



Risk stratification: The UK cardiothoracic experience

Graeme L Hickey¹; Stuart W Grant²; Iain Buchan¹;
Ben Bridgewater^{1,2}

¹Northwest Institute of BioHealth Informatics, Manchester University

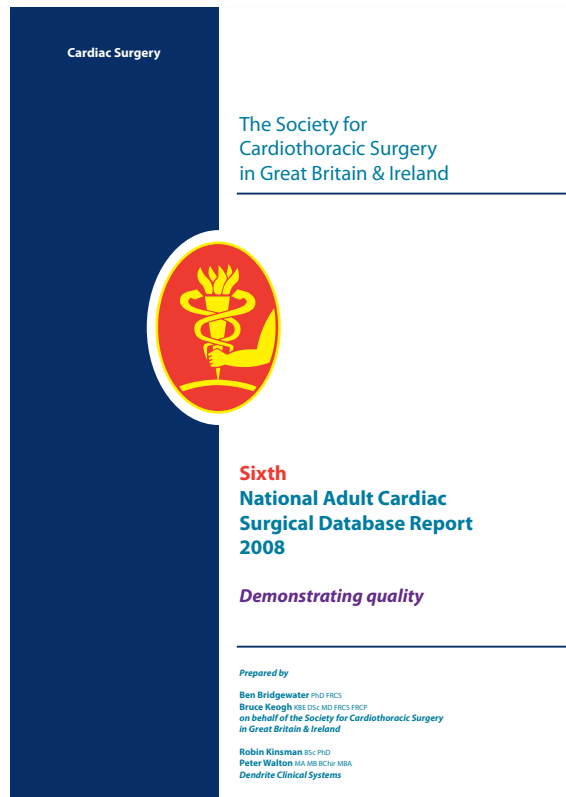
²Department of Cardiothoracic Surgery, University Hospital of South Manchester

Background

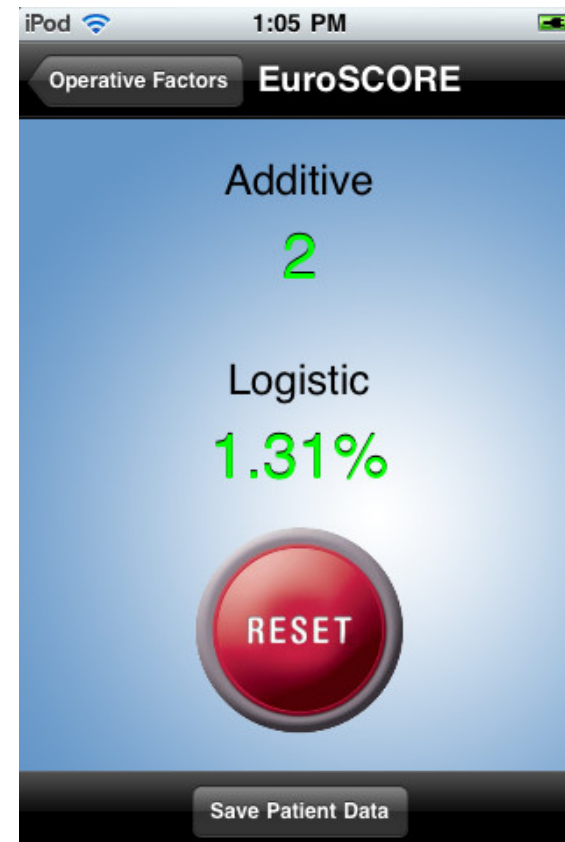
- Around **35,000** adult cardiac surgery procedures performed each year in UK
- In-hospital mortality rate in 2010-11 was **3.4%**

What's risk stratification used for?

Governance



Decision-making



Motivation

- Total cost = **£1.48m/year** in England (<1% of the total NHS spend on adult cardiac surgery)*
- Associated with a **50% reduction** in risk adjusted mortality*



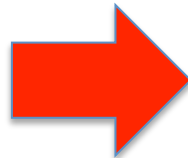
* *Maintaining Patients' Trust*, SCTS, Henley-on-Thames:
Dendrite Clinical Systems Ltd, 2011

Infrastructure

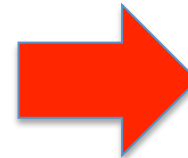
Aim: 3 months
Reality: 1 year



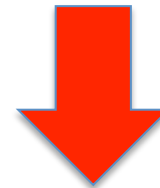
Cardiac surgery



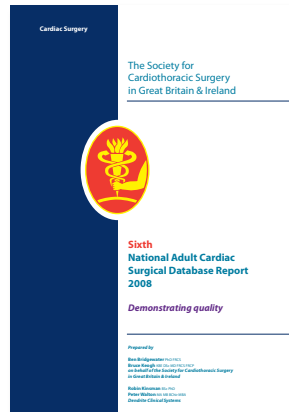
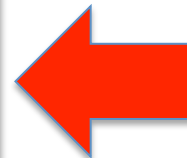
Input data locally



Uploaded periodically
to central database



Statistician + clinicians



National audit

Aim: <1 year
Reality: 3 years

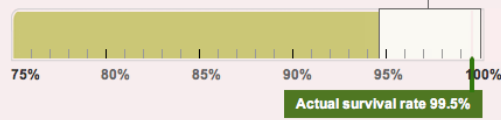


Coronary artery bypass graft operations

Operations for 3 years ending March 2009: 222 operations performed

Survival rate as expected by UK standards

Percentage range of patients expected to survive taking into account patients' risk factors



