ECHO

EUROPEAN COLLABORATION FOR HEALTHCARE OPTIMIZATION

Coronary revascularisation in England

I. EXECUTIVE SUMMARY

Mortality and morbidity from cardiovascular disease are considered a public health issue. In fact, coronary ischaemic disease is one of the leading causes of death in Europe.

The study of systematic variation on the management of the burden of ischemic heart disease and the implementation of alternative revascularization procedures offer s a critical view on how healthcare organizations provide care to patients.

- This report analyses the magnitude and the variation of ischaemic coronary disease and its clinical management and treatment. To this end, the analysis is two-folded: it includes population exposure to burden of disease and to intensity of treatment, depending on their place of residence; but, it also examines quality of hospital care, by benchmarking providers' case fatality rates for patients with acute myocardial infarction (AMI) and for the procedures of election in those cases.
- Percutaneous Coronary Intervention (PCI, commonly known as coronary angioplasty) and Coronary Artery Bypass Graft (CABG) are effective and safe revascularization procedures that have improved survival and quality of life in the last decades. By and large, PCI has been proven to be a better option at reducing the risk of death, especially when there are few blocked/affected blood vessels; and particularly, primary PCI supersedes any other alternative. Nevertheless, CABG is still considered more effective when dealing with multivessel disease (3 or more vessels implied).
- In the geographical approach, the mismatching between patterns of burden of coronary ischaemic disease (CID) and intensity of use of revascularization procedures is examined; previous evidence shows that populations living in certain geographic areas are less exposed to revascularisation interventions than residents in other areas, regardless the burden of disease or the socioeconomic status of the area; this might signal over and under-exposure to this type of procedures.
    - In 2009, England had the highest CID admission rate among ECHO countries– 1 admission per 291 adult inhabitants, but the third highest PCI and CABG rate. English PCI rate is 30% bigger than the Portuguese, the country with the lowest rate; meanwhile, the CABG rate in England is up to 2.7 times higher than the Spanish.
    - In 2009, 141,167 CID admissions occurred in England, representing 1 admission per 311 English adult inhabitants. Differences between local authorities with extreme high and low rates of CID admissions reached 2.4-fold rate. Although systematic variation was just 8% above that

randomly expected, it was highly influenced- up to 29%- by the region (GOR) of reference.

- The same year, 63,220 PCI interventions and 20,434 CABG surgeries were performed. Variation observed in both interventions was quite similar: the ratio across local authorities with extremes rates was around 2.5-fold and variation not deemed random was 8% above that expected for PCI and 7% for CABG. Even the region effect was comparable, despite being a bit higher in CABG, 11% versus 7% in PCI.

- Some positive correlation between CID admissions (considering CID admission as a proxy for burden of coronary disease) and PCI procedures was found in North East region. South East and East of England regions on the other hand, showed a certain negative relationship. In turn, London residents, standing the highest PCI rates do not bear significantly more risk of CID.

- CABG utilisation correlated even less than PCI with burden of disease at LA level. A coincidental pattern was found in North West and South East. In Yorkshire, East Midlands, East of England and South West regions CABG intensity of use and the risk of CID hospitalisation was inversely related.

- Comparing the relative risk of exposure to PCI and CABG, at regional level, Yorkshire, East Midlands and East of England have less exposure than expected to both procedures, while residents in London region showed higher exposure to both interventions. Thus, no substitution between revascularisations procedures seems to have occurred in these regions. North West region behaviour, on the other hand, denotes a certain pattern, where CABG may be the preferred revascularisation alternative as residents bear risk below average of undergoing PCI, but more risk than the national average of having CABG.

- From 2002 to 2009, coronary ischaemic disease admissions decreased by 18%, from 1 admission per 234 to 1 admission per 284 adult inhabitants. Of these hospitalisations, those corresponding to AMI declined by 10%.

- In the same period, PCI utilisation have doubled its rates while CABG rate decreased by 11%. The low and stable systematic variation observed for both interventions pointed out a homogeneous exposure to them across the territory. There is no a clear interaction pattern between the two revascularisation options, since CABG rates hardly decreased despite PCI having doubled theirs.

- From 2002 to 2009, significant more CID admissions occurred in the most deprived local authorities than in wealthier ones. Besides, less affluent areas also showed significantly higher PCI and CABG utilisation rates than those better-off.

- It is worth noting that PCI utilisation has increased in all wealth levels, meanwhile CABG utilisation have decreased in the most deprived local authorities, and remained stable in wealthier ones. Since, worse-off areas bear more CID admissions; we could expect higher need for health care than high income areas. Thus, it would be advisable further detailed analysis to understand implications for equity in access to revascularisation procedures

- On the other hand, when performing the analysis on provider basis, different meso and micromanagement approaches towards the cardiovascular ischaemic disease could explain an important part of the *unwarranted variation in outcomes*, not expected by chance. Differences in the risk-adjusted case fatality rates (CFR) after both revascularisation procedures are still noticeable, with considerable variation across hospitals, where "volume" (number of interventions carried out) has been argued as a plausible factor of these differences.

    - English Risk-adjusted CFR for AMI, in 2009, was 94.41 per 1,000 patients aged 18 and older; the second lowest rate, almost 5 per thousand points below the ECHO average. In terms of exposure, only 8% of all English AMI patients were treated at poor performing hospitals –the second lowest share of patients among ECHO countries. On the other hand, 34.25% of AMI patients were admitted to hospitals flagged as "good" or even "excellent" performers –also the second lowest proportion, below the ECHO average.

    - Regarding the revascularisation procedures, in-hospital mortality after PCI in England, in 2009, was 13.7 per 1,000 patients aged 40 and older, the lowest among ECHO countries, 6 per thousand points below ECHO average. Besides, only 3.35% of patients undergoing a PCI were treated at "alarm" performer hospitals (the lowest proportion among ECHO countries), while 36% of patients were intervened at hospitals pointed out as "good performers" (the highest share for this procedure among ECHO countries).

    - The risk-adjusted CFR after CABG surgery in England, in 2009, was also by far the lowest among ECHO countries -27.8 per 1,000 patients aged 40 and older, almost half the ECHO's average rate. Besides, all English hospitals were labelled not only as high volume (above 250 procedures per year) but also showed the highest share of activity per centre among hospitals in all ECHO countries. In addition, 86.4% of patients were intervened at "*good/excellent performers*" hospitals, again by far the highest share among ECHO countries.

II. INTERNATIONAL COMPARISON

The cross-country comparison of the geographical distribution of population exposure to burden of disease and to intensity of use of procedures provides the basis for flagging situations of over and under-use of revascularisation.

The benchmarking of hospitals' case fatality rates adds a dimension of quality and safety of the care provided and its variation within each country.

Accounting for specific organisation features, the international comparison provides a wider perspective, boosting assessment beyond national inertias.

This chapter offers a view as to how England behaves compared to the other ECHO countries when it comes to ischaemic coronary disease and its clinical management and treatment. To this end, the analysis is two-folded:

a. Geographic approach: it compares the population burden of disease and the exposure to intensity of treatment, depending on the place of residence (both the magnitude and the within-country variation);

b. Hospital approach: it examines the quality of hospital care in terms of their case fatality rates for patients with acute myocardial infarction (AMI) and for the procedures of election in those cases. These outcomes are used to benchmark all hospitals across ECHO, providing a view of where English hospitals' outcomes seat compared to those in the other ECHO countries.

a. Geographic approach

This section offers a rough picture of the incidence of coronary ischaemic disease (CID) and AMI admissions taken as a proxy of burden of coronary disease; it also examines the intensity of use of the alternative revascularization procedures in England compared to what happens at the other ECHO countries.

The geographic approach is focused on population exposure. The key question for analysis is how the risk of coronary disease and access to revascularisation procedures correlate, depending on the place where individuals live.

All through this section paired dot plots are used to show results. The chart on the right is always intended to give the reader a sense of the magnitude of burden of disease or utilisation of revascularisation procedures in each country; the image on the left provides an idea of the actual variation comparable across countries. Note that each dot represents the relevant health care geographic unit in each country.

Coronary Ischaemic Disease (CID)

In 2009, England has the highest CID admission rate among ECHO countries– 1 admission per 291 adult inhabitants. That means almost 2-fold difference in relation to Portugal, the country with the lowest rate (see table 1 in appendix 1.a).

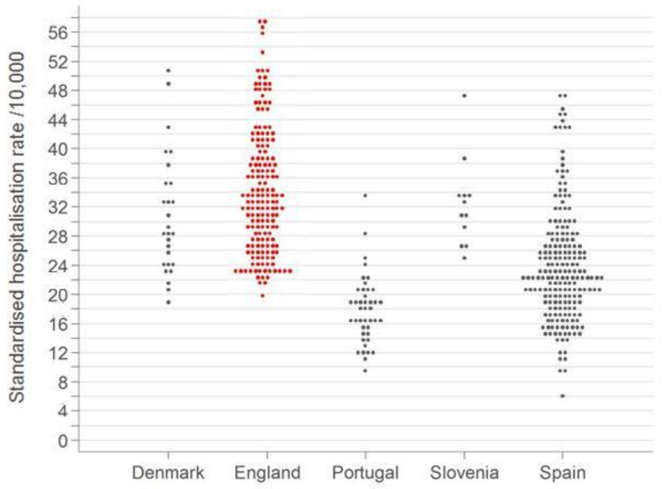

Figure 1.a. Age-sex standardised hospitalisation rates of CID per 10,000 inhabitants (natural scale to compare actual rates). Year 2009

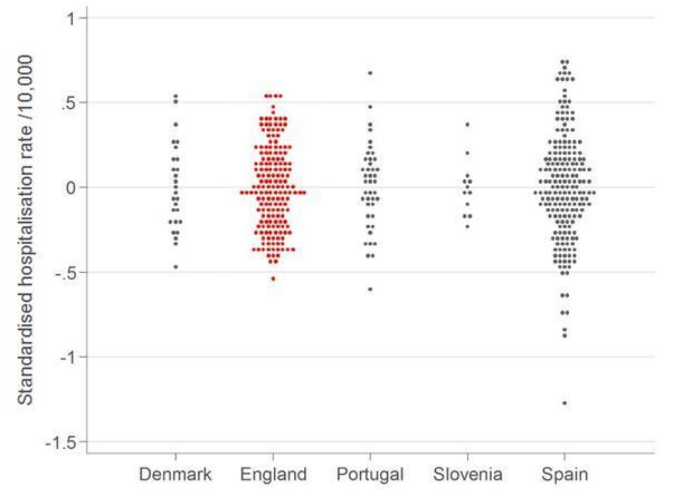

Figure 1.b. Age-sex standardised hospitalisation rates of CID per 10,000 inhabitants (normalised scale to compare degree of variation). Year 2009

** Each dot represents the relevant healthcare administrative area in each ECHO country (Local Authorities for England). The y-axis charts the administrative areas standardised rate per 10,000 inhabitants (+18 age). The figure is built over the total amount of CID hospitalisations in 2009 in ECHO countries. In Figure 1b admission rates have been normalised to ease comparison of the degree of variation across countries*

Similar ratios between areas with extreme rates are detected in England, Denmark, Slovenia and Portugal: residents in areas with the highest rates have around twice the probability of CID admission to a hospital than those living in areas with the lowest. In Spain the ratio increases to more than 3 times. Although England shows the highest variation not deemed random, 24% beyond that expected, values are moderate/low in all countries, ranging from 9% (Slovenia) to 24% (England).

Acute Myocardial Infarction (AMI)

AMI admission rate in England is the second highest among ECHO countries, 1 hospitalisation per 597 adults, but quite similar to Denmark, Portugal and Spain. Slovenia stands out showing the highest rate, 1 admission per 449 adult inhabitants.

Differences between areas with extreme rates of AMI hospitalisations are around 2 fold In all ECHO countries.

The part of the observed variation not amenable to chance is low, except in Slovenia where it reaches 34% above that expected. In England 15% of variation exceeds what could be randomly expected (see table 2 in appendix 1.a).

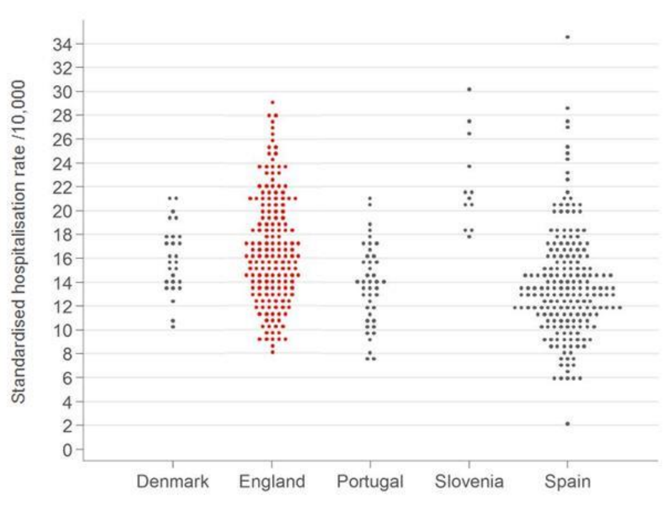

Figure 2.a. Age-sex standardised hospitalisation rates of AMI per 10,000 inhabitants (natural scale to compare actual rates). Year 2009

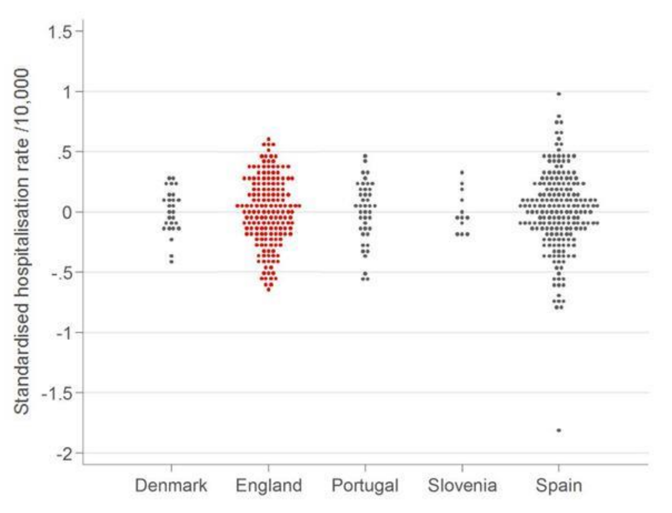

Figure 2.b. Age-sex standardised hospitalisation rates of AMI per 10,000 inhabitants (normalised scale to compare degree of variation). Year 2009

** Each dot represents the relevant healthcare administrative area in each ECHO country (Local Authorities for England). The y-axis charts the administrative area standardised rate per 10,000 inhabitants (+18 age). The figure is built over the total amount of AMI hospitalisations held in 2009 in the ECHO countries. In Figure 2b admission rates have been normalised to ease comparison of the degree of variation across countries*

Percutaneous Coronary Interventions (PCI)

England shows the third highest PCI rate among ECHO countries, 1 admission per 368 inhabitants aged 40 or older. This rate is 30% bigger than the one found in Portugal, the country with the lowest rate. The ratio between the highest and lowest PCI rate found at local level is similar in England, Denmark, Portugal and Slovenia: ranging from 1.9 to 2.6 folded chance of undergoing a PCI intervention for residents in those areas with the highest rates. In Spain this ratio is close to 5, pointing out acute differences in PCI utilisation across the Spanish territory.

In this case, systematic variation ranges from just 8% above that expected by chance in England and Portugal to 1.8 times greater than expected in Slovenia (see table 3 in appendix 1.a).

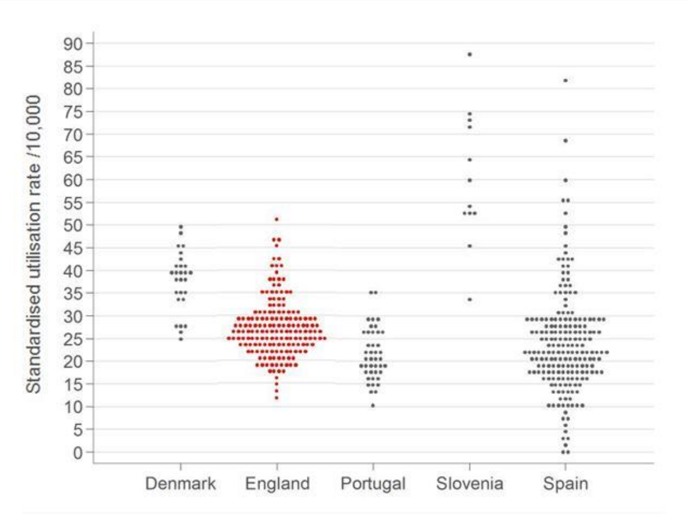

Figure 3.a. Age-sex standardised utilisation rates in PCI per 10,000 inhabitants (natural scale to compare actual rates).
Year 2009

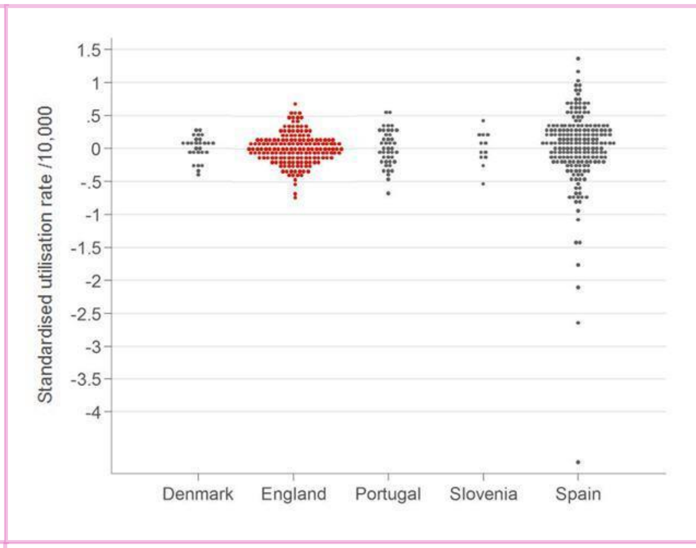

Figure 3.b. Age-sex standardised utilisation rates in PCI per 10,000 inhabitants (normalised scale to compare degree of variation).
Year 2009

** Each dot represents the relevant healthcare administrative area in each ECHO country (Local Authorities for England). The y-axis charts the administrative areas' standardised rate per 10,000 inhabitants (+40 age). The figure is built over the total amount of PCI procedures held in 2009 in the ECHO countries. In Figure 3b intervention rates have been normalised to ease comparison of the degree of variation across countries*

Coronary Artery Bypass Grafting (CABG)

England has the third CABG rate among ECHO countries – 1 admission per 1,111 inhabitants aged 40 or older. That represents 2.7-fold utilisation compared to Spain, the country with the lowest rate.

Conversely, the ratio between the highest and lowest CABG rate found at local level is close to the Danish ratio and quite low compared to the other countries: just 2.3 folded chance of undergoing a CABG intervention for residents in those local authorities with the highest rates. In Spain, depending on their area of residence, populations stand almost 10 times more probability of getting a CABG procedure.

The systematic part of this variation is high in all countries, going up to 41% above that randomly expected in England (see table 4 in appendix 1.a).

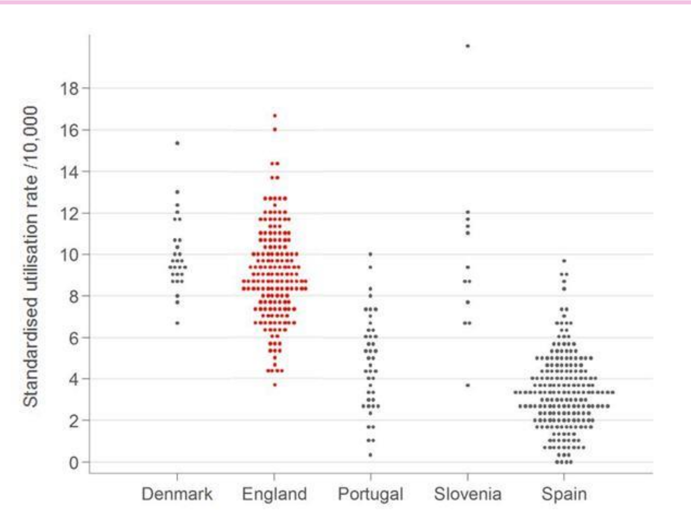

Figure 4.a. Age-sex standardised utilisation rates in CABG per 10,000 inhabitants (natural scale to compare actual rates). Year 2009

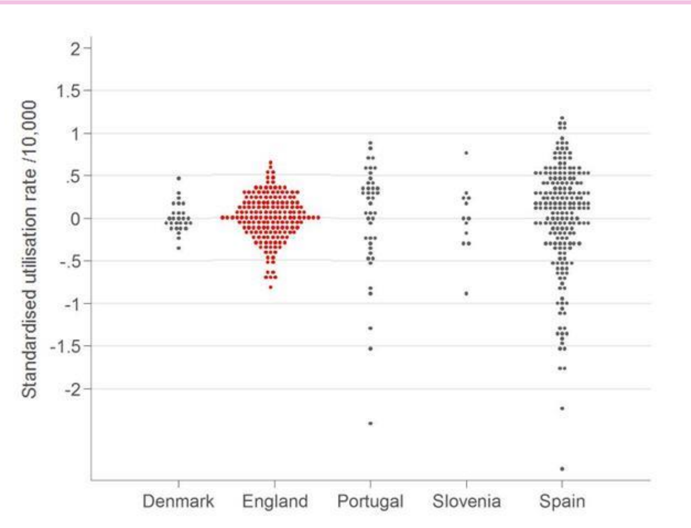

Figure 4.b. Age-sex standardised utilisation rates in CABG per 10,000 inhabitants (normalised scale to compare degree of variation). Year 2009

** Each dot represents the relevant healthcare administrative area in each ECHO country (Local Authorities for England). The y-axis charts the administrative area standardised rate per 10,000 inhabitants (+40 age). The figure is built over the total amount of CABG interventions held in 2009 in the ECHO countries.. In Figure 4b intervention rates have been normalised to ease comparison of the degree of variation across countries.*

b. Hospital approach

Different healthcare systems across Europe, with different organizational features, might obtain different outcomes in dealing with ischaemic coronary disease. Comparing the outcomes across individual hospitals in each country provides insights as to where intervention might be targeted to improve case fatality rate for patients with coronary conditions.

