FINAL REPORT

HOSPITAL EPISODE STATISTICS AND REVALIDATION

Creating the evidence to support revalidation

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Summary and recommendations

Background

This report outlines the results of a project which started in September 2009. The project's aim was to assess the strengths and weaknesses of using administrative data for revalidation in the areas of *ischaemic heart disease, urological malignancies,* and *peripheral vascular disease*. We distinguished between *procedure-specific indicators* and *disease-specific indicators* as well as between *hospital-specific* and *consultant-specific* outcomes.

Results

A *rapid literature review* of studies that used administrative databases in the UK to describe procedures and outcomes in the three defined disease areas was carried out. The results of this literature review are presented in chapter 3. 35 studies reported in the peer-reviewed literature were retrieved. These were all carried out in England and used the Hospital Episode Statistics database (HES), an administrative database of all admission to the English NHS. Most identified studies focused on procedures. None reported clinician-specific results. In-hospital mortality and length of stay were the most frequently used outcomes. The majority of studies used some form of risk adjustment that included at least age and sex.

A number of *case studies* based on HES data are presented in chapter 4. These studies used indicators for the purpose of revalidation defined by surgical specialist societies (Society for Cardiothoracic Surgery, British Association of Urological Surgeons, and Association of Surgeons of Great Britain and Ireland). We found that only a few of the defined indicators were fit for purpose. Important limitations were related to the indicators' *validity* (i.e. ability to distinguish between good and bad quality), *statistical power* (i.e. number of procedures and number of relevant events), *fairness* (i.e. ability to adjust for potential differences in case mix), and *adequacy of coding specification* (i.e. coding of diagnoses and procedures).

In chapter 5 we present an *overview of national clinical databases* that were available in 2010 covering any of the three clinical areas. We demonstrated that only the databases from the Society for Cardiothoracic Surgery (SCTS) and the British Cardiovascular Intervention Society (BCIS) had levels of case ascertainment and data completeness deemed high enough to justify a comparison with HES. Extracts of these databases were received from the SCTS in late 2010 and from BCIS in spring 2011. The results of the analyses of these databases are described in chapter 7.

A *case study of the accuracy of HES coding* used for patients undergoing abdominal aortic aneurysm repair(AAA), presented in chapter 6, demonstrated a high level of consistency between diagnostic and procedure codes which supports the use of administrative data for the purpose of revalidation. Of the patients undergoing AAA surgery for example, 94.9% had a consistent diagnosis of ruptured or an unruptured aneurysm. This study highlighted the importance of a detailed scrutiny of the codes before HES is to be used for revalidation.

In chapter 7, we describe the *comparison of HES with SCTS data* on coronary artery bypass graft (CABG) procedures and *with BCIS data* on percutaneous coronary interventions (PCIs). There was considerable agreement in the numbers of CABG procedures recorded in HES and in the SCTS database as well as in the corresponding mortality results. This was true both at NHS trust and at consultant level. There was no clear pattern that could explain the observed differences. In some NHS trusts, more CABG procedures were recorded in HES than in the SCTS database whereas the reverse was true in some other trusts. A similar pattern was observed for the mortality results. A remarkable result in our view is that performance of the risk adjustment models for mortality after CABG procedures developed in HES and in SCTS data was very similar.

We found larger differences between the numbers of PCI procedures recorded in HES and in the BCIS database than when comparing HES with the SCTS database. It seemed that there was under-recording of PCI procedures in HES by about 10%. Also, the differences in the mortality results according to BCIS and HES in individual NHS trusts were larger. The mortality differences went in both directions which indicated that there was no systematic under- or over-recording of mortality in either BCIS or HES data.

These results give some support for the use of HES data to measures the outcome of CABG procedures. However, HES-based indicators should not be used for PCIs as there were substantial differences between the numbers of procedures and the mortality results according to HES and BCIS data. In addition, the risk adjustment with HES data was less accurate than with BCIS data.

Disease-specific indicators can only be developed if patients can be identified from the time of diagnosis or from another time-defining event in the course of the disease. In chapter 8, we demonstrate how patients with prostate cancer could be followed up from the time of diagnosis through linkage with Cancer Registry data. We found that the linkage rates between HES and Cancer Registry data are high as 95% of Cancer Registry records could be linked to HES. However, the completeness of staging data in the Cancer Registry data is very poor and consequently our ability to adjust for case mix is limited. In the two other disease areas, ischaemic heart disease and peripheral vascular disease, it was not possible to develop *disease-specific indicators* as we could not identify patients at the time of diagnosis.

Discussion

The aim of this project was to assess the value of HES data for the purpose of revalidation. The results summarised above indicate that there is no single answer to this question as it will depend on the clinical area, the condition and procedure that are involved, and the specific indicator that is used to evaluate performance. For that reason, we propose a checklist that can be used for the evaluation of newly proposed indicators.

For the purpose of revalidation, it is key that indicators can be linked to individual consultants. The analyses described in this report compare results based on HES and those based on clinical databases. We found for example that the number of CABG procedures carried out by individual consultants according to HES agreed well with the corresponding number according to SCTS data and that relatively large differences between consultant-specific numbers based on HES and SCTS were confined to two hospitals. However, we could not investigate in other clinical areas to what extent the consultants responsible for the procedure were accurately identified in HES.

A further limitation of the value of HES data for revalidation is that it is difficult to determine the nature and severity of a patient's condition based on HES data alone. Using patients undergoing a PCI as an example, HES cannot distinguish between patients with ST-elevated myocardial infarction and those with non-ST elevated myocardial infarction. This may be one of the explanations for discrepancies between results based on HES and clinical data.

Recommendations

- Performance indicators based on HES should only be used for the purpose of revalidation if they are carefully developed and if their suitability for this purpose has been demonstrated.

- An explicit and step-wise *coding framework* should be used to develop and evaluate diagnostic and procedure codes when HES data are going to be used for revalidation. The following steps are recommended:
    - Specification of potentially relevant diagnostic and procedure codes
    - Exploration of frequency with which these codes are used in practice
    - Checks of the consistency of diagnostic, procedure and administrative codes
    - Evaluation of coding practice at individual NHS trusts or hospitals

- Final adjustments of the specification of the diagnostic and procedure codes informed by the preceding steps.

- The *suitability of indicators* needs to be evaluated before they are recommended for the purpose of revalidation. This requires feasibility studies that should look at:
  - The *validity* of the indicators
  - The *statistical power* to detect divergent performance
  - The *fairness* of the proposed comparison and the risk adjustment approach
  - The *adequacy of the coding* of the diagnoses and procedures.

  We developed an *explicit checklist* that can be used to evaluate these criteria. The above-listed criteria can only be met if data completeness and data quality are at an appropriate level.

- *Data linkage* with external data is needed to allow HES data to be used for *disease-specific indicators*. External data can provide the time of diagnosis or another time-defining event so that all patients can be followed-up from the same time point in the course of their disease.

  It is essential to choose the appropriate *level of analysis*, especially for *disease-specific indicators*. The indicator should be linked to a unit that has control over aspects of care or outcomes that are measured by the indicator.[1]

- The development of *consultant-specific indicators* does not differ fundamentally from the development of *hospital-specific indicators*. However, special considerations should be given to:
  - The *statistical power* because number of patients treated by individual consultants can be low
  - The *accuracy with which the responsible consultant can be identified in HES* is unresolved. Given that it is crucial that indicators can be linked to individual consultants, this is an important area for further investigation.
  - The *shared responsibility* of the care for patients among colleagues or among members of a multidisciplinary team can make it difficult to link indicators to individual clinicians.

[1] For example, NHS trusts and their consultants have only a limited influence on how many patients with prostate cancer will have a radical prostatectomy as they can only see patients who are referred to them. The most appropriate level of analysis for this indicator is therefore the Primary Cancer Trust (PCT) or the Cancer Network area in which the patients live.

1. Background

It was highlighted in the Chief Medical Officer's report *Good Doctors, Safer Patients* (DH 2006)[1] that patients would like to see outcomes of their treatment as part of the evidence required for doctors to demonstrate that they remain fit for practice. As a result, the General Medical Council (GMC) introduced the revalidation process. The revalidation will commence in late 2012.

The process of revalidation was initially set up in two parts: "re-licensing" for practicing doctors requiring them to demonstrate that they continue to practice in accordance with GMC standards, and "recertification" for practising doctors on the GMC's specialist register requiring them to demonstrate their fitness-to-practice as a specialist. These two parts are now combined into one process with revalidation mainly based on standards set by the Royal Colleges.

In this final report, we present the results of a project that aimed to assess the value of the Hospital Episode Statistics (HES) database to support the process of revalidation. The rationale to focus on the value of administrative data is that its use would not place an additional burden on the NHS.

There have been reports in the media and in medical journals that questioned the quality of HES data,[2,3] whereas others have demonstrated the opposite.[4] This in turn has led to concerns from consultants about the appropriateness of HES for measuring their individual performance. Some of the issues raised include problems with the accuracy and completeness of diagnosis and procedure coding as well as the lack of clinical detail that is being recorded in the HES database.

However, the accuracy and completeness of HES data is thought to vary between clinical specialties. For example, data quality will depend on whether care involved acute or long term conditions, whether data items capture elements of the care process or outcomes, or whether outcomes being measured become apparent in or out of hospitals. It is important for each specialty to assess the value of HES data for revalidation in its own area. Therefore, we carried out a literature review and a number of case studies in three clinical areas:

- ischaemic heart disease
- peripheral vascular disease
- urological malignancy

These areas were chosen as it was envisaged that the findings from these areas would be applicable across other surgical and medical specialties. Also, information on the treatment and outcomes of patients in these areas is currently being collected in HES and in clinical databases. The latter is especially important as it allows a direct comparison between results derived from HES and from other data sources.

Another consideration to explore in these areas was that the Society for Cardiothoracic Surgery (SCTS), Association of Surgeons of Great Britain and Ireland (ASGBI) and British Association of Urological Surgeons (BAUS) had outlined lists of outcome indicators based for the purpose of revalidation based on routinely collected data. These lists include outcomes such as length of stay, postoperative mortality, readmission, and return to theatre (RTT).

Procedure-specific and disease-specific indicators

In this project, we were required to distinguish between procedure-specific and disease-specific indicators. Procedure-specific indicators compile and summarise data on outcomes of patients undergoing a specific procedure. Disease-specific indicators do the same but for patients from the time of a specific diagnosis (or another time-defining event in the course of the disease). Disease-specific indicators reflect the impact that all clinical specialties involved in the treatment have on patient outcomes along a disease pathway.

It was thought that the development of disease-specific indicators could provide an accessible representation of the outcomes for individual clinicians as well as for "clinical teams". At the same time, it was noted that when disease-specific indicators are used it is more complicated to define the patient population as well as the timing of their follow-up. It will also be more difficult to relate disease-specific metrics to individual clinicians given that a number of clinicians may have been responsible for different aspects of care during a patient's journey.

Hospital-specific and consultant-specific outcomes

An issue that is relevant for the results presented in this report is that some have argued that HES data should not be used to examine the performance of individual consultants as the assignment of a patient to a single consultant in HES records may not fully reflect the involvement of a number of consultants often from different specialties. Hospital-specific outcomes may therefore be more appropriate. In addition, if the performance of an individual consultant is reviewed, this should also take into account that patients are treated by trainees or career grade surgeons under the consultant's supervision, given that the consultant leads the team and in that capacity has a strong influence on the care given to patients.

2. Aims and Objectives

The overall aim of the project was to assess the value of HES data for revalidation and to support the measurement of outcomes across disease pathways. It was envisaged that this would enable the measurement of the performance of hospitals as well as individual clinicians working within them.

Initially, we expected that the project would be carried out in two stages. In the first stage, we would consider the feasibility and validation of procedure-specific indicators and we would do the same in the second stage for disease-specific indicators. However, the work that was carried out to deal with these two types of indicators strongly overlapped and therefore we report the results of both stages together in this report.

The specific objectives were:

- To undertake a *rapid review* of initiatives that used *procedure-specific* and *disease-specific metrics* derived from administrative data to evaluate performance of individual hospitals and/or consultants.
- To carry out a number of *case studies* using administrative data to evaluate the feasibility and validity of the outcome indicators proposed by professional specialty bodies in the areas of
    - ischaemic heart disease
    - peripheral vascular disease
    - urological malignancies
- To compare the results of these case studies based on administrative data with those based on available *clinical databases* with satisfactory case ascertainment and data completeness.
- To develop *guidance* for the use of an administrative database for the process of recertification.

In addition to the pre-specified objectives, we also carried out a project that defines an explicit and transparent *coding framework* to support the use of HES data. The proposed coding framework is based on the expected internal consistency of diagnostic and procedure codes.

The *literature review* helped us to identify projects that already had developed procedure- and disease-specific indicators using administrative data and to evaluate how well these indicators match the outcomes indicators that had been suggested by the professional specialty bodies.

The *case studies* were carried out to assess the feasibility and suitability of the outcome indicators suggested by the professional specialty bodies in the three clinical areas. When evaluating their suitability, we used a set of explicit criteria including *validity* (ability to distinguish between poor and good quality of care), *statistical power* (adequate number of patients and events to detect truly outlying performance), *fairness* (ability to adjust for important differences in case mix), and *technical fitness for purpose* (ability of diagnosis and procedure codes to capture relevant clinical details).

We evaluated clinical databases available within the three clinical areas of interest and found that the databases from the Society for Cardiothoracic Surgery (SCTS) and the British Cardiovascular Intervention Society (BCIS) had levels of case ascertainment and data completeness deemed high enough to justify a comparison with HES.

The results of all these components of the project were used to discuss the potential for the use of HES data to support revalidation.

3. Rapid literature review of Hospital Episode Statistics database to describe health care processes and their outcomes

Introduction

The Hospital Episode Statistics is a database that includes records of all admissions and day cases in the English NHS. The HES database is increasingly being used as a data source for studies addressing a wide range of issues. For this project, we were only interested in studies that used HES to describe care *procedures* and their *outcomes* in the areas of ischaemic heart disease, urological malignancy, and peripheral vascular disease.

The specific objectives of this systematic review were to describe the scope of the individual studies where HES has been used as the sole or main source of data on process and outcome, what methods if any were used for risk adjustment, the outcomes measured, statistical methods used, the clinical acceptability, and the extent of implementation. We were also especially interested to find whether the results had been reported for individual clinicians rather than just hospitals or NHS trusts. Also, we wanted to compare the outcomes used in the studies found with those recommended by the professional specialty bodies.

Methods

We only considered studies that were published after 1 January 2002 as it was felt that the review should be representative of the most current experience with HES given trends in data quality and methodological approaches. Searches were carried out for publications with terms linked to procedures relevant to the three defined disease areas. For ischaemic heart disease, we searched for CABG procedures, angioplasty and stenting; for peripheral vascular disease, we searched for abdominal aortic aneurysm (AAA) repair, carotid endarterectomy, femoral bypass surgery, lower limb amputation and angioplasty and stenting; and for urology, we searched for procedures in radical nephrectomy, radical prostatectomy, and radical cystectomy.

We searched Medline, Embase and Web of Knowledge databases. We also searched the internet using Google Scholar. In a first step, we searched for peer-reviewed publications that have used HES or that stated they had used administrative or routine data in England based on text words ("HES", "hospital episode statistics", "administrative data" and "routine data"). In a second step, we selected only those that had included patients undergoing one of the relevant procedures within the three disease areas. In a third step, we included only those publications if they were used as a major source of data and if the study had a national perspective. Studies which reported only on incidence, prevalence, aetiology or used HES for background information were excluded.

The resulting papers were examined to determine what patient characteristics were included (disease and procedure, age, sex, socio-economic status, comorbidity, type of admission); what outcomes were used (e.g. mortality, length of stay); and what method of risk adjustment/statistical technique was applied.

Description of the identified studies

A total of 35 studies could be identified (Figure 1). Table 1 describes the seven publications that were identified related to ischaemic heart disease. [5-11] All studies included patients undergoing coronary artery bypass grafting and five also included those who had a percutaneous coronary intervention[5-8, 10]. Six studies looked at number of procedures according to patient characteristics in the context of questions related to equality of access[5-8, 10, 11]. Three studies considered mortality as an outcome[5, 9, 11].

Table 2 describes the 18 publications that were found related to peripheral vascular disease[9, 12-28]. Of these, 14 included patients undergoing abdominal aortic aneurysm repair[9, 12, 15-24, 27, 28], three included those undergoing carotid endarterectomy[19, 20, 25], and three included those who had femoral bypass (and other revascularisation procedures of the lower limb) and above or below knee amputation[13, 14, 26]. Three studies investigated comparing outcomes of endovascular and open procedures[15-17]. Five investigated the impact of hospital volume on outcomes[16, 23-25, 27]. One study demonstrated how well case mix derived from HES predicts in-hospital mortality[19]. Another compared the number of abdominal aortic aneurysm repair cases and deaths in HES with hospital case notes[12].

Table 3 describes the publications related to 11 publications on urological malignancies.[29-39] All studies looked at the hospital volume of procedures and seven investigated the impact of hospital volume on in-hospital mortality and length of stay[29-31, 33-36]. One study looked at complications and readmissions[33].

All but one study considered mortality as an outcome[9, 12-25, 27, 28]. Other outcomes were reinterventions[17], emergency readmissions[17] within 30 days or 1 year, complications[24, 25], length of hospital stay[16, 24, 25], repeat bypass[13] and composite of death or amputation[13]. Others addressed equality of access[22, 26], access to revascularisation of lower limb by age[26] and geographical variation in amputation rates[14].

The majority of the studies have used age and gender for risk adjustment. Some used other factors, including type of admission, waiting time, socio-economic status, comorbidity and previous admissions[5-7, 9, 10, 13-15, 18, 19, 22, 28, 29, 31, 33, 37, 38]. Most studies used simple descriptive statistical techniques. Of the papers found, four used funnel plots to present performance specific results according to volume[16, 22, 24, 25].

Discussion

All identified studies were carried out in England and used HES data. With respect to their *scope*, we found that most were procedure-specific and none reported consultant-specific results. The relationship between hospital volume and outcomes was the most frequent topic. In-hospital mortality and length of hospital stay were the most frequently reported *outcomes*. A relatively small number of studies used emergency readmissions or specific complications as outcomes.

Most studies used age and sex in some form of *risk adjustment.* A small number used other factors, including type of admission, socio-economic status, comorbidity and previous admissions. One study which included patients undergoing coronary artery bypass grafting used the number of arteries replaced as a measure of severity.