CQC website

Monitoring methodology

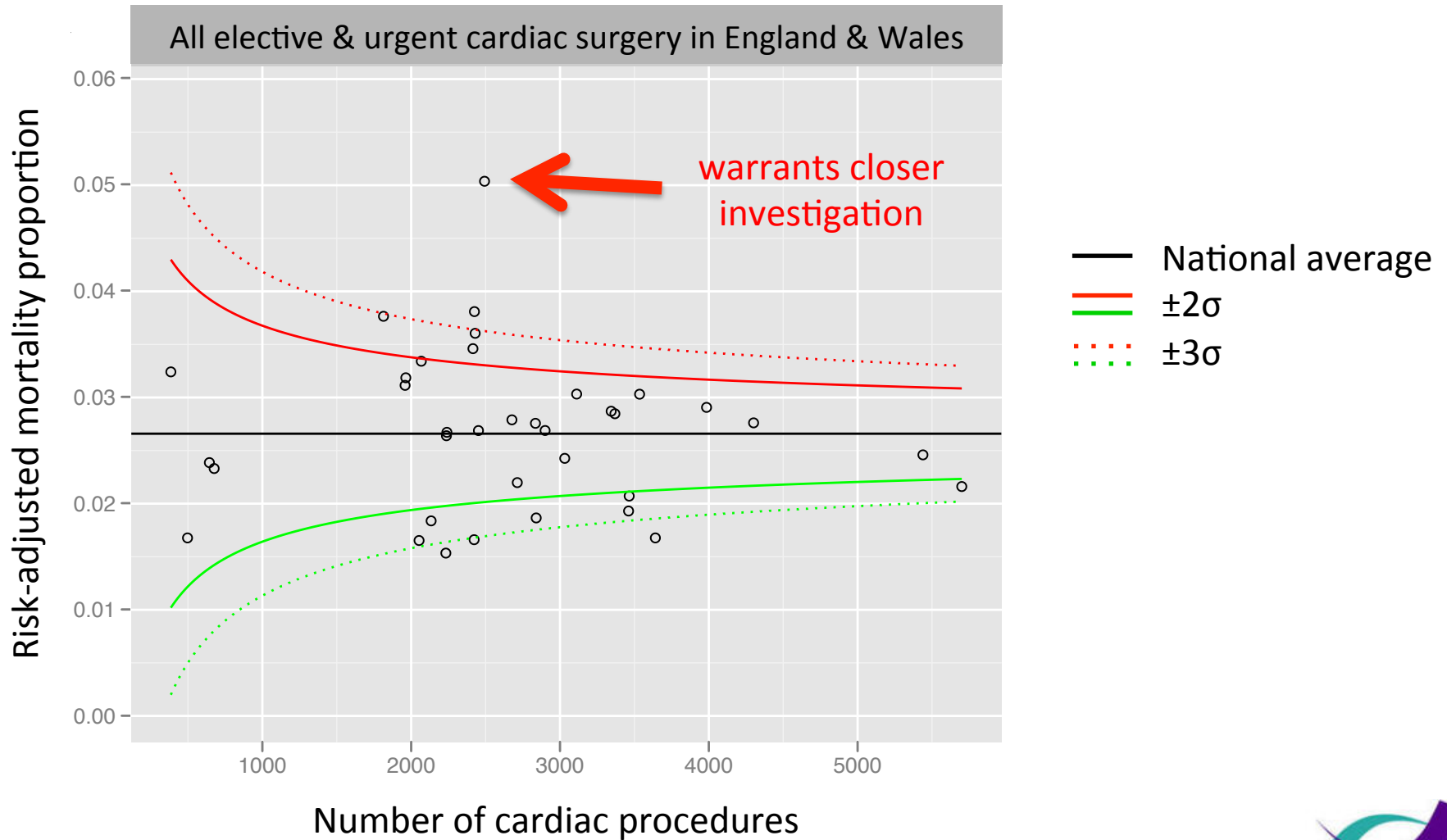
1. Funnel plot

- Fixed time period (e.g. 3 years)
- Identify 'outlier' units
- Doesn't address whether hospitals are getting worse

2. Variable life adjusted display (VLAD) plot

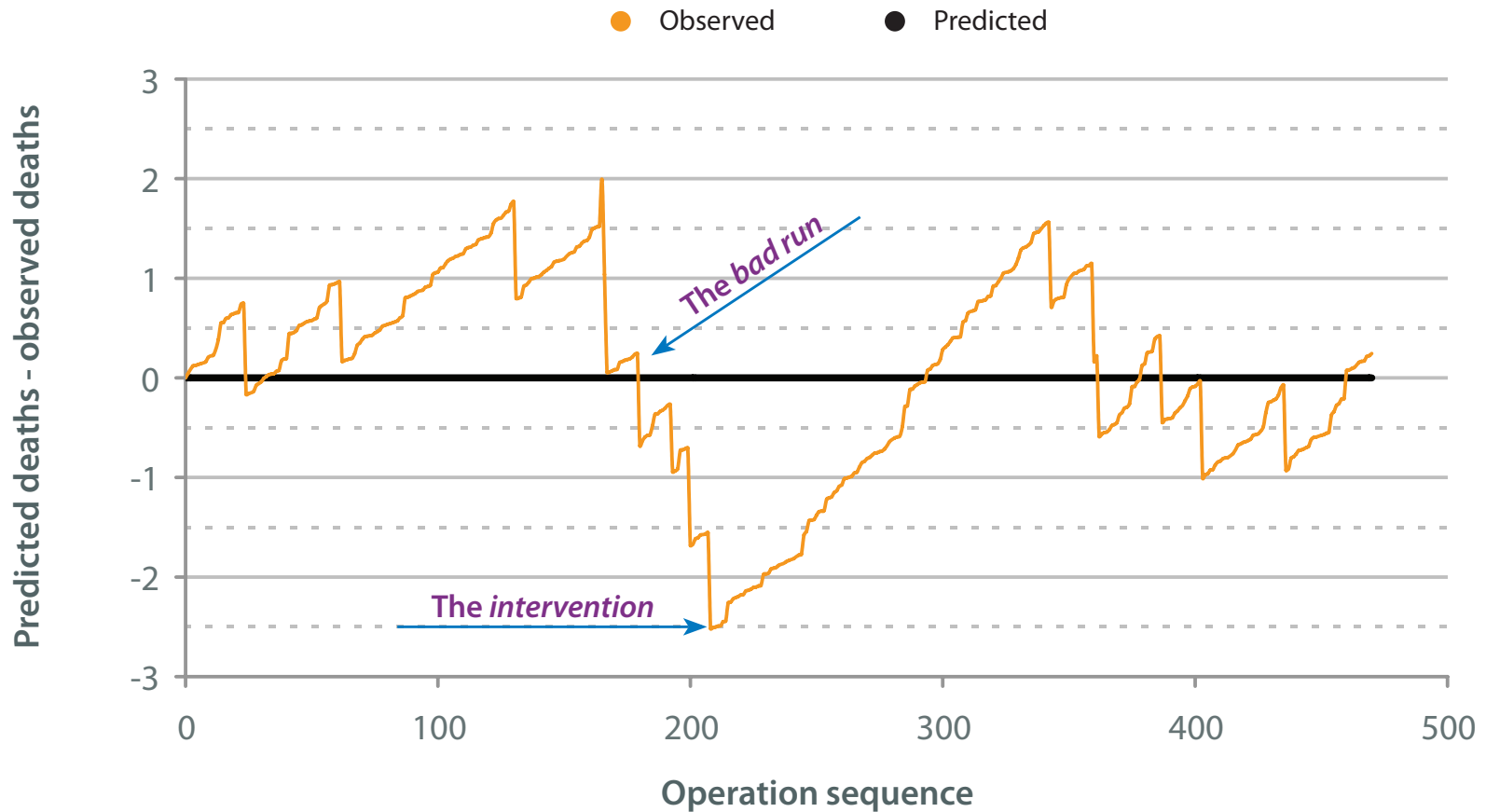
- Intuitive dynamic summary
- Doesn't identify when a unit is an outlier

