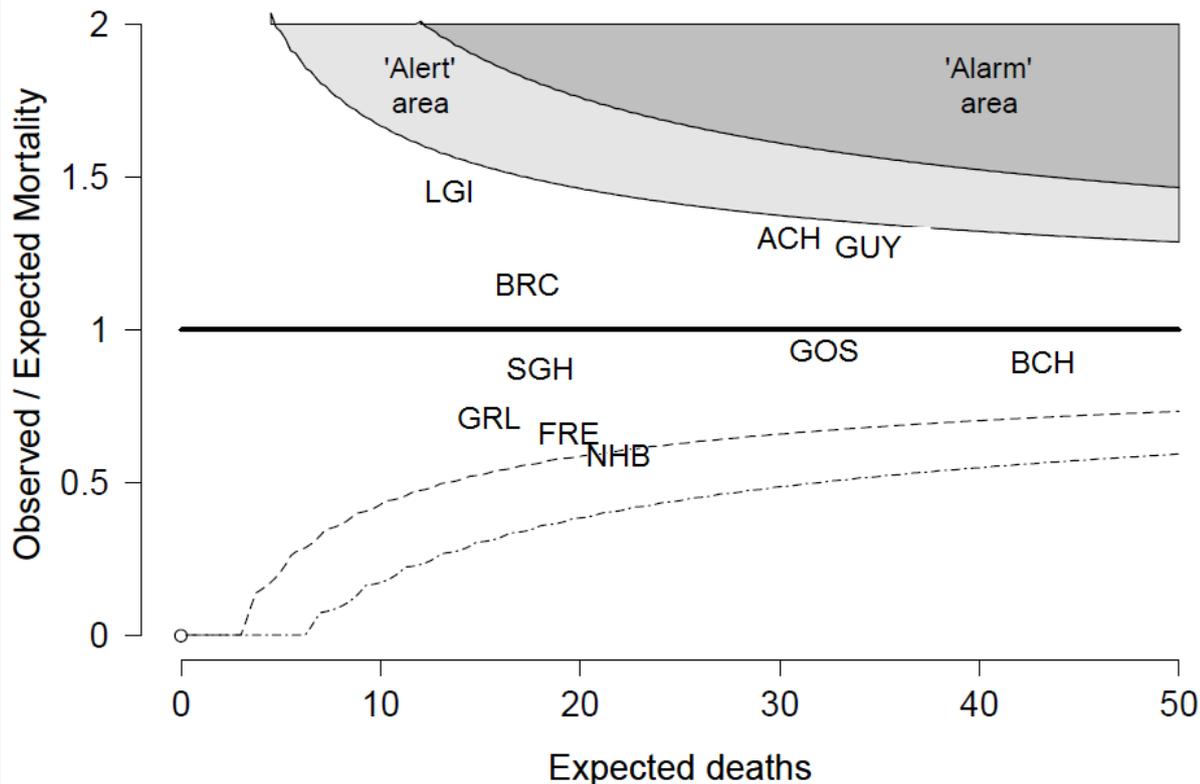


**Impact case study (REF3b)**

<p><b>Institution:</b> University of Cambridge</p>
<p><b>Unit of Assessment:</b> UoA10</p>
<p><b>Title of case study:</b> Methods for Comparing Clinical Outcomes across Institutions</p>
<p><b>1. Summary of the impact</b> (indicative maximum 100 words) This case study concerns the research of Professor David Spiegelhalter on ‘funnel plot’ methodology for comparing institutions. This system has now become the standard method within the National Health Service for comparing clinical outcomes, including hospital Trusts with apparently ‘outlying’ mortality rates. In particular, mortality following children’s heart surgery is analysed and presented using funnel plots, and Professor Spiegelhalter’s work has been instrumental in handling high-profile cases such as surgery at Oxford Radcliffe Infirmary and Leeds General Infirmary.</p>
<p><b>2. Underpinning research</b> (indicative maximum 500 words)  Professor Spiegelhalter joined the Medical Research Council (MRC) Biostatistics Unit at Cambridge in 1981, was returned as Category C in subsequent RAEs was appointed Professor for the Public Understanding of Risk in the Department of Pure Mathematics and Mathematical Statistics at the University in 2007. Since 2003 he researched appropriate graphical methods for comparing institutions, in particular the funnel plot, which presents a set of performance measures versus their precisions, with added control limits around a target value. Spiegelhalter’s highly-cited 2005 paper has become the definitive text on this topic [1]. The control limits, generally set at 2 and 3 standard deviations (95% and 99.8% intervals) create a ‘funnel’, visually emphasising that we can expect more variability in smaller institutions. Dating back to early work on control charts by Shewhart in the 1930s, traditionally a 3 standard-deviation funnel has been used to identify ‘special-cause’ variation (although the NHS Information Centre currently display 2 standard-deviation limits).  Basic funnels can be based on simple outcome rates assuming a Binomial distribution. More sophisticated versions incorporate allowance for different case-mix by producing a risk-adjusted Expected mortality rate: the funnel is then based on the standardised mortality rate (Observed/Expected), with limits based on a Poisson model. An additional refinement, unique to Spiegelhalter’s model, is the allowance for ‘over-dispersion’ – that is a degree of permissible variability in underlying risk that is intended to take into account the inevitable limitation in risk adjustment [2]. This has the effect of producing a funnel that does not narrow indefinitely as the volume increases, but tends to parallel control limits.