Most studies used simple descriptive *statistical techniques*. Funnel plots were used to present hospital-specific results according to volume. The concept of safety charts was mentioned in some studies on procedures in the area of peripheral vascular disease.[18, 19] Studies that presented results adjusted for differences in the patients' case mix used either a form of regression or presented results that were standardised using conventional epidemiological methods.

In conclusion, this review demonstrates that the HES has database has already been used to describe procedures and their outcomes in the three clinical areas. However, disease-specific indicators were rarely used, most studies used outcomes limited to short-term mortality and length of stay, and the adjustment for case mix differences often considered only the age and sex of the patients.

Figure 1- Flow chart of the literature search of studies using HES to describe health care processes and their outcomes

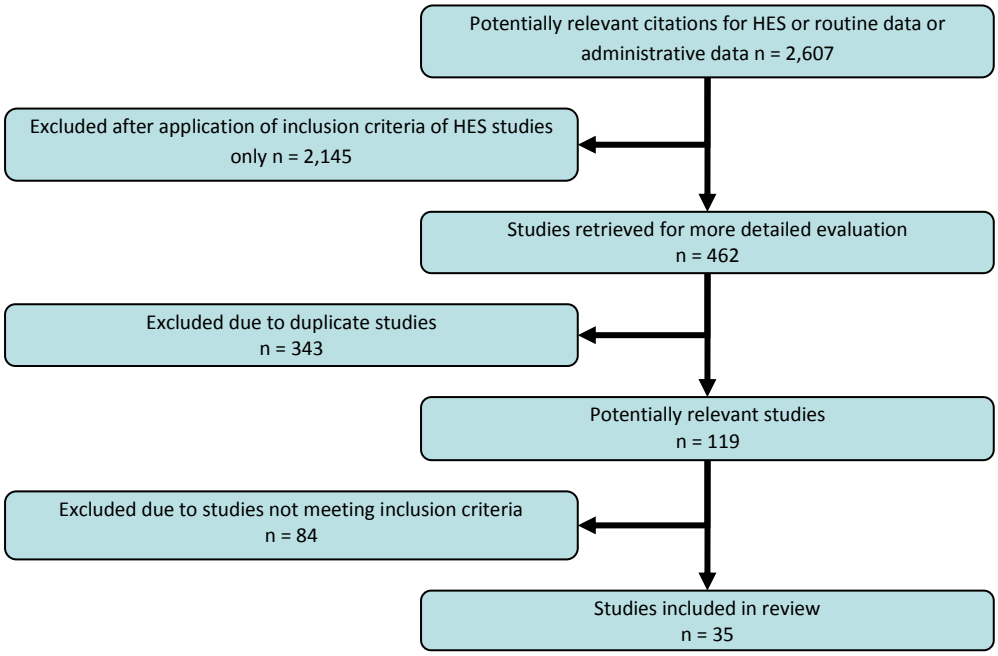


Table 1 – Results of literature search for ischaemic heart disease procedures: angioplasty and coronary artery bypass graft

Study	Inclusion period	Procedure	Number patients	Type admission	Process	Outcome	Case mix	Statistical methods	Conclusions
Bottle, Diabetologia, 2009[5]	1996-2006	Coronary artery bypass graft Percutaneous coronary intervention	87,586	All	Annual number of procedures	In-hospital mortality	Age Gender Socio economic (IMD)	Logistic and Poisson regression	Increase number of procedures in patients with type 2 diabetes
Bottle, J Gen Intern Med, 2008[6]	2004-2005	Coronary artery bypass graft Percutaneous coronary intervention		All	Procedure rates in PCTs according to QOF performance		Socio-economic	Directly and indirectly standardised rates	No association between quality of primary care for CHD (according to QOF) and numbers of procedures
Mindell, J Public Health, 2008[7]	2002-2004	Coronary artery bypass graft Percutaneous coronary intervention	19,282	All	Procedure rates		Age Gender Ethnicity	"Proportional ratios"	Access to revascularisation procedure depends on ethnic background
Mindell, Heart, 2008[8]	2001 - 2003	Coronary artery bypass graft Percutaneous coronary intervention	28,405 (of which 3,400 in private hospitals)	All	Procedure rates in PCTs according to NHS or private funding		Age Gender	Direct standardisation GINI coefficients	Private provision exacerbates inequalities

Study	Inclusion period	Procedure	Number patients	Type admission	Process	Outcome	Case mix	Statistical methods	Conclusions
Aylin, BMJ, 2007[9]	1996-2004	Coronary artery bypass graft (without preceding PCI)	152,523	All		In-hospital mortality.	Age Gender Type of admission Socio economic (IMD) Comorbidity (Charlson) Previous admissions for IHD, myocardial infraction, heart surgery Number of arteries replaced	Logistic regression	Routinely collected data can be used to predict risk with similar discrimination to clinical databases
Shaw, Soc Sci Med, 2004[10]	1991-1999	Coronary artery bypass graft Percutaneous coronary intervention	295,130	All	Number of procedures	Undergoing CABG and PCTA	Age Gender Myocardial infarction	Standardised rates	Women and elderly people are receiving less revascularisation than their need would indicate
Martin, J Epidemiol Community Health, 2002[11]	1998-1999	Coronary artery bypass graft	15,000	Elective	Length of stay on waiting list (overall estimate)	*Estimated mortality* on waiting list and within 6 months after surgery *Estimated morbidity* within 6 months after surgery		Estimated mortality and morbidity based on published incidence figures	Number of patients who die on waiting list similar to that of those who die within 6 months after surgery Number of patients who have myocardial infarction on waiting list is half that of corresponding number within 6 months after surgery

Table 2 – Results of literature search for peripheral vascular disease: abdominal aortic aneurysm repair, carotid endarterectomy and lower limb revascularisation

Study	Inclusion period	Procedure	Number patients	Type admission	Process	Outcome	Case mix	Statistical methods	Conclusions
Holt, Br J Surg, 2011[12]	2005-2007	Open abd aortic aneurysm repair	1,102	Elective	Hospital volume of procedures	All-mortality	Age Gender Charlson Score	Funnel plot	HES can be used to identify mortality between trusts
Moxey, Br J Surg, 2011[13]	2002-2007	Major amputations, lower-limb surgical bypass	25,133	All	Annual volume of procedures	In-hospital mortality, 1 year mortality, major amputation, repeat bypass, composite adverse event	Comorbidity	Descriptive statistics Multivariable logistic regression	Major amputation rates remain high after femorodistal bypass. Diabetes and chronic renal failure were main predictors of poor outcomes.
Moxey, Br J Surg, 2010[14]	2003-2008	Major amputations (below and above knee) Minor amputations	48,142	All	Annual volume of procedures	In-hospital mortality	Age Sex Diabetes	Linear regression Logistic regression Annual rates for amputation & revascularisation Below knee to above knee ratio	Minor and major amputations are stable across England. Evidence of geographical variation for amputation rates, mortality and above/below knee ratios.
Holt, Br J Surg, 2010[15]	2003-2008	Endovascular abd aortic aneurysm repair Open abd aortic aneurysm repair	143,237	All	Endovascular open procedures Hospital volume of procedures	In-hospital mortality	Charlson Score	Logistic regression Scatter plot.	Survival advantage for endovascular patients over open repair for non-elective admissions
Holt, Circ Cardiovasc Qual Outcomes, 2009[16]	2005-2007	Endovascular abd aortic aneurysm repair Open abd aortic aneurysm repair	7,313	Elective	Endovascular and open procedures Hospital volume of procedures	In-hospital mortality Length of stay.		Logistic regression, control charts, and "safety plots" (funnel plot) Funnel plot	High-volume units had lower mortality and median length of stay both for endovascular and open procedures
Holt, Eur J Vasc Surg, 2009[17]	2003-2008	Endovascular abd aortic aneurysm repair Open abd aortic	18,060	Elective	Endovascular and open procedures	In-hospital mortality Discharge destination		Significance tests and odds ratios	Method of repair has impact on some of the outcomes

Study	Inclusion period	Procedure	Number patients	Type admission	Process	Outcome	Case mix	Statistical methods	Conclusions
		aneurysm repair				Re-intervention emergency readmission with 30 days or 1 year			
Holt, Br J Surg, 2008[18]	2000-2005	Open infrarenal abd aortic aneurysm repair	26,822	Elective		In-hospital mortality	Age Gender Type of admission	"Safety chart"	In-hospital mortality varies across hospitals in England
Holt, Br J Surg, 2008[19]	2000-2005	Abd aortic aneurysm repair Carotid endarterectomy		All	Annual hospital volume of procedures	In-hospital mortality	Age Gender Type of admission	"Risk adjusted safety plot". Significance tests and odds ratios.	A strategic model may improve outcomes after AAA and carotid
Aylin, BMJ, 2007[9]	1996-2004	Abd aortic aneurysm repair	44,486	All		In-hospital mortality	Age Gender Type of admission Socio economic (IMD) Comorbidity (Charlson) Previous admissions for IHD, myocardial infraction, heart surgery Number of arteries replaced	Logistic regression	Routinely collected data can be used to predict risk with similar discrimination to clinical databases

Study	Inclusion period	Procedure	Number patients	Type admission	Process	Outcome	Case mix	Statistical methods	Conclusions
Aylin, Euro J Vasc Endovasc Surg, 2007[20]	2001-2004	Carotid endarterectomy Infrainguinal bypass Abd aortic aneurysm repair	32,242	All		In hospital mortality		Significance test of difference between proportions	There are four times more procedures in HES than in National Vascular Database with mortality being lower in NVD
Filipovic, J Epidemiol Community Health, 2007[21]	1998-2002	Abd aortic aneurysm repair	11,338	Elective		30-day mortality In-hospital mortality		Funnel plot	In-hospital mortality in England is higher than compared with results elsewhere derived from literature.
Filipovic, Br J Surg, 2007[22]	1998-2002	Admissions for ruptured aortic aneurysm repair	10,078	Emergency		30-day mortality	Age Gender Comorbidity	Logistic regression	Women are less likely to be surgically treated for ruptured AAA and have a higher overall mortality rate.
Holt, Br J Surg, 2007[23]	2000	Abd aortic aneurysm repair	352,888	All	Annual hospital volume of procedures	In-hospital mortality	Age,	HES combined with results for systematic review Meta-analysis of odds ratios comparing mortality in low / high volume hospitals	Higher annual volume of procedures is associated with lower mortality for both elective and ruptured abd aortic aneurysm repair
Holt, Br J Surg, 2007[24]	2001-2005	Infrarenal abd aortic aneurysm repair	26,822	All (elective, rupture, urgent)	Annual hospital volume of procedures	In-hospital mortality Length of stay Complications (Respiratory, sepsis, local infection, shock, local complication, VTE, cardiac, DIC,	Age Gender	Significance test comparing quintiles of volume Logistic regression Funnel plot	Increased annual volumes are associated with reduced mortality for elective and urgent but not for ruptured abd aortic aneurysm repair

Study	Inclusion period	Procedure	Number patients	Type admission	Process	Outcome	Case mix	Statistical methods	Conclusions
						ischaemic stroke, transfusion)			
Holt, Eur J vasc Endovasc Surg, 2007[25]	2000-2005	Carotid endarterectomy.	18,248	All (elective and emergency)	Annual hospital volume of procedures.	In-hospital mortality Length of stay Complications ((Respiratory, sepsis, local infection, shock, local complication, VTE, cardiac, DIC, ischaemic stroke, transfusion)	Age Gender	Descriptive statistics of proportions and logistic regression Safety chart Funnel plot	Strong relationship between hospital volume and outcome. Age adjusted. Gender adjusted. Relative risk of mortality.
McCaslin, Br J Surg, 2007[26]	1989-2004	Lower-limb revascularisation (infrainguinal endarterectomy, embolectomy, patch angioplasty and bypass graft) Major amputation (below and above knee)			Lower limb surgical revascularization aged 45-64,65-74,75+	Age (< 75 and ≥ 75) Diabetes Annual rates for amputation, finished consultant episodes in PVD and peripheral embolic disease.		Annual rates for amputation and revascularization. Below knee to above knee ratio.	Peak in vascularisation procedures in mid nineties followed by steady decline. Amputation rates showed marked decline in those ≥ 75
Jibawe, Eur J Vasc Endovasc Surg, 2006[27]	1997-2002	Abd aortic aneurysm repair	32,078	All		In hospital mortality		Scatter plot Comparisons of mortality in low and high volume hospitals with varying volume threshold	Increasing elective workload decreases in-hospital mortality for elective and emergency admissions.

Study	Inclusion period	Procedure	Number patients	Type admission	Process	Outcome	Case mix	Statistical methods	Conclusions
Michaels, Br J Surg, 2003[28]	1996-2001	Abd aortic aneurysm repair	38,319	All (complex, elective, emergency, unoperated)		In-hospital mortality	Super renal or visceral renal	Descriptive statistics comparing proportions	Mortality rate may be misleading due to differences in case mixing and selection.

Table 3 – Results of literature search for urological cancer procedures: cystectomy, nephrectomy and prostatectomy.

Study	Inclusion period	Procedure	Number patients	Type admission	Process	Outcome	Case mix	Statistical methods	Conclusions
Hanchanale, Urol J, 2010[29]	1998-2005	Prostatectomy	14,300	All	Hospital volume and surgeon volume of procedures Waiting time	In-hospital mortality Length of stay	Age Admission method Waiting time Surgeon volume Annual hospital volume	Significance tests assessing case mix variables, volume groups and outcomes Logistic regression	Evidence of exponential increase in number of RPs with increase in laparoscopic procedures. Inverse volume outcome relationship.
Hanchanale, Urol Int, 2010[30]	1998-2005	Cystectomy Nephrectomy Prostatectomy	43,946	All	Hospital volume of procedures Waiting time	In-hospital mortality Length of stay	Age Gender	Significance tests across volume groups	Some evidence of effect of hospital volume on mortality and length of stay.
Mayer, BMJ, 2010[31]	2000-2007	Cystectomy	8,596	Elective	Hospital volume and surgeon volume of procedures	30 day in hospital mortality & 30 day total mortality	Age Gender Comorbidity (Charlson) Carstairs Index	Logistic regression, significance tests assessing case mix variables and volume groups.	Some evidence of effect of hospital and surgeon case volume on mortality after adjustment for process of care.
Mayer, BJU Int, 2009[32]	2000-2007	Cystectomy Prostatectomy	27,007	All	Hospital volume of procedures Catchment population			Linear and logistic regression for trends over time without adjustment for case mix	Evidence of centralisation

Study	Inclusion period	Procedure	Number patients	Type admission	Process	Outcome	Case mix	Statistical methods	Conclusions
Judge, BJU Int, 2007[33]	1997-2005	Prostatectomy	18,027	Elective	Hospital volume of procedures	30-day in-hospital mortality Length of stay 30-day in-hospital complications (cardiac, respiratory, vascular, wound / bleeding, genitourinary, miscellaneous medical, miscellaneous surgical) 30-day in-hospital *specific* complications (VTE, wound infection, bladder neck stricture) Readmissions within year	Age Socio economic (IMD) Comorbidity (Charlson)	Linear, logistic and Cox regression	Evidence of effect of hospital volume on outcomes
Hanchanale, Eur Urol Suppl, 2007[34]	Not available	Cystectomy Prostatectomy	23,274	All	Hospital volume of procedures	In-hospital mortality Length of stay		Significance tests across volume groups	Evidence of effect of hospital volume on length of stay and mortality
Hanchanale, Eur Urol Suppl, 2006[35]	1997-2004	Prostatectomy	11,303	All	Surgeon volume of procedures	in-hospital mortality Length of stay		Significance test across volume groups	Evidence of effect of surgeon volume on length of stay
McCabe, BJU Int, 2005[36]	1998-2003	Cystectomy	6,317	All	Hospital volume of procedures	In-hospital mortality	Age Gender	Significance test comparing low and high volume hospitals based on different volume thresholds	Evidence of effect of hospital volume on mortality

Study	Inclusion period	Procedure	Number patients	Type admission	Process	Outcome	Case mix	Statistical methods	Conclusions
Nuttall, BJU Int, 2005[37]	1995-2002	Cystectomy	8,228	All	Hospital volume of procedures Emergency admissions Waiting time	In-hospital mortality Length of stay	Age Gender Type of admission	Linear and logistic regression for trends over time *without* adjustment for case mix	No evidence of centralisation Decrease in mortality and length of stay over time
Nuttall, BJU Int, 2005[38]	1995-2002	Nephrectomy	17,308	All	Hospital volume of procedures Emergency admissions Waiting time	In-hospital mortality Length of stay	Age Gender Type of admission	Linear and logistic regression for trends over time *without* adjustment for case mix	Weak evidence of centralisation Decrease in length of stay and emergency admission rate
Oliver, BJU Int, 2002[39]	1991-2000	Prostatectomy	2,615	All	Annual number of procedures in England Hospital volume of procedures Age-standardised regional procedure rate		Age	Descriptive statistics of trends of time *without* adjustment for case mix	20-fold increase in annual number of procedures "Diffusion" of procedure across country "not uniform" and "influenced by socio-economic status".

4. Case studies of outcome indicators defined by specialist societies

Introduction

Before the start of this project in 2010, the Society for Cardiothoracic Surgery in Great Britain and Ireland (SCTS), the Association of Surgeons of Great Britain and Ireland (ASGBI), and the British Association of Urological Surgeons (BAUS) had proposed possible outcome indicators relevant for ischaemic heart disease, urological malignancy and peripheral vascular disease. The indicators were chosen as they were considered to capture outcomes that are important and meaningful for the clinical area as well as available based on HES data. All the proposed indicators were *procedure-specific* and include mortality, unplanned readmission and return-to-theatre (RTT) within 30 days of the procedure, and length of hospital stay (LOS).

We carried out a number of case studies to evaluate these proposed indicators. We used a set of explicit criteria including *validity* (ability to distinguish between poor and good quality of care), *statistical power* (adequate number of patients and events to detect truly outlying performance), *fairness* (ability to adjust for important differences in case mix), and the t*echnical coding specification* (ability of diagnosis and procedure codes to capture relevant clinical details of diagnosis or procedure as well as the outcome).

For the case studies, we used funnel plots to present the results of comparisons at trust or consultant level with the proposed outcome indicators. In this chapter, we describe some of the case studies as an illustration of the proposed criteria. We also developed a framework for the evaluation of outcome indicators. This framework highlights important issues that need to be considered when outcome indicators are defined and proposed for revalidation.

Methods

Data were extracted from HES for admissions between 1st April 2003 and 31st March 2008 except for endovascular aneurysm repairs (EVAR). For EVAR procedures, records of admissions between 1st April 2006 and 28st February 2009 were used to avoid as much as possible changes in the definition of the OPCS codes for endovascular procedures influencing the results. Most funnel plots therefore included data for a period of five years. The denominator was always the total number of admissions for the specific procedure in that period. The definition of the numerator varies according to the outcome.