Funnel plot



VLAD plot

Variable Life-Adjusted Display plot for an individual surgeon

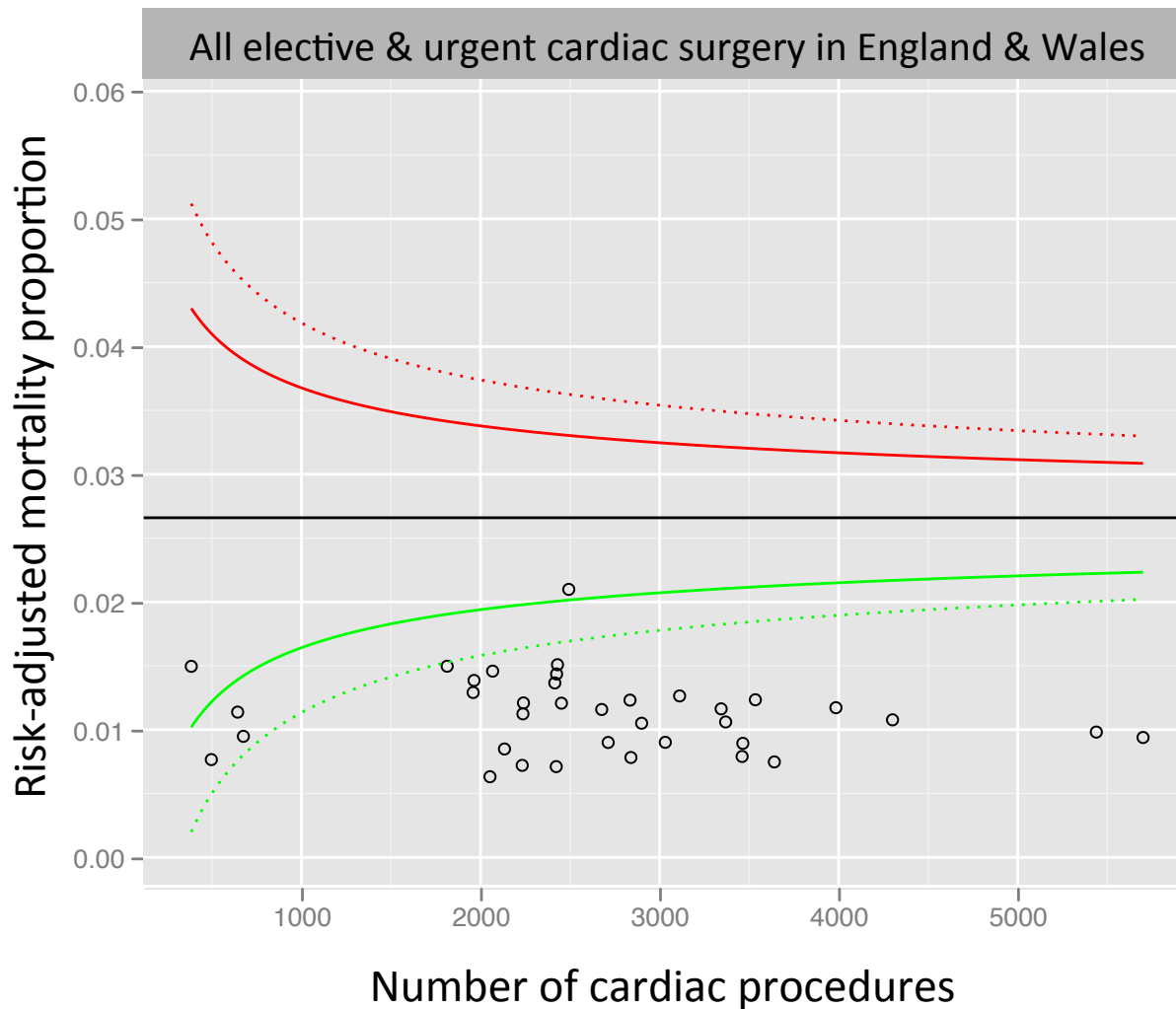


Problems to overcome

1. Systematic model miscalibration
2. Data dissemination
3. Pooled vs. separate models
4. Data quality
5. Gaming
6. Subgroup performance
7. Ancillary methodology