It also allows for a comparison of national patterns of hospital behaviour (minimum volume of cases, discharging policies …) drawing useful lessons.

Through this section, analysis will focus on providers, benchmarking for 3 quality outcome indicators. Two insights to retain: the actual value of the hospital case-fatality rate (CFR), and the relative position compared to the ECHO benchmark and its confidence interval limits (95 and 99% levels) built into a funnel plot. This relative position allows for an assessment of the hospital performance as average, good, excellent, alarm and alert.

ECHO benchmark is built as the expected average behaviour, using data from all hospitals in the 5 countries analysed (multilevel regression modelling). All CFR are Risk-adjusted for sex, age, severity of the underlying condition and co-morbidity (Elixhauser index). This way, differences across providers should not be amenable to patient characteristics affecting their inherent probability of dying after admission or surgery (appendix 4 provides details as to the variables included in risk-adjustment).

Hospitals treating less than 30 patients or procedures/year have been excluded from the analysis in order to avoid noise when modelling (table 5, appendix 1.b, details the number of hospitals, per indicator, excluded under this criterion and its percentage of treated patients). In fact, the amount of interventions held at each hospital, or so called "volume", is one of the significant explanatory variables when analysing the risk-adjusted CFR; therefore, it has been argued as a plausible factor underpinning the observed differences in rates across hospitals. The threshold for high and low volume hospitals has been empirically set at 250 patients or procedures/year.

Funnel plots enable the assessment of individual hospital performance against the international benchmark. Each hospital (dot) is charted by its risk-adjusted case fatality rate and the volume of patients or procedures in a year. The benchmark is built on the ECHO hospitals average CFR (risk-adjusted) and its 95% and 99% CIs. The solid grey line represents the ECHO CFR, while red lines correspond to the 95% confidence interval control limits and the dashed blue lines to the 99% limits. Those thresholds represent the boundary between *expected* variation in outcomes (not significantly different from average) and *significant variation*. Hospital outcomes laying beyond the upper thresholds flag hospitals as poorer performers (in the alert or alarm position); outcomes below the bottom limits signal hospitals as good or excellent performers. Whichever the direction, outliers warrant further investigation and analysis to identify underlying factors and either tackle them or use as examples of good practice.

In-hospital mortality in Acute Myocardial Infarction (AMI).

In-hospital risk-adjusted CFR per 1,000 AMI patients (urgent admission in patients 18 and older) is a widely used indicator of the quality and safety of the care provided in a hospital.

In 2009 at the ECHO countries, 146,859 hospital admissions in patients 18 and older were flagged as Acute Myocardial infarctions. From those, 12,582 passed away. After risk-adjusting modelling, these figures place the ECHO average CFR at 99.03 per 1,000 hospitalised patients, which means that 1 in 10 AMI admissions resulted in dead.

The total number of ECHO hospitals analysed is 435; 55% of them, flagged as *high volume* hospitals (more than 250 AMI patients in a year), took care of 82.5% of the total AMI hospitalised patients (see tables 5 and 6 in appendix 1.b).

Regarding the English hospitals, 125 out of 149 centres were *high volume* in 2009, and took care of 94% of all AMI hospitalised patients; this is the largest share of AMI patients treated at high volume hospitals among the ECHO countries.

On the other hand, 15 out of the 149 centres were flagged as “alert” or “alarm” performers. In terms of exposure, almost 8% of all AMI patients were treated at those “alert”/ “alarm” hospitals -still, the second smallest percentage among all ECHO countries. Nevertheless, it is also true that 34.25% of all AMI patients were admitted to hospitals placed as “good” or even “excellent performance”. (see table 6, appendix 1.b, for further details).

Figure 5 shows the risk-adjusted CFR in each of the ECHO hospitals, drawing their relative position to the ECHO benchmark in a funnel plot.

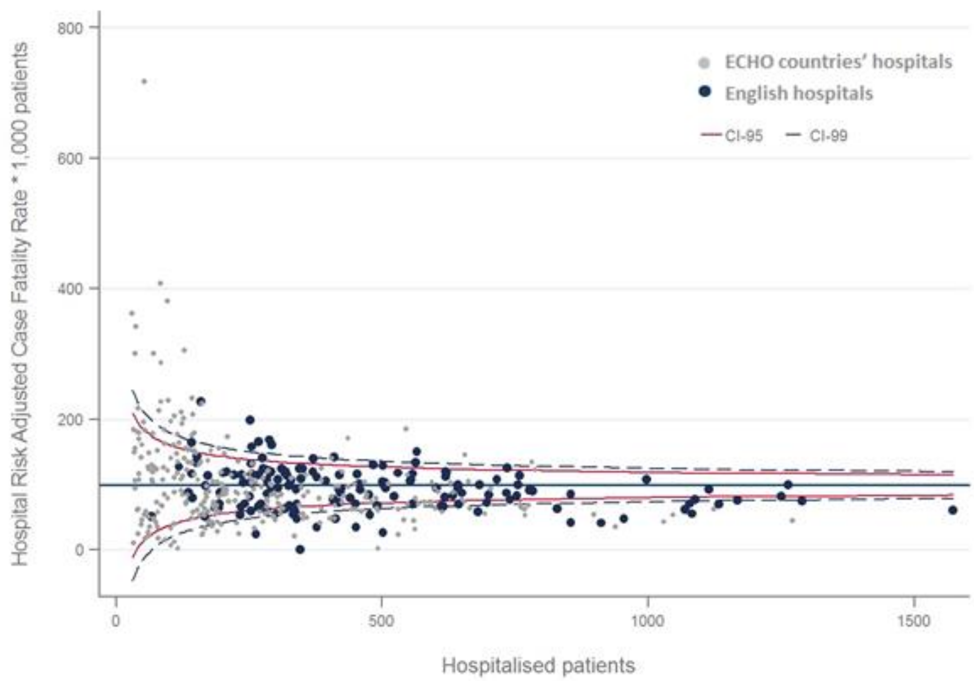

Figure 5. In-hospital case fatality rate for AMI admissions across hospitals in ECHO countries. Year 2009.

** Each dot represents one of the ECHO hospitals that treated more than 30 AMI cases in that year. The expected number of deceases per 1,000 hospitalised patients is built on the average across ECHO hospitals.*

Outcomes shown in the funnel indicate a rather good performance, where 66% of hospitals are at the average position indicating a risk-adjusted in-hospital mortality not significantly different from ECHO benchmark.

In the ECHO framework, an important issue to consider is the variation in outcomes among hospitals, depending on the volume of AMI patients treated. Most of hospitals flagged as alarm and alert are lower activity hospitals, even though this pattern does not show so clearly in England as in other ECHO countries, becomes low volume hospitals are rare.

In-hospital mortality after Percutaneous Coronary Intervention (PCI)

In 2009, 132,737 patients 40 and older underwent PCI procedure at one of the ECHO countries hospitals. 2,623 of them passed away, that is, 1 in each 51 intervened patients. These figures leave the ECHO risk-adjusted CFR at 19.86 per 1,000 patients (+40) undergoing PCI procedure. That year, England had by far the smallest risk-adjusted CFR, 6.2 per thousand points below ECHO benchmark. Within the ECHO framework, 80% of the hospitals performing PCI procedures were *high volume* and took care of 95.44% of patients undergoing that procedure. In England that figure reaches 97.2% (see tables 5 and 6 in appendix 1.b).

As shown in figure 6, English hospitals have rather good outcomes in performance according to ECHO benchmark. Clearly, the highest percentage in ECHO of patients undergoing PCI treated at good or excellent performing hospitals (36%). In this particular case, unlike what is generally observed and, thus, expected, volume does not seem to have an impact in outcomes (only one of the lower volume centres was flagged as poorer performer). Actually, only 3.35% of English patients undergoing coronary angioplasty were treated at alarm/alert hospitals, the smallest percentage across ECHO countries. (See table 7, appendix 1.b, for further details).

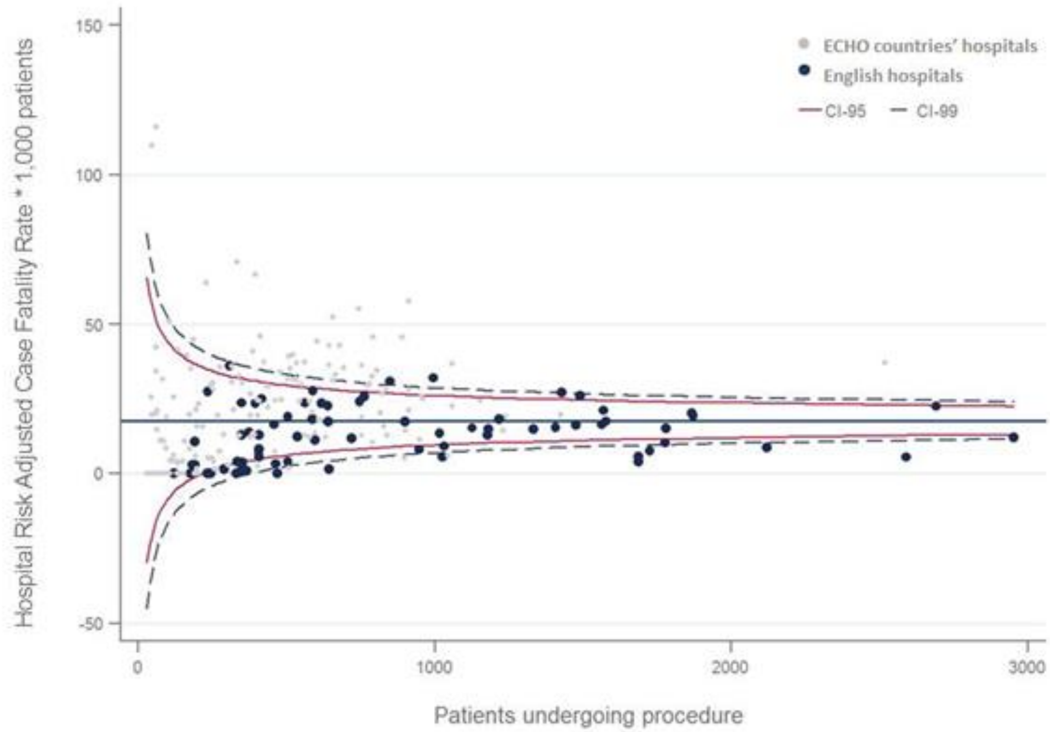

Figure 6. In-hospital case fatality rate after Percutaneous Coronary Intervention across hospitals in ECHO countries. Year 2009.

** Each dot represents one of the ECHO hospitals that performed more than 30 PCI in that year. The expected number of deceases per 1,000 hospitalised patients is built on the average across ECHO hospitals*

In-hospital mortality after Coronary Artery Bypass Graft (CABG)

In the 89 ECHO hospitals performing CABG surgery, 33,683 patients, aged 40 and older, were intervened in 2009 and almost 4% of them passed away. In terms of risk-adjusted CFR, this means 1 in 20 patients undergoing the procedure. More than half of those 89 centres was categorised as "high volume", and they took care of 82.16% of total CABG performed that year at ECHO countries.

It is also worth highlighting that 61.26% of all patients were treated at hospitals placed in the "*alert/alarm*" zone, versus the 5.61% treated at hospitals flagged as "*good/excellence performance*".

In this ECHO context, England shows a particularly different picture. The percentage of English patients undergoing CABG surgery treated at higher volume hospitals rises up to 100%. Only 29 of their hospitals perform CABG surgery and none of them was flagged as poor or less safe at performance while 83% were “good” or even “excellent”.

The scenario of the risk-adjusted case fatality rate after CABG shown in figure 7 placed England in 2009 at the highest level of performance. Compared to the ECHO benchmark, the English risk-adjusted CFR for CABG is the lowest, 22.52 per thousand points below the ECHO average and less than half of the Spanish one, the country with the highest rate.

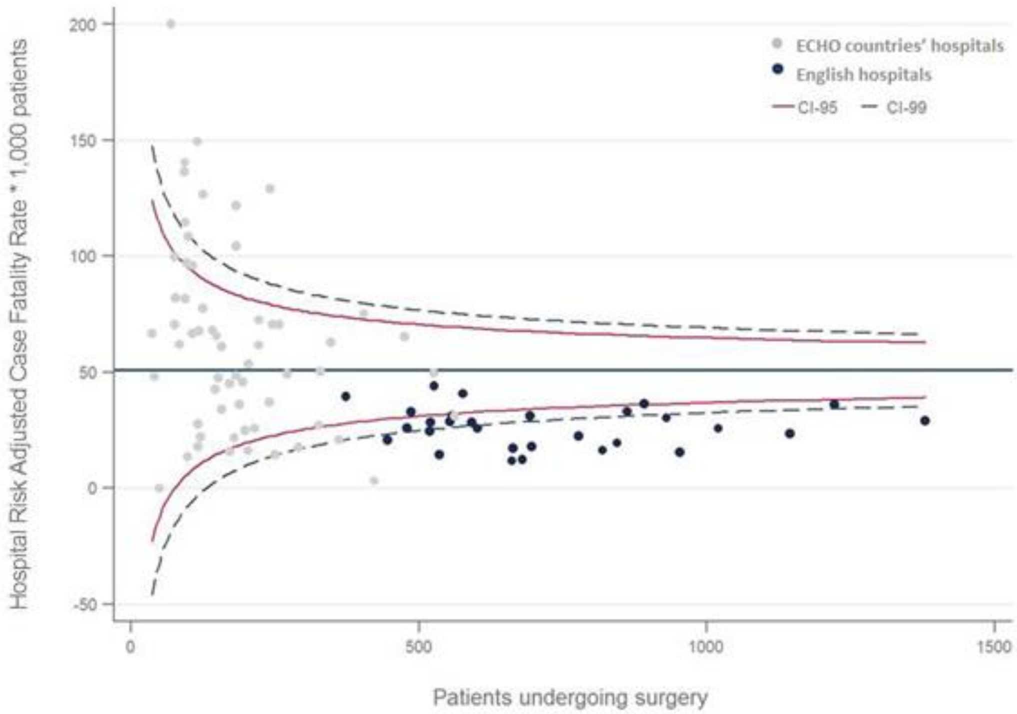

Figure 7. In-hospital case fatality rate after CABG across hospitals in ECHO countries. Year 2009.

** Each dot represents one of the ECHO hospitals that performed more than 30 BYPAS surgeries in that year. The expected number of deceases per 1,000 hospitalised patients is built on the average across ECHO hospitals*

III. IN COUNTRY VARIATION

CID admissions are considered a proxy of the burden of cardiovascular disease at a geographical level.

In the ECHO framework this indicator is used as "calibrator" and helps to interpret results about intensity of population exposure to revascularization options: coronary artery bypass graft and percutaneous coronary intervention.

At this section, the incidence of coronary ischaemic disease as well as the intensity of use of the alternative revascularization procedures performed in England will be analysed from an internal perspective, comparing what happens at the different health care relevant administrative areas (geographic approach) or hospitals (providers approach) within the country.

Following the same structure as the previous chapter, the analysis is two-folded:

a. Geographic approach: it compares the population burden of disease and the exposure to intensity of treatment, depending on the place of residence (both the magnitude and the within-country variation) across local authorities and regions;

b. Hospital approach: it examines the quality of hospital care in terms of their case fatality rates for patients with acute myocardial infarction (AMI) and for the procedures of election in those cases. These outcomes are used to benchmark individual English hospitals

a. Geographic approach

The magnitude and the variation in coronary condition and/or revascularization procedures across the country will be mapped out following two health relevant administrative tiers: 326 local authorities and 9 regions (Government Offices for Regions-GORs). While local authorities would represent local provision of care, regions are used as a surrogate for regional policies affecting all the local authorities within.

Coronary Ischaemic Disease admissions (CID)

In 2009, 141,167 CID admissions occurred in England, which means 1 admission per 311 English adult inhabitants.

Differences in CID admissions between local authorities with extreme high and low rates reached 2.4-fold difference. Although systematic variation was just 8% above that randomly expected, it was highly influenced- up to 29%- by the region where the local authority belongs (see tables 9 and 10 at the appendix 2.a).

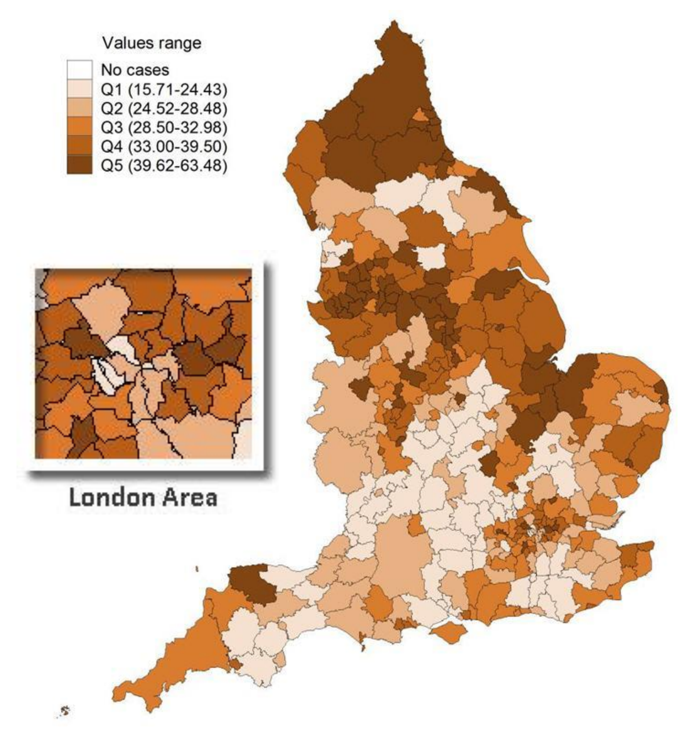

Figure 8. Age-sex standardised CID hospitalisation rate per 10,000 inhabitants by Local Authorities. Year 2009

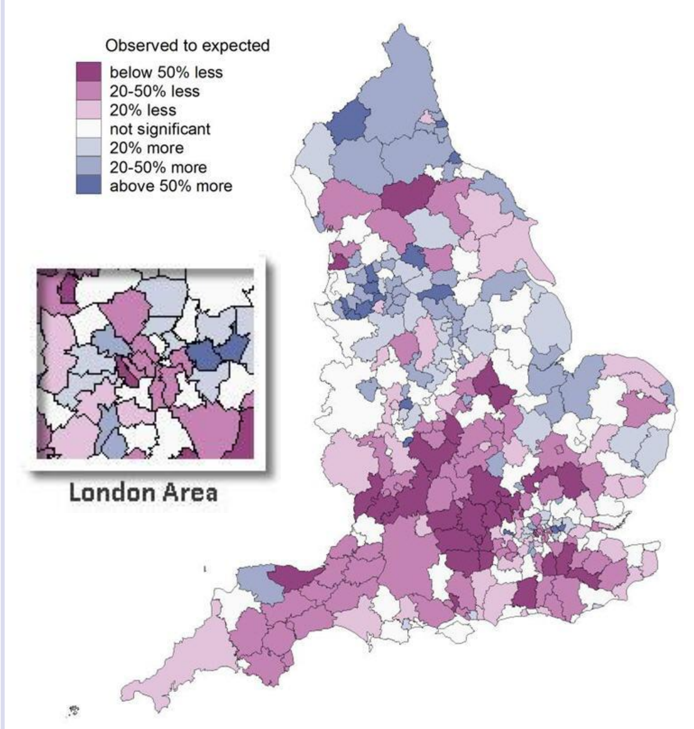

Figure 9. CID Admission Ratio *observed/expected* by Local Authorities. Year 2009

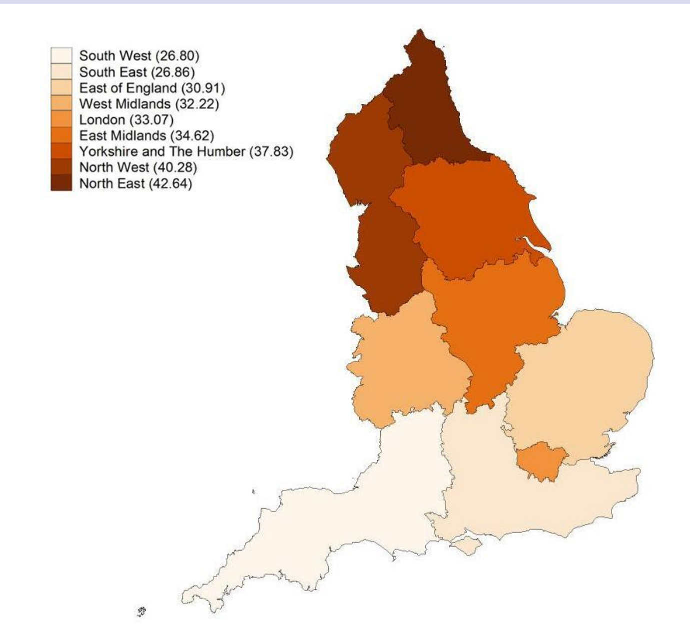

Figure 10. Age-sex standardised CID hospitalisation rate per 10,000 inhabitants by regions. Year 2009

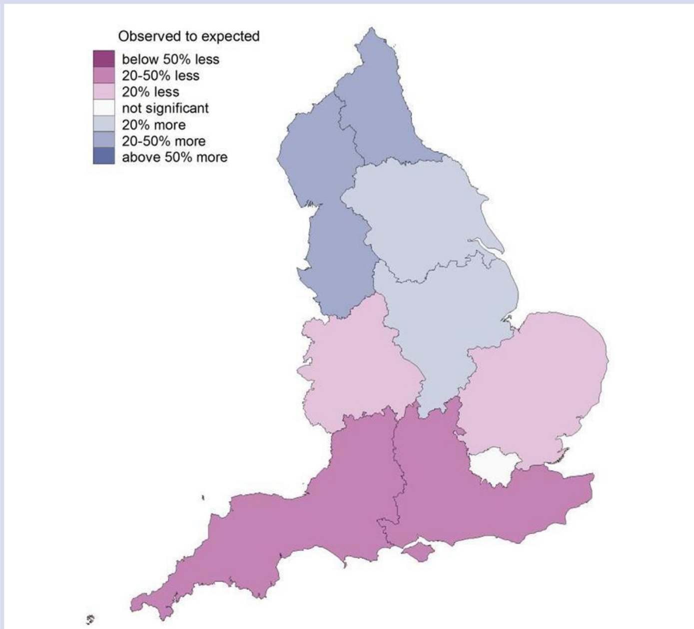

Figure 11. CID Admission Ratio *observed/expected* by regions. Year 2009

** Maps on the left (standardised rates) merely represent the amount of admissions flagged as CID admissions -the darker the colour, the higher the amount of admissions (always per 10,000 adult inhabitants). Areas are clustered into 5 quintiles according to their rate value (Q1 to Q5). –legend within the maps provides the range of standardised rates within each quintile. Maps on the right represent relative risk of hospitalization at each area using as a proxy the ratio observed to expected number of CID hospitalisations. Population living at areas with values above 1 (bluish) mean to be overexposed to risk of CID hospitalisation; population at areas with a ratio below 1 (pink) mean to be underexposed to risk of CID hospitalisation.*

Local authorities with high CID admission rates are found in the northern half of England (figure 8). Residents in most of these areas bear at least 20% more risk of CID admission than national average (bluish areas in figure 9). On the contrary local authorities with low rates, where residents have lower risk of CID hospitalisations are found in the southern part of the country.