For 30-day *mortality*, we looked at whether there was a date of death within 30 days of the procedure date given in HES obtained through data linkage with the Office for National Statistics (ONS).[40] *Unplanned readmissions* were defined as emergency admissions (codes 21, 22, 23, 24 or 28 in the admimeth field in HES) within 30 days of the initial procedure. *Return to theatre* (RTT) was defined as another procedure in patients who had been readmitted within 30 days of the initial procedure. For *length of stay* (LOS), we took the difference between the admission date and the discharge date (*total LOS*) as well as from the date of procedure to the discharge date (*post-operative LOS*).

Statistical methods

We used multivariable logistic regression to calculate results adjusted for case mix for proportions and multivariable linear regression to do the same for means. Details of the risk adjustment procedure are available on request. Comorbidity was captured with the Royal College of Surgeons (RCS) Charlson Comorbidity Score [41] which identifies 14 comorbid conditions. Other case mix factors included in the statistical models were age, gender, and socio-economic deprivation captured with the Index of Multiple Deprivation.[42]

The funnel plots were constructed in the following way. The national average was used to set a target. The control limits defined ranges of values for the outcome indicators that are within two standard deviations (inner control limits) or three standard deviations (outer control limits) from this target. This corresponds to statistically testing whether a unit's outcome indicator is different from the target at a 2-sided significance level of 0.05 (if a unit's indicator is outside the inner limits) or 0.002 (if indicator is outside the outer limit). In practice, this would imply that 95% of all providers are expected to be within the inner and 99.8% within the outer limits, if all providers are performing according to the target. For proportions (e.g. deaths), exact Binomial control limits were used. For continuous variables (e.g. length of stay) control limits were derived from the Normal distribution and the standard deviation that captures the distribution of observed values.

Examples of the case studies

Validity

The *validity* of an outcome indicator corresponds to the extent to which the indicator is clinically well-founded, reflects variations in the quality of care, and is able to distinguish good from poor practice. This implies that for an indicator to be valid it should be clinically plausible that differences in care quality are linked with differences in the metric derived from the indicator. Also, there should be clarity about which end of the metric's spectrum indicates better quality.

Figure 2 shows a funnel plot of the adjusted 30-day unplanned readmission rate after radical prostatectomy for individual NHS trusts. The funnel plot demonstrates that about 11 NHS trusts have high readmission rates. The obvious explanation for this pattern of results is that in a large number of hospitals patients are briefly admitted after their prostatectomy to have their urethral catheter removed. It is obvious that the readmission rate cannot be used as an outcome indicator because the readmission rate depends on local policies and there is no unambiguous link with good or poor quality.

In contrast, Figure 3 shows a funnel plot of adjusted 30-day mortality after emergency repair of an abdominal aortic aneurysm (AAA) for individual consultants. There is an obvious need to avoid early death after surgery and poorer care can lead to higher mortality, which provides support for the validity of this indicator.

Statistical power

The *statistical power* refers to the chance that units that are true outliers will be detected. Most outcome indicators suggested by the specialty organisations are events and the outcome indicators are expressed as the proportion of patients who experience that event. This implies that the power to detect outlying performance based on these indicators depends on the number of patients and the number of events experienced by these patients. For outcomes that are continuous variables, (e.g. length of stay, patient-reported measures of function or disability or health-related quality of life), the statistical power depends on the number of patients as well as the standard deviation of observed values.

Figure 4 shows a funnel plot of the adjusted 30-day mortality rate after elective coronary artery bypass graft surgery (CABG) by consultant. The national average of mortality was 1.9% and the average number of procedures carried out by a consultant over a 5-year period is about 350. Even with this relatively high number of procedures, the power to detect outliers was relatively low. For example, there is only about a 36% chance that a consultant who has carried out 350 procedures with a mortality that is twice the national average will have a result that lies above the outer funnel limit.

However, the situation was different if adjusted 30-day mortality after emergency repair of an AAA is considered. The average mortality at national level was much higher (34%) than after elective CABG surgery but the average number of procedures carried out by an individual consultant in the same 5-year period was much lower (17). A power calculation for this procedure demonstrates that the chance to find a result above the upper outer funnel for a consultant who has carried out 17 procedures with a mortality that is twice the national average is 45%.

Fairness

Comparisons of outcome indicators between units should be *fair*. Units may seem to have a worse performance simply because they treat higher risk patients. Statistical risk adjustment models allow estimates for individual units to be *adjusted* for differences in case mix. The adjusted results reflect results as if each unit treats patients of average risk. The extent to which comparisons can be considered fair depends therefore on the *extent and nature of the case mix differences between units* as well as on how well these *differences are captured by available data* and the *statistical performance of the risk adjustment model*.

Figure 5 presents the adjusted 30-day mortality after above the knee amputations by NHS trusts. The national average of mortality was 19% and there are no trusts with results above the upper outer funnel limit. Nevertheless, the fairness of these comparisons can be criticised as it is not unlikely that there were difference in case mix of patients treated in different trusts and at the same time these differences in risk were not well captured by the available diagnostic and procedure codes available in the HES records. An important limitation of the clinical information available in HES is that it indicates the *presence* of critical conditions in these patients (for example, diabetes, renal insufficiency, or heart failure) but not their *severity*.

However, as we will show later in chapter 7, the differences in baseline risk in patients undergoing CABG surgery are well captured by HES data. The performance of the risk adjustment model based on HES data is comparable to the widely accepted risk adjustment models based on clinical data (i.e. data derived from the patients' medical records for the purpose of research or clinical audit).

Adequacy of the coding specification

The ability to capture the relevant diagnostic and procedure codes is relevant as it determines the ability to *define the patient population* to be included, to *capture the relevant case differences* as well as the *care processes* and *outcomes* that define the indicators.

A first issue that is relevant in this context is the gradual emergence of new procedures which makes it difficult to capture the relevant patient population. The updates of procedures codes in HES will always lag a few years behind the introduction of new procedures. An example was the increasing use of EVAR. In the years immediate after the introduction of EVAR as routine treatment for patients with AAA, the same procedure codes were used for EVAR as for open repair in combination with a mix of additional codes to identify the endovascular approach. In Figure 6 we present the 30-day adjusted mortality after elective EVAR by consultant. As explained earlier, we tried to avoid including patients who had an open repair by only including patients operated after 1st April 2006. All results were within the outer funnel limits.

Capturing RTT is a further example where coding inadequacies may have an impact on the outcome indicators. RTT is captured by searching for specific procedure codes. However, if certain codes are found with a similar date as that of the initial procedure it is not possible to distinguish between procedures carried out during the initial theatre session or after a return to theatre for a second session. In the approach that we propose, only procedures carried out in theatre on subsequent days – and therefore excluding those that were carried out on the same

day as the initial procedure – were identified as evidence of a RTT. As a consequence, this approach does not detect early RTT and in that way underestimates the RTT rate. Figure 7 presents the adjusted 30-day RTT rate after radical cystectomy by trust. The national average RRT rate is 2.4% and all except two trusts are within the outer funnel limits.

Evaluation of proposed indicators

The case studies demonstrate that the suitability of the indicators depends on a number of explicit criteria. In this section we present a checklist that can be used to evaluate the indicators before their actual introduction. This checklist provides the professional specialty bodies with four explicit criteria that the indicators should meet (Table 4). For each criterion, there are a number of questions that need to be answered.

As a further illustration, we have evaluated the indicators proposed by the specialty bodies using the checklist presented in Table 4. We used a star rating with zero stars indicating that the criterion is not met, one star indicating that it is partially met and two stars indicating that it is fully met. A question mark indicates that the results cannot be determined without additional information. The results are presented in Tables 5, 6 and 7.

The evaluation of *validity* is straightforward for mortality but less so for length of stay, unplanned readmissions and RTT. For the latter three, differences may also reflect local circumstances and established clinical decision making. It is for that reason that the validity criterion is thought to be only partly met.

The *statistical power* criterion strongly depends on the number of patients with the disease of procedure of interest. It is therefore difficult to evaluate this criterion without having defined the time period over which patients are included as well as the level of the comparison. In our examples so far we used a period of five years, but it is obvious that shorter time periods may be more relevant which has an impact on the number of patients. More importantly, if indicators are considered for individual consultants then this will have a substantial impact on the statistical power.

In chapter 7, we demonstrate that the performance of a risk adjustment model for CABG surgery based on HES data is very similar to that based on clinical data. It is for that reason that we feel that the *fairness* criteria is fully met for this procedure. The performance of risk adjustment models based on HES for the two other clinical areas is less well established. However, the HES database includes age and gender as well as comorbidity based on the well-establish RCS Charlson Comorbidty score.[41] However, information contained in HES on the nature and severity of the primary condition is limited both for patients with vascular disease or with urological malignancies. For that reason, it seems most appropriate to consider the fairness criterion for indicators in these clinical areas only to be partially met.

The adequacy of the technical coding available in HES is not fully met for a number of indicators in the three clinical areas. As explained earlier, the definition of the patient population is not straightforward for EVAR procedures. Also, the detection of RTT is problematic if it takes place on the same day. In general however, the most important limitation of using HES data is that HES records contain limited information about the nature and severity of the condition. Also, it would be useful if there was more information about the patients' physical condition such as the ASA score defined by the American Society of Anesthesiologists.