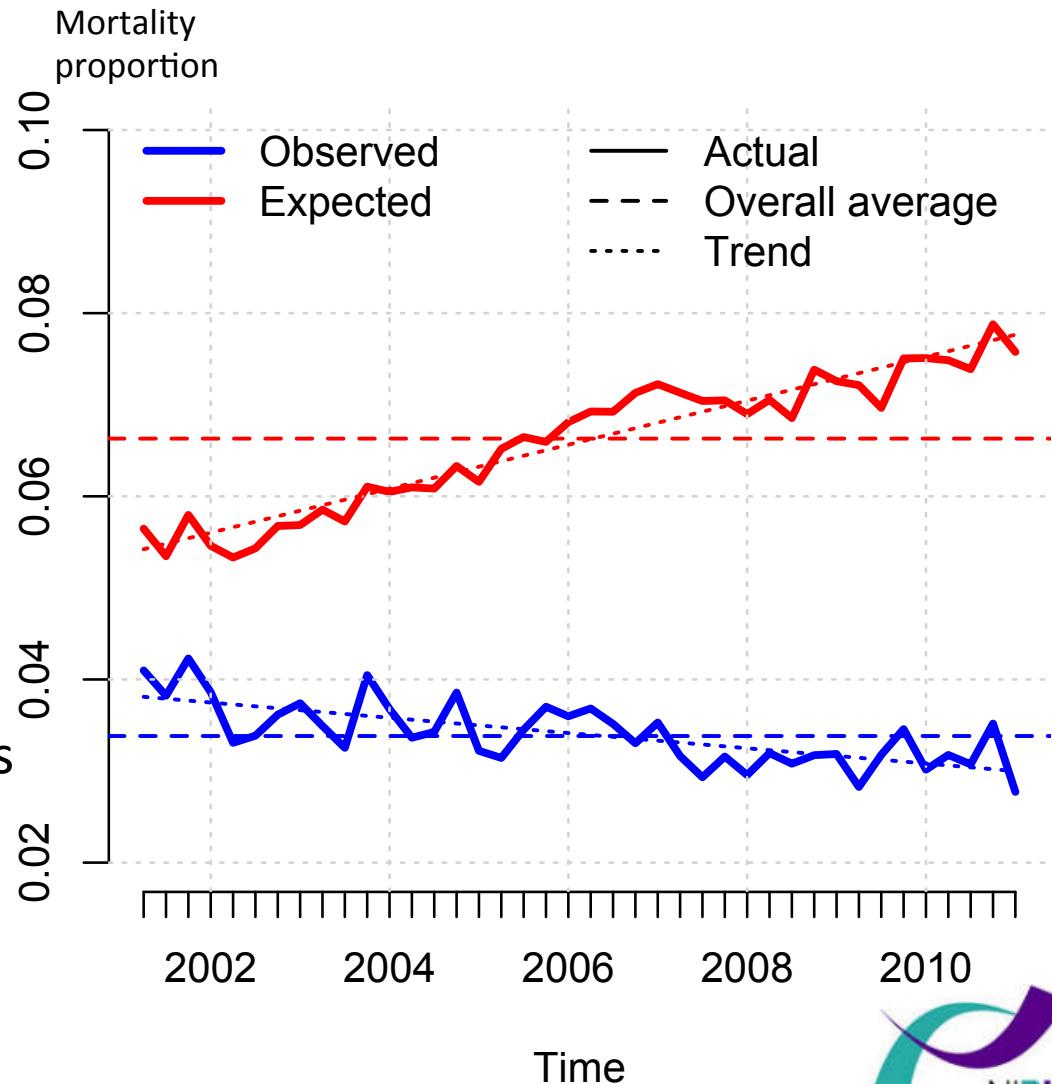
Systematic miscalibration

What's wrong with this?