</p> <p>Example Funnel Plot, taken from [Source 4]:</p>

### Congenital Heart Surgery 2009–2012



An average Unit has a 1 in 40 chance of being in the 'Alert' area, and 1 in 1000 chance of 'Alarm' area

In collaboration with members of the MRC Biostatistics Unit, Spiegelhalter determined how to deal with multiple comparisons, and critiqued a technique now often used in US health monitoring [3-4]. This research, and its application to comparing NHS Trusts, was summarised in a Royal Statistical Society discussion paper [5], with collaborators from the Care Quality Commission and other institutions.

### 3. References to the research (indicative maximum of six references)

\* [1] D J Spiegelhalter. Funnel plots for comparing institutional performance. *Statistics in Medicine*, **24**:1185-1202, 2005, DOI: 10.1002/sim.1970.

[2] D J Spiegelhalter. Handling over-dispersion of performance indicators. *Quality Safety Health Care*, **14**:347-351, 2005, DOI: 10.1136/qshc.2005.013755.

\* [3] HE Jones, DI Ohlssen, and DJ Spiegelhalter. Use of the false discovery rate when comparing multiple health care providers. *J Clin Epidemiol*, **61**:232-240, 2008, 10.1016/j.jclinepi.2007.04.017.

[4] Jones HE and Spiegelhalter DJ. The identification of 'unusual' health-care providers from a hierarchical model. *American Statistician*, **65** : 154-163, 2011, DOI: 10.1198/tast.2011.10190

\* [5] Spiegelhalter DJ, Sherlaw-Johnson C, Bardsley M, Blunt I, Wood C and Grigg O. Statistical methods for healthcare regulation: rating, screening and surveillance (with discussion). *J Roy Statist Soc Series A*, **175**, 1-47, 2012, DOI: 10.1111/j.1467-985X.2011.01010.x

\*References which best represent the quality of the underpinning research

## Impact case study (REF3b)

**4. Details of the impact** (indicative maximum 750 words)

Spiegelhalter's funnel plot methodology has been adopted by numerous organisations charged with communicating medical outcomes to the public, and has become increasingly influential in recent years with growing public concern resulting from the release of evidence of certain NHS performance outcomes .

