSMRs Jan 2001

Mortality (in-hospital) | Diagnoses | Fracture of neck of ...r (hip)

Intervention –
reduce time to operation
Evidence for value of reducing delay in operation for # NOF


• “Delay in operation was associated with an increased risk of death in hospital, which was reduced but persisted after adjustment for comorbidity.”

• “If death rates in patients with at most one day's delay had been repeated throughout all 151 trusts in this study, there would have been an average of 581 (478 to 683) fewer total deaths per year (9.4% of the total).”
Bolton Hospital # NOF actions

• Reduced time to theatre in medically unfit patients to a mean of 3 days

• Overall time to theatre reduced by 30%

• Length of stay reduced by 32%
Cusum reduction of Obs – Exp deaths # NOF compared with situation in Q1 2005
Change of two hospitals’ HSMRs (95% CIs) - comparison with USA Medicare

In 2005 these hospitals had 200 fewer deaths (in the diagnoses leading to 80% all US deaths) annually than would have been expected if their HSMR reduction had been at national rate (total 609, gradually increasing, over the 7 years)
Admissions: 436 – diagnosis AMI
First / Last: Jan-06 / Feb-07
Deaths: 79 (19.2%)
Expected: 49.9 (12.1%)
O-E: 29.1 (7.1%)
Relative Risk: 158.3 (125.3—197.3)
C-Statistic of ROC curve: 0.74
False Alarm Rate: 0.4%

This chart indicates that on two occasions over the last year, a risk-adjusted mortality of double the expected rate for AMI was recorded at this hospital.
Who’s using the systems in the NHS?

Usage by Month by Job Function (All 2005-2006)
Who’s using the systems in the NHS?

NHS Role Types

- Medical Director
- Support / Nurse
- Chief Exec
- Financial Director
- Public Health
- GP
- Finance Manager / Analyst
- Clinician
- GP Practice Manager
- Information Manager/Analyst
Web link

- [https://da.drfoster.co.uk/](https://da.drfoster.co.uk/)