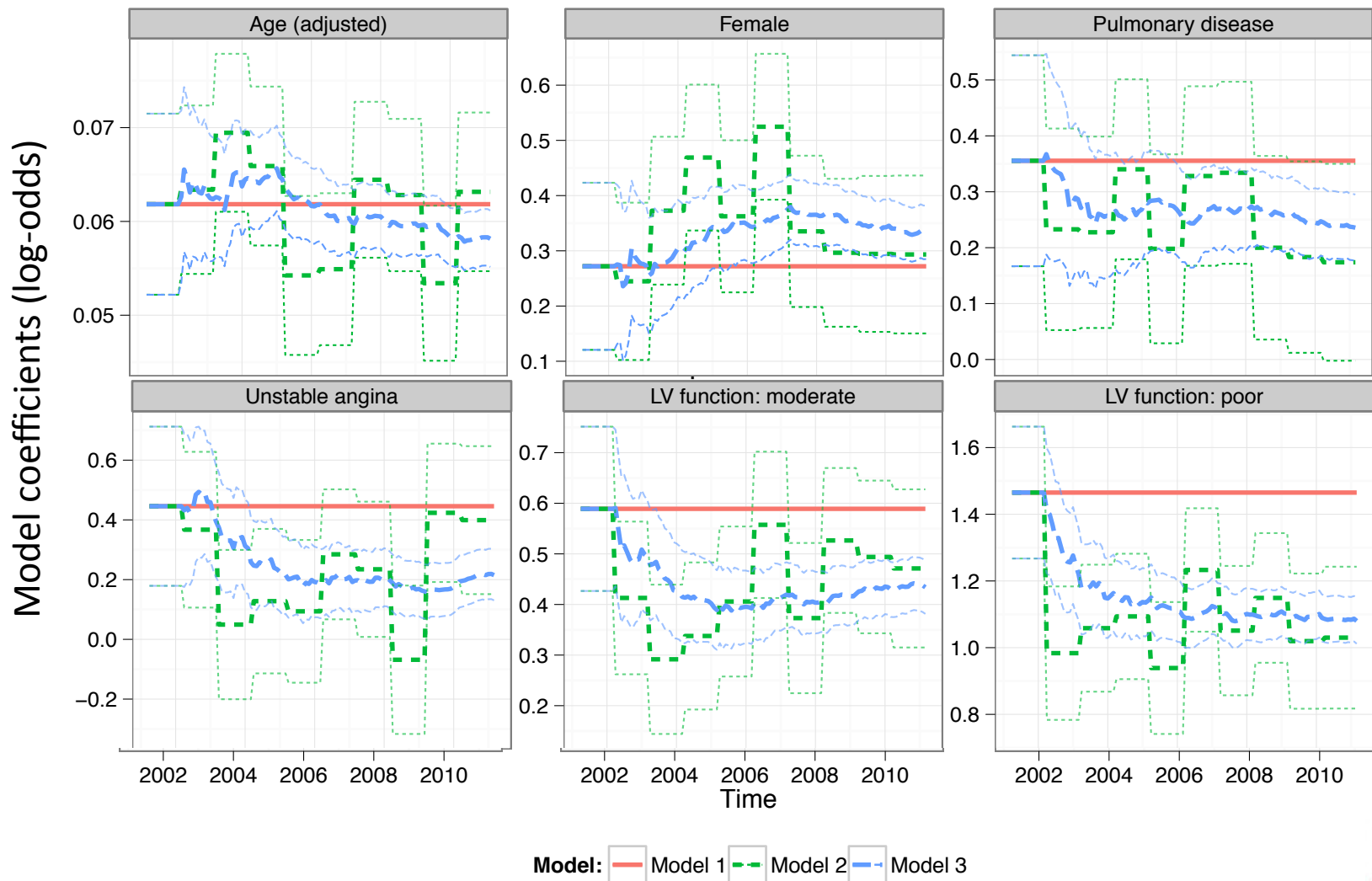


Systematic miscalibration

- **Observed mortality is decreasing**
 - better surgical tools
 - improvements in post-surgery treatment
- **Predicted mortality is increasing**
 - increase in older patients
 - more complex procedures
- **Model validation essential!**

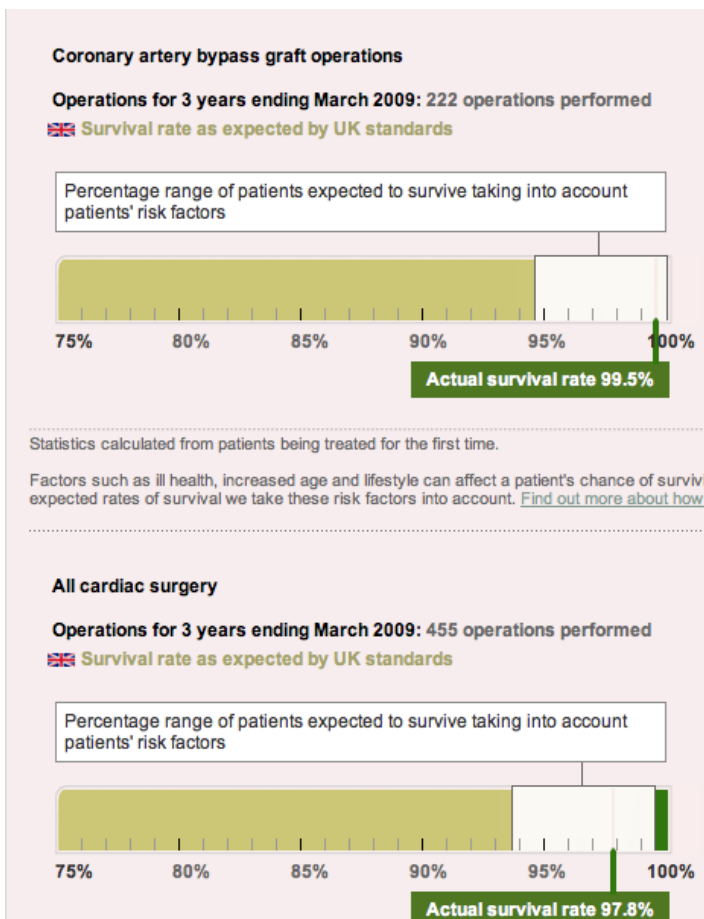


Dynamical modeling vs. periodic recalibration vs. doing nothing



Data dissemination: **past**

Abandoned CQC website

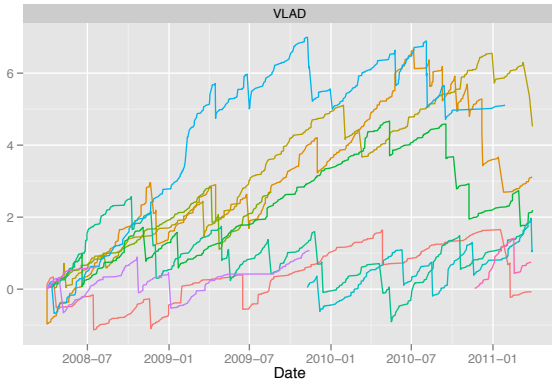
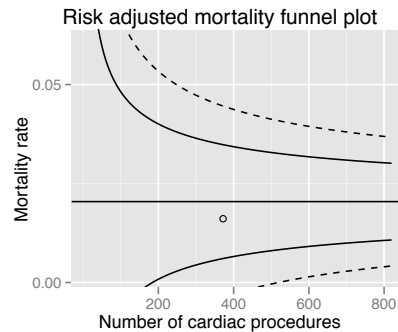
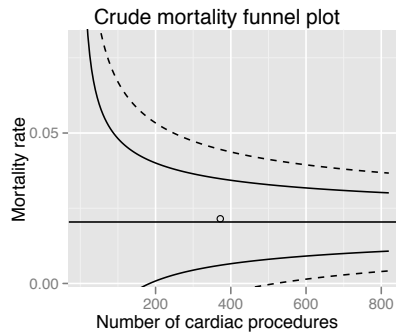
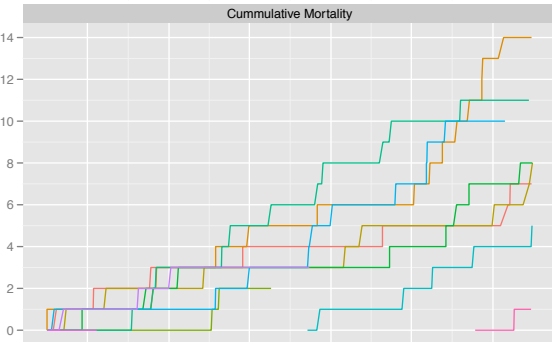
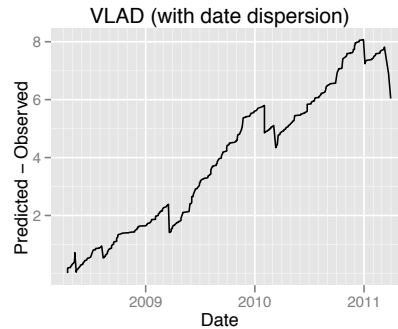
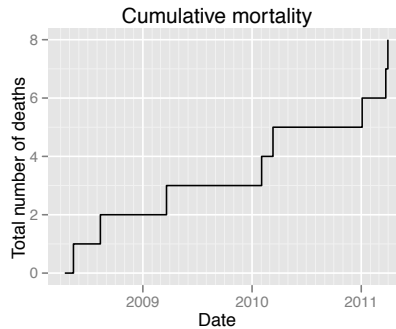
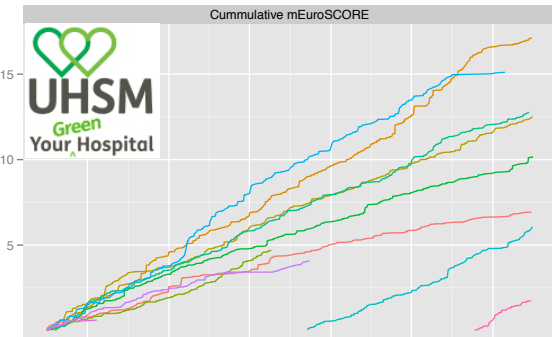
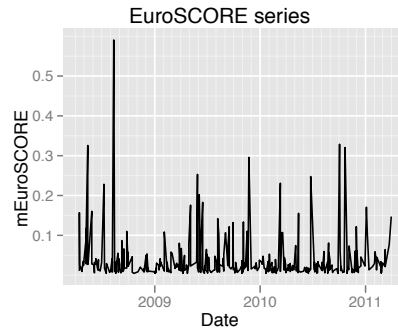