A major application area has been in child heart surgery. The National Institute for Cardiovascular Outcomes Research (NICOR) uses funnel plots to communicate risk of surgery for congenital heart disease to the public [6]. In addition they have strongly featured in Inquiries into possible performance failures in UK hospitals: based on his research in this area, Professor Spiegelhalter was a member of the 2010 Inquiry into child heart deaths at the Oxford Radcliffe Infirmary, which resulted in the ceasing of surgery in Oxford. In 2012 he also contributed funnel-plot analysis [7] to the controversial *Safe and Sustainable* [8] programme that recommended closure of centres for paediatric heart surgery. In April 2013, at the height of the controversy surrounding surgery at Leeds General Infirmary, Professor Spiegelhalter was part of the group analysing the revised data and he produced funnel plots to communicate the findings – this analysis contributed to the decision to restart surgery at Leeds. [9]

As a result of Spiegelhalter's research, funnel plots have become a standard method used for comparing outcomes within the National Health Service: Department of Health guidance on 'Detection and management of outliers' [10] is almost entirely based on Spiegelhalter's work. The National Joint Registry [11] uses them to identify centres with poor rates of knee-replacement problems, while Organ Donation compares kidney transplant success rates between centres. The initiative in 2013 to publish surgeon-specific outcome data makes extensive use of funnel plots, which appeared in news coverage [12]. The NHS Information Centre uses funnels as part of their reports on "Summary Hospital-level Mortality Indicator (SHMI) - Deaths associated with hospitalisation, England" [13] on an annual basis, including allowance for over-dispersion. Following the Mid-Staffordshire Inquiry (at which Professor Spiegelhalter was a witness), this information is used to select hospitals for further investigation.

Funnel plots have been included in software distributed by the Eastern Region Public Health Observatory (now part of Public Health England): a training video has been produced and 6500 downloads have been reported. [14]

**5. Sources to corroborate the impact** (indicative maximum of 10 references)

Use of funnels by NICOR

[6]

[https://nicor4.nicor.org.uk/CHD/an\\_paeds.nsf/WBenchmarksYears?openview&RestrictToCategory=2010&start=1&count=500](https://nicor4.nicor.org.uk/CHD/an_paeds.nsf/WBenchmarksYears?openview&RestrictToCategory=2010&start=1&count=500)

Response to analysis of Mortality data NHS Trust in England providing paediatric cardiac surgery 2000-2009 [7]

[http://www.specialisedservices.nhs.uk/library/30/Appendix\\_F\\_Response\\_to\\_the\\_analysis\\_of\\_Mortality\\_Data\\_of\\_NHS\\_Trust\\_in\\_England\\_Providing\\_Paediatric\\_Cardiac\\_Surgery\\_2000\\_2009\\_including\\_Terms\\_of\\_Reference.pdf](http://www.specialisedservices.nhs.uk/library/30/Appendix_F_Response_to_the_analysis_of_Mortality_Data_of_NHS_Trust_in_England_Providing_Paediatric_Cardiac_Surgery_2000_2009_including_Terms_of_Reference.pdf)

"Safe and Sustainable" documents reporting analysis based on funnel plots:

[8] <http://www.specialisedservices.nhs.uk/news/view/response-to-south-central-sha-analysis-outcome-data>

Report on children's heart surgery in Leeds

[9] <http://www.england.nhs.uk/2013/04/12/reports-chs-leeds/>

Department of Health Guidance on handling outliers

[10] <https://www.gov.uk/government/publications/detection-and-management-of-outliers-guidance-prepared-by-national-clinical-audit-advisory-group>

**Impact case study (REF3b)**

National Joint Registry and 2012 Annual Report

[11] <http://www.njrcentre.org.uk/njrcentre/default.aspx>

BBC News web-page showing funnel plot to display mortality rates for vascular surgeons

[12] <http://www.bbc.co.uk/news/uk-politics-22489062>

Details of methodology used by NHS

[13] <http://www.ic.nhs.uk/CHttpHandler.ashx?id=11151&p=0>

[14] Download information: email from Director of Knowledge and Intelligence Knowledge and Intelligence Team (East), Public Health England