Figure 2

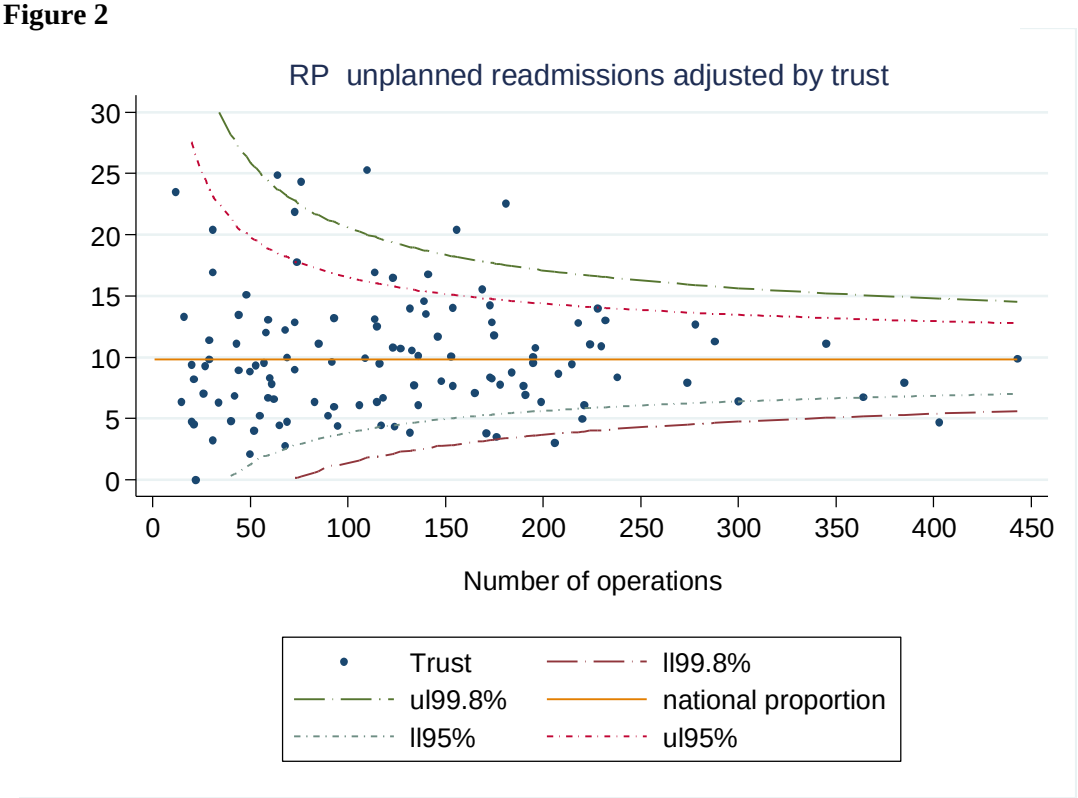


Figure 3

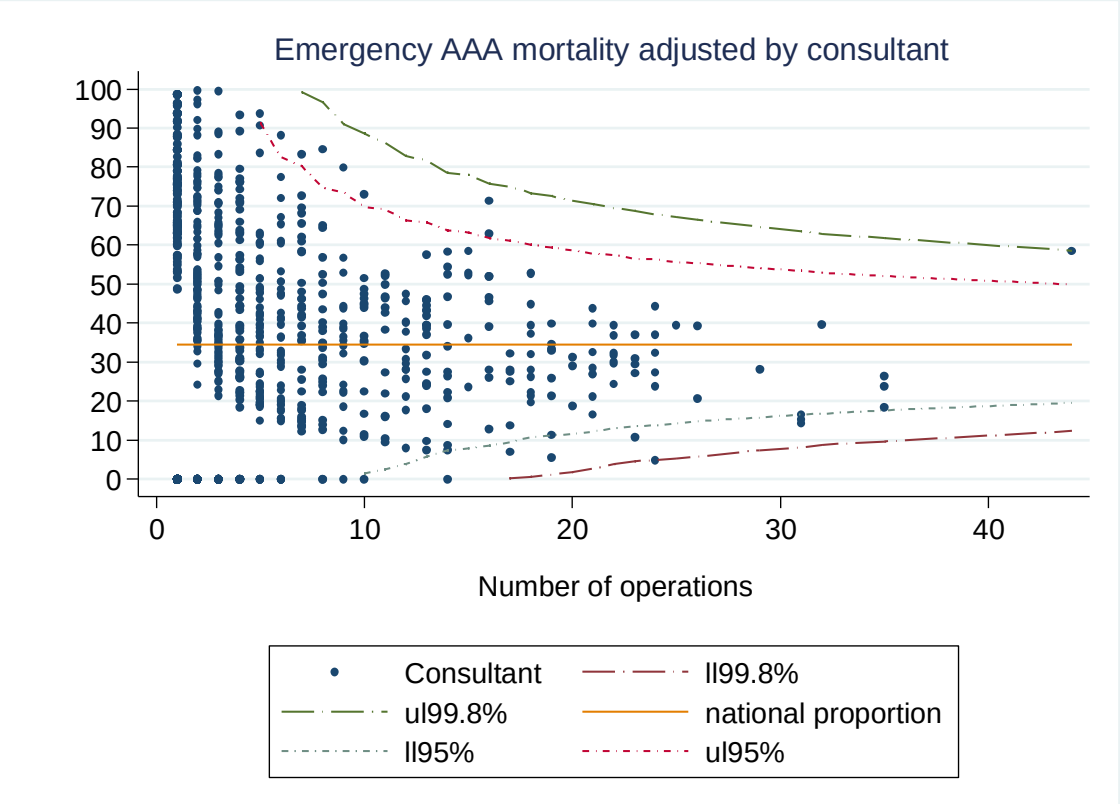


Figure 4

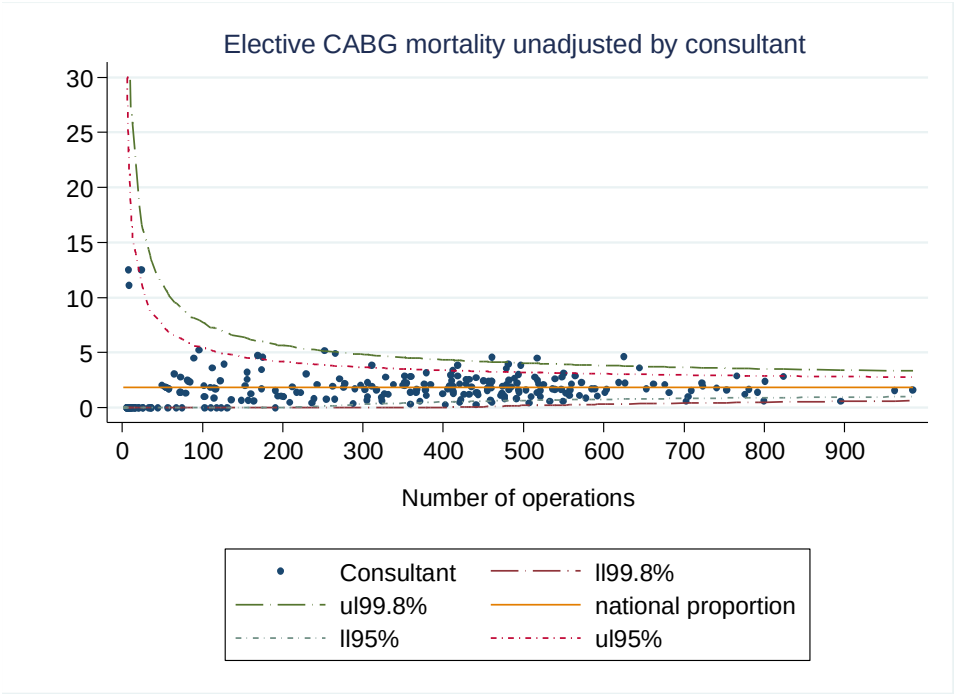


Figure 5

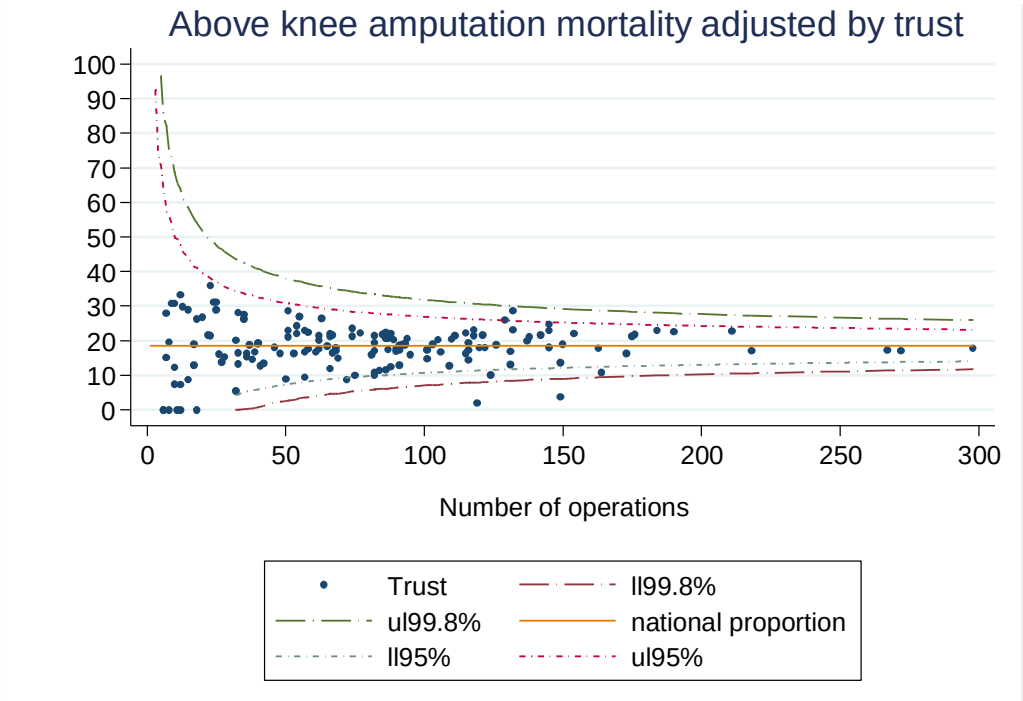


Figure 6

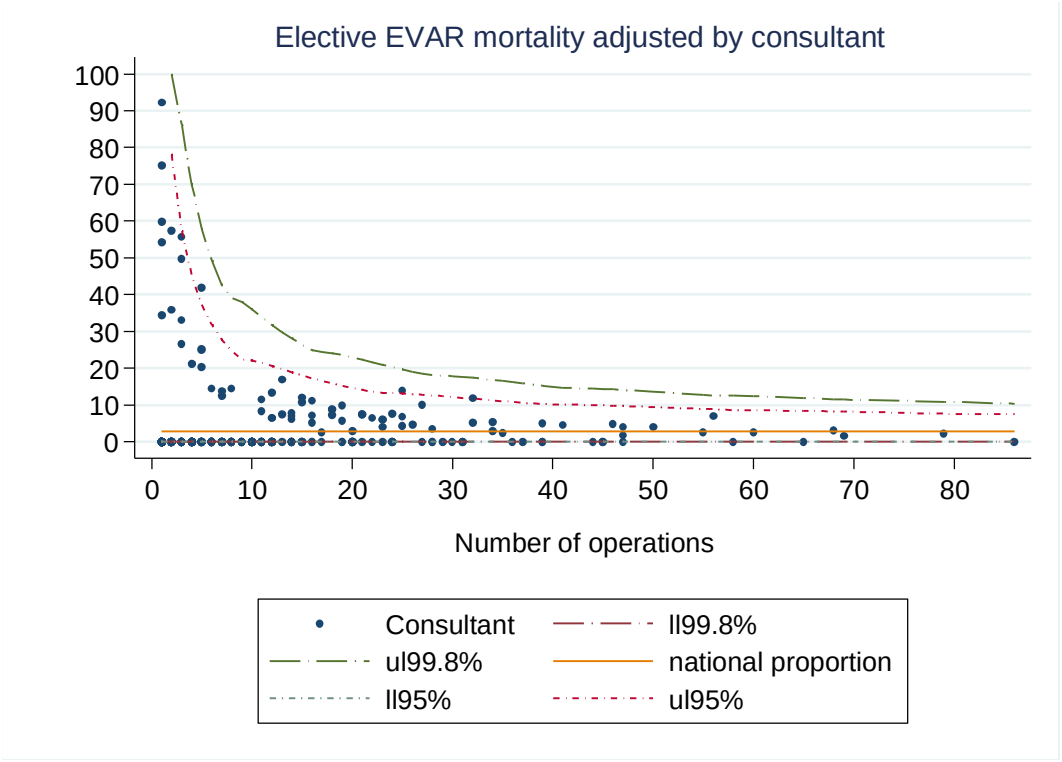


Figure 7

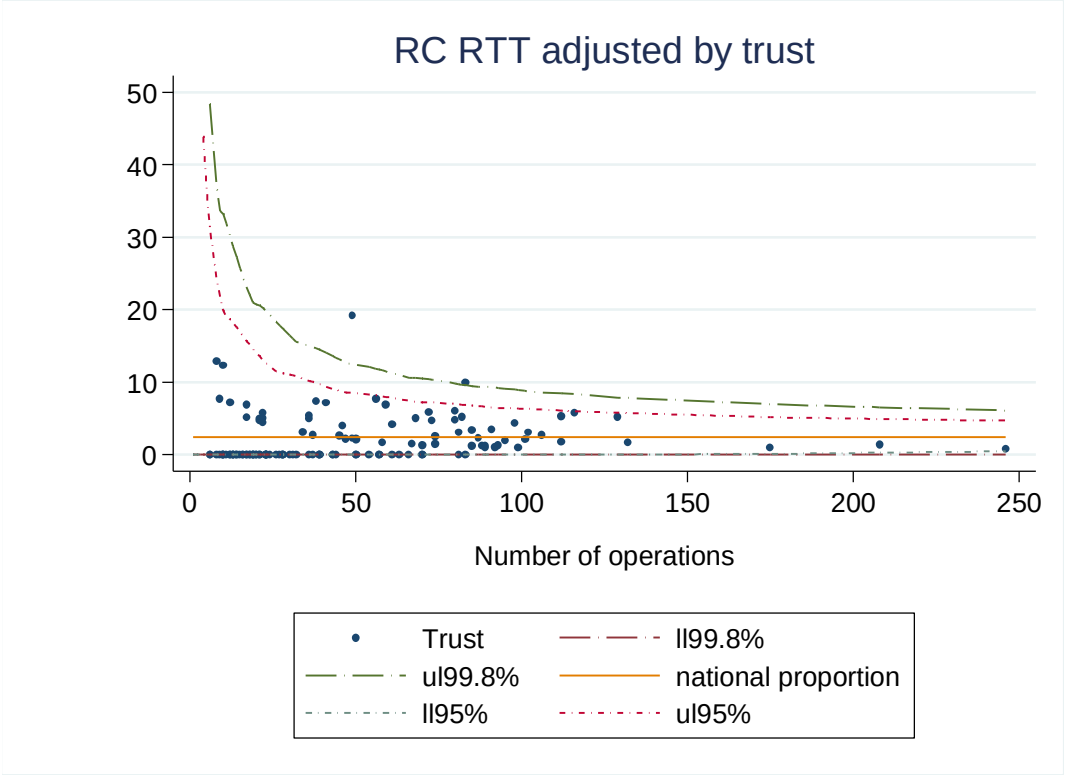


Table 4 – Checklist for the evaluation of outcome indicators.

Is this indicator *valid*?	
	Is it likely that differences in the indicator reflect the quality of care?
	Is it clear which end of the spectrum of the indicator reflects better quality?
What is the *statistical power*?	
	What is the average number of patients within each unit with the disease or procedure of interest?
	What is the average number of relevant events within each unit?
	What is the chance that a true outlier will be detected (in a unit of average size)?
Is the indicator *fair*?	
	How big are the case mix differences of patients treated by different units?
	How well are important case mix differences captured by the available data?
	How well does the risk adjustment approach reduce the impact of case mix differences?
Is the *technical coding* of the indicator and other relevant clinical information *adequate*?	
	How well can the patient population of interest be defined with the available diagnostic and procedure codes?
	How well can the important cased mix difference be captured by the available codes?
	How well can the procedures or outcomes that define the indicator be captured?

Table 5 - Indicators for ischaemic and valvular heart disease proposed by the Society for Cardiothoracic Surgery in Great Britain and Ireland based on Hospital Episode Statistics data

		Validity	Power		Fairness		Technical coding adequate
CABG	30-day mortality	**	Elective Emergency	· ·	Elective Emergency	** **	**
	Length of stay	*	Elective Emergency	? ?	Elective Emergency	** **	**
	30-day unplanned readmissions	*	Elective Emergency	· ·	Elective Emergency	** **	**
	30-day return to theatre	*	Elective Emergency	· ·	Elective Emergency	** **	*
Aortic valve replacement	30-day mortality	**	Elective Emergency	· ·	Elective Emergency	** **	**
	Length of stay	*	Elective Emergency	? ?	Elective Emergency	** **	**
	30-day unplanned readmissions	*	Elective Emergency	· ·	Elective Emergency	** **	**
	30-day return to theatre	*	Elective Emergency	· ·	Elective Emergency	** **	*
Mitral valve replacement	30-day mortality	**	Elective Emergency	· ·	Elective Emergency	** **	**
	Length of stay	*	Elective Emergency	? ?	Elective Emergency	** **	**
	30-day unplanned readmissions	*	Elective Emergency	· ·	Elective Emergency	** **	**
	30-day return to theatre	*	Elective Emergency	· ·	Elective Emergency	** **	*

Table 6 - Indicators for peripheral vascular disease proposed by the Association for Surgeons of Great Britain and Ireland based on Hospital Episode Statistics data

		Validity	Power		Fairness		Technical coding adequate
Open repair abdominal aortic aneurysms	30-day mortality	**	Elective Emergency	? ?	Elective Emergency	* *	**
	Length of stay	*	Elective Emergency	? ?	Elective Emergency	* *	**
	30-day unplanned readmissions	*	Elective Emergency	? ?	Elective Emergency	* *	**
Endovascular aortic aneurysm repair	30-day mortality	**	Elective Emergency	? ?	Elective Emergency	* *	*
	Length of stay	*	Elective Emergency	? ?	Elective Emergency	* *	*
	30–day unplanned readmissions	*	Elective Emergency	? ?	Elective Emergency	* *	*
Amputations above the knee	30-day mortality	**		?		*	**
	Length of stay	*		?		*	**
	30-day return to theatre	**		?		*	*
Carotid endarterectomy	30-day mortality	**	Elective Emergency	· ?	Elective Emergency	* *	**
	Length of stay	*	Elective Emergency	? ?	Elective Emergency	* *	**
	30-day readmissions	*	Elective Emergency	? ?	Elective Emergency	* *	**

Table 7 – Indicators for peripheral vascular disease proposed by the British Association of Urological Surgeons based on Hospital Episode Statistics data

		Validity	Power	Fairness	Technical coding adequacy
Radical Prostatectomy	30-day mortality	**	·	*	**
	Length of stay	*	?	*	**
	30-day unplanned readmissions	·	?	*	**
	30-day return to theatre	*	?	*	*
Radical cystectomy	30-day mortality	**	?	*	**
	Length of stay	**	?	*	**
	30-day unplanned readmissions	*	?	*	**
	30-day return to theatre	**	?	*	*
Radical nephrectomy	30-day mortality	**	·	*	**
	Length of stay	**	?	*	**
	30-day unplanned readmissions	*	?	*	**
	30-day return to theatre	*	?	*	*

5. Overview of clinical databases

Introduction

One of the aims of the Revalidation and HES Project was to compare results based on HES data with those based on existing clinical databases. In preparation of that work, we contacted the Project Board members to seek detailed information about the clinical databases that are available in their clinical area. Databases were eligible for inclusion if they hold data at national level about individual patients with a relatively common diagnosis or intervention within the three clinical areas of interest.

In this section, we summarise the characteristics of the following databases:

- ischaemic heart disease:
    - Society for Cardiothoracic Surgery (SCTS) database
    - British Cardiovascular Intervention Society (BCIS) percutaneous coronary intervention database
- urological malignancy:
    - British Association of Urological Society (BAUS) Cancer Registry
- peripheral vascular disease:
    - National Vascular Database (NVD)
    - British Society of Intervention Radiology (BSIR) databases
        - Registry for Endovascular Treatment of Aneurysms (RETA)
        - British Iliac and Angioplasty Stenting register (BIAS)

Methods

To assess these databases, a questionnaire was created to describe key characteristics of the database, data quality, and data items. The questionnaire was sent out to Project Board members as well as to others who have a direct responsibility for these databases. Answers were obtained by contacting the recipients of the questionnaires via telephone or email and by consulting recent reports about the databases, data dictionaries, and relevant websites.

Results

Data collection was mandatory for the full SCTS database, part of the BCIS database and voluntary for the others (Table 8). The RETA database has stopped collecting data in 2009 and was merged with the NVD. All but one of the databases collected the data electronically, either via a web-based data entry system or via uploads of data files. The BAUS database has a web based entry system and stopped accepting paper forms in early 2010. The RETA database was solely paper-based.

All databases collected information on diagnosis, treatment, and disease severity (Table 9). All but the RETA database collect information on comorbidity. All databases collect in-hospital outcomes. There is considerable variety in the long term outcomes that are being collected. The SCTS and BCIS databases obtain long term mortality data from the Office for National Statistics (ONS). Long term outcomes other than mortality are collected by SCTS, BAUS and the NVD at follow up appointments. The RETA database mailed out a questionnaire at one year.

All databases contain fields to measure outcomes such as length of stay and mortality. The SCTS tracks outcomes at 30 days and 1 year; mortality is derived from ONS. BCIS also uses ONS mortality. Two other databases (NVD and BAUS) record long term outcomes at follow up appointments. How robust the follow up data is compared to the initial admission data is unclear.

The SCTS and BCIS stand out in terms of high case ascertainment and data completeness (Table 10). BAUS reported a case ascertainment between 60% and 70%, but there is no information on data completeness. Case ascertainment and data completeness for the other databases is less certain.

Discussion

Based on the information that was available in 2010, the SCTS and the BCIS databases were the best candidates to be compared against HES for the purpose of revalidation. The quality of these databases, especially their high case ascertainment, compared well against the others. The BAUS database could have been a further candidate but its case ascertainment is lower and data quality is unknown. The other databases are in a state of development or transition. We felt that it was better to wait until they have reached a consistent level of data quality.

Immediately following the conclusions from the overview of the clinical databases, we approached both the SCTS and the BCIS in May 2010 with a request to share their data with us. The SCTS provided an extract in late 2010. We received an extract of the BCIS data in April 2011.

Table 8 - Characteristics of the clinical databases

	SCTS	BCIS	BAUS	NVD	RETA	BIAS
Data collection mandatory or voluntary?	Mandatory	Part of dataset mandatory	Voluntary	Voluntary	Voluntary	Voluntary
Web based or paper based?	Electronic data file uploaded to central system	Variety of local database entry systems; electronic data file uploaded to central system	Web based data entry into central database	Web based data entry into central database; also electronic data file uploaded to central system	Paper form sent to central data entry facility	Web base data entry into central database; also paper form sent to central data entry facility
Geographical coverage	UK & Ireland	UK	UK	UK	UK	UK
Database lifespan	1994 – present	2003 – present	1998 – present	1997 – present	1996 – 2009	2000 – present
Linkable to HES?	Yes	Yes	Yes	Yes	Yes	Yes
Are audit reports produced?	Most recent report 2009	Annually; most recent report 2008	Annually; date of most recent report unknown	Annually; most recent report 2009	No reports available; a report is being produced	Most recent report 2008

Table 9 - Data quality of the clinical databases

	SCTS	BCIS	BAUS	NVD	RETA	BIAS
Case Ascertainment	No formal data available; believed to be close to 100%	Close to 100% compared with self-reported total numbers of procedures	60-70% compared to Cancer Registry	2009 figures: 50% compared to HES for AAA and LLB, 70 % for CEA and 33% for amputations	Unknown	Unknown
Data completeness	High; "basic data" > 99% complete; "other data" (e.g. previous MI) > 90%	Most data item > 95% complete	Unknown	Unknown	Unknown	Unknown
Is data validated?	Range and consistency checks within the database	Range and consistency checks within the database	Range and consistency checks within the database	Range and consistency checks at data entry	No	No

Table 10 - Data items included in the clinical databases

	SCTS	BCIS	BAUS	NVD	RETA	BIAS
Dictionary availability	Yes	Yes	Yes	Yes	No	Yes
Does the database collect previous treatment	Yes; including PCI	Yes; including CABG, PCI.	No	Yes; aortic repair, IIB	No	No
Diagnosis details given in database?	Yes	Yes	Yes	Yes	Yes	Yes
Treatment details given	Yes; including number of vessels treated	Yes, including number of vessels / lesions treated	Yes	Yes	Yes	Yes, including emergency/elective
Details on disease severity given in database?	Yes	Yes	Yes, including Gleason score and grade of tumour	Yes; also first date of diagnosis given	Yes	Yes, including severity of stenosis
Comorbidity included?	Yes	Yes, including diabetes, angina, MI, hypertension	Yes, including diabetes, angina, MI, hypertension	Yes, diabetes, MI	No	Yes, including diabetes, renal disease
Are short term outcomes available?	Yes based on in-hospital events, including death, return to theatre, complications, discharge date,	Yes based on in-hospital events, including death, complications, discharge date	Yes based on in-hospital events, including complications, discharge date; death not included in minimum dataset	Yes based on in-hospital events, including death, discharge date	Yes based on in-hospital events, including death, discharge date	Yes based on in-hospital complications, including death, complications, discharge date
Are long term outcomes recorded and how?	Yes, outcomes captured at follow up appointments at 30 days and 1 year; death derived from ONS	Yes, but only mortality derived from ONS only	Yes, outcomes captured at follow up appointments, but timing not specified	Yes, outcomes captured at follow up appointments, but timing not specified	Yes, outcomes captured by sending follow up form 1 year after procedure	No outcomes captured after discharge

6. Use of Hospital Episode Statistics to investigate abdominal aortic aneurysm surgery in England

Introduction

One of the issues concerning HES is the accuracy in coding. This has gone as far as the columns of a national newspaper[2] where differences were reported between self-reported trust figures and HES numbers for procedures in AAA. Since AAA is a major procedure in England with a high mortality rate, this was taken as a case study to assess the level of data accuracy in HES.

In this analysis, an explicit and transparent coding framework is proposed and evaluated to study the HES data on patients undergoing open AAA surgery. The guiding principle underlying this coding framework is that it aims to define groups of patients who are homogeneous with respect to their diagnosis and prognosis as well as the treatment they have received. Firstly, definitions of diagnoses and procedures were considered to identify codes that are potentially relevant. Secondly, the frequency with which these potentially relevant codes had been used and the consistency of diagnostic and procedure codes within the records of individual patients was assessed. Furthermore, administrative codes were compared with diagnostic and procedure codes to check that patients who had undergone emergency surgery for a ruptured AAA were admitted as an emergency. Thirdly, the variation in the consistency of diagnostic and procedure codes among hospitals to identify hospitals that had unusual coding practices was explored.