At regional level, residents in North East, North West, Yorkshire and East Midlands bear more risk of undergoing CID hospitalisation than national average. In turn, population living in South West, South East, East of England and West Midlands has at least 20% less risk than average. Residents in London region stand an average risk of admissions (figure 11).

Percutaneous Coronary Interventions (PCI) compared to burden of Coronary Ischaemic Disease (CID).

During 2009, 63,220 PCI interventions were performed in England - 1 procedure per 407 inhabitants aged 40 or older.

A 2.5-fold difference in exposure to the procedure was found between local authorities with extreme rates. Systematic variation was 8% above that randomly expected, and regions explain only 7% of it, which may suggest that local authorities are the main drivers of variation in this procedure (see tables 9 and 10 in appendix 2.a).

There was no clear geographical pattern for PCI utilisation, may be some concentration of local authorities with higher rates in the south-central part of the country (figure 12).

One could expect some overlapping between intensity of PCI utilisation and risk of CID admission, considering CID admission as a proxy of burden of coronary disease. That correlation was detected in North East region (high PCI rates and population enduring higher risk than average of CID admission) and in South East and East of England (low PCI rates and risk of CID admission lower than expected). In turn, residents in London, where the highest PCI rate was found, do not bear significantly more risk of CID admission (figures 14 and 15).

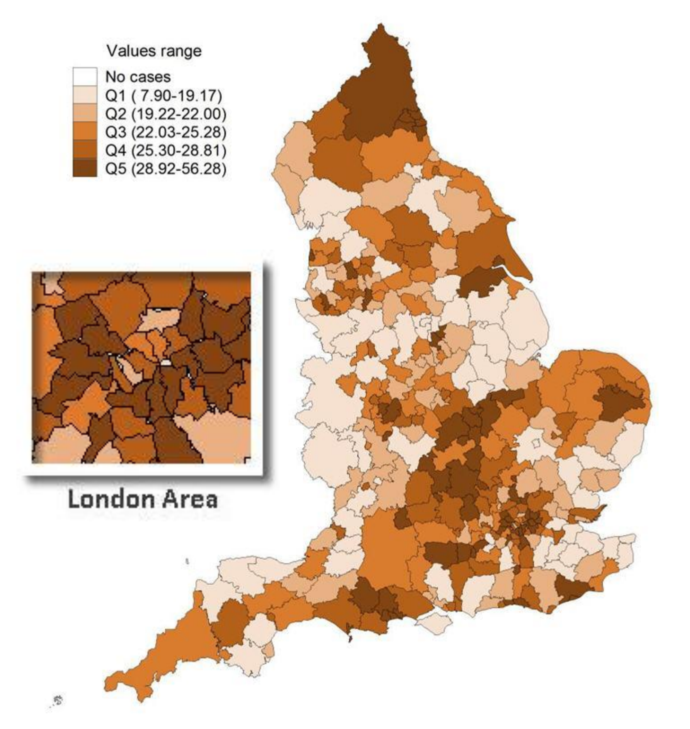

Figure 12. Age-sex standardised PCI utilisation rate per 10,000 inhabitants by Local Authorities. Year 2009

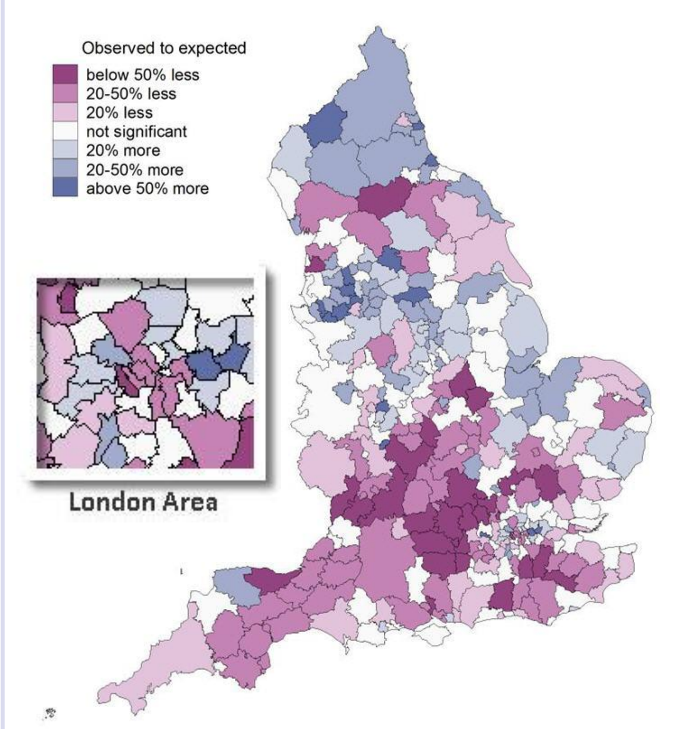

Figure 13. CID Admissions Ratio *observed/expected* by Local Authorities. Year 2009

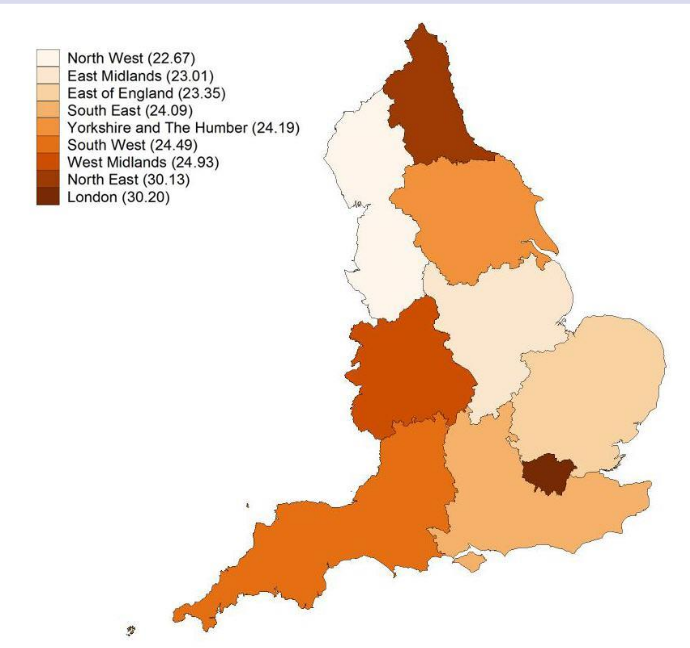

Figure 14. Age-sex standardised PCI utilisation rate per 10,000 inhabitants by regions. Year 2009

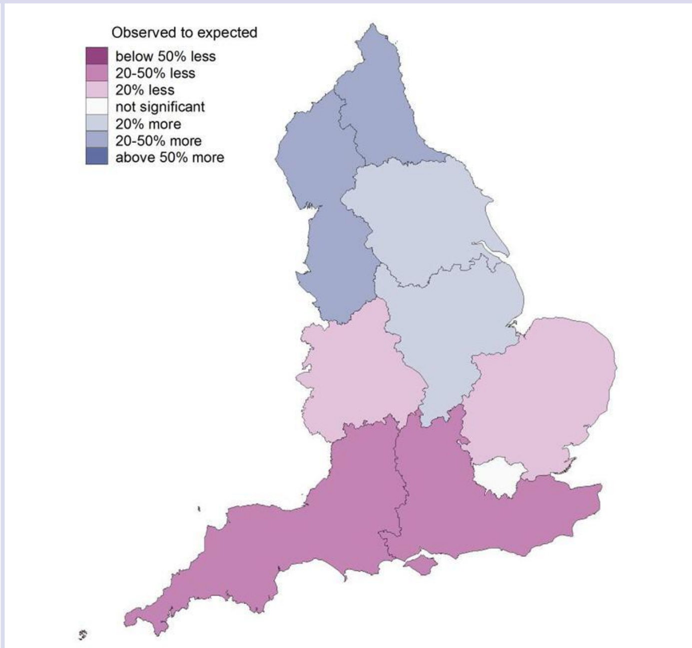

Figure 15. CID Admissions Ratio *observed/expected* by regions. Year 2009

** Maps on the left (standardised rates) merely represent the amount of procedures flagged as Percutaneous Coronary Intervention -the darker the colour, the higher the amount of procedures performed, per 10,000 inhabitants over 40 years old. Areas are clustered into 5 quintiles according to their rate value (Q1 to Q5). –legend within the maps provides the range of standardised rates within each quintile. Maps on the right represent relative risk of hospitalization at each area using as a proxy the ratio observed to expected number of CID hospitalisations. Population living at areas with values above 1 (bluish) mean to be overexposed to risk of Cardiovascular hospitalisation; population at areas with a ratio below 1 (pink) mean to be underexposed to risk of Cardiovascular hospitalisation.*

Coronary Artery Bypass Graft (CABG) compared to burden of Coronary Ischaemic Disease (CID).

Along 2009, 20,434 CABG procedures were performed in England, which represents 1 surgery per 1,248 inhabitants aged 40 or older.

The ratio across local authorities with extreme rates reached 2.7-fold difference and 7% of this variation could not be deemed random. As described for PCI utilisation, variation in CABG surgery is poorly explained by regions, just 11% of the observed variation could be related to the region where the local authority belongs (see tables 9 and 10 in appendix 2.a).

Again, there was no clear geographical distribution of CABG utilisation. Local authorities with high CABG rates were found in south-eastern and north western parts of the country. In this case, there was no clear shared pattern for CABG intensity and CID admission risk. At local level there was some correlation in a few local authorities (figure 16 and 17). Zooming out at regional level, intensity of CABG use and the risk of CID hospitalisation seem inversely related in Yorkshire, East Midlands, East of England and South West regions. In turn, there was some positive correlation in North West and South East regions, high CABG rates with high risk of CID admissions in the first case, and low CABG rates with less relative CID admission risk in the second (figures 18 and 19).

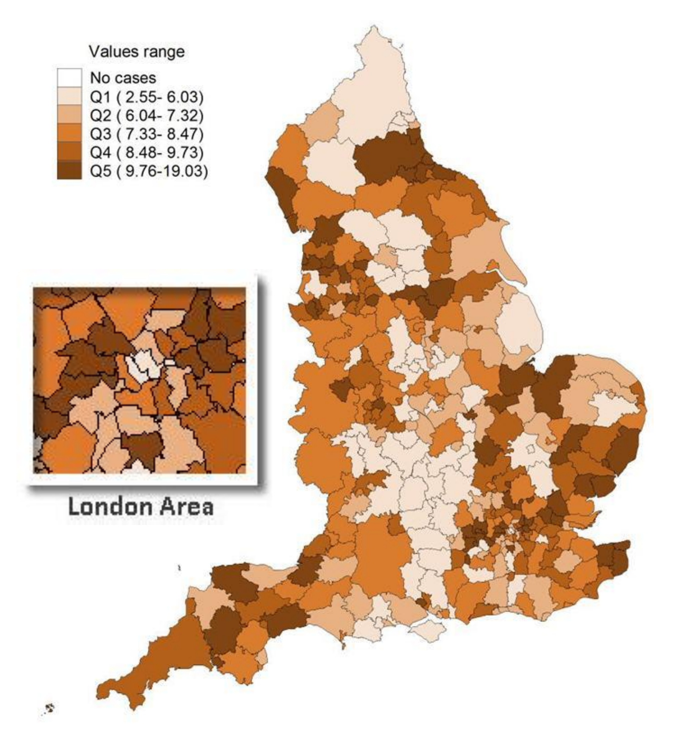

Figure 16. Age-sex standardised CABG utilisation rate per 10,000 inhabitants by Local Authorities. Year 2009

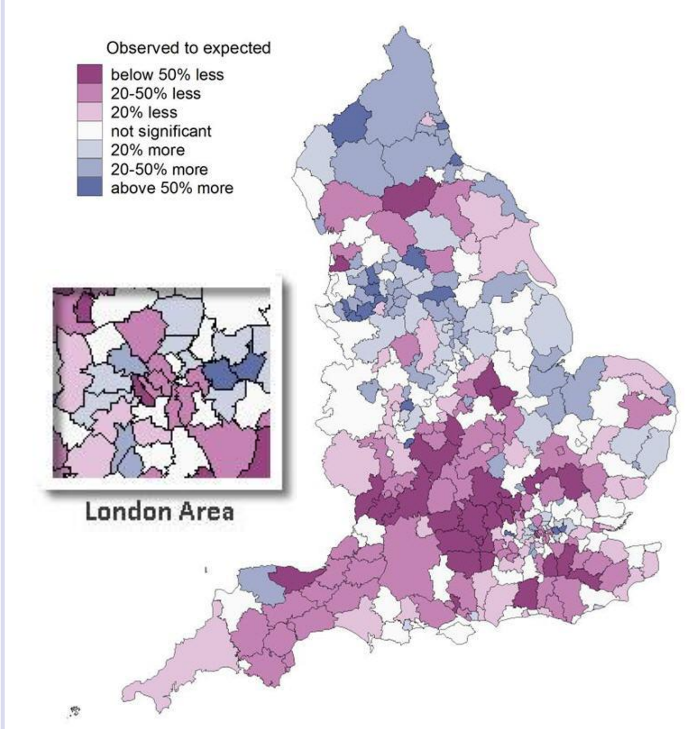

Figure 17. CID Admissions Ratio *observed/expected* by Local Authorities. Year 2009

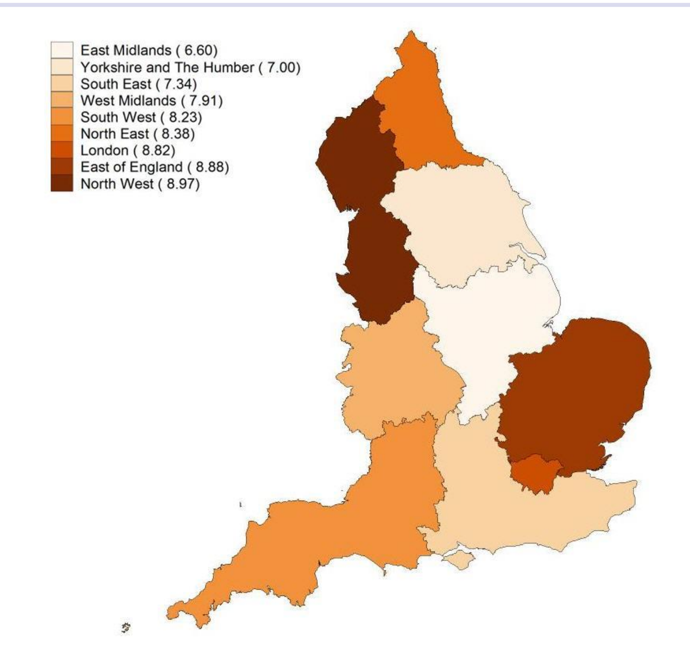

Figure 18. Age-sex standardised CABG utilisation rate per 10,000 inhabitants by regions. Year 2009

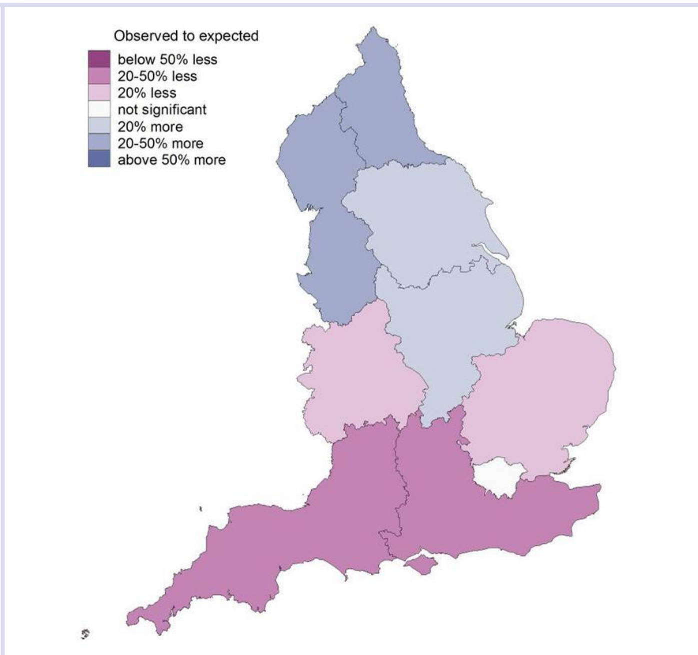

Figure 19. CID Admissions Ratio *observed/expected* by regions. Year 2009

** Maps on the left (standardised rates) merely represent the amount of procedures flagged as Coronary Artery Bypass Graft -the darker the colour, the higher the amount of surgeries performed, per 10,000 inhabitants over 40 years old. Areas are clustered into 5 quintiles according to their rate value (Q1 to Q5). –legend within the maps provides the range of standardised rates within each quintile. Maps on the right represent relative risk of hospitalization at each area using as a proxy the ratio observed to expected number of CID hospitalisations. Population living at areas with values above 1 (bluish) mean to be overexposed to risk of Cardiovascular hospitalisation; population at areas with a ratio below 1 (pink) mean to be underexposed to risk of Cardiovascular hospitalisation).*

Percutaneous Coronary Interventions (PCI) vs. Coronary Artery Bypass Graft (CABG).

PCI and CABG are effective and safe revascularization procedures that have improved survival and quality of life in the last decades. PCI has been proven to be the best option at reducing the risk of death, mostly when the number of affected blood vessels is low (in fact, primary PCI has superseded any other alternative); however, CABG is still considered more effective when dealing with multivessel disease (3 or more vessels implied).

To a certain extent these procedures could be acting as two interventions with different clinical indications, or, alternatively, as “substitute” approaches to the same clinical condition. Therefore, considering together their patterns of utilisation may shed some light as to how populations are being served. Trends in the same direction for both procedures may discard the “substitution” hypothesis; opposed patterns, on the other hand, may suggest a certain degree of compensation across procedures.

Another hypothesis that may contribute to explain how utilisation of each procedure relates to the other, lays on the fact that greater exposure to PCI may lead to lower need for CABG by effectively diminishing the population probability of disease progressing to the multivessel stage –which is the primary indication for CABG. Under this hypothesis, sustained high levels of PCI intensity would lead to a decrease in CABG utilisation, and may be also lowering the CID/AMI admission rate.

Comparing the relative risk of exposure to both interventions, in a few local authorities exposure is above the expected for the two procedures, and in others, PCI exposure below expectation coexisted with under exposure to CABG. At regional level, Yorkshire, East Midlands and East of England stand less exposure than expected to both procedures, meanwhile residents in London region showed higher relative risk of undergoing both interventions. Thus, in those regions, substitution between revascularisation procedures does not seem to occur.