The SCTS 'Blue Book'

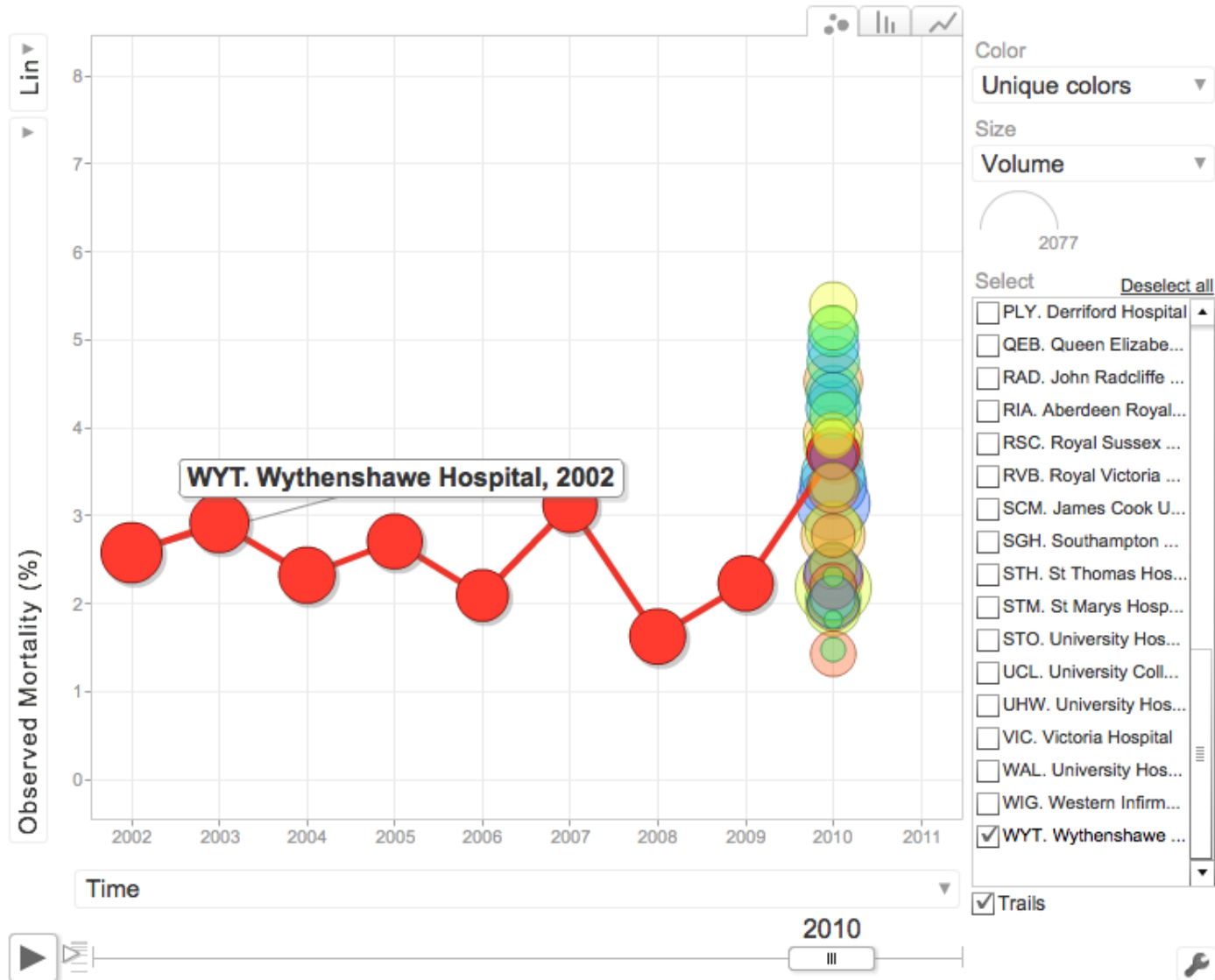


512 pages!