Methods

In HES, the main diagnoses and procedures are represented within 3-character ICD-10 and OPCS-4 codes. A fourth character is used to provide a more detailed description. At 3-character level, the ICD-10 code I71 represents patients with "aortic aneurysm and dissection". No other 3-character level codes were deemed relevant for the diagnosis of AAA. Within I71, only the 4-character level codes I71.3 ("abdominal aortic aneurysm, ruptured") and I71.4 ("abdominal aortic aneurysm, without mention of rupture") were considered potentially relevant. The other 4-character codes within I71 represented another diagnosis ("dissection of aorta"), aortic aneurysms at other anatomical locations ("thoracic aortic aneurysm, ruptured", "thoracic aortic aneurysm, without mention of rupture", "thoracoabdominal aortic aneurysm, ruptured", or "thoracoabdominal aortic aneurysm, without mention of rupture"), or aortic aneurysms at unspecified locations ("aortic aneurysm of unspecified site, ruptured" or "aortic aneurysm of unspecified site, without mention of rupture").

With respect to the procedure codes, L18 ("emergency replacement of aneurysmal segment of aorta") and L19 ("other replacement of aneurysmal segment of aorta") were considered potentially the most relevant, but other related 3-character level codes had to be considered as well: L20 ("other emergency bypass of segment of aorta"), L21 ("other bypass of segment of aorta"), L22 ("attention to prosthesis of aorta"), L23 ("plastic repair of aorta"), and L25 ("other open operations on aorta" which includes endarterectomies and embolectomies). Codes for transluminal procedures were not included as the objective was to include only open surgical procedures.

Funnel plots were used to explore the variation among NHS hospitals in the consistency of diagnostic and procedure codes within records of individual patients. The plots show the percentage of patients undergoing an AAA replacement who had a consistent diagnosis code as a function of the number of patients who were operated. Only NHS hospitals were included that had carried out more than 40 procedures between 2003 and 2008. The inner funnel limits define the range of percentages that are within two standard deviations of the national average and the outer limits define the range of percentages which are within three standard deviations of the national average.

Results

Frequency and consistency of diagnostic and procedure codes

Data were extracted from HES for all 31,043 patients who were admitted to an English NHS hospital between 1st April 2003 and 31st March 2008 and who had a HES record with a potentially relevant procedures code (L18 to L23 or L25). Of these patients, 25,880 (83.4%) had either L18 ("emergency replacement of aneurysmal segment of aorta") or L19 ("other replacement of aneurysmal segment of aorta") as 3-character level procedure code (Table 11). Of the 7,647 patients with a L18 procedure code, 7,452 (97.4%) had I71 as diagnosis code ("aortic aneurysm and dissection"). Of the 18,233 patients with a L19 procedure code, 17,348 (95.1%) had this diagnosis code. The corresponding percentages of patients with an I71 diagnosis code among those who had other procedure codes (L20 to L23 or L25) were much lower.

Table 12 shows the frequencies and consistency of diagnostic and procedure codes at 4 -character level in all 7,647 patients with L18 as 3-character level procedure code ("emergency replacement of aneurysmal segment of aorta"). 5,981 patients (78.2%; see blue shaded area in Table 12) had a replacement of an abdominal segment of the aorta (L18.3 to L18.6). Within this group of patients, 5,705 (95.4%; see red shaded area in Table 12) had 4-character level diagnosis codes representing an abdominal aortic aneurysm; 4,522 (79.3%) were coded as ruptured (I71.3) and 1,183 (20.7%) as unruptured (I71.4).

A similar exploration was carried out in all 18,233 patients with L19 as 3-character level procedure code ("other replacement of aneurysmal segment of aorta"). Table 13 shows that 14,309 of these patients (78.5%; see blue shaded area in Table 13) had a replacement of an abdominal segment (L19.3 to L19.6). Of these patients, 13,544 (94.7%; see red shaded area in (Table 13) had 4-character level diagnosis codes representing an abdominal aortic aneurysm with only 582 (4.3%) coded as ruptured (I71.3) and 12,962 (95.7%) as unruptured (I71.4).

Comparison of method of admission with diagnostic and procedure codes

The percentage of patients with an "administrative" code indicating that they were admitted as an emergency was high in patients who had a procedure code indicating that they had an emergency replacement procedure or a diagnosis indicating a ruptured aneurysm (Table 14). This percentage was highest (93.3%) in patients who had a code of an emergency replacement of a ruptured aneurysm. The corresponding percentage was low (9.8%) in patients who were coded as having had a non-emergency replacement procedure for an unruptured aneurysm.

Coding consistency among NHS hospitals

The funnel plot in Figure 8 shows 59 NHS hospitals that carried out more than 40 emergency AAA replacement procedures (L18.3 - L18.6). This plot gives for each hospital the percentage of patients who had a diagnosis code of a ruptured (I71.3) or unruptured AAA (I71.4). Only one hospital had a percentage below the outer funnel limit. This indicates that in this hospital more often than expected patients who were coded as having had an emergency replacement of their AAA did not have a consistent diagnosis code. A detailed analysis of the diagnosis codes used in this hospital demonstrated that patients were relatively frequently coded as having a ruptured aortic aneurysm with an unspecified site (6.7% had had I17.8 as diagnostic code). Five NHS hospitals had percentages between the inner and outer funnel limits.

Similarly, the funnel plot in Figure 9 shows 112 NHS hospitals that carried out more than 40 non-emergency AAA replacement procedures (L19.3 - L19.6). This plot gives for each hospital the percentage of patients who had an unruptured AAA (code I71.4). Eleven of the 112 hospitals (9.8%) had a percentage below the outer funnel limits. An analysis of the codes used in these hospitals demonstrated that they frequently used the code for a ruptured AAA (I71.3), an unruptured thoracoabdominal aortic aneurysm (I71.6) or an unruptured aortic aneurysm of unspecified site (I71.9).

Discussion

The results show that the coding consistency is high. For example, 95% of patients undergoing AAA replacement had a consistent diagnosis. The direction of the association between the urgency of the operation and whether or not the AAA was ruptured was as expected: only 4% undergoing a non-emergency replacement were coded as having a ruptured AAA. There was also a clear association between administrative and clinical codes: 93% of the patients who had undergone an emergency replacement of a ruptured AAA were coded as having been admitted as an emergency whereas the corresponding figure was 10% in those who had undergone a non-emergency replacement of an unruptured AAA.

The proposed stepwise coding approach provides a number of advantages. First, the coding framework can be used to improve the selection of patients depending on the purpose of the study. The price to pay for only including patients who have consistent diagnostic and procedure codes is the loss of about 5% of the patients. This is equivalent to a case ascertainment of 95% which compares favourably with the case ascertainment achieved by almost all of the national clinical audits (i.e. prospective studies of the process and outcome of care) carried out in England[43].

Second, the coding framework allows an assessment of the extent of the potential miscoding. The urgency of the procedure can be matched against whether the aneurysm was ruptured or not and against whether the patient was admitted as an emergency. In this study, it is reassuring to observe that only about 4% of the patients undergoing a non-emergency replacement had a diagnostic code of a ruptured AAA whereas about 20% of patients undergoing an emergency replacement had a diagnostic code of AAA without mention of rupture. One expects the latter percentage to be higher as the urgency of the replacement of an unruptured AAA may also depend on the presence of symptoms as well as its size or the extent of its growth.

A third advantage is that an investigation of consistency of diagnostic and procedure codes among NHS hospitals can help to identify individual hospitals that seem to have divergent coding practices and may benefit from a comparison of their HES data with case notes. These hospitals could then be specifically targeted to bring their coding practice into line with national recommendations. Alternatively, it may help to recognise hospitals that are more likely to have diverse patients including those with suprarenal and thoracoabdominal aortic aneurysms.

Applying the proposed coding framework and the reporting of the frequency and consistency of the diagnostic and procedure codes at national level could have a similar positive impact on clinicians' confidence in the accuracy of HES data. It is therefore recommended that each study that uses HES for audit or research should use an explicit and transparent coding framework and report coding frequency and consistency.

Figure 8 – Emergency AAA procedures in 59 hospitals. Chart depicts percentage of patients with diagnosis of unruptured AAA (I71.4) or ruptured AAA (I71.3).

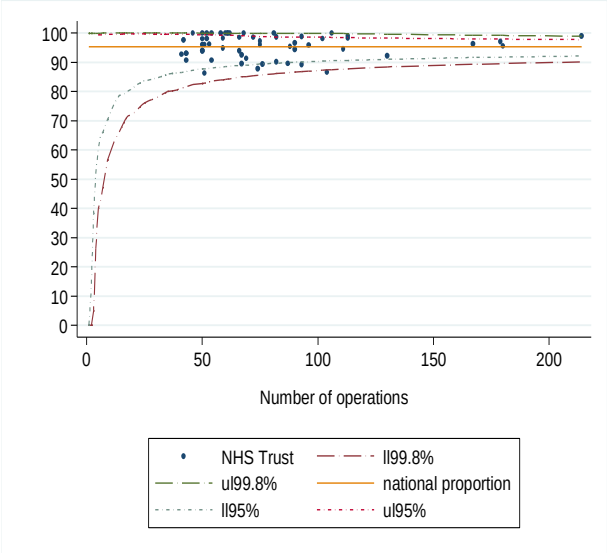


Figure 9 – Non-emergency AAA procedures in 112 hospitals. Chart depicts percentage of patients with diagnosis of unruptured AAA (I71.4).

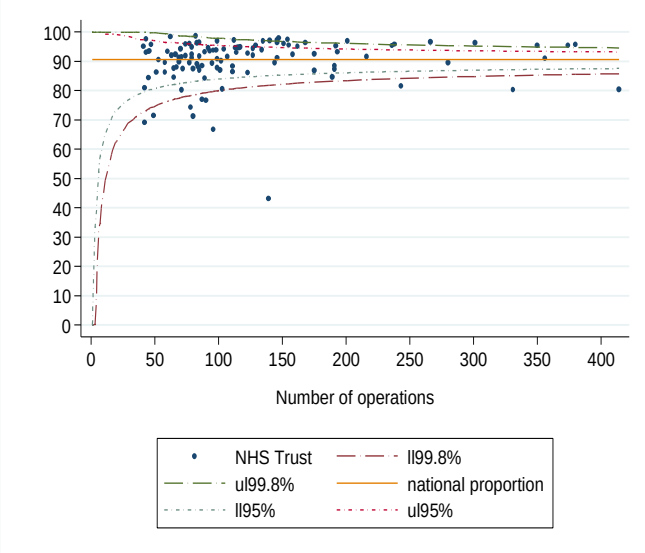


Table 11 – Summary of most frequent primary diagnosis codes for AAA procedures (% in brackets).

	Diagnosis Code					
Procedure code	I71 - Aortic aneurysm and dissection	I72 - Other aneurysm	I73 - Other peripheral vascular disease	I74 - Arterial embolism and thrombosis	Other	Total
L18 - Emergency replacement of aneurysmal segment of aorta	7,452 (97)	39 (1)	9 (0)	10 (0)	137 (2)	7,647 (100)
L19 - Other replacement of aneurysmal segment of aorta	17,348 (95)	165 (1)	43 (0)	50 (0)	627 (3)	18,233 (100)
L20 - Other emergency bypass of segment of aorta	299 (79)	2(1)	5(1)	14(4)	57 (15)	377 (100)
L21 - Other bypass of segment of aorta	613 (34)	31(2)	303 (17)	251 (14)	583 (33)	1,781 (100)
L22 - Attention to prosthesis of aorta	23 (15)	5 (3)	2 (1)	0 (0)	122 (80)	152 (100)
L23 - Plastic repair of aorta	460 (23)	8 (0)	0 (0)	4(0)	1,547 (77)	2,019 (100)
L25 - Other open operations on aorta	468 (56)	10 (1)	14 (2)	55 (7)	287 (34)	834 (100)
Total	26,663	260	376	384	3,360	31,043

Table 12 – Cross tabulation of four character procedure code L18 against diagnosis code I71 (% in brackets). Shaded regions represent patient groups discussed in the text.

		Diagnosis																		
		Dissection of aorta		Thoracic aortic aneurysm, ruptured		Thoracic aortic aneurysm, without mention of rupture		AAA ruptured		AAA without mention of rupture		Thoraco AAA ruptured		Thoraco AAA without mention of rupture		Aortic aneurysm of unspecified site, ruptured		Aortic aneurysm of unspecified site, without mention of rupture		Other codes		
Procedure code	Emergency replacement of aneurismal	I71.0		I71.1		I71.2		I71.3		I71.4		I71.5		I71.6		I71.8		I71.9				Total
L18.1	segment of ascending aorta	300	(60)	28	(6)	27	(5)	73	(15)	30	(6)	1	(0)	0	(0)	2	(0)	8	(2)	27	(5)	496
L18.2	segment of thoracic aorta	38	(31)	19	(16)	21	(17)	11	(9)	3	(2)	10	(8)	5	(4)	0	(0)	1	(1)	13	(11)	121
L18.3	segment of suprarenal abdominal aorta	0	(0)	0	(0)	0	(0)	123	(80)	22	(14)	4	(3)	1	(1)	0	(0)	1	(1)	2	(1)	153
L18.4	infrarenal abdominal aorta	23	(1)	3	(0)	2	(0)	1,997	(75)	588	(22)	6	(0)	2	(0)	14	(1)	7	(0)	35	(1)	2,677
L18.5	segment of abdominal aorta	31	(1)	3	(0)	4	(0)	1,740	(78)	373	(17)	4	(0)	0	(0)	21	(1)	6	(0)	39	(2)	2,221
L18.6	bifurcation of aorta by anastomosis of aorta to iliac artery	12	(1)	0	(0)	1	(0)	662	(71)	200	(22)	2	(0)	0	(0)	9	(1)	2	(0)	42	(5)	930
L18.8	Other specified	38	(9)	5	(1)	3	(1)	273	(63)	77	(18)	5	(1)	0	(0)	6	(1)	3	(1)	22	(5)	432
L18.9	Unspecified	27	(4)	2	(0)	1	(0)	418	(68)	131	(21)	1	(0)	1	(0)	17	(3)	4	(1)	15	(2)	617
Total		469	(6)	60	(1)	59	(1)	5,297	(69)	1,424	(19)	33	(0)	9	(0)	69	(1)	32	(0)	195	(3)	7,647

Table 13 – Cross tabulation of four character procedure code L19 against diagnosis code I71 (% in brackets). Shaded regions represent patient groups discussed in the texts.

		Diagnosis																					
		Dissection of aorta		Thoracic aortic aneurysm, ruptured		Thoracic aortic aneurysm, without mention of rupture		AAA ruptured		AAA without mention of rupture		Thoraco AAA ruptured		Thoraco AAA without mention of rupture		Aortic aneurysm of unspecified site, ruptured		Aortic aneurysm of unspecified site, without mention of rupture		Other codes		
Procedure code	Other replacement of aneurismal	I71.0		I71.1		I71.2		I71.3		I71.4		I71.5		I71.6		I71.8		I71.9				Total
L19.1	segment of ascending aorta	150	(14)	29	(3)	315	(30)	12	(1)	199	(19)	0	(0)	3	(0)	4	(0)	74	(7)	270	(26)	1,056
L19.2	segment of thoracic aorta	52	(12)	20	(4)	143	(32)	8	(2)	56	(12)	10	(2)	85	(19)	0	(0)	6	(1)	71	(16)	451
L19.3	segment of suprarenal abdominal aorta	1	(0)	1	(0)	9	(2)	19	(5)	300	(76)	3	(1)	37	(9)	0	(0)	5	(1)	22	(6)	397
L19.4	infrarenal abdominal aorta	16	(0)	3	(0)	10	(0)	217	(3)	5,821	(92)	3	(0)	18	(0)	3	(0)	83	(1)	133	(2)	6,307
L19.5	segment of abdominal aorta	15	(0)	1	(0)	12	(0)	271	(6)	4,383	(91)	6	(0)	14	(0)	9	(0)	43	(1)	81	(2)	4,836
L19.6	bifurcation of aorta by anastomosis of aorta to iliac artery	8	(0)	1	(0)	21	(1)	75	(3)	2,458	(89)	0	(0)	8	(0)	5	(0)	52	(2)	141	(5)	2,769
L19.8	Other specified	38	(3)	17	(1)	69	(5)	57	(4)	1,062	(74)	3	(0)	25	(2)	2	(0)	41	(3)	127	(9)	1,441
L19.9	Unspecified	4	(0)	0	(0)	8	(1)	77	(8)	820	(84)	0	(0)	3	(0)	2	(0)	22	(2)	40	(4)	976
Total		284	(2)	72	(0)	587	(3)	736	(4)	15,099	(83)	25	(0)	193	(1)	25	(0)	326	(2)	885	(5)	18,233

Table 14 – Percentage of patients admitted as an emergency* by 4-character level diagnostic and procedure code

Percentage of patients admitted as an emergency*

	Diagnostic code	
	I71.3	I71.4
	Abdominal aortic aneurysm, ruptured	Abdominal aortic aneurysm without mention of rupture
Procedure code		
L18.3 to L18.6 Emergency replacement of aneurysmal segment of abdominal aorta	93.3% (=4,219 / 4,522)	80.4% (=951 / 1,183)
L19.3 to L19.6 Other replacement of aneurysmal segment of abdominal aorta	79.7% (=464 / 582)	9.8% (=1,270 / 12,962)

* Identified in HES as patients with an admission method code of 21, 22, 23, 24 and 28.

7. Comparison of HES with clinical databases of the Society for Cardiothoracic Surgery and the British Cardiovascular Intervention Society

Introduction

An important objective of this project was to compare results of the case studies based on Hospital Episode Statistics database (HES) with those based on available clinical databases. For this comparison to be informative, the case ascertainment and data completeness of the clinical databases need to have reached a satisfactory level. As explained in Chapter 5, only the databases from the Society for Cardiothoracic Surgery (SCTS) and the British Cardiovascular Intervention Society (BCIS) had levels of case ascertainment and data completeness deemed high enough to justify a comparison with HES.

In this chapter, we describe the comparison of the SCTS and the BCIS databases with the HES database. Our original plan for this work was to explore the level of agreement in the number of procedures and number of patients who die in the period after coronary artery bypass graft surgery (CABG) and after a percutaneous coronary intervention (PCI). This includes the level of agreement at trust level and at consultant level.

Comparison of HES with SCTS data for CABG surgery

In HES, we defined patients who had a CABG procedure if a relevant OPCS code (Table 15) was found in any of the first twelve procedure fields in a record of a hospital admission between 1st April 2007 to 31st March 2009. The dataset was then filtered further to only include patients with a diagnosis of angina (International classification of diseases ICD-1044 code I20), myocardial infarction (I21-I23), or ischaemic heart disease (I24-I25) in any of the first nine diagnosis fields. Records which had a valve procedure concurrent with CABG were excluded (mitral, aortic, pulmonary or tricuspid).

The data provided to us by the SCTS was filtered for the same time period as HES for procedures recorded as 'CABG only' or 'CABG + other'. The latter indicates that only minor procedures have taken place in addition to CABG. As with HES, we excluded records with evidence of a valve procedure.