Conversely, a certain inverse relation or substitution between these two procedures could be observed in North West region, where residents’ exposure was below average for PCI and above for CABG. Thus, in this region CABG may be the preferred revascularisation alternative (figure 22-23). It is also possible that relative under-exposure to PCI could be increasing the proportion of severe cases and, thus, the need for CABG.

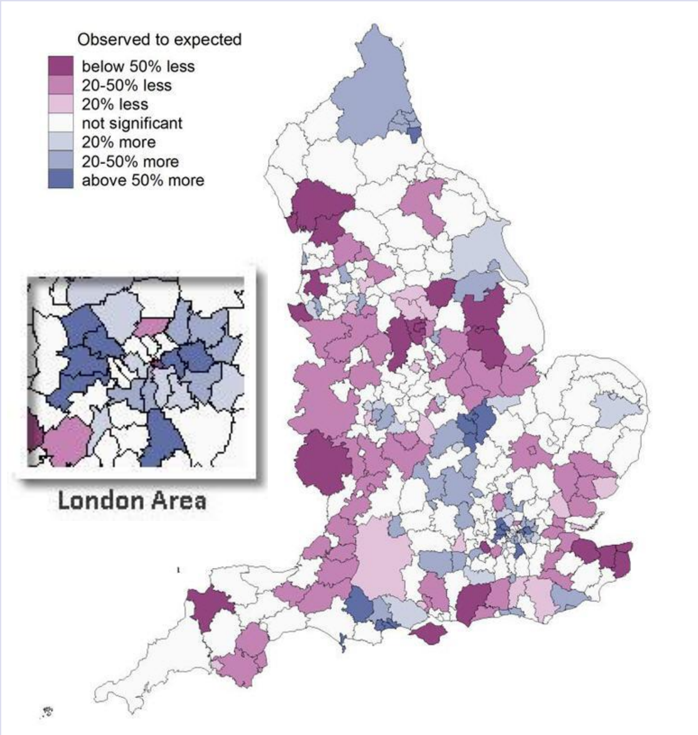

Figure 20. PCI utilisation ratio *observed/expected* by Local Authorities. Year 2009

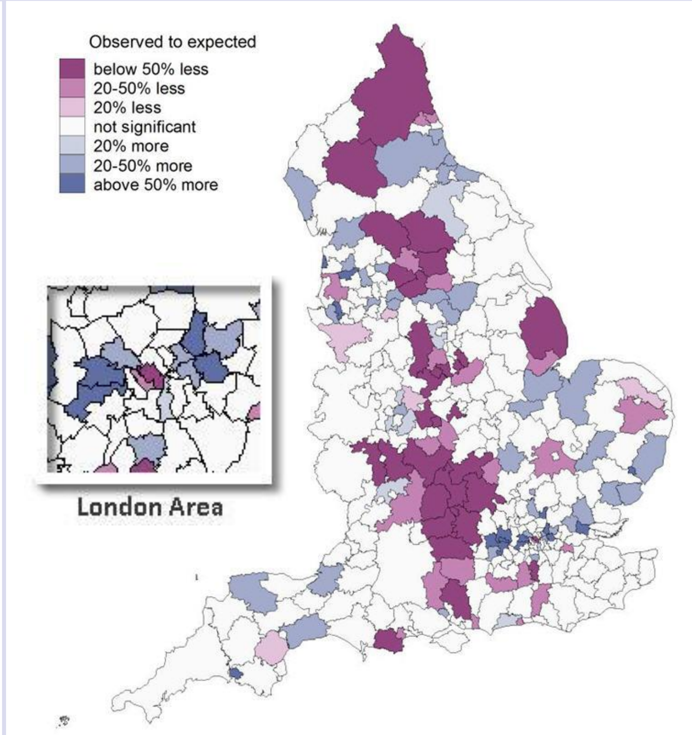

Figure 21. CABG utilisation ratio *observed/expected* by Local Authorities. Year 2009

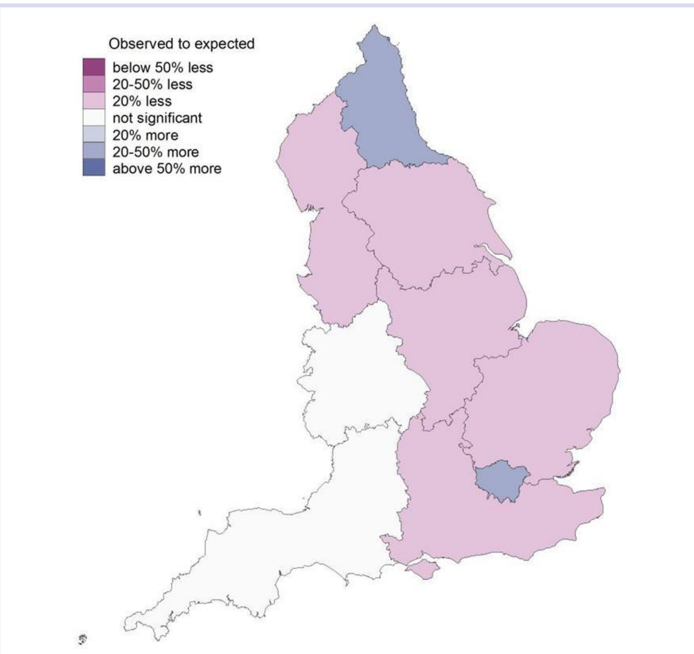

Figure 22. PCI utilisation ratio *observed/expected* by regions. Year 2009

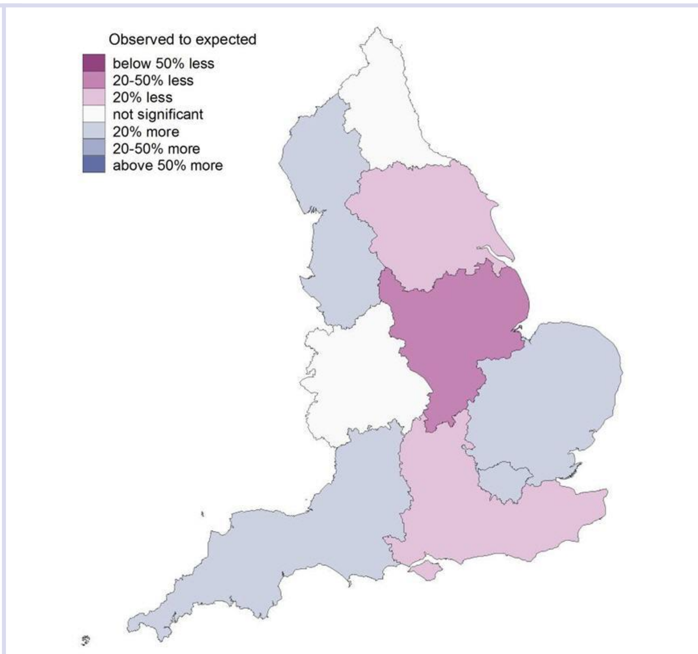

Figure 23. CABG utilisation ratio *observed/expected* by regions. Year 2009

** These maps represent the level of performance at each area, using the ratio "observed to the expected" number of revascularisation procedures as a proxy of the risk of cardiovascular intervention. Population living at areas with values above 1 (bluish) mean to be overexposed to the risk of certain cardiovascular interventions; population at areas with a ratio below 1 (pink) mean to be underexposed to the risk of those cardiovascular interventions.*

b. Hospital approach

Higher hospital risk-adjusted case fatality rates might signal lower quality and safety of care for coronary ischemic conditions.

The following sections will deal with in-hospital case fatality rates (CFR) after admission from Acute Myocardial Infarction (AMI) and after one of the revascularization procedures, percutaneous coronary intervention (PCI) or coronary bypass surgery (CABG), across English hospitals.

When analysing data on a provider basis, different meso and micromanagement arrangements towards coronary ischaemic disease could explain an important part of the observed variation in outcomes.

Funnel plots are used along this section to represent at a glance English hospitals performance against their national standard or benchmark.

Each hospital (dot and numerical code) is charted by its risk-adjusted case fatality rate and the volume of patients or procedures in a year. The benchmark is built on the English hospitals average CFR (risk-adjusted) and its 95% and 99% CIs. The solid grey line represents the English CFR, while red lines correspond to the 95% confidence interval control limits and the dashed blue lines to the 99% limits. Those thresholds represent the boundary between expected variation in outcomes (not significantly different from average) and unwarranted variation. Hospital outcomes laying beyond the upper thresholds flag hospitals as poorer performers (in the alert or alarm position); outcomes below the bottom limits signal hospitals as good or excellent performers. Whichever the direction, outliers warrant further investigation and analysis to identify underlying factors and either tackle them or use as examples of good practice.

For methodological reasons, those hospitals treating less than 30 episodes or procedures per year have been excluded from the analysis.

In-hospital case fatality rate for Acute Myocardial Infarction patients.

In 2009, 70,994 admissions across 149 English hospitals were flagged as Acute Myocardial Infarction, from which 6,281 patients died –8.85% of patients. The overall risk-adjusted case fatality rate adds up to 1 death per 10.6 AMI admissions, setting the English average at 94.4 per 1,000 patients, 4.62 per thousand points below ECHO benchmark.

Individual hospitals' risk-adjusted CFR ranged from 22.34 (minimum CFR) to 200.5 (maximum) per 1,000 AMI patients; thus, depending on the centre where they were treated, AMI patients could bear up to a 9-folded probability of dying. (See table 11 at the appendix 2.b for further details).

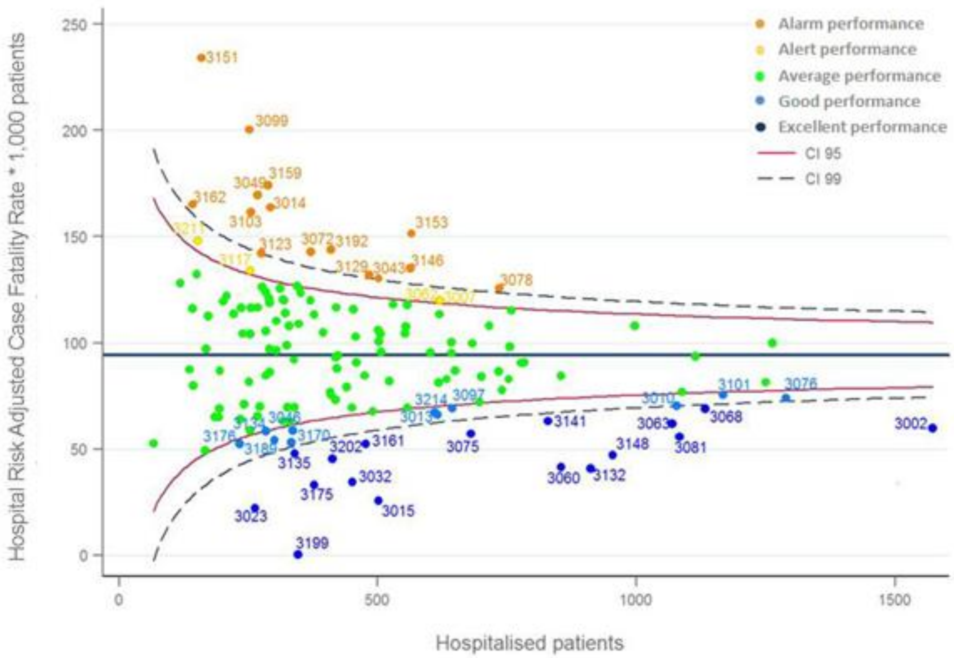

Figure 24. In-hospital mortality after AMI admission at English hospitals. Year 2009.

**Each dot represents one of the hospitals in the country that treated more than 30 AMI cases. The expected number of deceases per 1,000 hospitalised patients is built on the average across English hospitals*

Examining the funnel in figure 24, the results of national benchmarking differ slightly from those shown in the international comparison (figure 5, section II.b). Since the national average risk-adjusted CFR for AMI is lower than ECHO countries', English hospitals' performance as assessed per this in-country funnel shows a different scenario, where 19 hospitals are flagged alert/alarm (instead of the 15 by ECHO standards) and 28 as good/excellent performers (instead of 36).

In 2009, most English hospitals showed an annual volume of AMI patients above 250 (94% of the hospitals),which in ECHO terms was set as the threshold for low vs. high activity volume; however, a certain trend to better performance can be still observed as the number of patients treated increases. Actually the poorest performers (showing risk-adjusted CFR up to 2.5 times larger than the national average) are close to the low volume threshold (table 12 at the Appendix 2.b provides detailed information on each hospital).

Nevertheless, outcomes in 2009 still indicate a rather good performance; only 10.2% of patients were hospitalised at alert/alarm centres while 30% of patients were at good or excellent centres. 69% of hospitals were at the average position indicating risk-adjusted in-hospital mortality not significantly different from benchmark.

In-hospital case fatality rate for Percutaneous Coronary Interventions.

In 2009, 64,139 PCI procedures were performed across 73 English hospitals, yielding a risk-adjusted case fatality rate of 1 death per each 73 interventions in patients aged 40 or older.

PCI risk-adjusted CFRs varied widely across hospitals in a range from cero to 39 deaths in 1,000 patients, i.e. depending on the hospital where the procedure was performed, patients faced almost 25.5-times higher probability of dying (see table 13 at the appendix 2.b for further details).

As with AMI outcomes, English in-country benchmark for PCI is lower than ECHO's; thus, a more demanding scenario in assessing hospitals' performance. Figure 25 shows how, when nationally benchmarked, 18 hospitals were flagged as alert/alarm (instead of the 3 in the ECHO benchmarking), while 11 were assessed as good or excellent performers (instead of 25).

Those hospitals in the alert/alarm position (a fourth of the total), took care of 28% of all patients undergoing PCI, while hospitals flagged as good/excellent provided PCI for 17.5% of patients.

Contrary to expected, for this particular procedure in England, the "volume effect" seems all but reversed: the proportion of hospitals carrying on more than 1,000 procedures/year was clearly higher among those flagged as alert/alarm than among good or excellent performers.

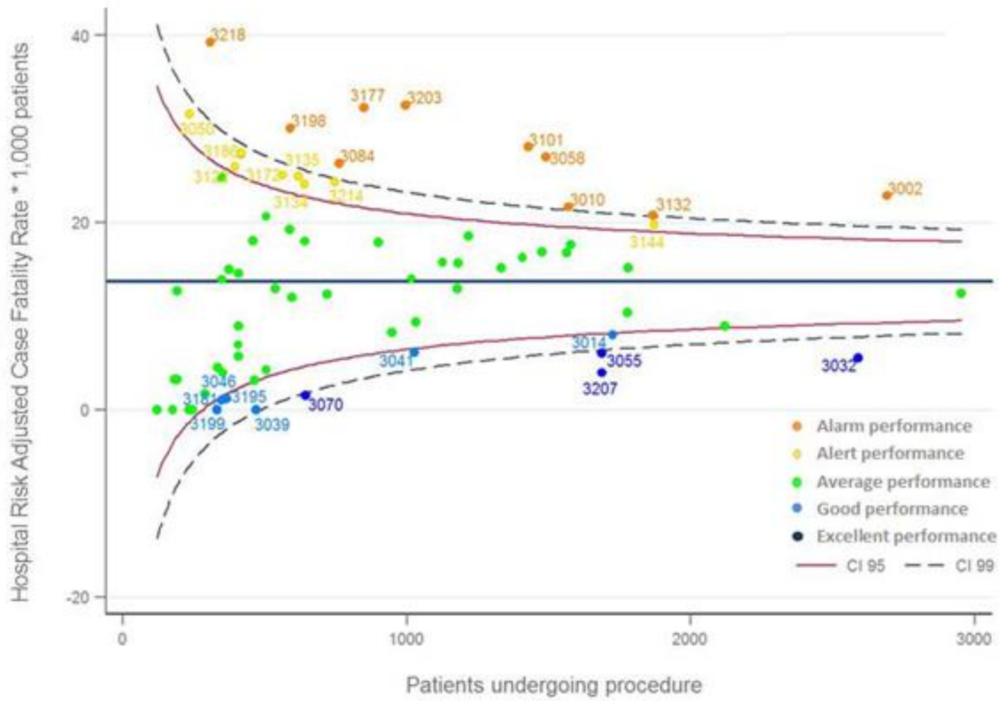

Figure 25. In-hospital mortality after going through PCI procedure at English hospitals. Year 2009.

** Each dot represents one of the hospitals in the country performing more than 30 interventions during the period of analysis. Given the limited number of centres the risk-adjusted case fatality rates per 1,000 patients undergoing PCI surgery is depicted in respect of the ECHO's average.*

In-Hospital case fatality rate for Coronary Artery Bypass Graft procedure.

In 2009, 21,006 CABG surgeries were performed at 29 English hospitals, of which 2.7% resulted in death. As for risk-adjusted hospital CFR, this means 1 death in 36 interventions for patients aged 40 or older.

In terms of individual hospitals, CABG CFRs took values from 12 to 49 deaths per 1,000 interventions, so patients undergoing CABG surgery could be bearing 4 times higher probability of death (risk-adjusted), depending on the hospital (See table 14 at the appendix 2.b for further details).

Average hospital risk-adjusted CFR for CABG in England is almost half ECHO's, as seen in section II.b; therefore in-country benchmarking turns to be, once again, more demanding than international comparison. As shown in figure 26, national benchmarking flagged 4 hospitals as alert/alarm performers (none was labelled as such in the ECHO benchmarking) while only 3 were assessed as good or excellent performers (vs. 24 in ECHO's). 76% of hospitals were at the average level of performance, indicating risk-adjusted in-hospital mortality not significantly different from benchmark.

11.3% of patients were intervened at alert/alarm centres, while another 11% underwent their surgery at good or excellent hospitals.

The three forerunners, flagged as good/excellent by both national and international standards, showed a lower than expected risk-adjusted CFR at 95% level of confidence, actually, 2 times smaller than the benchmark. (See table 14 at the appendix 2.b for further details)

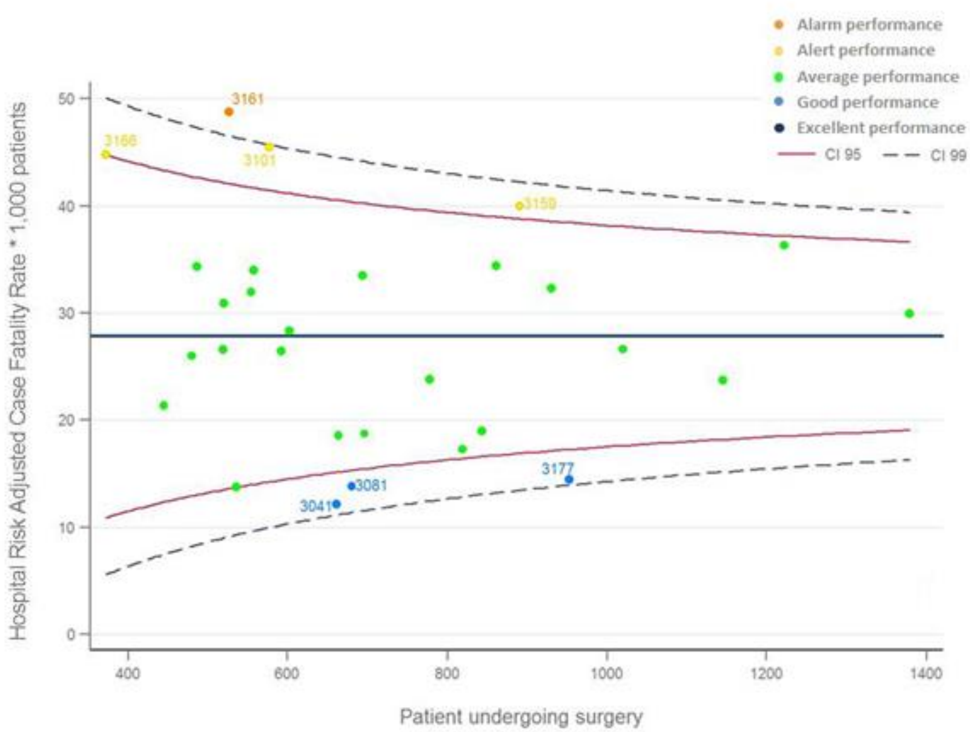

Figure 26. In-hospital mortality after going through CABG surgery at English hospitals. Year 2009.

** Each dot represents one of the hospitals in the country performing more than 30 interventions during the period of analysis. Given the limited number of centres the risk-adjusted case fatality rates per 1,000 patients undergoing CAGB surgery is depicted in respect of the ECHO's average.*

IV. EVOLUTION OVER TIME

Along the period 2002-2009, hospitalisations from coronary ischaemic disease have decreased, while the utilisation of revascularisation procedures has increased.

In terms of hospital outcomes, CFR s for AMI patients and following CABG or PCI have been generally improving in all hospitals over the period; however there are cases whose evolution warrants further investigation to identify both success and failure factors

a. Geographic approach

From 2002 to 2009, coronary ischaemic disease admissions decreased by 18%, from 1 admission per 234 to 1 admission per 284 adult inhabitants. Its systematic variation increased over the period, but values remained low: between 6% and 8% above that expected by chance (see table 15 in appendix 3.a).