Data dissemination: future

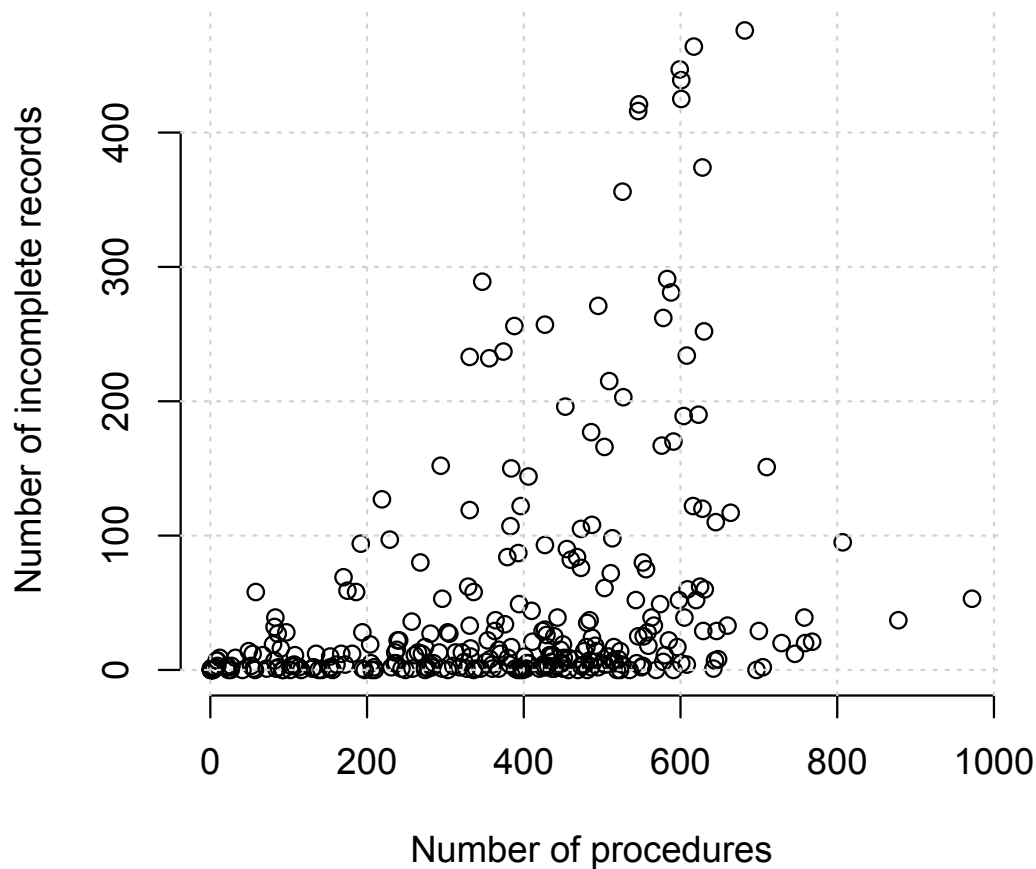


Data dissemination: future



Data quality

Outlier surgeon \neq rogue surgeon



- Missing data
- Input software errors
- Registry cleaning errors

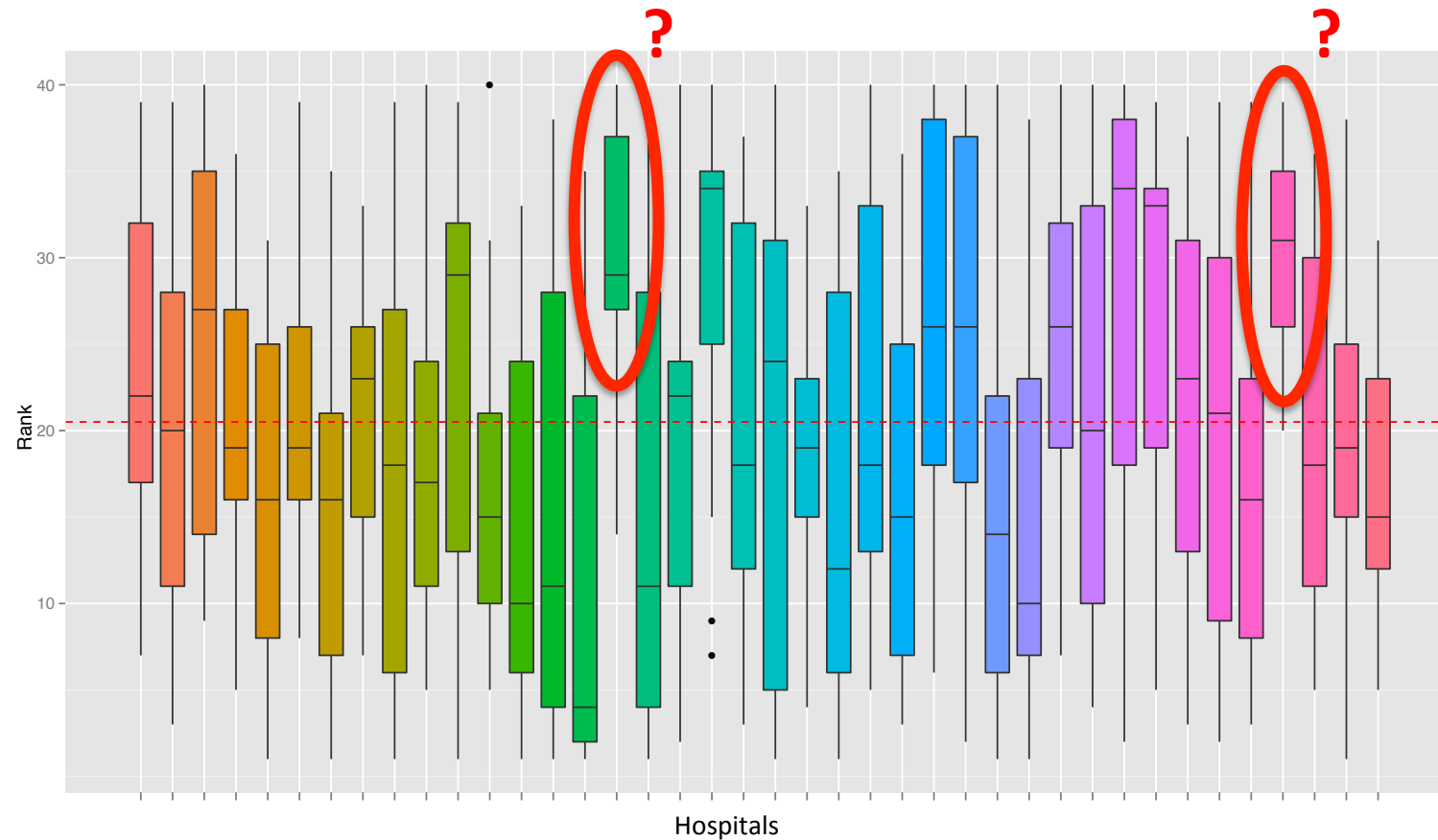


- Imputation
- Validation

Pooled vs. separate models

- CABG + MVR + Tricuspid repair = AVR?
- Cardiac surgery is a 'catch-all' term
- We could have risk prediction models for:
 1. all procedures (combinations)
 2. all procedures with multiple procedure variables
 3. each procedure group (e.g. CABG, Valve, CABG + Valve, ...)