To compare mortality data in HES and SCTS, we measured 30-day in hospital mortality. Again, HES was linked to ONS for mortality data. For SCTS, mortality was identified as records which had 'dead' under status at discharge or dead under 'discharge destination'. For those flagged as deceased, the discharge date and procedure date was used to measure the 30-day period.

The SCTS dataset holds fields for various risk factors, 17 of which have been included in the mortality risk scoring system EuroSCORE [45]. If a categorical risk factor for a patient which contributes to EuroSCORE was missing, this field was recorded as zero. The EuroSCORE model that we used was created by re-estimating the coefficients of the 17 risk factors in a logistic regression model. We also developed a model in HES that included age, sex, ethnicity, socio-economic status, type of admission, number of prior emergency admissions and comorbidity using the RCS Charlson comorbidity score [41] as well as previous myocardial information and prior CABG procedures.

To compare risk the adjustment models for both comparisons, we used the C statistics as a measure of discriminatory power which corresponds to the area under the receiver operative characteristic (ROC) curve scores. To compare how well the models were calibrated, we applied the Hosmer Lemeshow test [46]. This test splits patients into ten risk groups according

to the predicted mortality and compares the observed and predicted mortality in each of these risk groups. Funnel plots were created as described in Chapter 4 to compare mortality among the NHS trusts.

Table 16 demonstrates that 37,712 patients were identified in the SCTS database for CABG procedures with a 30-day mortality rate of 1.5% (= 556 / 37,712). These patients were treated in 29 NHS trusts in England. In HES, we identified 37,542 patients treated in the same NHS trusts and we observed a mortality rate of 1.4% (= 535 / 37,542).

We compared the number of procedures at NHS trust level and found very good agreement for 18 trusts (ratio of number of procedure in HES and number of procedures in SCTS between 97% and 103%). Two NHS trusts showed very poor agreement (ratios of 63% and 122%). We also compared the mortality according to HES and the SCTS database and found that mortality according to HES was at least 10% higher in five NHS trusts and at least 10% lower in ten NHS trusts than according to SCTS data.

We found that applying the logistic EuroSCORE with coefficients re-estimated in SCTS data had good discriminatory power with a C statistic of 0.83 (Table 17). A similar model derived in HES data had a C statistic of 0.81. The calibration plots comparing observed and expected mortality by risk groups in HES and SCTS data show good calibration (Figure 10 and Figure 11).

When comparing risk-adjusted mortality at trust level, we found two trusts to be above the upper outer control limit according to SCTS data. These trusts are marked with a circle and a triangle in Figure 12. The mortality results of these trusts were only above the upper inner control limit of the funnel according to HES data (see Figure 13). We have also indicated in Figure 12 and 13 the NHS trusts with the largest differences in number of procedures recorded according to HES and SCTS (denoted by x and +).

We found two consultants to have mortality results, indicated with a circle and square in Figure 14 above the upper outer funnel according to SCTS data. The results for one of these consultants were found to be within the outer funnel limits according to HES data (Figure 15). When comparing the numbers of procedures at consultant level we found four with higher numbers according to SCTS data than according to HES (Figure 16). These consultants were all from the same NHS trust. Three consultants were found to have lower numbers of procedures according to SCTS data and these were all from the same trust as well.

Comparison of HES with BCIS data for percutaneous coronary interventions

In HES we identified percutaneous coronary interventions (PCIs) according to the OPCS codes presented in Table 15. Patients were selected if they had a PCI code between 1st April 2007 and 31st March 2009 according to any of the first twelve procedure fields in a HES record. Furthermore, the data was validated and cleaned. The same validation cleaning procedures were applied to the BCIS dataset. The BCIS dataset was then filtered further to only include admissions in English NHS trusts.

We compared 30-day mortality according to HES and BCIS data. We used a similar risk adjustment approach as described earlier for the CABG procedures.

The BCIS database contained records from 71 NHS trusts (Table 18). In HES 110 trusts were found which had recorded a PCI. When comparing only the 71 trusts in HES which were also in the BCIS database, HES had 106,202 PCIs. The exclusion of data for 39 NHS trusts (= 110 – 71) resulted in the removal of only 278 cases. A total of 115,828 PCIs were found in

the BCIS database. We found a 30-day mortality of 1.69% in HES and 1.63% in the BCIS database.

Seven NHS trusts had very good agreement in the total number of procedures (ratio of number of procedure in HES and number of procedures in BCIS (between 97% and 103%). Agreement in the number of procedures was very poor in 8 trusts (corresponding to less than 80% agreement). Mortality according to HES was at least 10% higher in 23 NHS trusts and at least 10% lower in 15 NHS trusts than according to BCIS data.

The discriminatory power of the risk-adjustment model was strongest in BCIS data with a C statistic of 0.86 (Table 19). The C statistic was 0.78 for the risk-adjustment model derived in HES data. The calibration of both risk-adjustment models was good in both databases (Figure 17 and Figure 18).

When comparing risk-adjusted mortality at NHS trust level, we found two trusts to be above the upper outer control limit when using BCIS. These trusts are marked with a circle and a square in Figure 19. According to HES, these two trusts were within the inner control limits but now three different NHS trusts were observed to have results above the upper outer funnel limit (Figure 20).

Discussion

We have provided comparisons of HES with the SCTS database for CABG procedures and with the BCIS data for PCIs. We found reasonable agreement in the numbers of CABG procedures recorded in HES and in the SCTS database as well as in the corresponding mortality results at NHS trust and consultant level. There was no clear pattern that could explain the differences. In some NHS trusts, more CABG procedures were recorded in HES than in the SCTS database and in other trusts it was the other way round. A similar pattern was observed for the mortality results. For a small number of consultants the number of procedures according to HES differed considerably from the number according to SCTS data. However, these differences were all confined to consultants in two NHS trusts.

We found larger differences between the numbers of PCI procedures recorded in HES and in the BCIS database than when comparing the numbers of CABG procedures. Also, the differences in the mortality results according to PCI and HES were larger. It seems that there is under-recording of PCI procedures in HES by about 10%. The mortality differences go in both directions which indicates that there are no indications for systematic under- or over-recording in either BCIS or HES data.

It is important to note in this context that it is difficult in HES to determine the nature and severity of a patient's myocardial infarction. For example, we cannot distinguish patients with ST-elevated myocardial infarction and those with non-ST elevated myocardial infarction and this may explain the discrepancy between results based on HES and BCIS data.

A remarkable result in our view is that performance of the risk adjustment models for mortality after CABG procedures developed in HES and in SCTS data is very similar. The risk adjustment for PCI procedures is better in BCIS data.

The comparison of SCTS data with HES suggests that the HES database can be used to measure the outcome of CABG procedures in the majority of NHS trusts. A similar conclusion cannot be drawn for PCIs as the differences between the numbers of procedures and the mortality results according to HES and BCIS data are more substantial and the risk adjustment with HES data is less accurate than with BCIS data.

Figure 10 – HES CABG mortality goodness of fit chart

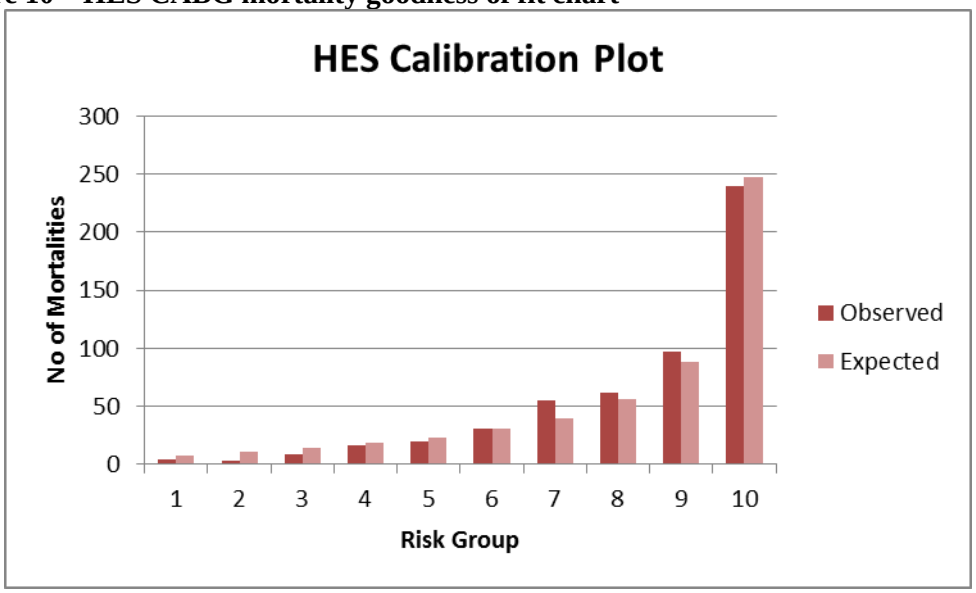


Figure 11 – SCTS CABG mortality goodness of fit chart

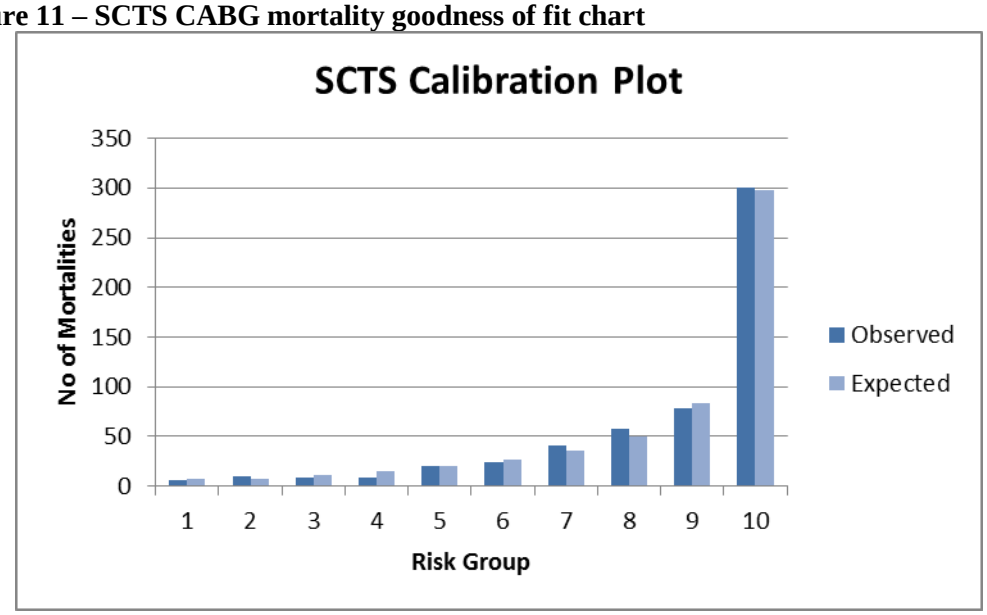


Figure 12 – SCTS CABG mortality funnel chart by trust. Symbols denote outlying trusts.

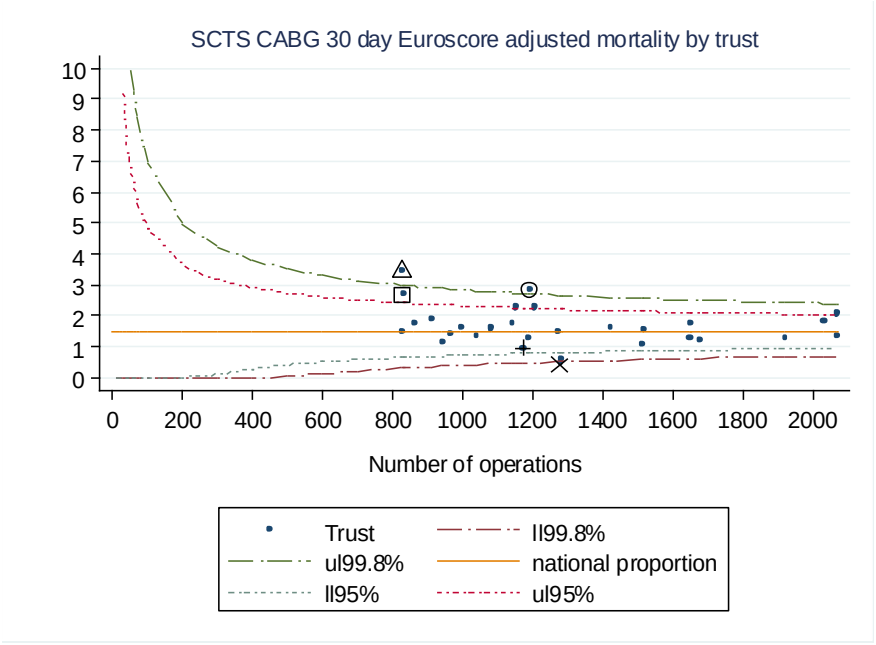


Figure 13 – HES CABG mortality funnel chart by trust. Symbols denote outlying trusts.

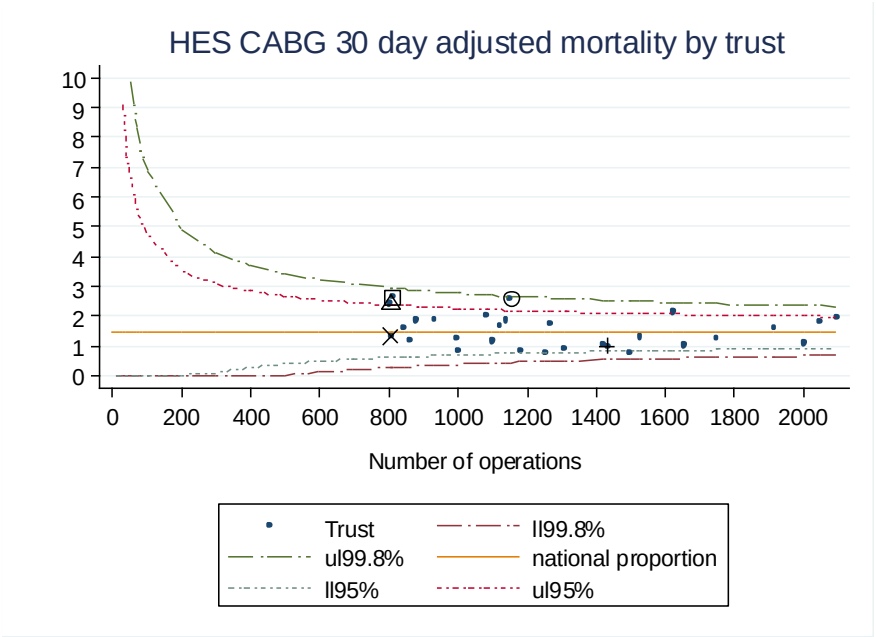


Figure 14 – SCTS CABG mortality funnel chart by consultant. Symbols denote outlying consultants

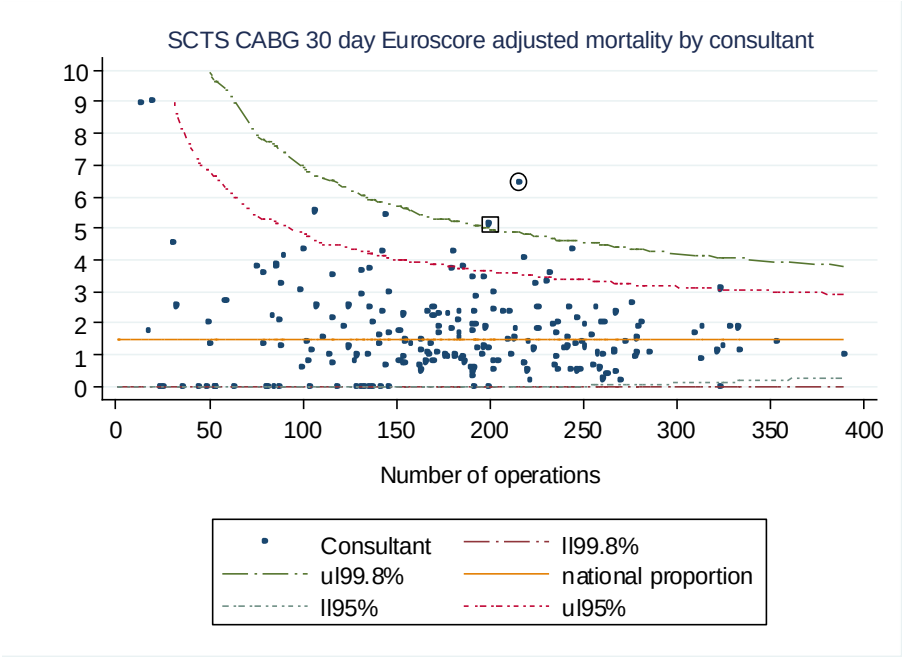


Figure 15 – HES CABG mortality funnel chart by consultant. Symbols denote same outlying consultants in HES

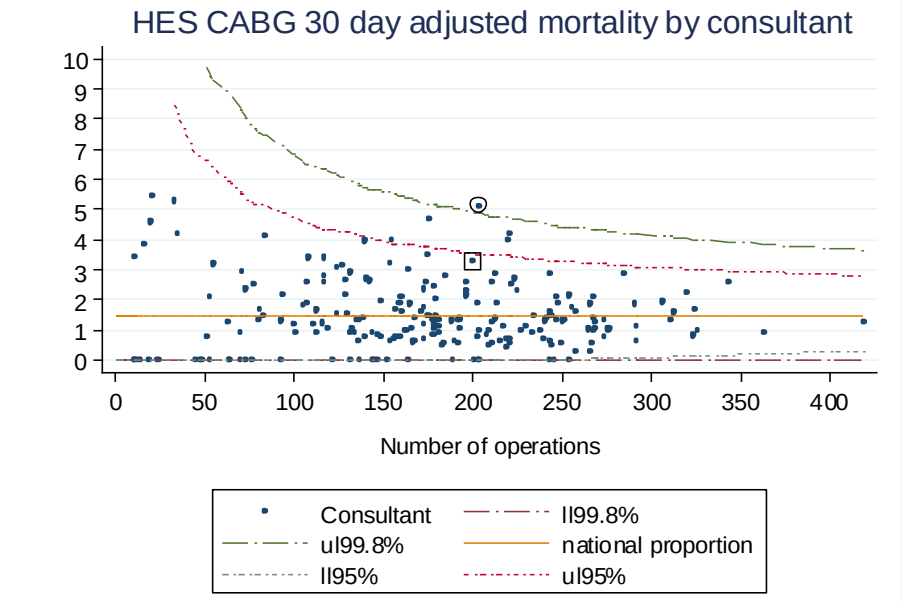


Figure 16 – Comparison of number of CABG procedures by consultants in SCTS against HES. Squares and circles denote consultants from same hospitals, 12 & 21 respectively.