Analysing the part of CID corresponding to AMI admissions, we found that rates have declined by 10%, from 1 admission per 512 to 1 admission per 569 adult inhabitants. Variation not deemed random remained low and stable along the period (see table 16 in appendix 3.a)

Concurrently, PCI utilisation doubled its rates, that is, from 1 admission per 802 inhabitants aged 40 or older in 2002 to 1 admission per 371 in 2009. Besides, systematic variation decreased over this period, exceeding what randomly expected from 16% in 2002 to 7% in 2009 (see table 17 in appendix 3.a). That suggests a certain homogeneous PCI utilisation across the territory, despite having doubled the overall rate.

Establishing the trend (upwards, downwards or steady) in revascularisation surgery over time is helpful in understanding the overall dynamic of adoption/ established use/withdrawing of the medical procedure. Both smaller and larger than expected utilisation rates should be looked into; the first may suggest inequalities in population access to care; the second could be also pointing out over-use and, thus, increased probability of inappropriate care for the residents.

The degree of systematic variation denotes how homogeneous population's exposure to the procedure has been at each point in time; the higher the SCV, the more the unwarranted variation in exposure to the procedure across residents in different local authorities.

Conversely, CABG rate decreased slightly by 11% over the same period, – from 1 admission per 1002 to 1 admission per 1131 inhabitants aged 40 or older. Systematic variation in CABG utilisation remained stable and low along the period, ranging from 9% to 7% above that expected by chance (see table 18 in appendix 3.a).

So although PCI has doubled its rates, it seems that it did not substitute CABG since its rates have hardly decreased at the same rate.

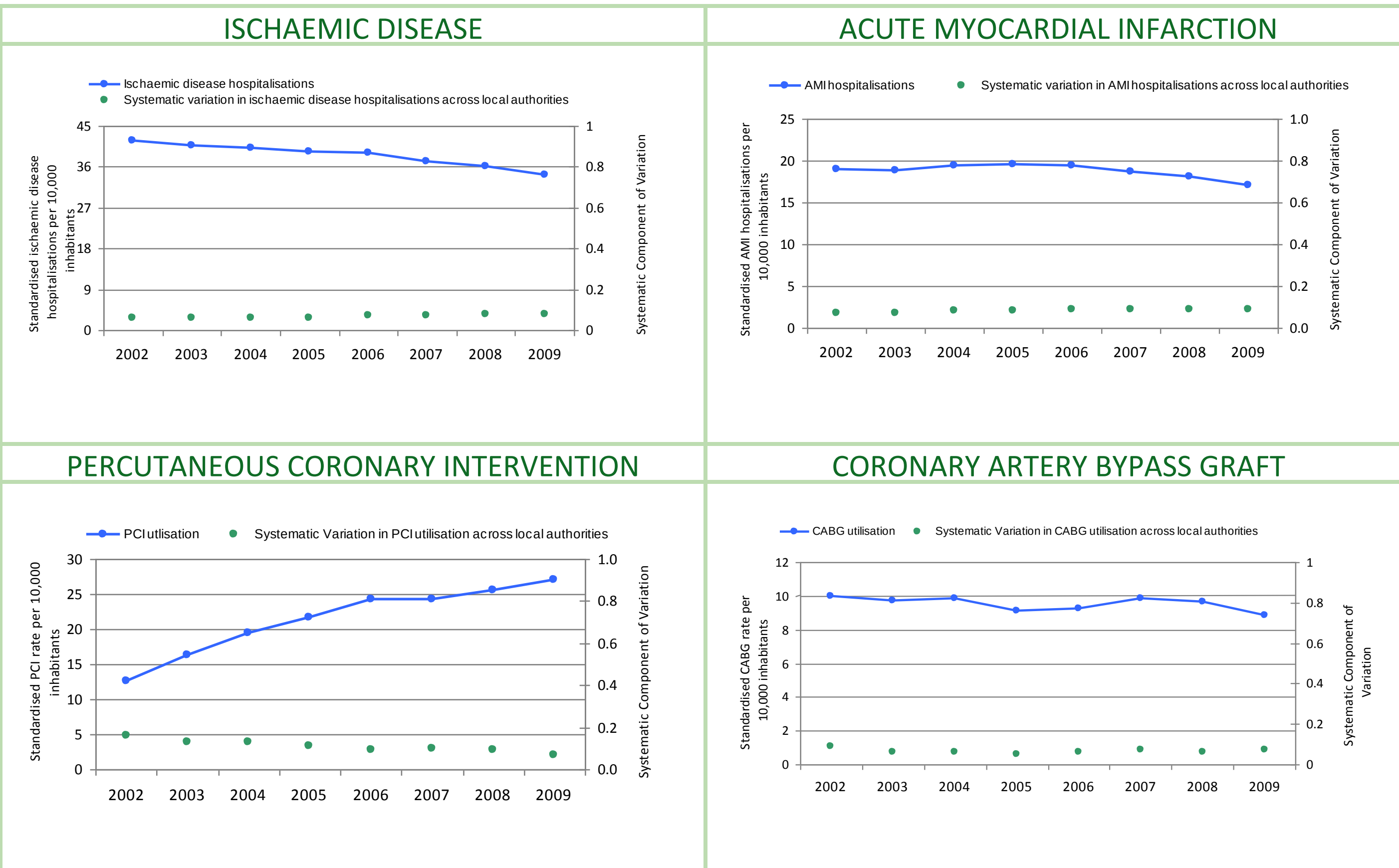

Figure 27. Temporal evolution of cardiovascular indicators from a geographical approach

** At these graphs the evolution over time of two different types of outcomes about the same indicator are jointly depicted: Blue lines inform about the standardised rates (either hospitalisation or utilisation rates) and green dots inform about the systematic variation across healthcare administrative areas (Local Authorities).*

Trends at those Local Authorities within the lowest and highest quintiles of utilisation intensity for PCI and CABG.

This section offers only a few selected examples, but individual Local Authorities' evolution over time can be tracked in their original dynamic charts at

http://echo-health.eu/handbook/quintiles_cv_eng.html

Besides the specific examples of change in revascularisation utilisation, it is also relevant to consider the spread of bubbles on 2009; since they all started at the same utilisation quintile in 2002, the variety of colours they have taken up by the final year (one for each quintile of utilisation intensity), provides a flavour of how established might be the medical practice underpinning such utilisation and how homogeneous or diversely shaped over time and across Local Authorities.

Analysing evolution of local authorities whose PCI rates were among the lowest at the beginning of the period (Q1), we see that all rates have gone upwards. However, most local authorities at low intensity of use, such as ***Malvern Hills***, have remained in the lowest quintile of PCI utilisation; while a few others have increased their rate reaching higher utilisation levels, i.e. ***Welwyn Hatfield*** which in 2009 is in the highest utilisation quintile (Q5) (figure 28). Figure 29 portraits the same phenomenon, but for local authorities starting at the top of the utilisation range (Q5). The resulting array of bubbles in 2009 shows some areas, as ***Tower Hamlets***, which have remained at the same intensity. Others, such as ***Ashford***, have seen their rates drop until the lowest quintile of PCI utilisation (Q1).

Similar patterns of local authorities spreading across all utilisation quintiles over time can be observed for CABG surgery. Taking as an example ***Derbyshire*** and ***Hartlepool***, both areas showed low intensity of use in 2002, but their evolution was quite uneven. While ***Derbyshire Dales*** remained among the lowest quintiles, ***Hartlepool***, reached the highest utilisation levels by the end of the period (figure 30).

Moreover, it can be observed that areas with the highest CABG utilisation in 2002 (Q5 in orange) also experienced diverging evolution over the period. For example, while ***Hounslow*** remained in the same quintile for almost all years, the CABG rate in ***Calderdale*** decreased steadily over time reaching the lowest quintile of exposure (figure 31)

You can track the evolution of individual Local Authorities at:

http://www.echo-health.eu/handbook/quintiles_cv_eng.html

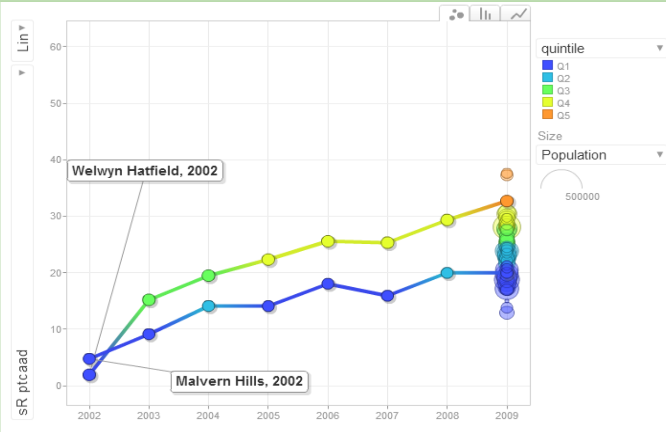

Figure 28. Trends in utilisation rates of PCI across Local Authorities showing the lowest rates at the beginning of the period.

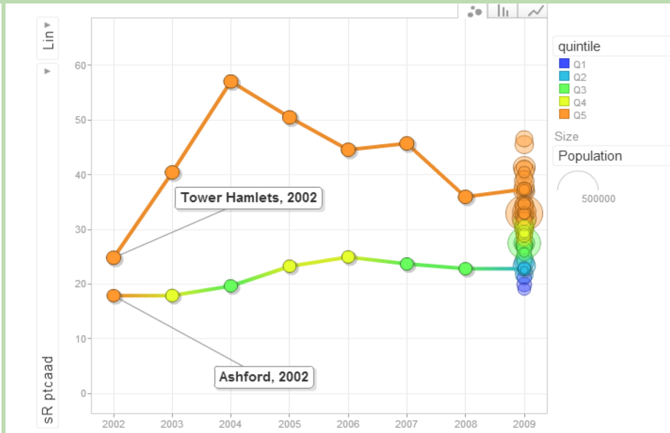

Figure 29. Trends in utilisation rates of PCI across Local Authorities showing the highest rates at the beginning of the period.

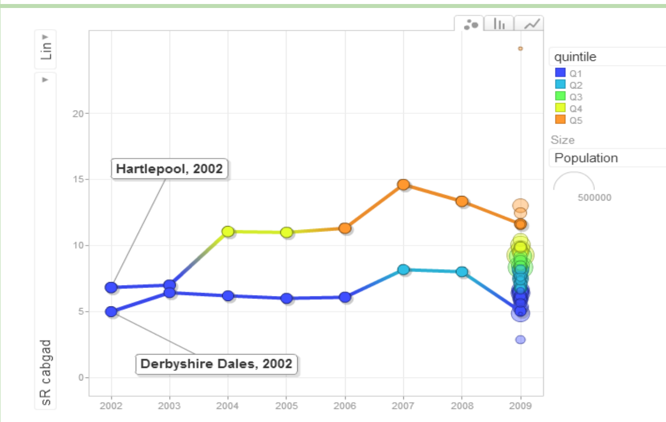

Figure 30. Trends in utilisation rates of CABG across Local Authorities, showing the lowest rates at the beginning of the period.

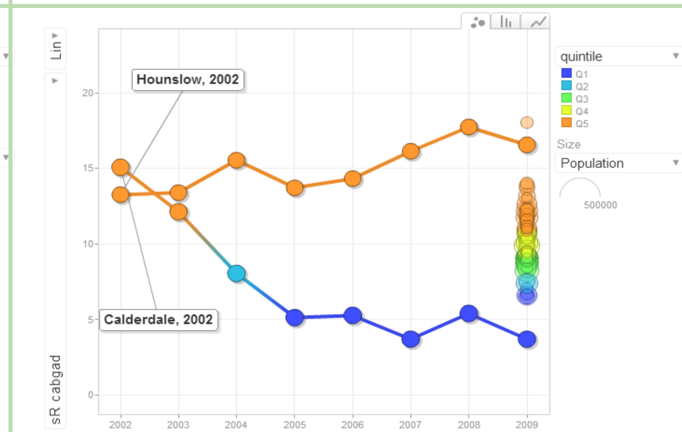

Figure 31. Trends in utilisation rates of CABG across Local Authorities, showing the highest rates at the beginning of the period.

b. Hospital approach

In order to study how the in-hospital mortality behaved along the period of analysis, some examples are offered showing the evolution of hospitals with the lowest or the highest rates at the beginning of the period.

For further details, please have a look at the dynamic graphics where you can track individual hospitals' behaviour from 2002 to 2009:

http://echo-health.eu/handbook/hospital_cv_eng.html

Bubble dynamic graphs show the sequence of results from funnel plots assessing outcomes annually along the period of analysis. The size of the bubble is proportional to the amount of patients or interventions. Hospitals flagged as good or even excellence performers (blue coloured bubbles) in 2002 are expected to remain blue all along the period. However, those hospitals identified as poorer performers in alert/alarm position at the beginning of the period (orange coloured bubbles) should had improved their results along time (turning into green – average- or ideally bluish).

Departures from this pattern of change can be considered undesirable trends, warranting further investigation.

In-hospital case fatality rate trends for Acute Myocardial Infarction patients, period 2002-2009.

Regarding the behaviour of hospital risk-adjusted CFR for AMI patients, figure 32 shows four examples of hospitals which improve or worsen their performance along the analysed period or which remain in the same position.

For instance, ***The Royal Wolverhampton hospital NHS Trust*** which starts from a "*good performance*" remained as such or even improved to "*excellent performance*" along the period. Both, ***South London Healthcare NHS Trust*** and ***Mid Yorkshire Hospital NHS Trust***, started at the average performance position but the first one evolved to "alarm" while the other moved up to "excellent". On the other hand, ***Whipps Cross University Hospital NHS Trust*** is an example of a hospital that diminished its activity along the analysed period (*note that the size of the bubble is proportional to the amount of cases treated)* while remaining flagged as alarm performer. Further details of the evolution of English hospitals' relative performance for AMI admissions along this period in table19, appendix 3.b.

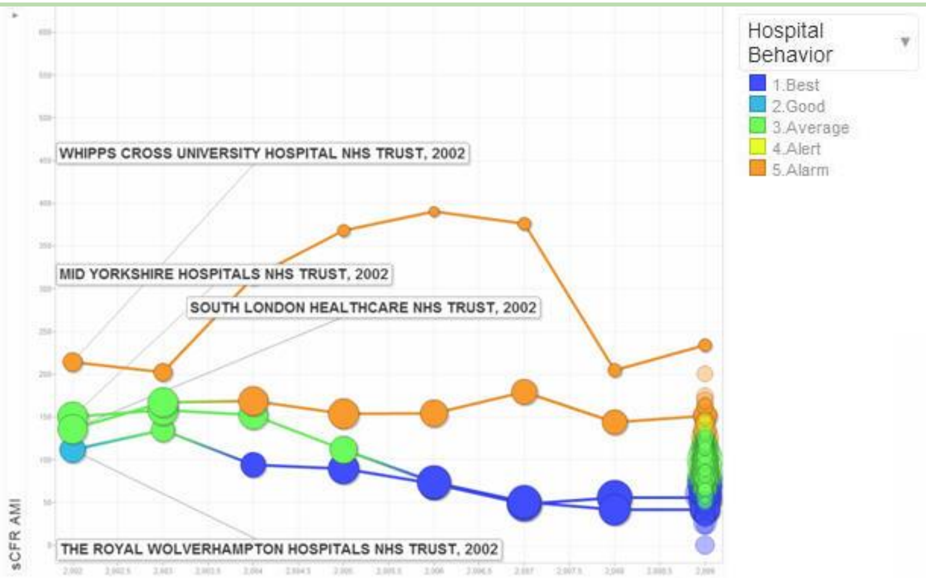

Figure 32. In-Hospital mortality trends of AMI, 2002-2009, showing some of the highest and lowest rates and their evolution.

** Bubbles represent hospitals. The broader the bubble, the larger the amount of AMI hospitalised patients at that hospital. Dark-blue bubbles represent hospitals with risk-adjusted case fatality rates below the CI-99% control limit, so then pointed as an "excellent performance". Light-blue bubbles represent hospitals with risk-adjusted case fatality rates below the CI-95% control limits, so then pointed as a "good performance". Yellow bubbles represent hospitals with risk-adjusted case fatality rates above the CI-95% control limits, so then pointed as "alert positioned". Orange bubbles represent hospitals with risk-adjusted case fatality rates above the CI-99% control limits, so the pointed as "alarm positioned".*

In-hospital case fatality rate for Percutaneous Coronary Intervention, period 2002-2009.

In this case, as shown in figure 33, we find hospitals starting and ending at an "alert/alarm performance" (***Sandwell and West Birmingham Hospital NHS Trust***), hospitals fluctuating between the areas of non-significant differences and "alarm performance" (***Imperial College Healthcare centre NHS Trust***), but, also, hospitals improving from average to an "excellent performance" (***The Cardiothoracic centre Liverpool NHS Trust***). The hospital ***Barts and the London NHS Trust*** is an example of erratic evolution, fluctuating from average performance to excellent, but then again back to average and finally alarm performance for the last years of the series. Further details of the evolution of English hospitals' relative performance for PCI along this period in table 20, appendix 3.b.

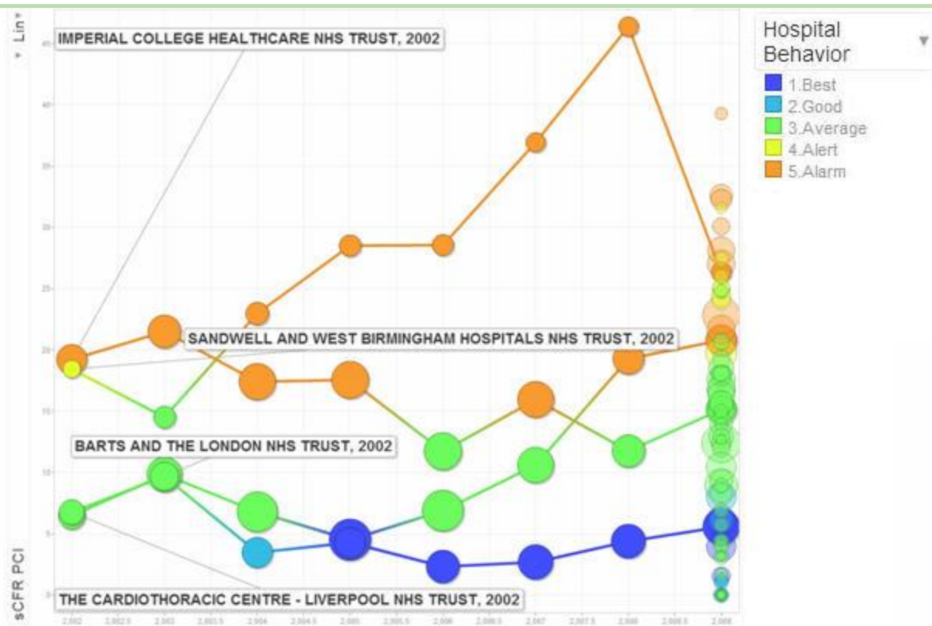

Figure 33. In-Hospital mortality trends of PCI -2002-2009, showing some of the highest and lowest rates and their evolution

** Bubbles represent hospitals. The broader the bubble, the larger the amount of patients undergoing PCI procedure at that hospital. Dark-blue bubbles represent hospitals with risk-adjusted case fatality rates below the CI-99% control limit, so then pointed as an "excellent performance". Light-blue bubbles represent hospitals with risk-adjusted case fatality rates below the CI-95% control limits, so then pointed as a "good performance". Yellow bubbles represent hospitals with risk-adjusted case fatality rates above the CI-95% control limits, so then pointed as "alert positioned". Orange bubbles represent hospitals with risk-adjusted case fatality rates above the CI-99% control limits, so the pointed as "alarm positioned".*

In-hospital case fatality rate trends for Coronary Artery Bypass Graft surgery, period 2002-2009.

Concerning the coronary artery bypass procedure, there are some hospitals which remarkably changed position during the period. Figure 34 shows as examples four centres; ***Oxford Radcliffe Hospital NHS Trust*** whose performance started at "alarm position", fluctuated for a few years to the average performance to end up again at "alarm position"; ***King's College Hospital NHS Trust*** whose performance started at "average" and worsened to "alert/alarm position"; ***Southampton University Hospital NHS Trust*** instead, seemed to worsen going from average to "*alert/alarm performance*", but then improved reducing its risk-adjusted fatality rate to position itself as "*good performer*" and finally ***South Manchester University Hospital NHS Trust*** which remained steady at "*good/excellent performance*" position all along. Further details of the evolution of English hospitals' relative performance for CABG along this period in table 21, appendix 3.b.