- Decision depends on application.

Gaming (+ other unexpected extraneous variation)



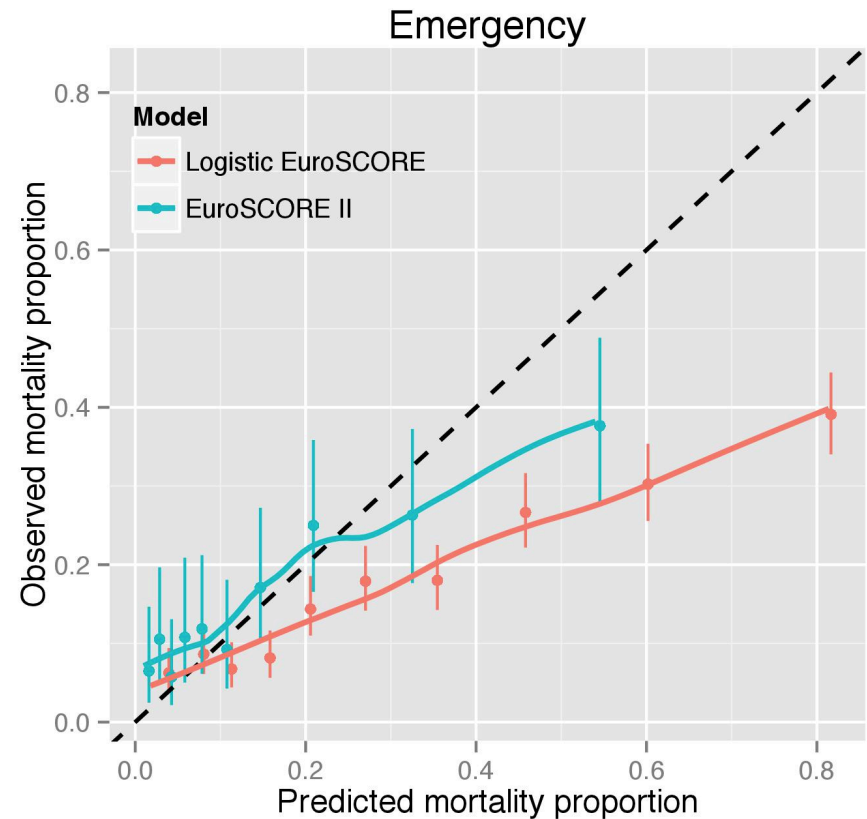
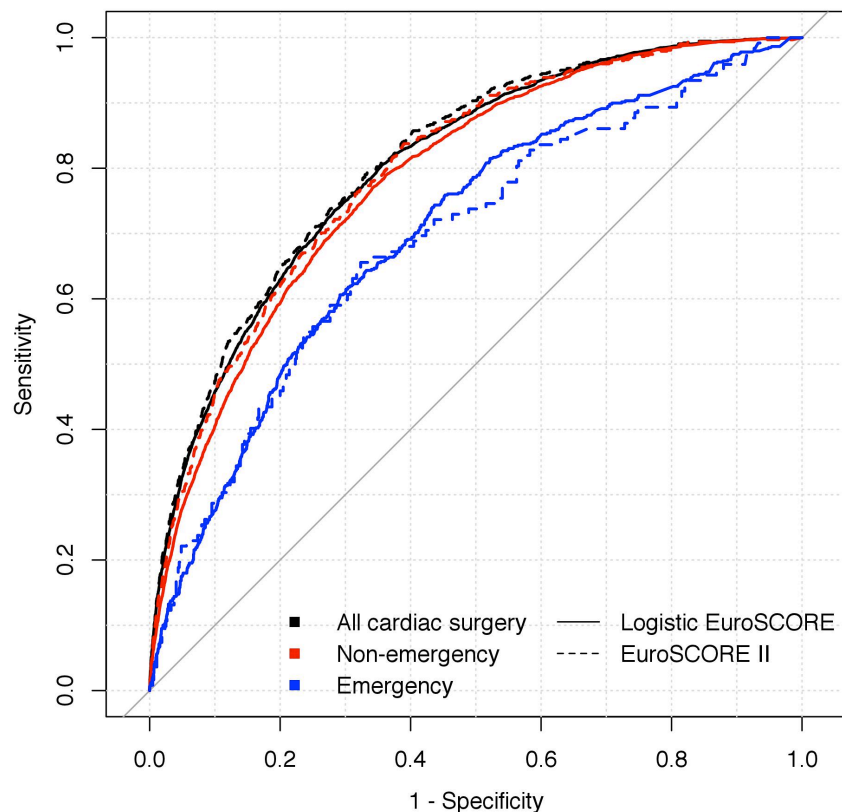
Distribution of ranks of risk factor prevalence might be expected to be homogenous across hospitals



Further investigation required

Subgroup performance

- Stratification does not ensure good model performance



Ancillary methodology

- **Multiple testing**
 - correction adjustments (e.g. Bonferroni)
- **Overdispersion**
 - multiplicative variance inflation
 - random effects models