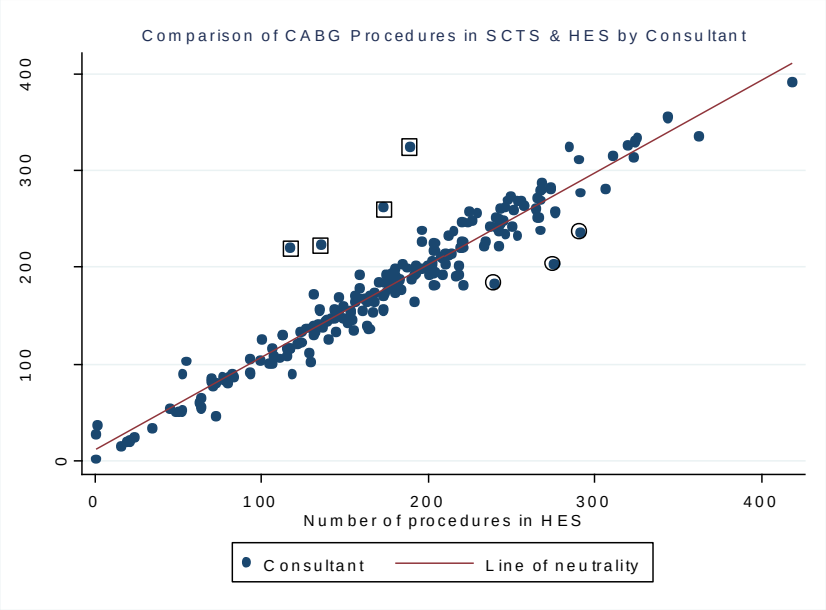


Figure 17 – BCIS PCI mortality goodness of fit chart

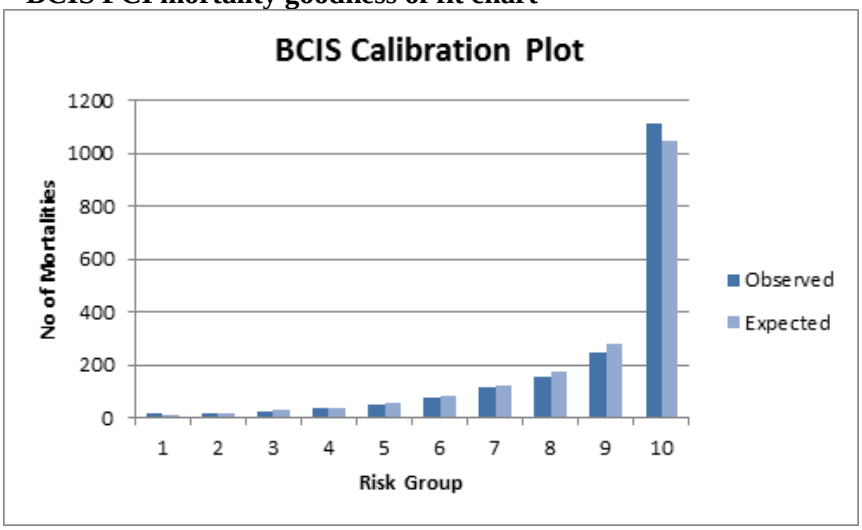


Figure 18 – HES PCI mortality goodness of fit chart

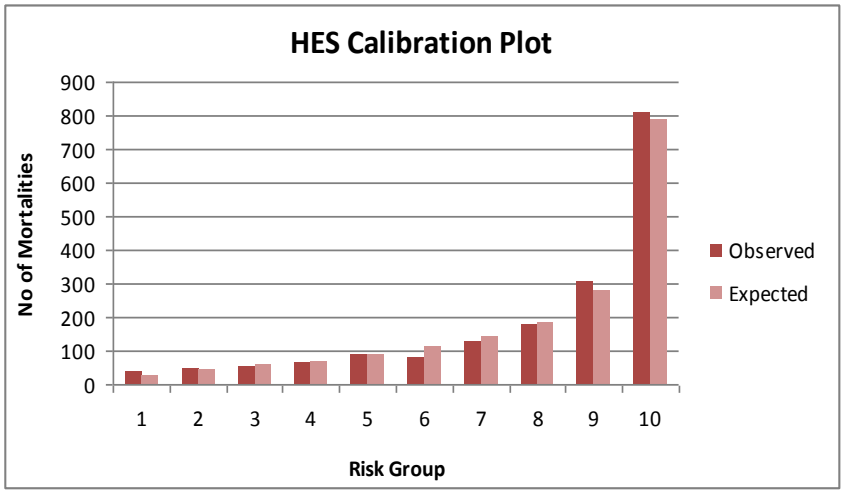


Figure 19 – BCIS PCI mortality funnel chart. Square and circle denote outlying trusts.

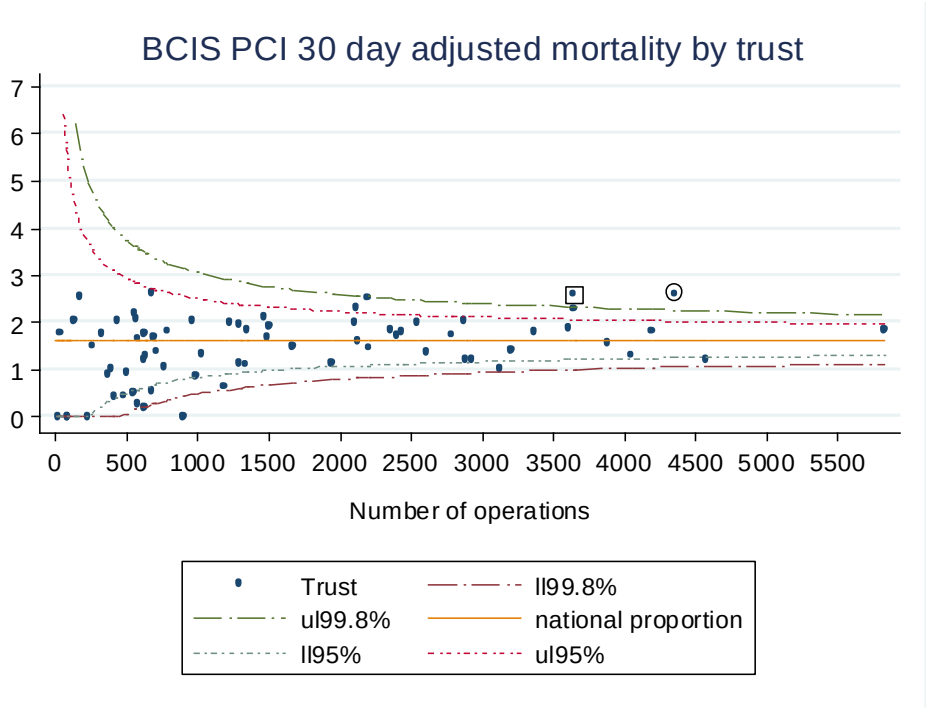


Figure 20 – HES PCI mortality funnel chart. Square and circle denote outlying trusts in BCIS.

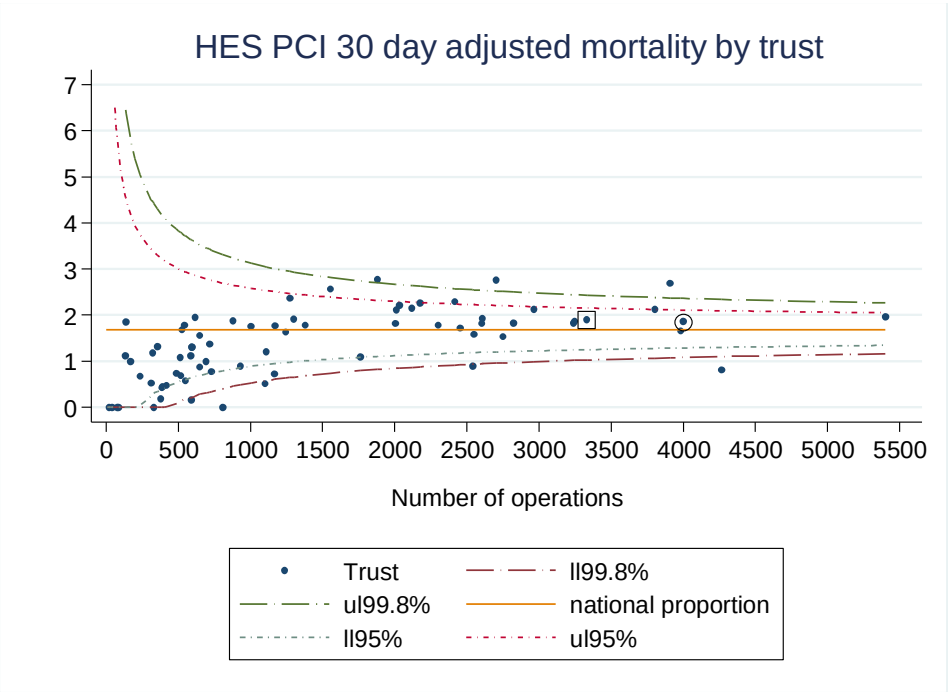


Table 15 – OPCS codes used to identify PCI and CABG procedures in HES

SCTS – CABG	BCIS – PCI
K40 – Saphenous vein graft replacement of coronary artery K41 – Other autograft replacement of coronary artery K42 – Allograft replacement of coronary artery K43 – Prosthetic replacement of coronary artery K44 – Other replacement of coronary artery K45 – Connection of thoracic artery to coronary artery K46 – Other bypass of coronary artery	K49 – Transluminal balloon angioplasty of coronary artery K50.1 – Percutaneous transluminal laser coronary angioplasty K50.4 – Percutaneous transluminal atherectomy of coronary artery K50.8 – Other specified K50.9 – Unspecified K75 – Percutaneous transluminal balloon angioplasty and stenting of coronary artery

Table 16 – Comparison of number of CABG procedures and 30 day mortality for SCTS and HES at trust level in England. Penultimate column indicates HES count divided by SCTS count as a percentage. Last column calculates HES percentage mortality divided by SCTS percentage mortality.

Hospital	SCTS numbers	Mortality	HES numbers	Mortality	Differences in procedures HES /SCTS %	Differences in mortality HES /SCTS %
1	2,069	33	2,097	41	101	123
2	2,069	38	2,050	32	99	85
3	2,033	37	2,004	30	99	82
4	1,923	22	1,916	28	100	128
5	1,679	16	1,655	15	99	95
6	1,651	24	1,750	21	106	83
7	1,649	42	1,624	40	98	97
8	1,518	20	1,529	22	101	109
9	1,513	10	1,499	9	99	91
10	1,423	15	1,422	14	100	93
11	1,284	11	1,310	14	102	125
12	1,281	10	807	10	63	159
13	1,273	15	1,269	15	100	100
14	1,205	21	1,099	19	91	99
15	1,194	26	1,153	25	97	100
16	1,187	11	1,253	10	106	86
17	1,174	17	1,436	18	122	87
18	1,152	21	1,140	21	99	101
19	1,143	21	1,085	18	95	90
20	1,082	12	1,183	9	109	69
21	1,041	13	1,122	17	108	121
22	997	10	1,002	8	101	80
23	967	13	933	13	96	104
24	942	15	997	16	106	101
25	911	13	882	12	97	95
26	864	20	846	13	98	66
27	833	20	812	18	97	92
28	829	9	862	10	104	107
29	826	21	805	17	97	83
Total	37,712	556	37,542	535		

Table 17 – Mortality and ROC score comparison for HES and SCTS

Model	Observations	30 day mortality	ROC Score	95% confidence interval	
SCTS logistic EuroSCORE - CABG	37,712	1.47%	0.81	0.79	0.83
SCTS recalibrated logistic EuroSCORE - CABG	37,712	1.47%	0.83	0.81	0.85
HES – CABG (model 2)	37,542	1.43%	0.81	0.79	0.83

Table 18 – Number of PCI procedures and 30 day mortality in BCIS and HES by trust.

Hospital	BCIS numbers	BCIS Mortality	HES numbers	HES Mortality	HES/BCIS numbers	HES/BCIS mortality
1	5,835	115	5,401	101	93	95
2	4,581	34	4,265	31	93	98
3	4,364	84	3,998	85	92	110
4	4,200	100	3,910	96	93	103
5	4,053	32	3,982	33	98	105
6	3,890	64	3,804	74	98	118
7	3,653	52	3,242	51	89	111
8	3,650	59	3,334	54	91	100
9	3,611	71	3,247	54	90	85
10	3,369	47	2,966	46	88	111
11	3,213	49	2,825	49	88	114
12	3,137	31	2,541	30	81	119
13	2,929	46	2,606	47	89	115
14	2,893	48	2,751	46	95	101
15	2,886	65	2,705	65	94	107
16	2,788	27	2,548	31	91	126
17	2,613	33	2,609	51	100	155
18	2,555	49	2,417	48	95	104
19	2,448	49	2,122	46	87	108
20	2,404	43	2,032	37	85	102
21	2,361	42	2,303	41	98	100
22	2,213	39	2,177	33	98	86
23	2,203	58	2,177	48	99	84
24	2,133	36	2,012	31	94	91
25	2,119	62	1,881	54	89	98
26	2,113	28	2,453	26	116	80
27	1,954	20	1,762	22	90	122
28	1,677	45	1,557	41	93	98
29	1,514	62	1,273	58	84	111
30	1,493	38	1,383	36	93	102
31	1,471	32	1,302	26	89	92
32	1,353	33	1,245	32	92	105
33	1,348	17	1,168	12	87	81
34	1,301	26	1,169	25	90	107
35	1,300	17	1,112	15	86	103
36	1,229	30	1,004	22	82	90
37	1,195	5	1,101	6	92	130
38	1,036	12	932	11	90	102
39	996	6	731	5	73	114
40	967	19	882	20	91	115
41	908	0	809	0	89	n/a
42	797	16	716	13	90	90
43	773	8	695	8	90	111
44	722	12	650	14	90	130
45	698	11	596	11	85	117
46	684	16	618	11	90	76
47	683	3	420	3	61	163
48	642	11	594	9	93	88
49	639	1	550	3	86	349
50	637	8	514	7	81	108
51	635	9	586	11	92	132
52	592	1	592	1	100	100
53	583	14	542	14	93	108
54	580	9	517	4	89	50
55	565	10	525	10	93	108
56	556	3	651	6	117	171
57	514	6	485	5	94	88
58	492	2	391	2	79	126
59	448	10	354	6	79	76
60	424	2	381	1	90	56
61	405	1	332	0	82	0
62	377	3	325	4	86	155
63	337	2	311	2	92	108
64	270	3	235	2	87	77
65	234	0	388	2	166	n/a
66	176	3	138	2	78	85
67	141	3	135	2	96	70
68	99	0	77	0	78	n/a
69	96	0	85	0	89	n/a
70	46	1	40	0	87	0
71	27	0	21	0	78	n/a
Total	115,828	1,893	106,202	1,792		

Table 19 – Mortality and ROC score comparison between BCIS and HES

Model	Observations	30 day mortality	ROC Score	95% confidence interval	
BCIS model	115,828	1.63%	0.86	0.85	0.86
HES model 1	106,202	1.69%	0.75	0.74	0.76
HES model 2	106,202	1.69%	0.78	0.77	0.79

8. Disease-specific indicators

Introduction

One of the objectives of this project was to distinguish between procedure-specific and disease-specific indicators. Procedure-specific indicators give information on outcomes of patients undergoing a specific procedure whereas disease-specific indicators do the same but then for patients from the time of diagnosis (or another time-defining event in the course of the disease). Consequently, disease-specific indicators reflect the impact of all clinical specialties who are involved in the treatment of patients along the entire disease pathway. As a result, it is immediately obvious that it will be difficult in many situations to link disease-specific indicators to individual NHS trusts and clinicians.

When disease-specific indicators are being used it is more difficult to define the patient population as well as the timing of their follow-up than when procedure-based indicators are used. It is also likely that the impact of case mix differences is greater for disease-specific than for procedure-specific indicators.

To explore the issues related to the development and use of disease-specific indicators, we looked at the treatments given to patients who were diagnosed with prostate cancer as an example of a urological malignancy. This is the only one of the three disease areas in which disease-specific indicators can be developed. Linkage with Cancer Registry data would allow patients to be followed up from the time of diagnosis. In the two other disease areas, ischaemic heart disease and peripheral vascular disease, it is not possible to identify patients at the time of diagnosis or at any other relevant point in time that is not directly or indirectly related to the timing of a procedure based on data that is routinely available.

We analysed HES data linked to cancer data that was collected by the eight English Cancer Registries. The cancer data contained details of patients' demographics, the cancer diagnoses, and treatments that these patients had received. The HES data provides additional treatment details as well as clinical outcomes.

Cancer Registry data

The Cancer Registry database contains fields that record the stage of cancer patients including the Gleason Score, tumour grade, tumour size, tumour (T) stage, nodal (N) stage, and metastatic (M) stage. Also available is information about age, socio-economic deprivation and ethnicity. On initial examination of the data completeness, we found that the T, N and M stage were poorly recorded with nearly 99% missing data. For this reason, we opted not to use these fields but used the Gleason Score (51% complete) and tumour grade (64% complete) instead.

The Gleason Score is used to evaluate the stage of the disease at diagnosis and is based on a 5-point pathological grading system that describes tumour glandular differentiation and growth pattern with 1 being well differentiated and 5 being poorly differentiated disease.[15] The two most prevalent patterns are combined to give a Gleason Score (e.g. 3 + 4) with consequently 2 being the lowest and 10 the highest. The Cancer Registry also provides the date of the prostate cancer diagnosis.

Prior to the linkage of the Cancer Registry data to HES, we assessed the coding consistency between diagnosis and procedure codes for the two datasets for patients diagnosed between 1997-2008. 19,980 patients were found in the Cancer Registry data with a record of a radical prostatectomy (OPCS code M61). 19,818 of these patients (99%) were recorded to have a

prostate cancer diagnosis (ICD - 10 code C61). In HES, 32,471 patients were found with records that contained a code for a radical prostatectomy. 27,258 of these patients (84%) also had a prostate cancer diagnosis. As there were fewer procedures found in the Cancer Registry data, we used the treatment data from HES for further analysis of radical prostatectomies and the Cancer Registry as the data source for diagnosis and other cancer details.

We identified all patients from the Cancer Registry data with a diagnosis of prostate cancer and with a diagnosis date between 1st April 1997 and 31st December 2008. This was the latest date available in the Cancer Registry dataset. The Cancer Registry data was then linked to HES based on a pseudonymised identifier provided by the NHS Information Centre.