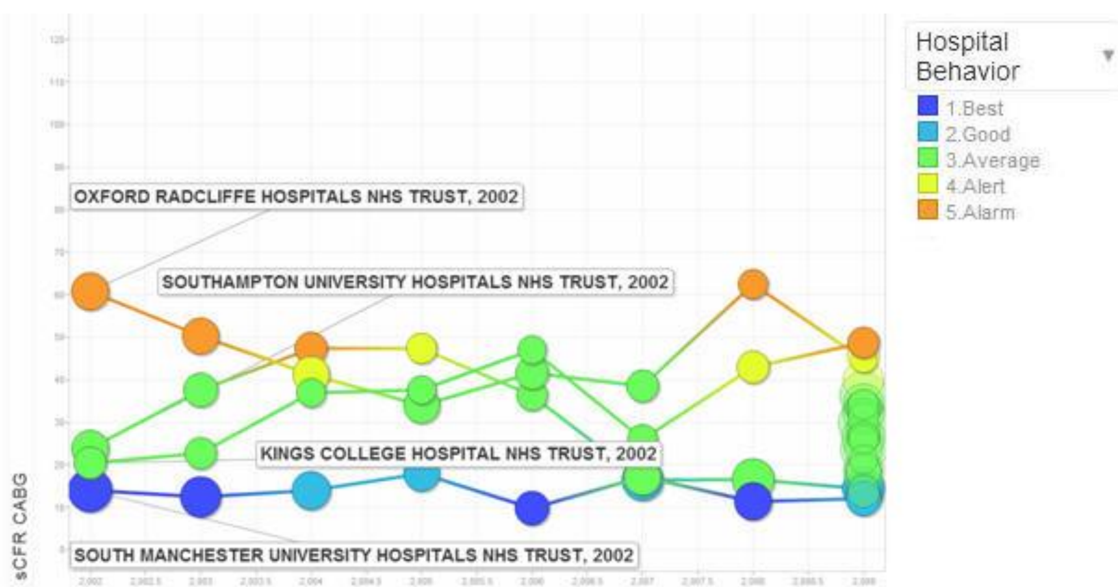

Figure 34. In-Hospital mortality trends of CABG -2002-2009, showing some of the highest and lowest rates and their evolution

** Bubbles represent hospitals. The broader the bubble, the larger the amount of patients undergoing CABG surgery at that hospital. Dark-blue bubbles represent hospitals with risk-adjusted case fatality rates below the CI-99% control limit, so then pointed as an "excellent performance". Light-blue bubbles represent hospitals with risk-adjusted case fatality rates below the CI-95% control limits, so then pointed as a "good performance". Yellow bubbles represent hospitals with risk-adjusted case fatality rates above the CI-95% control limits, so then pointed as "alert positioned". Orange bubbles represent hospitals with risk-adjusted case fatality rates above the CI-99% control limits, so the pointed as "alarm positioned".*

V. SOCIAL GRADIENT

Most deprived Local Authorities showed significantly higher PCI and CABG utilisation rates than most affluent ones, but also endured more CID admissions.

Significantly more CID admissions occurred in most deprived local authorities than in wealthier ones. The same happened when analysing specifically AMI admissions, although, in that case, differences across areas were not significant from 2005 to 2007. Thus, the variation in CID admissions across local authorities described in previous sections seemed to be related to the area level of deprivation.

When analysing PCI utilisation, most deprived areas showed significantly higher utilisation rates than those better-off over the period 2002-2009. Besides, the gap between extreme levels of wealth became wider over time.

CABG utilisation was also significantly more intense in deprived areas than in wealthier ones. It is worth noting that, the gap between extreme quintiles become narrower over time due to the decrease in CABG rates in most deprived areas, while remaining quite stable in the more affluent.

To sum up, PCI utilisation has increased in all areas; meanwhile, CABG utilisation has decreased in the most deprived ones, and remained stable in better-off local authorities. Since worse-off areas bear more CID admissions burden, it would be advisable further detailed analysis to warrant equity in access to revascularisation procedures.

Graphs in this section aim at providing some sense of the behaviour of CID admissions and revascularization procedures depending on the average level of affluence in the local authority. At a glance it will show whether there are differences between the better-off and the worse-off areas, and if these differences vary over time.

The wider the gap between most and least affluent quintile lines, the more inequitably distributed the exposure to revascularisation surgery will be. It is also relevant to keep track of the 95% confident interval (whiskers) drawn around the annual rates estimated for quintiles 1 and 5. Only those not overlapping signal a statistically significant difference between wealthier and deprived areas.

The desirable pattern will show no statistically significant differences across local authorities amenable to their wealth. As a second best, any eventual existing gap should disappear over time.

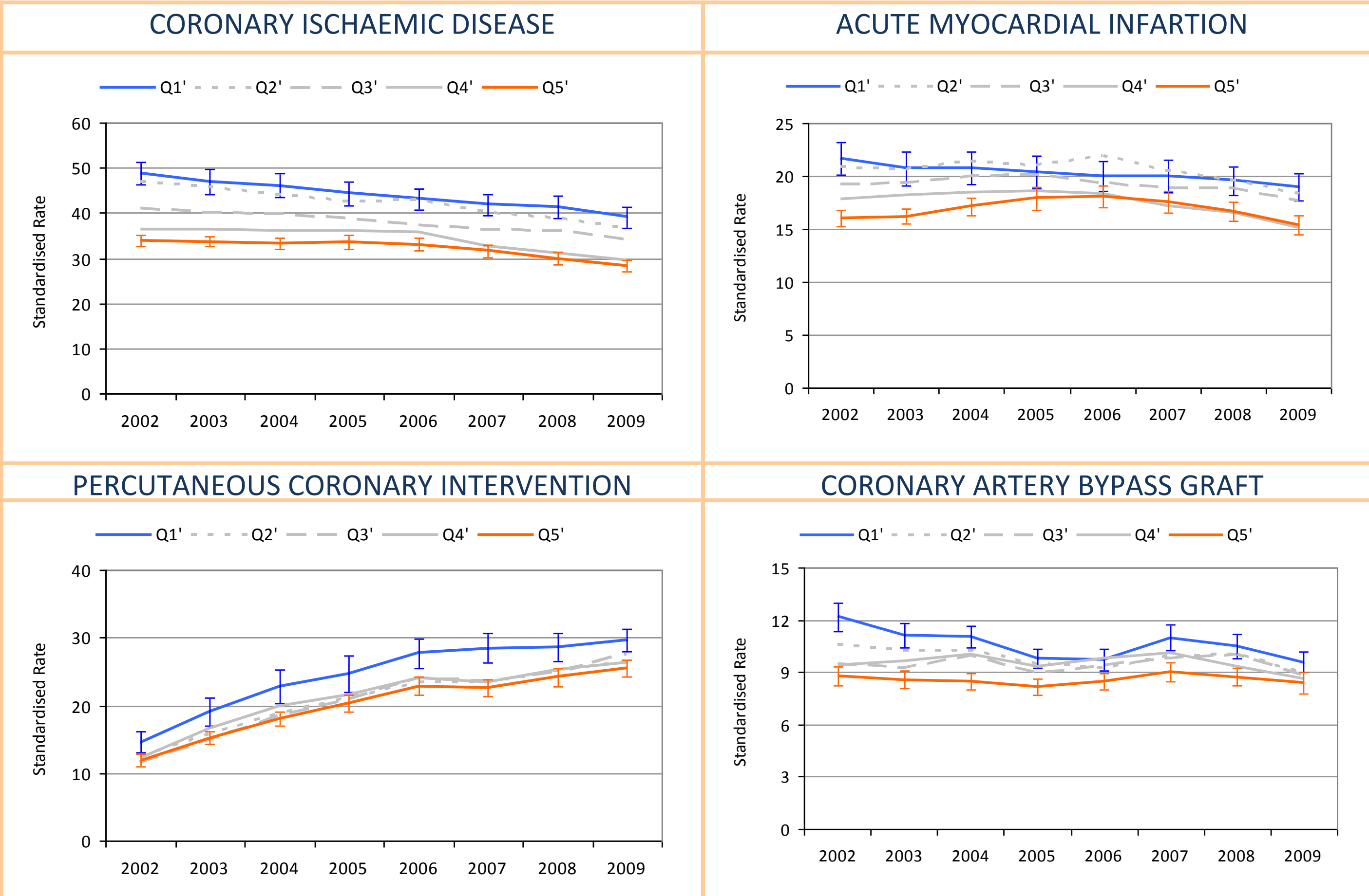

Figure 35. Trends in standardised rate by income quintile

** Areas are divided in 5 categories of wealth (deprivation index): from Q1 (blue) corresponding to the worse-off areas, to Q5 (orange) corresponding to the better off areas. Each line in the graph corresponds to the evolution of PAH rates in a wealth level (evolution in Q1 in blue and in Q5 in orange). Statistical differences across income quintiles will occur just when the confidence intervals (whiskers) for different quintiles do not overlap.*

VI. POLICY IMPLICATIONS

Coronary ischaemic disease is one of the leading causes of death, disability and decreased quality of life in Europe; particularly, together with cancer, the main cause of death in England in 2009. It is also a leading cause of premature death in men, generating important social costs associated to potential years of life lost. Hence, mortality and morbidity from cardiovascular disease have become a relevant issue for all health systems in Europe, as well as an important driver of health expenditure.

Several studies in the last decade showed that the incidence of coronary heart disease in the northern half of Europe, particularly Scandinavian countries, is higher than in the south. Even though hospitalisations for ischemic heart disease show a decreasing trend, rates showed higher figures in England and Denmark (in this order) than in Spain and Portugal. This is a factor that should be taken into account in assessing hospitalisation fluxes and the intensity of consequent interventions; this section will highlight elements in the healthcare system and/or the organisational processes that may underpin the observed results and thus, might be worth a closer examination.

The mapping out of burden of disease and PCI intensity of use produces contradicting patterns: *Local Authorities* counting among the highest PCI utilisation rates could show either lower relative risk of CID hospitalisation or come along with the highest risks. Given the potential benefit of primary PCI, two hypotheses are at play (perhaps concomitant, rather than alternative): a higher amount of early interventions might be preventing hospitalisation at further stages of the disease, and thus, reducing the corresponding admission rate. But, at the same time, the local risk of suffering a hospitalisation from CID should be also leading the need for PCI procedures and, thus, the local intensity of use; if that were not the case, such high intensity of PCI revascularisation unrelated to need might be pointing out over-utilisation of the procedure, that is, populations being over-exposed and thus, subject to inadequate provision of care.

The geographical analysis also revealed a relevant role for the regional tier in explaining variation in CID admissions (burden of disease) –up to 29% that could be amenable to some sort of contextual phenomenon that differs between regions. This may be due to the application of different regional health plans or differing implementation of a national strategy at local level. Nevertheless, this regional tier is not present regarding exposure to PCI or CABG revascularisation procedures.

At Local Authority level, PCI and CABG utilisation do not correlate with the burden of disease either. The joint analysis of utilisation patterns for both revascularisation procedures (PCI and CABG) does not provide grounds to induce any general substitution or complementary utilisation. A case by case further analysis of discrepant trends may shed some light. One conclusion that could be drawn is that factors other than need or technological change might be at play in explaining English revascularisation rates.

Looking now at the case fatality rates for these patients and those procedures at hospital level, English risk-adjusted in-hospital mortality rate for AMI patients has shown a decrease in one third since 2002 and was the second lowest among ECHO countries in 2009. Detailed analysis reveals that most English hospitals, nearly 69%, provide care for AMI patients within the expected (average) levels of quality and safety. Nevertheless, this fact coexists with two other extreme patterns of care provision: on the one hand, 12.8% of hospitals -treating close to 10% of all English AMI patients- obtained in-hospital mortality results significantly higher than expected, and were consequently flagged as alert/alarm; meanwhile, another 18.8% of them -treating 27% of total AMI patients (mostly high volume) - were flagged as good or excellent in performance with CFR significantly lower than expected. There was a 9–folded difference in the risk of dying depending on where the AMI patient was hospitalised, even though multilevel analysis showed that the hospitals did not explain this variation in outcomes (cluster effect just contributing a 2.2%). Volume has been argued as one of the plausible factors underpinning these differences; Though the vast majority of English hospitals registered a volume of annual patients well beyond the ECHO threshold for high volume, the lower the volume the higher the probability of worse outcomes; however, there must be other factors that deserve further and deeper look.

The literature recommends assessing a number of factors critical to explain differences in hospital outcomes (both at local and global levels); these include pre-hospital diagnosis and planning of urgent transportation to the appropriate medical centre. In this respect, assessing the relationship to the eventual hospital of reference could provide relevant insights as to whether there is a well-defined, stable and fluid bypass circuit for severe patients or special techniques and if transfer to reference centres takes place immediately or within 24 hours, depending on the severity of the situation. Such are key elements of care in successful treatment and, thus, their further understanding could be very helpful in improving patient outcomes as well as overall costs for the health system.

The analysis conducted, suggests that there is room for enhancing outcomes in the English system. Burden of disease and revascularisation rates are generally larger as compared with other ECHO countries; however, they do not seem to relate to each other, suggesting that factors other than need or technological change might be driving the revascularisation intensity.

Although English hospitals' outcomes come out exceedingly well according to the international benchmarking picture, the comparatively poorer results of some of them by national and international benchmarking, regarding PCI and AMI patients, warrant some closer look. The fact that 28% of the patients undergoing PCI procedure were treated in "alert/alarm" hospitals, well above the high volume empirical threshold of activity, deserves further consideration.

APPENDIX 1.a:

International Comparison across ECHO countries

GEOGRAPHICAL APPROACH

Year 2009

Table 1. General descriptive statistics for burden of disease: CID admissions

	CORONARY ISCHAEMIC DISEASE				
	DENMARK	ENGLAND	PORTUGAL	SLOVENIA	SPAIN
Cases	13225	141167	14526	4288	78585
Stand. Rate	30.68	34.32	17.86	32.40	23.79
EQ5-95	2.32	2.16	2.12	1.89	3.04
SCV	0.14	0.24	0.15	0.09	0.10

** sR: Age-sex Standardised Rate per 10,000 inhabitants (Reference population: ECHO countries 2009); EQ: Extremal Quotient; SCV: Systematic Component of Variation;*

Table 2. General descriptive statistics for burden of disease: AMI admissions

	ACUTE MYOCARDIAL INFARCTION				
	DENMARK	ENGLAND	PORTUGAL	SLOVENIA	SPAIN
Cases	6711	69713	11365	2911	46206
Stand. Rate	15.90	16.76	13.80	22.29	13.78
EQ5-95	1.91	2.63	2.37	1.67	2.98
SCV	0.05	0.15	0.05	0.34	0.11

** sR: Age-sex Standardised Rate per 10,000 inhabitants (Reference population: ECHO countries 2009); EQ: Extremal Quotient; SCV: Systematic Component of Variation;*

Table 3. General descriptive statistics for utilisation of PCI procedure

	PERCUTANEOUS CORONARY INTERVENTION				
	DENMARK	ENGLAND	PORTUGAL	SLOVENIA	SPAIN
Cases	9253	63220	10587	5025	48368
Stand. Rate	37.50	27.18	21.37	60.16	23.89
EQ5-95	1.86	2.20	2.24	2.61	4.71
SCV	0.33	0.08	0.08	1.97	0.22

** sR: Age-sex Standardised Rate per 10,000 inhabitants (Reference population: ECHO countries 2009); EQ: Extremal Quotient; SCV: Systematic Component of Variation;*

Table 4. General descriptive statistics for utilisation of CABG surgery

	CORONARY ARTERY BYPASS GRAFT				
	DENMARK	ENGLAND	PORTUGAL	SLOVENIA	SPAIN
Cases	2371	20434	2446	774	7068
Stand. Rate	9.99	9.00	4.77	9.77	3.38
EQ5-95	1.71	2.33	7.42	5.32	9.83
SCV	0.50	0.41	0.19	0.74	0.27

** sR: Age-sex Standardised Rate per 10,000 inhabitants (Reference population: ECHO countries 2009); EQ: Extremal Quotient; SCV: Systematic Component of Variation;*

APPENDIX 1.b:

International Comparison across ECHO countries

HOSPITAL APPROACH

Year 2009

Table 5. Data description of hospitals and patients included* in the analysis

	ECHO	DENMARK	ENGLAND	PORTUGAL	SLOVENIA	SPAIN
	ACUTE MYOCARDIAL INFARCTION					
Total discharges	147670	8124	71001	12391	3471	52683
Total nº hospitals	522	35	154	46	16	271
hospitals excluded	87	5	5	6	2	69
(% patients excluded)	0.55%	0.48%	0.01%	0.28%	0.06%	1.38%
Discharges analysed	146859	8085	70994	12356	3469	51955
Nº Hospitals analysed	435	30	149	40	14	202
	PERCUTANEOUS CORONARY INTERVENTION					
Total discharges	133161	9306	64253	10760	4817	44025
Total nº hospitals	283	25	97	39	9	113
hospitals excluded	84	18	24	9	1	32
% patients excluded	0.32%	0.43%	0.18%	0.92%	0.29%	0.36%
Discharges analysed	132737	9266	64139	10661	4803	43868
Nº Hospitals analysed	199	7	73	30	8	81
	CORONARY ARTERY BYPASS GRAFT					
Total discharges	33765	2390	21036	2496	678	7165
Total nº hospitals	145	17	53	10	2	63
hospitals excluded	56	11	24	4	---	17
% patients excluded	0.24%	1.26%	0.14%	0.16%	---	0.25%
Discharges analysed	33683	2360	21006	2492	678	7147
Nº Hospitals analysed	89	6	29	6	2	46

**Hospitals treating less than 30 patients or procedures/year have been excluded from the analysis in order to avoid noise when estimating risk-adjustment within logistic multivariate modelling.*

Table 6. ECHO hospitals' description and relative performance per country for AMI hospitalised patients. (ECHO benchmark estimation)

	ACUTE MYOCARDIAL INFARCTION					
	ECHO	DENMARK	ENGLAND	PORTUGAL	SLOVENIA	SPAIN
Discharges	146859	8085	70994	12356	3469	51955
Deceased	12582	674	6281	1183	240	4204
Nº Hospitals	435	30	149	40	14	202
Hospitals > 250 (% patients treated)	239 (82.47%)	6 (70.3%)	125 (93.9%)	23 (79%)	3 (66.59%)	82 (70.59%)
Average expected Risk-adjusted CFR	99.03	133.45	94.41	109.57	101.58	93.75
hosp. Alarm position (% patients treated)	40 (5.83%)	10 (21.13%)	9 (4.30%)	10 (20.31%)	3 (7.81%)	6 (1.09%)
hosp. Alert position (% patients treated)	18 (3.19%)	3 (3.45%)	6 (3.54%)	1 (1.45%)	1 (1.59%)	9 (4.09%)
hosp. Good performers (% patients treated)	42 (11.42%)	2 (3.15%)	14 (10.65%)	3 (9.43%)	2 (5.85%)	20 (13.97%)
hosp. Excellent performers (% patients treated)	67 (26.7%)	5 (60.63%)	22 (23.6%)	5 (19.06%)	3 (51.14%)	32 (25.85%)

** Hospitals>250: Hospitals above the activity threshold of 250 AMI hospitalisations/year; Alarm position: hospitals above the CI-99 control limit; Alert position: hospitals above the CI-95 control limit; Good performers: hospitals below the CI-95 control limit; Excellent performers: hospitals below the CI-99 control limit. In brackets the percentage of AMI patients in the country hospitalised at those hospitals.*

APPENDIX 1.b:

International Comparison across ECHO countries

HOSPITAL APPROACH

Year 2009

Table 7. ECHO hospitals' description and relative performance per country for patients undergoing PCI. (ECHO benchmark estimation)

	PERCUTANEOUS CORONARY INTERVENTION					
	ECHO	DENMARK	ENGLAND	PORTUGAL	SLOVENIA	SPAIN
Discharges	132737	9266	64139	10661	4803	43868
Deceased	2623	255	924	188	143	1113
Nº Hospitals	199	7	73	30	8	81
Hospitals > 250 (% patients treated)	159 (95.44%)	7 (100%)	64 (97.17%)	15 (84.05%)	5 (97.04%)	68 (94.53%)
Average expected Risk-adjusted CFR	19.86	22.78	13.70	20.77	15.61	25.59
hosp. Alarm position (% patients treated)	28 (17.26%)	4 (67.47%)	1 (1.55%)	3 (9.69%)	2 (74.47%)	18 (25.19%)
hosp. Alert position (% patients treated)	10 (3.9%)	--- ---	2 (1.80%)	1 (1.76%)	--- ---	7 (8.74%)
hosp. Good performers (% patients treated)	17 (4.8%)	2 (7.52%)	13 (7.80%)	--- ---	1 (5.58%)	1 (0.92%)
hosp. Excellent performers (% patients treated)	15 (15.51%)	--- ---	12 (28.27%)	1 (9.80%)	--- ---	2 (3.20%)

** Hospitals>250: Hospitals above the activity threshold of 250 PCI performed/year; Alarm position: hospitals above the CI-99 control limit; Alert position: hospitals above the CI-95 control limit; Good performers: hospitals below the CI-95 control limit; Excellent performers: hospitals below the CI-99 control limit. In brackets the percentage of patients in the country undergoing PCI procedure at those hospitals.*

Table 8. ECHO hospitals' description and relative performance per country for patients undergoing CABG. (ECHO benchmark estimation)

	CORONARY ARTERY BYPASS GRAFT					
	ECHO	DENMARK	ENGLAND	PORTUGAL	SLOVENIA	SPAIN
Discharges	33683	2360	21006	2492	678	7147
Deceased	1212	96	571	87	37	421
Nº Hospitals	89	6	29	6	2	46
Hospitals > 250 (% patients treated)	46 (82.16%)	5 (93.43%)	29 (100%)	6 (100%)	1 (70.06%)	5 (20.93%)
Average expected Risk-adjusted CFR	50.33	44.54	27.81	33.55	44.97	66
hosp. Alarm position (% patients treated)	9 (3.58%)	--- ---	--- ---	--- ---	--- ---	9 (16.87%)
hosp. Alert position (% patients treated)	4 (2.03%)	--- ---	--- ---	1 (16.21%)	--- ---	3 (3.92%)
hosp. Good performers (% patients treated)	13 (20.65%)	--- ---	8 (26.09%)	2 (32.58%)	1 (29.94%)	2 (6.46%)
hosp. Excellent performers (% patients treated)	18 (40.61%)	1 (24.79%)	16 (60.32%)	1 (16.97%)	--- ---	--- ---

** Hospitals>250: Hospitals above the activity threshold of 250 CABG performed/year; Alarm position: hospitals above the CI-99 control limit; Alert position: hospitals above the CI-95 control limit; Good performers: hospitals below the CI-95 control limit; Excellent performers: hospitals below the CI-99 control limit. In brackets the percentage of patients in the country undergoing CABG surgery at those hospitals.*

APPENDIX 2.a:

Tables England

WITHIN-Country analysis

GEOGRAPHICAL APPROACH

Year 2009

Table 9. Descriptive Statistics of burden of coronary disease and use of revascularisation procedures across local authorities.