Disease-specific indicators

We included patients who had a prostate cancer diagnosis according to the Cancer Registry data. We determined two disease-specific indicators. First, we established how many patients diagnosed with cancer had a radical prostatectomy. The denominator was the number of patients with a prostate cancer diagnosis observed in the Cancer Registry data and the numerator was the number of radical prostatectomies in these patients observed in HES data. Second, we determined the time from the date of the prostate cancer diagnosis to the date of surgery in the patients who had a radical prostatectomy. For these patients, the date of diagnosis was derived from the Cancer Registry data and the date of the procedure from HES.

An important issue that needs to be considered is the appropriate level of analysis for disease-specific indicators. The NHS trusts and their consultants have only a limited influence on how many patients with prostate cancer will have a radical prostatectomy as they can only see patients who are referred to them. The most appropriate level of analysis for the proportion of patients with prostate cancer who have radical surgery is therefore the Primary Cancer Trust (PCT) or the Cancer Network area in which the patients live. One could argue that the time from diagnosis to treatment could be a relevant indicator for NHS trusts and even consultants as they can influence the time that patients will need to wait for radical treatment after a prostate cancer diagnosis has been made.

Statistical Method

For both indicators, we adjusted for differences in case mix using statistical regression models. The models included patient age, socio economic deprivation score based on quintiles of the Index of Multiple Deprivation[42], Gleason Score, tumour grade and the RCS Charlson Comorbidity Score.[41] To account for the missing data found in the Gleason and tumour grade scores, multiple imputation was used [47]. Following imputation, a logistic regression model was applied for the prostatectomy indicator and a linear regression model for the time to surgery.

Results

We obtained 322,584 patients with a prostate cancer diagnosis between 1997 and 2008 from the Cancer Registry database. For 307,144 of these patients (95%), we could find a matching HES record (Figure 21). 26,856 of these 307,144 patients (9%) were identified as having had a radical prostatectomy.

Three PCTs were found to have a high proportion of prostate cancer patients who had a radical prostatectomy above the upper inner limit of the funnel plot demonstrating a higher level of radical treatment compared to the national average of 9% and three PCTs had results below the lower inner limit demonstrating a lower level of activity (Figure 22). The lowest prostatectomy rate observed in a PCT was 3% and the highest 19%. When looking at the Cancer Network level (Figure 23), one Cancer Network had a prostatectomy rate above the upper inner funnel limit and two below the lower inner funnel limit. The highest prostatectomy rate in a Cancer Network was 13% and the lowest 6%.

The average time from diagnosis to radical prostatectomy was 172 days. When comparing mean times at NHS trust level (Figure 24), three trusts were found above the upper outer control limit demonstrating a longer intervention time than the national average. When comparing consultant data (Figure 25), four consultants were found to have results above the upper outer control limit. None of these consultants was attached to the three trusts with results above the upper outer control limit. At Cancer Network level (Figure 26), only one network was found above the upper outer control limit. This Cancer Network had a time from diagnosis to treatment of 246 days.

Discussion

We highlighted in the Introduction of this report that there are a number of challenges for the development of disease-specific indicators based on HES. First, it is necessary to have external data that identifies patients at the time of diagnosis and that can be linked to HES at patient level. Second, it requires follow-up of patients over time in order to assess their management and outcomes. Third, the ability to adjust for case mix is even more important for the analysis of disease-specific indicators than for the analysis of procedure-specific indicators because at the time of diagnosis patients are likely to be more heterogeneous than at the time of treatment.

In this chapter we demonstrate that all these challenges can be overcome in principle when looking at the management of prostate cancer patients. However, the results of our feasibility work also highlight that data quality and completeness are major barriers. Although we can identify most patients with a cancer diagnosis using Cancer Registry data, our ability to adjust for case mix is limited due to poor levels of completeness on staging.

Our feasibility study also highlighted the advantage of using HES instead of Cancer Registry data for some data items on the procedures. We found more radical prostatectomies recorded in HES. Also, HES included patients who were more recently treated. A drawback of using HES is that it only includes patients who have had a treatment in secondary care whereas the Cancer Registry data includes all patients who had a cancer diagnosis.

Lastly, it is also important to note that it is difficult to develop disease-specific indicators for other diseases than cancer (e.g. ischaemic heart disease as well as peripheral vascular disease) based on routinely available clinical or administrative data. The date of diagnosis is often not available. Therefore, it will not be possible to follow patients up from diagnosis if there is no additional data source. In addition, HES does not contain information about the severity of cardiac or vascular conditions which impacts on the ability to adjust for case mix.

Figure 21 – Schematic of HES and CR data population.

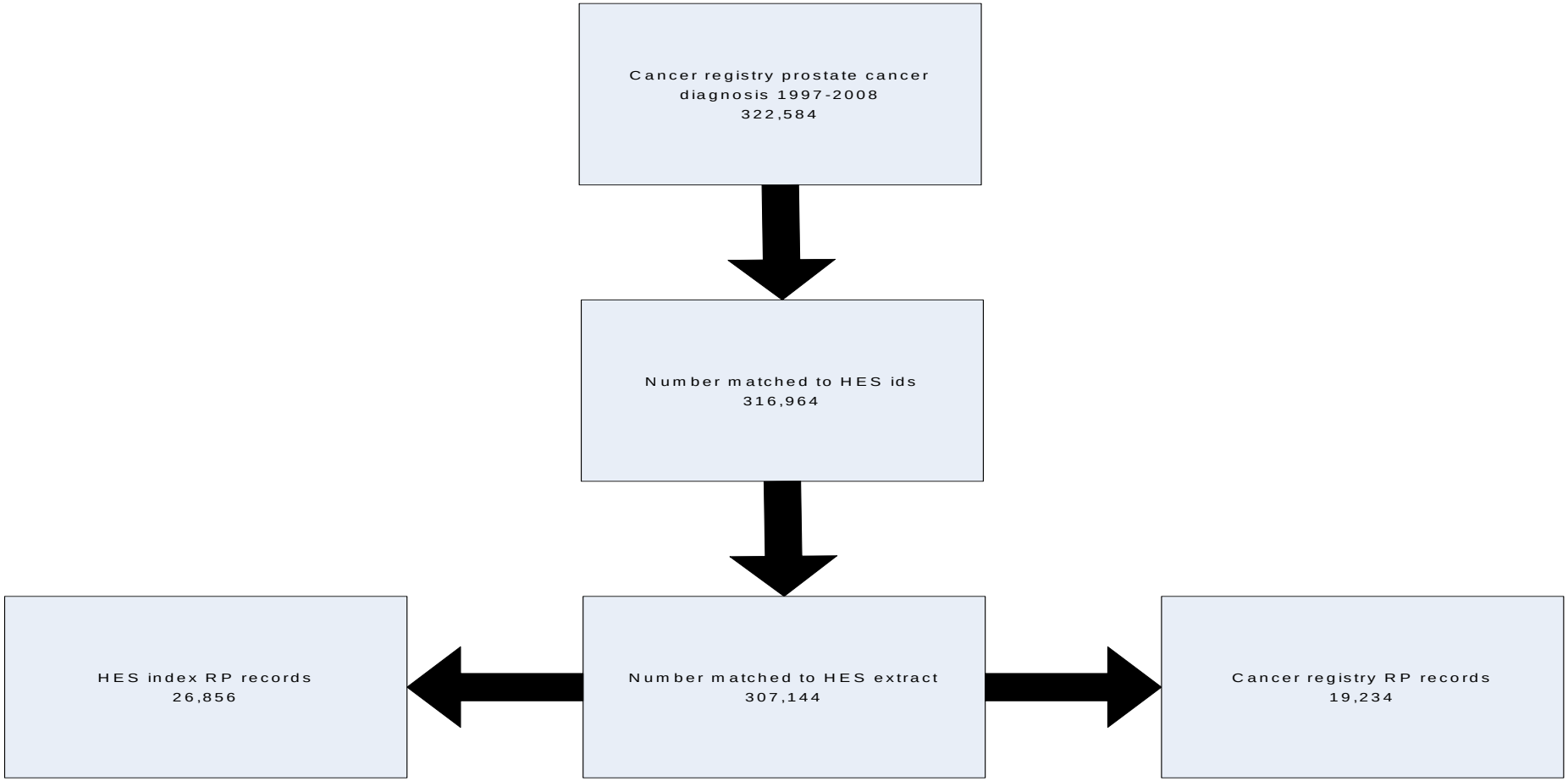


Figure 22 – Likelihood of intervention by primary trust area

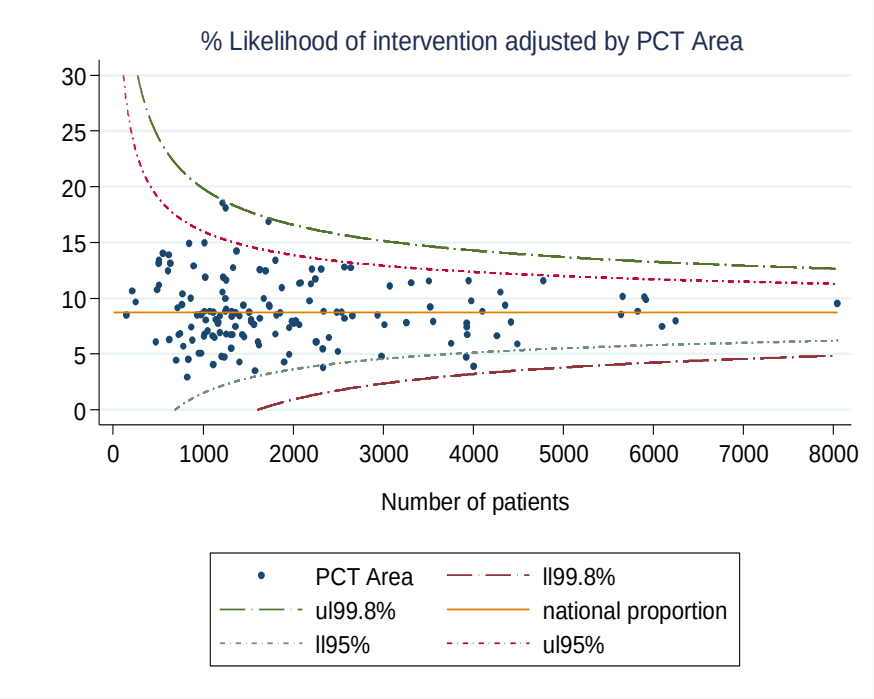


Figure 23 – Likelihood of intervention by cancer network

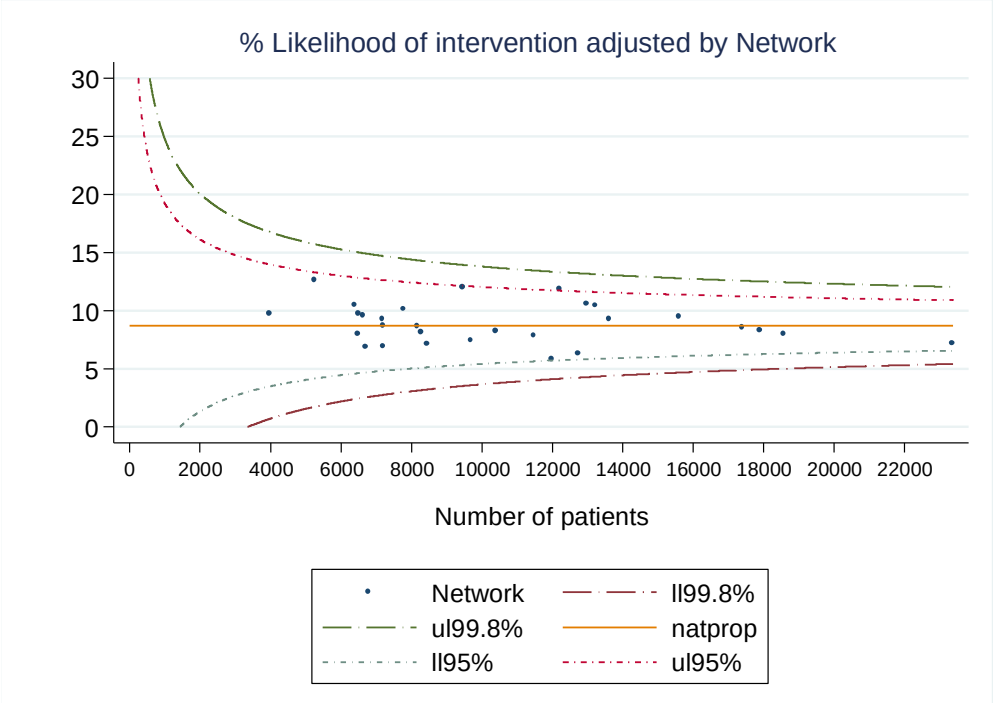


Figure 24 – Time to intervention by trust

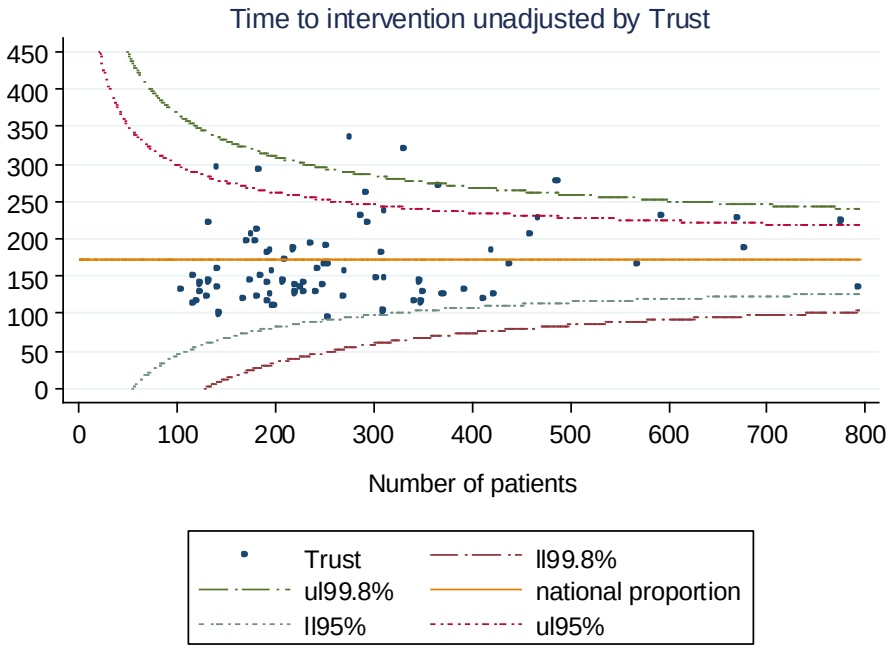


Figure 25 – Time to intervention by consultant

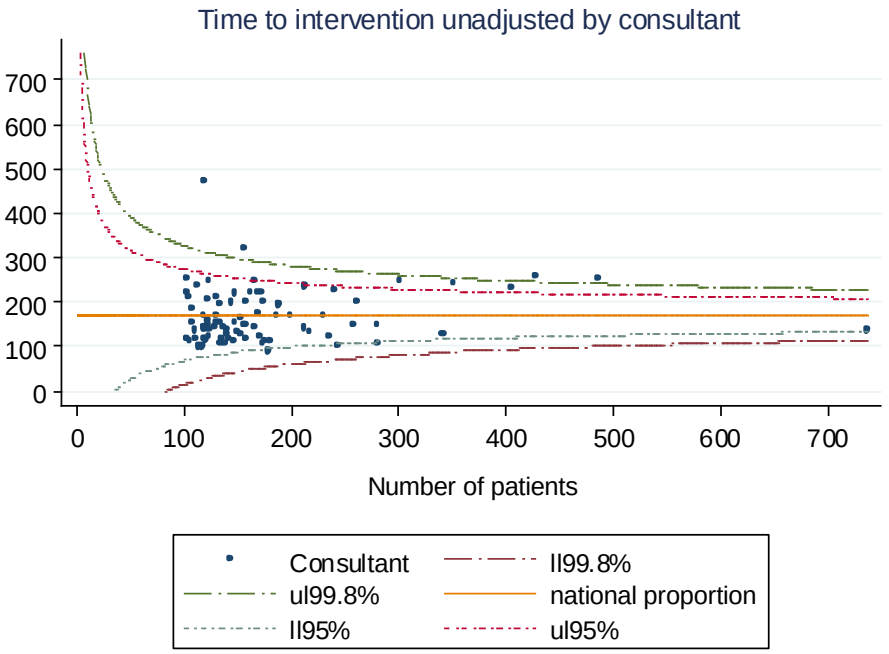
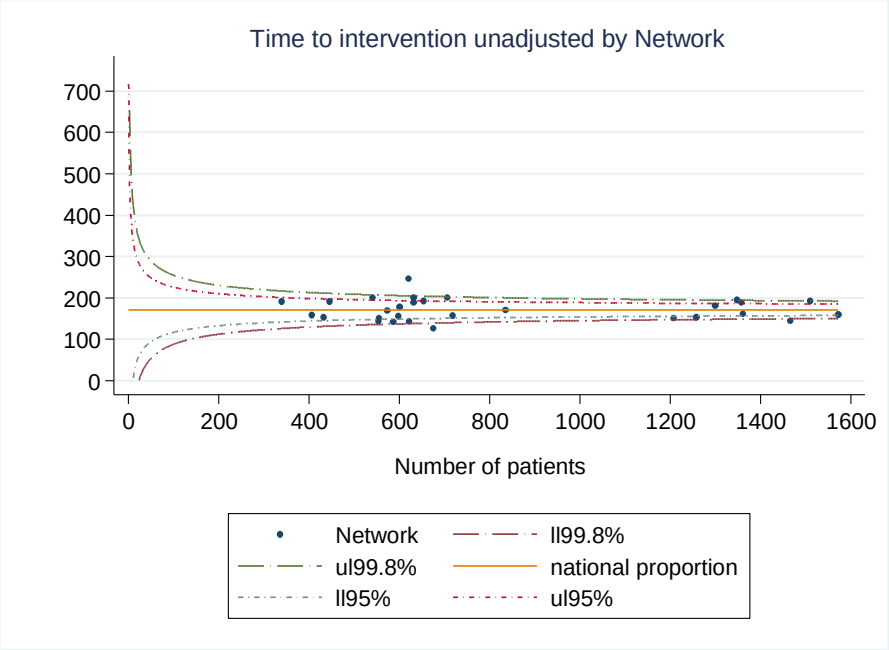


Figure 26 – Time to intervention by cancer network



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