	Ischaemic	AMI	PCI	CABG
Cases	141167	69713	63220	20434
Population	42734036	42734036	25435816	25435816
Crude Rate	33.38	16.69	24.58	8.06
Stand. Rate	32.14	15.96	24.57	8.01
sR Min.	15.71	4.84	7.9	2.55
sR Max.	63.48	32.18	56.28	19.03
sR. P5	20.26	9.51	15.27	4.47
sR. P25	25.61	12.43	20.04	6.48
sR. P50	30.12	15.26	23.76	7.86
sR. P75	37.77	19.32	27.66	9.35
sR. P95	49.37	24.89	37.51	11.99
EQ5-95	2.44	2.62	2.46	2.68
EQ25-75	1.48	1.55	1.38	1.44
ICC	0.29	0.23	0.07	0.11

** sR: Age-sex Standardised Rate per 10,000 inhabitants (Reference population: national 2009); sR Px: percentile x of sR distribution; EQ: Extreme Quotient; ICC: Intra class Correlation Coefficient*

Table 10. Relative risk of exposure to coronary disease and revascularisation procedures across local authorities.

	Ischaemic	AMI	PCI	CABG
SUR Mín.	0.47	0.34	0.35	0.32
SUR Máx.	1.92	1.97	2.27	2.46
SUR P5	0.61	0.58	0.61	0.55
SUR P25	0.77	0.76	0.81	0.8
SUR P50	0.91	0.93	0.96	0.99
SUR P75	1.14	1.17	1.12	1.17
SUR P95	1.49	1.52	1.52	1.49
SCV	0.08	0.09	0.08	0.07

** SUR: Standardised admission/Utilisation Ratio (observed/expected); SUR Px: percentile x of the SUR distribution; SCV: Systematic Component of Variation;*

APPENDIX 2b:

Tables England

WITHIN-Country analysis

HOSPITAL APPROACH

Year 2009

Table 11. Descriptive statistics of hospital activity and outcomes.

	AMI in-hospital mortality	PCI in-hospital mortality	CABG in-hospital mortality
Deceased	6281	924	571
N. hospitals	149	73	29
Crude CFR	92.82	12.95	27.40
Risk-adjusted CFR	94.41	13.70	27.81
R-adj CFR MIN	22.34	0	12.11
R-adj CFR MAX	200.49	39.28	48.76
Rho statistic	0.022	0.067	0.076

**CFR: Case Fatality Rate per 1,000 hospitalised patients or patients undergoing procedure; R-adj CFRx: risk-adjusted rate of the percentile x of the CRF distribution; Rho-statistic: cluster effect.*

Table 12: Hospital outcomes for Acute Myocardial Infarction patients*
National benchmark estimation

Hospital					Expected Rate		Relative Position		Expected Rate		Relative Position	
Code	Name	AMI cases (i)	Hospital CFR	Hospital sCFR	UCI 95%	LCI 95%	Above IC95	Below IC95	UCI 99%	LCI 99%	Above IC99	Below IC99
3151	WHIPPS CROSS UNIVERSITY HOSPITAL NHS TRUST	160	187.50	234.08	142.02	46.80	*		156.98	31.84	*	
3099	MID STAFFORDSHIRE GENERAL HOSPITALS NHS TRUST	253	177.87	200.49	132.27	56.55	*		144.17	44.65	*	
3159	GUYS AND ST THOMAS NHS TRUST	288	138.89	174.21	129.90	58.93	*		141.05	47.78	*	
3049	SCARBOROUGH AND NORTH EAST YORKSHIRE HEALTH CAR	268	149.25	169.61	131.20	57.63	*		142.76	46.07	*	
3162	EALING HOSPITAL NHS TRUST	142	147.89	165.30	144.95	43.87	*		160.83	27.99	*	
3014	BLACKPOOL, FYLDE AND WYRE HOSPITALS NHS TRUST	293	146.76	163.68	129.60	59.23	*		140.65	48.17	*	
3103	DUDLEY GROUP OF HOSPITALS NHS TRUST	255	141.18	161.59	132.13	56.70	*		143.98	44.85	*	
3153	SOUTH LONDON HEALTHCARE NHS TRUST	565	145.13	151.41	119.75	69.08	*		127.71	61.12	*	
3211	EAST SOMERSET NHS TRUST	153	124.18	147.99	143.10	45.73	*		158.40	30.43		
3192	MAIDSTONE AND TUNBRIDGE WELLS NHS TRUST	410	129.27	143.88	124.15	64.67	*		133.50	55.33	*	
3072	NORTHAMPTON GENERAL HOSPITAL NHS TRUST	371	129.38	142.86	125.68	63.15	*		135.50	53.32	*	
3123	THE PRINCESS ALEXANDRA HOSPITAL NHS TRUST	275	127.27	142.05	130.73	58.10	*		142.14	46.69		
3146	BARKING, HAVERING AND REDBRIDGE HOSPITALS NHS TRU	563	129.66	135.17	119.79	69.03	*		127.77	61.06	*	
3117	PETERBOROUGH HOSPITALS NHS TRUST	254	122.05	134.17	132.20	56.63	*		144.07	44.75		
3157	THE HILLINGDON HOSPITAL NHS TRUST	151	125.83	132.33	143.42	45.40			158.82	30.00		
3129	BASILDON AND THURROCK UNIVERSITY HOSPITALS NHS TR	484	119.83	131.97	121.79	67.04	*		130.39	58.44	*	
3043	NORTH CHESHIRE HOSPITALS NHS TRUST	502	123.51	130.26	121.29	67.53	*		129.74	59.09	*	
3138	THE WHITTINGTON HOSPITAL NHS TRUST	119	109.24	128.05	149.62	39.21			166.97	21.86		
3186	SURREY AND SUSSEX HEALTHCARE NHS TRUST	345	115.94	126.72	126.84	61.99			137.02	51.80		
3209	POOLE HOSPITALS NHS TRUST	277	119.13	126.28	130.60	58.23			141.97	46.86		
3078	SOUTHERN DERBYSHIRE ACUTE HOSPITALS NHS TRUST	736	120.92	125.81	116.61	72.21	*		123.59	65.24	*	
3006	CITY HOSPITALS SUNDERLAND NHS TRUST	312	115.38	125.40	128.51	60.32			139.22	49.60		
3122	EAST AND NORTH HERTFORDSHIRE NHS TRUST	284	112.68	123.73	130.15	58.68			141.38	47.45		
3052	HARROGATE HEALTH CARE NHS TRUST	352	122.16	123.55	126.51	62.31			136.60	52.23		
3040	CENTRAL MANCHESTER AND MANCHESTER CHILDRENS UNI	208	100.96	122.00	136.17	52.66			149.29	39.53		
3028	AINTREE HOSPITALS NHS TRUST	290	113.79	121.04	129.78	59.05			140.89	47.94		
3203	UNITED BRISTOL HEALTHCARE NHS TRUST	318	113.21	120.20	128.18	60.64			138.80	50.03		
3007	COUNTY DURHAM AND DARLINGTON ACUTE HOSPITALS NH	619	117.93	120.14	118.62	70.21	*		126.22	62.60		
3062	CALDERDALE AND HUDDERSFIELD NHS TRUST	621	112.72	119.99	118.58	70.25	*		126.17	62.65		
3210	WEST DORSET GENERAL HOSPITALS NHS TRUST	370	118.92	119.99	125.72	63.10			135.56	53.27		
3082	WALSALL HOSPITALS NHS TRUST	320	112.50	119.98	128.08	60.75			138.66	50.17		
3213	TAUNTON AND SOMERSET NHS TRUST	202	108.91	119.57	136.79	52.04			150.10	38.73		
3140	KINGSTON HOSPITAL NHS TRUST	291	120.27	118.94	129.72	59.11			140.81	48.02		
3165	EPSOM AND ST HELIER NHS TRUST	530	116.98	118.16	120.57	68.25			128.79	60.03		

APPENDIX 2b:

Tables England

WITHIN-Country analysis

HOSPITAL APPROACH

Year 2009

Table 12 (continued): Hospital outcomes for Acute Myocardial Infarction patients*
National benchmark estimation

3026	WIRRAL HOSPITAL NHS TRUST	557	113.11	117.76	119.93	68.90			127.95	60.88	
3172	ROYAL BERKSHIRE AND BATTLE HOSPITALS NHS TRUST	420	107.14	116.54	123.80	65.03			133.03	55.79	
3080	BURTON HOSPITALS NHS TRUST	268	108.21	116.54	131.20	57.63			142.76	46.07	
3029	ROYAL LIVERPOOL AND BROADGREEN UNIVERSITY HOSPIT.	255	109.80	116.43	132.13	56.70			143.98	44.85	
3131	NORTH MIDDLESEX UNIVERSITY HOSPITAL NHS TRUST	236	110.17	116.28	133.61	55.21			145.93	42.89	
3035	TRAFFORD HEALTHCARE NHS TRUST	142	112.68	116.03	144.95	43.87			160.83	27.99	
3130	BARNET AND CHASE FARM HOSPITALS NHS TRUST	454	114.54	115.62	122.68	66.15			131.56	57.27	
3083	BIRMINGHAM HEARTLANDS AND SOLIHULL (TEACHING) NH	758	106.86	115.29	116.29	72.54			123.16	65.67	
3024	ST HELENS AND KNOWSLEY HOSPITALS NHS TRUST	322	114.91	113.97	127.97	60.85			138.52	50.31	
3005	SOUTH TYNESIDE HEALTH CARE NHS TRUST	222	117.12	113.64	134.83	53.99			147.53	41.29	
3091	SHREWSBURY AND TELFORD HOSPITALS NHS TRUST	619	108.24	113.36	118.62	70.21			126.22	62.60	
3124	MID ESSEX HOSPITAL SERVICES NHS TRUST	377	103.45	113.08	125.43	63.40			135.18	53.65	
3158	THE LEWISHAM HOSPITAL NHS TRUST	173	115.61	112.75	140.20	48.63			154.59	34.24	
3204	ROYAL UNITED HOSPITAL BATH NHS TRUST	305	108.20	110.44	128.90	59.93			139.73	49.09	
3118	KINGS LYNN AND WISBECH HOSPITALS NHS TRUST	348	109.20	108.84	126.70	62.13			136.84	51.99	
3195	EAST KENT HOSPITALS NHS TRUST	997	107.32	108.19	113.49	75.34			119.48	69.35	
3025	SOUTHPORT AND ORMSKIRK HOSPITAL NHS TRUST	329	100.30	108.14	127.61	61.21			138.05	50.78	
3191	EAST SUSSEX HOSPITALS NHS TRUST	716	107.54	108.13	116.92	71.91			123.99	64.83	
3050	BRADFORD TEACHING HOSPITALS NHS TRUST	555	102.70	107.78	119.98	68.85			128.01	60.82	
3194	MEDWAY NHS TRUST	501	99.80	106.02	121.32	67.51			129.77	59.05	
3108	WEST SUFFOLK HOSPITALS NHS TRUST	285	108.77	105.46	130.09	58.74			141.30	47.53	
3177	SOUTHAMPTON UNIVERSITY HOSPITALS NHS TRUST	395	103.80	105.01	124.71	64.11			134.24	54.59	
3154	NORTH WEST LONDON HOSPITALS NHS TRUST	554	108.30	104.68	120.00	68.83			128.04	60.79	
3105	BEDFORD HOSPITALS NHS TRUST	240	104.17	104.39	133.29	55.54			145.50	43.32	
3114	JAMES PAGET HEALTHCARE NHS TRUST	254	102.36	104.10	132.20	56.63			144.07	44.75	
3188	BRIGHTON AND SUSSEX UNIVERSITY HOSPITALS NHS TRUS	506	100.79	104.00	121.19	67.64			129.60	59.23	
3128	ESSEX RIVERS HEALTHCARE NHS TRUST	457	100.66	102.85	122.58	66.24			131.44	57.39	
3067	CHESTERFIELD AND NORTH DERBYSHIRE ROYAL HOSPITAL I	503	99.40	100.53	121.27	67.56			129.70	59.12	
3012	NORTH CUMBRIA ACUTE HOSPITALS NHS TRUST	643	97.98	100.23	118.16	70.66			125.63	63.20	
3039	PENNINE ACUTE HOSPITALS NHS TRUST	1264	97.31	100.09	111.35	77.47			116.67	72.15	
3183	WESTERN SUSSEX HOSPITALS NHS TRUST	683	99.56	99.74	117.46	71.37			124.70	64.13	
3182	ROYAL SURREY COUNTY HOSPITAL NHS TRUST	324	95.68	98.90	127.87	60.96			138.38	50.44	
3112	IPSWICH HOSPITAL NHS TRUST	756	101.85	98.00	116.32	72.51			123.20	65.63	
3070	KETTERING GENERAL HOSPITAL NHS TRUST	291	92.78	97.21	129.72	59.11			140.81	48.02	
3119	HINCHINGBROOKE HEALTH CARE NHS TRUST	168	101.19	97.09	140.88	47.95			155.48	33.35	
3085	UNIVERSITY HOSPITAL BIRMINGHAM NHS TRUST	304	88.82	96.26	128.95	59.87			139.81	49.02	
3041	SOUTH MANCHESTER UNIVERSITY HOSPITALS NHS TRUST	507	90.73	95.82	121.16	67.67			129.56	59.26	
3094	UNIVERSITY HOSPITALS COVENTRY AND WARWICKSHIRE N	602	93.02	95.49	118.96	69.87			126.67	62.16	
3180	PORTSMOUTH HOSPITALS NHS TRUST	643	93.31	95.17	118.16	70.66			125.63	63.20	
3173	HEATHERWOOD AND WEXHAM PARK HOSPITALS NHS TRU	423	92.20	94.02	123.69	65.13			132.90	55.93	
3121	NORFOLK AND NORWICH UNIVERSITY HOSPITAL NHS TRUS	1114	93.36	93.38	112.46	76.37			118.13	70.70	
3218	SOUTH DEVON HEALTH CARE NHS TRUST	418	93.30	93.32	123.87	64.96			133.12	55.70	
3111	ADDENBROOKES NHS TRUST	338	97.63	92.01	127.17	61.66			137.46	51.36	
3056	BARNSLEY DISTRICT GENERAL HOSPITAL NHS TRUST	460	91.30	90.98	122.49	66.33			131.32	57.51	
3166	OXFORD RADCLIFFE HOSPITALS NHS TRUST	783	88.12	90.81	115.93	72.89			122.70	66.13	
3219	ROYAL CORNWALL HOSPITALS NHS TRUST	777	91.38	90.65	116.02	72.81			122.81	66.02	
3048	YORK HOSPITALS NHS TRUST	422	87.68	88.06	123.73	65.10			132.94	55.88	
3147	WEST MIDDLESEX UNIVERSITY NHS TRUST	137	87.59	87.42	145.86	42.96			162.03	26.79	
3200	SALISBURY HEALTH CARE NHS TRUST	195	87.18	86.91	137.54	51.29			151.09	37.73	
3084	SANDWELL AND WEST BIRMINGHAM HOSPITALS NHS TRUS	650	84.62	86.82	118.03	70.79			125.46	63.37	
3198	GLOUCESTERSHIRE HOSPITALS NHS TRUST	734	87.19	86.69	116.64	72.18			123.63	65.20	
3206	WESTON AREA HEALTH NHS TRUST	292	99.32	86.30	129.66	59.17			140.73	48.10	
3022	THE MID CHESHIRE HOSPITALS NHS TRUST	475	86.32	84.70	122.05	66.78			130.73	58.10	
3115	WEST HERTFORDSHIRE HOSPITALS NHS TRUST	284	91.55	84.50	130.15	58.68			141.38	47.45	
3001	NORTHUMBRIA HEALTH CARE NHS TRUST	855	87.72	84.40	115.01	73.82			121.48	67.35	
3065	DONCASTER AND BASSETLAW HOSPITALS NHS TRUST	700	82.86	84.03	117.18	71.65			124.33	64.50	
3047	STOCKPORT NHS TRUST	634	86.75	82.98	118.33	70.50			125.85	62.98	
3207	ROYAL BOURNEMOUTH AND CHRISTCHURCH HOSPITALS N	753	82.34	82.78	116.36	72.47			123.26	65.57	

APPENDIX 2b:

Tables England

WITHIN-Country analysis

HOSPITAL APPROACH

Year 2009

Table 12 (continued): Hospital outcomes for Acute Myocardial Infarction patients* National benchmark

3045	BOLTON HOSPITALS NHS TRUST	523	82.22	82.01	120.75	68.08			129.02	59.80		
3171	MILTON KEYNES GENERAL HOSPITAL NHS TRUST	252	83.33	81.70	132.35	56.48			144.27	44.56		
3074	UNITED LINCOLNSHIRE HOSPITALS NHS TRUST	1251	83.13	81.40	111.44	77.39			116.79	72.04		
3055	HULL AND EAST YORKSHIRE HOSPITALS NHS TRUST	618	77.67	81.14	118.64	70.19			126.25	62.58		
3096	SOUTH WARWICKSHIRE GENERAL HOSPITALS NHS TRUST	144	83.33	79.86	144.60	44.23			160.37	28.46		
3009	NORTH TEES AND HARTLEPOOL NHS TRUST	441	79.37	79.06	123.09	65.74			132.10	56.72		
3053	NORTHERN LINCOLNSHIRE AND GOOLE HOSPITALS NHS TR	740	75.68	77.80	116.55	72.27			123.51	65.32		
3058	SHEFFIELD TEACHING HOSPITALS NHS TRUST	1088	77.21	76.96	112.67	76.16			118.41	70.42		
3036	TAMESIDE AND GLOSSOP ACUTE SERVICES NHS TRUST	409	78.24	76.87	124.19	64.63			133.55	55.28		
3101	UNIVERSITY HOSPITAL OF NORTH STAFFORDSHIRE NHS TR	1168	73.63	75.39	112.03	76.79		*	117.57	71.25		
3216	NORTHERN DEVON HEALTHCARE NHS TRUST	410	78.05	75.37	124.15	64.67			133.50	55.33		
3076	NOTTINGHAM UNIVERSITY HOSPITALS NHS TRUST	1289	75.25	74.07	111.19	77.64		*	116.46	72.37		
3057	ROTHERHAM GENERAL HOSPITALS NHS TRUST	418	74.16	73.11	123.87	64.96			133.12	55.70		
3017	EAST LANCASHIRE HOSPITALS NHS TRUST	697	73.17	72.09	117.22	71.60			124.39	64.43		
3179	NORTH HAMPSHIRE HOSPITALS NHS TRUST	242	70.25	71.27	133.13	55.70			145.29	43.54		
3010	SOUTH TEES HOSPITALS NHS TRUST	1078	71.43	70.25	112.76	76.07		*	118.52	70.31		*
3051	AIREDALE NHS TRUST	273	73.26	69.96	130.86	57.96			142.31	46.51		
3144	ROYAL BROMPTON AND HAREFIELD NHS TRUST	326	64.42	69.88	127.77	61.06			138.25	50.58		
3004	GATESHEAD HEALTH NHS TRUST	340	76.47	69.65	127.07	61.75			137.34	51.49		
3217	PLYMOUTH HOSPITALS NHS TRUST	557	73.61	69.39	119.93	68.90			127.95	60.88		
3106	LUTON AND DUNSTABLE HOSPITAL NHS TRUST	450	77.78	69.38	122.80	66.02			131.72	57.10		
3097	WORCESTERSHIRE ACUTE HOSPITALS NHS TRUST	644	71.43	69.19	118.14	70.68		*	125.60	63.22		
3164	MAYDAY HEALTHCARE NHS TRUST	194	82.47	68.95	137.65	51.18			151.24	37.59		
3068	UNIVERSITY HOSPITALS OF LEICESTER NHS TRUST	1133	73.26	68.80	112.30	76.52		*	117.93	70.90		*
3181	ASHFORD AND ST PETERS HOSPITALS NHS TRUST	491	73.32	67.82	121.59	67.23			130.13	58.69		
3214	ROYAL DEVON AND EXETER HEALTHCARE NHS TRUST	611	73.65	67.03	118.78	70.05		*	126.43	62.39		
3013	MORECAMBE BAY HOSPITALS NHS TRUST	616	69.81	65.96	118.68	70.15		*	126.30	62.52		
3038	SALFORD ROYAL HOSPITALS NHS TRUST	268	74.63	65.42	131.20	57.63			142.76	46.07		
3093	GEORGE ELIOT HOSPITAL NHS TRUST	186	69.89	65.15	138.57	50.26			152.45	36.38		
3109	PAPWORTH HOSPITAL NHS TRUST	193	62.18	64.81	137.76	51.06			151.38	37.44		
3156	NEWHAM HEALTHCARE NHS TRUST	235	76.60	63.91	133.70	55.13			146.04	42.78		
3141	IMPERIAL COLLEGE HEALTHCARE NHS TRUST	830	63.86	63.25	115.32	73.51		*	121.89	66.94		*
3020	COUNTESS OF CHESTER HOSPITAL NHS TRUST	318	69.18	63.15	128.18	60.64			138.80	50.03		
3127	SOUTHEND HOSPITAL NHS TRUST	330	75.76	62.77	127.56	61.26			137.98	50.84		
3063	LEEDS TEACHING HOSPITALS NHS TRUST	1070	63.55	62.01	112.82	76.00		*	118.61	70.22		*
3002	THE NEWCASTLE UPON TYNE HOSPITALS NHS TRUST	1572	59.80	59.61	109.60	79.22		*	114.37	74.45		*
3046	WRIGHTINGTON, WIGAN AND LEIGH NHS TRUST	336	62.50	58.90	127.27	61.56		*	137.59	51.23		
3090	HEREFORD HOSPITALS NHS TRUST	254	62.99	58.88	132.20	56.63			144.07	44.75		
3134	ROYAL FREE HAMPSTEAD NHS TRUST	284	63.38	58.34	130.15	58.68		*	141.38	47.45		
3075	SHERWOOD FOREST HOSPITALS NHS TRUST	680	63.24	57.16	117.51	71.32		*	124.76	64.06		*
3081	THE ROYAL WOLVERHAMPTON HOSPITALS NHS TRUST	1083	55.40	55.75	112.71	76.11		*	118.46	70.36		*
3189	DARTFORD AND GRAVESHAM NHS TRUST	301	63.12	54.38	129.12	59.70		*	140.03	48.79		
3170	BUCKINGHAMSHIRE HOSPITALS NHS TRUST	334	59.88	53.23	127.37	61.46		*	137.72	51.11		
3142	CHELSEA AND WESTMINSTER HEALTHCARE NHS TRUST	67	74.63	52.58	167.99	20.84			191.11	-2.28		
3176	WINCHESTER AND EASTLEIGH HEALTHCARE NHS TRUST	234	64.10	52.44	133.78	55.04		*	146.15	42.67		
3161	KINGS COLLEGE HOSPITAL NHS TRUST	477	56.60	52.41	121.99	66.84		*	130.65	58.17		*
3150	HOMERTON UNIVERSITY HOSPITAL NHS TRUST	167	59.88	49.06	141.01	47.81			155.66	33.17		
3135	UNIVERSITY COLLEGE LONDON HOSPITALS NHS TRUST	340	50.00	47.73	127.07	61.75		*	137.34	51.49		*
3148	ST GEORGES HEALTHCARE NHS TRUST	954	51.36	47.26	113.91	74.91		*	120.04	68.79		*
3202	NORTH BRISTOL NHS TRUST	413	58.11	45.47	124.05	64.78		*	133.36	55.47		*
3060	MID YORKSHIRE HOSPITALS NHS TRUST	855	46.78	41.45	115.01	73.82		*	121.48	67.35		*
3132	BARTS AND THE LONDON NHS TRUST	912	43.86	40.90	114.35	74.47		*	120.62	68.20		*
3032	THE CARDIOTHORACIC CENTRE - LIVERPOOL NHS TRUST	451	39.91	34.64	122.77	66.05		*	131.68	57.14		*
3175	FRIMLEY PARK HOSPITAL NHS TRUST	377	42.44	33.19	125.43	63.40		*	135.18	53.65		*
3015	LANCASHIRE TEACHING HOSPITALS NHS TRUST	502	37.85	25.66	121.29	67.53		*	129.74	59.09		*
3023	EAST CHESHIRE NHS TRUST	263	38.02	22.34	131.55	57.28		*	143.22	45.61		*
3199	SWINDON AND MARLBOROUGH NHS TRUST	347	2.88	0.20	126.74	62.08		*	136.90	51.92		*

(i) Total amount of AMI admissions per hospital accumulated during the period of analysis.

** Hospitals with less than 30 AMI admissions per year are dropped from the analysis.*

CFR: Crude case fatality rate per 1,000 AMI hospitalised patients; sCFR: Risk-adjusted Case Fatality Rate per 1,000 AMI hospitalised patients. Hospitals above the CI-99 control limit are considered in "Alarm position"; hospitals above the CI-95 control limit are considered in an "Alert position"; hospitals below the CI-95 control limit are considered "Good performers" and hospitals below the CI-99 control limit are considered "Excellent performers".

APPENDIX 2b:

Tables England

IN-Country analysis

HOSPITAL APPROACH

Year 2009

Table 13: Hospital outcomes for Percutaneous Coronary Interventions, 2009. National benchmark estimation*

Hospital					Expected Rate		Relative Position		Expected Rate		Relative Position	
Code	Name	PCI cases (i)	Hospital CFR	Hospital sCFR	UCI 95%	LCI 95%	Above IC95	Below IC95	UCI 99%	LCI 99%	Above IC99	Below IC99
3218	SOUTH DEVON HEALTH CARE NHS TRUST	308	29.22	39.28	26.78	0.63	*		30.88	-3.48	*	
3203	UNITED BRISTOL HEALTHCARE NHS TRUST	997	31.09	32.59	20.97	6.44	*		23.25	4.15	*	
3177	SOUTHAMPTON UNIVERSITY HOSPITALS NHS TRUST	849	28.27	32.25	21.58	5.83	*		24.05	3.35	*	
3050	BRADFORD TEACHING HOSPITALS NHS TRUST	236	21.19	31.57	28.64	-1.23	*		33.33	-5.92		
3198	GLOUCESTERSHIRE HOSPITALS NHS TRUST	590	23.73	30.07	23.15	4.26	*		26.12	1.29	*	
3101	UNIVERSITY HOSPITAL OF NORTH STAFFORDSHIRE NHS	1428	25.21	28.12	19.77	7.63	*		21.68	5.72	*	
3186	SURREY AND SUSSEX HEALTHCARE NHS TRUST	416	21.63	27.40	24.95	2.45	*		28.49	-1.08		
3058	SHEFFIELD TEACHING HOSPITALS NHS TRUST	1489	24.18	27.03	19.65	7.76	*		21.52	5.89	*	
3084	SANDWELL AND WEST BIRMINGHAM HOSPITALS NHS T	763	24.90	26.34	22.01	5.40	*		24.62	2.79	*	
3122	EAST AND NORTH HERTFORDSHIRE NHS TRUST	394	20.30	25.99	25.26	2.14	*		28.89	-1.49		
3172	ROYAL BERKSHIRE AND BATTLE HOSPITALS NHS TRUST	562	21.35	25.10	23.38	4.03	*		26.42	0.98		
3135	UNIVERSITY COLLEGE LONDON HOSPITALS NHS TRUST	620	20.97	24.91	22.92	4.49	*		25.81	1.59		
3204	ROYAL UNITED HOSPITAL BATH NHS TRUST	350	22.86	24.81	25.97	1.44			29.82	-2.41		
3214	ROYAL DEVON AND EXETER HEALTHCARE NHS TRUST	746	25.47	24.35	22.10	5.30	*		24.74	2.66		
3134	ROYAL FREE HAMPSTEAD NHS TRUST	639	20.34	24.08	22.78	4.63	*		25.63	1.77		
3002	THE NEWCASTLE UPON TYNE HOSPITALS NHS TRUST	2693	21.91	22.84	18.12	9.28	*		19.51	7.89	*	
3010	SOUTH TEES HOSPITALS NHS TRUST	1571	21.01	21.67	19.49	7.91	*		21.31	6.10	*	
3132	BARTS AND THE LONDON NHS TRUST	1867	19.82	20.79	19.01	8.39	*		20.68	6.72	*	
3213	TAUNTON AND SOMERSET NHS TRUST	505	17.82	20.66	23.91	3.49			27.12	0.29		
3144	ROYAL BROMPTON AND HAREFIELD NHS TRUST	1871	18.71	19.73	19.01	8.40	*		20.67	6.73		
3191	EAST SUSSEX HOSPITALS NHS TRUST	588	17.01	19.27	23.17	4.24			26.14	1.27		
3148	ST GEORGES HEALTHCARE NHS TRUST	1218	18.06	18.54	20.28	7.13			22.34	5.06		
3179	NORTH HAMPSHIRE HOSPITALS NHS TRUST	459	15.25	18.08	24.41	2.99			27.78	-0.37		
3219	ROYAL CORNWALL HOSPITALS NHS TRUST	642	17.13	18.03	22.76	4.65			25.60	1.80		
3085	UNIVERSITY HOSPITAL BIRMINGHAM NHS TRUST	899	16.69	17.89	21.36	6.05			23.76	3.65		
3068	UNIVERSITY HOSPITALS OF LEICESTER NHS TRUST	1576	18.40	17.58	19.48	7.92			21.30	6.11		
3040	CENTRAL MANCHESTER AND MANCHESTER CHILDRENS U	1476	15.58	16.85	19.68	7.73			21.55	5.85		
3166	OXFORD RADCLIFFE HOSPITALS NHS TRUST	1562	16.01	16.75	19.51	7.90			21.33	6.07		
3081	THE ROYAL WOLVERHAMPTON HOSPITALS NHS TRUST	1408	14.91	16.29	19.82	7.59			21.74	5.67		
3076	NOTTINGHAM UNIVERSITY HOSPITALS NHS TRUST	1127	15.08	15.70	20.54	6.87			22.69	4.72		
3159	GUYS AND ST THOMAS NHS TRUST	1182	14.38	15.63	20.38	7.03			22.47	4.93		
3121	NORFOLK AND NORWICH UNIVERSITY HOSPITAL NHS T	1332	15.02	15.19	19.99	7.42			21.97	5.44		
3141	IMPERIAL COLLEGE HEALTHCARE NHS TRUST	1780	15.17	15.14	19.14	8.27			20.85	6.56		
3164	MAYDAY HEALTHCARE NHS TRUST	374	13.37	14.99	25.57	1.84			29.29	-1.89		

APPENDIX 2b:

Tables England

IN-Country analysis

HOSPITAL APPROACH

Year 2009

Table 13 (continued): Hospital outcomes for Percutaneous Coronary Interventions, 2009. National benchmark estimation*

3078	SOUTHERN DERBYSHIRE ACUTE HOSPITALS NHS TRUST	408	12.25	14.58	25.06	2.34			28.63	-1.22		
3083	BIRMINGHAM HEARTLANDS AND SOLIHULL (TEACHING)	1017	13.77	14.00	20.90	6.51			23.16	4.25		
3115	WEST HERTFORDSHIRE HOSPITALS NHS TRUST	350	14.29	13.95	25.97	1.44			29.82	-2.41		
3217	PLYMOUTH HOSPITALS NHS TRUST	536	13.06	12.97	23.61	3.79			26.73	0.68		
3161	KINGS COLLEGE HOSPITAL NHS TRUST	1180	13.56	12.93	20.38	7.02			22.48	4.93		
3202	NORTH BRISTOL NHS TRUST	192	10.42	12.67	30.26	-2.85			35.46	-8.06		
3063	LEEDS TEACHING HOSPITALS NHS TRUST	2954	12.19	12.38	17.92	9.48			19.25	8.16		
3180	PORTSMOUTH HOSPITALS NHS TRUST	719	12.52	12.37	22.26	5.15			24.95	2.46		
3175	FRIMLEY PARK HOSPITAL NHS TRUST	597	11.73	12.01	23.09	4.31			26.04	1.36		
3129	BASILDON AND THURROCK UNIVERSITY HOSPITALS NH!	1778	10.69	10.43	19.14	8.26			20.85	6.55		
3094	UNIVERSITY HOSPITALS COVENTRY AND WARWICKSHIF	1032	10.66	9.35	20.85	6.56			23.09	4.32		
3109	PAPWORTH HOSPITAL NHS TRUST	2120	8.96	8.93	18.69	8.72			20.25	7.15		
3006	CITY HOSPITALS SUNDERLAND NHS TRUST	409	9.78	8.92	25.05	2.36			28.61	-1.21		
3188	BRIGHTON AND SUSSEX UNIVERSITY HOSPITALS NHS TF	948	9.49	8.24	21.15	6.25			23.50	3.91		
3014	BLACKPOOL, FYLDE AND WYRE HOSPITALS NHS TRUST	1726	8.11	7.99	19.23	8.18		*	20.96	6.45		
3154	NORTH WEST LONDON HOSPITALS NHS TRUST	406	9.85	6.92	25.09	2.32			28.67	-1.26		
3041	SOUTH MANCHESTER UNIVERSITY HOSPITALS NHS TRU!	1027	6.82	6.11	20.86	6.54		*	23.11	4.29		
3055	HULL AND EAST YORKSHIRE HOSPITALS NHS TRUST	1686	6.52	6.05	19.29	8.12		*	21.05	6.36		*
3097	WORCESTERSHIRE ACUTE HOSPITALS NHS TRUST	409	7.33	5.72	25.05	2.36			28.61	-1.21		
3032	THE CARDIOTHORACIC CENTRE - LIVERPOOL NHS TRUS	2590	6.56	5.57	18.21	9.19		*	19.63	7.78		*
3072	NORTHAMPTON GENERAL HOSPITAL NHS TRUST	336	5.95	4.50	26.22	1.19			30.15	-2.75		
3170	BUCKINGHAMSHIRE HOSPITALS NHS TRUST	504	5.95	4.21	23.92	3.48			27.13	0.27		
3207	ROYAL BOURNEMOUTH AND CHRISTCHURCH HOSPITAL	1687	5.33	3.94	19.29	8.12		*	21.04	6.36		*
3183	WESTERN SUSSEX HOSPITALS NHS TRUST	352	5.68	3.94	25.93	1.47			29.77	-2.37		
3151	WHIPPS CROSS UNIVERSITY HOSPITAL NHS TRUST	192	5.21	3.22	30.26	-2.85			35.46	-8.06		
3153	SOUTH LONDON HEALTHCARE NHS TRUST	182	5.49	3.17	30.71	-3.30			36.05	-8.65		
3210	WEST DORSET GENERAL HOSPITALS NHS TRUST	463	6.48	3.13	24.37	3.04			27.72	-0.31		
3173	HEATHERWOOD AND WEXHAM PARK HOSPITALS NHS T	290	3.45	1.71	27.18	0.23			31.41	-4.00		
3070	KETTERING GENERAL HOSPITAL NHS TRUST	643	3.11	1.54	22.75	4.66		*	25.59	1.81		*
3195	EAST KENT HOSPITALS NHS TRUST	360	2.78	1.21	25.80	1.61		*	29.60	-2.19		
3046	WRIGHTINGTON, WIGAN AND LEIGH NHS TRUST	366	2.73	1.21	25.70	1.71		*	29.46	-2.06		
3181	ASHFORD AND ST PETERS HOSPITALS NHS TRUST	347	2.88	0.98	26.02	1.39		*	29.89	-2.48		
3039	PENNINE ACUTE HOSPITALS NHS TRUST	470	0.00	0.00	24.29	3.12		*	27.61	-0.21		
3074	UNITED LINCOLNSHIRE HOSPITALS NHS TRUST	233	0.00	0.00	28.73	-1.33			33.46	-6.05		
3075	SHERWOOD FOREST HOSPITALS NHS TRUST	245	0.00	0.00	28.36	-0.95			32.97	-5.56		
3189	DARTFORD AND GRAVESHAM NHS TRUST	176	0.00	0.00	31.00	-3.59			36.43	-9.03		
3192	MAIDSTONE AND TUNBRIDGE WELLS NHS TRUST	239	0.00	0.00	28.54	-1.14			33.21	-5.80		
3194	MEDWAY NHS TRUST	121	0.00	0.00	34.56	-7.15			41.12	-13.71		
3199	SWINDON AND MARLBOROUGH NHS TRUST	332	0.00	0.00	26.30	1.11		*	30.25	-2.85		

(i) Total amount of interventions per hospital accumulated during the period of analysis.
** The national benchmarking is based on the average outcomes obtained using just the 7 Danish hospitals while the ECHO benchmarking uses the average across all hospitals in ECHO performing this type of intervention*
Hospitals performing less than 30 interventions per year are dropped form the analysis
CFR: Crude case fatality rate per 1,000 patients undergoing PCI procedure; sCFR: Risk-adjusted Case Fatality Rate per 1,000 patients undergoing PCI procedure. Hospitals above the CI-99 control limit are considered in "Alarm position"; hospitals above the CI-95 control limit are considered in an "Alert position"; hospitals below the CI-95 control limit are considered "Good performers" and hospitals below the CI-99 control limit are considered "Excellent performers".

EUROPEAN COLLABORATION FOR HEALTHCARE OPTIMIZATION

APPENDIX 2b:

Tables England

WITHIN-Country analysis

HOSPITAL APPROACH

Year 2009

Table 14. Hospital outcomes for Coronary Artery Bypass Graft, 2009. National benchmark estimation*

Hospital					Expected Rate		Relative Position		Expected Rate		Relative Position	
Code	Name	CABG cases (i)	Hospital CFR	Hospital sCFR	UCI 95%	LCI 95%	Above IC95	Below IC95	UCI 99%	LCI 99%	Above IC99	Below IC99
3161	KINGS COLLEGE HOSPITAL NHS TRUST	527	43.64	48.76	42.05	13.57	*		46.52	9.10	*	
3101	UNIVERSITY HOSPITAL OF NORTH STAFFORDSHIRE NHS	577	39.86	45.46	41.41	14.20	*		45.69	9.93		
3166	OXFORD RADCLIFFE HOSPITALS NHS TRUST	373	40.21	44.80	44.73	10.88	*		50.05	5.57		
3159	GUYS AND ST THOMAS NHS TRUST	891	35.91	39.99	38.76	16.86	*		42.20	13.42		
3032	THE CARDIOTHORACIC CENTRE - LIVERPOOL NHS TRUST	1222	36.82	36.30	37.16	18.46			40.10	15.52		
3217	PLYMOUTH HOSPITALS NHS TRUST	861	33.68	34.38	38.95	16.67			42.45	13.17		
3085	UNIVERSITY HOSPITAL BIRMINGHAM NHS TRUST	487	34.91	34.31	42.62	13.00			47.27	8.34		
3040	CENTRAL MANCHESTER AND MANCHESTER CHILDRENS (	557	32.32	33.95	41.66	13.96			46.01	9.61		
3141	IMPERIAL COLLEGE HEALTHCARE NHS TRUST	694	31.70	33.47	40.21	15.40			44.11	11.50		
3132	BARTS AND THE LONDON NHS TRUST	930	30.11	32.28	38.53	17.09			41.89	13.72		
3135	UNIVERSITY COLLEGE LONDON HOSPITALS NHS TRUST	554	28.88	31.92	41.69	13.92			46.06	9.56		
3002	THE NEWCASTLE UPON TYNE HOSPITALS NHS TRUST	520	28.85	30.93	42.14	13.48			46.64	8.97		
3109	PAPWORTH HOSPITAL NHS TRUST	1379	29.73	29.89	36.61	19.01			39.37	16.24		
3055	HULL AND EAST YORKSHIRE HOSPITALS NHS TRUST	602	26.58	28.28	41.13	14.49			45.31	10.30		
3203	UNITED BRISTOL HEALTHCARE NHS TRUST	1020	26.47	26.60	38.04	17.57			41.26	14.36		
3063	LEEDS TEACHING HOSPITALS NHS TRUST	519	26.97	26.56	42.15	13.46			46.66	8.95		
3068	UNIVERSITY HOSPITALS OF LEICESTER NHS TRUST	592	32.09	26.45	41.24	14.37			45.46	10.15		
3076	NOTTINGHAM UNIVERSITY HOSPITALS NHS TRUST	480	29.17	25.94	42.73	12.89			47.41	8.20		
3058	SHEFFIELD TEACHING HOSPITALS NHS TRUST	778	23.14	23.75	39.53	16.09			43.21	12.41		
3144	ROYAL BROMPTON AND HAREFIELD NHS TRUST	1145	24.45	23.72	37.47	18.15			40.50	15.11		
3188	BRIGHTON AND SUSSEX UNIVERSITY HOSPITALS NHS TF	445	22.47	21.29	43.30	12.31			48.17	7.45		
3010	SOUTH TEES HOSPITALS NHS TRUST	844	21.33	18.93	39.06	16.56			42.59	13.02		
3148	ST GEORGES HEALTHCARE NHS TRUST	696	18.68	18.70	40.20	15.42			44.09	11.53		
3129	BASILDON AND THURROCK UNIVERSITY HOSPITALS NH!	664	18.07	18.55	40.49	15.12			44.48	11.14		
3014	BLACKPOOL, FYLDE AND WYRE HOSPITALS NHS TRUST	819	17.09	17.25	39.23	16.39			42.82	12.80		
3177	SOUTHAMPTON UNIVERSITY HOSPITALS NHS TRUST	953	17.84	14.41	38.40	17.22		*	41.72	13.89		
3081	THE ROYAL WOLVERHAMPTON HOSPITALS NHS TRUST	680	13.24	13.76	40.34	15.27		*	44.28	11.34		
3094	UNIVERSITY HOSPITALS COVENTRY AND WARWICKSHIF	536	16.79	13.69	41.93	13.69			46.36	9.25		
3041	SOUTH MANCHESTER UNIVERSITY HOSPITALS NHS TRU!	661	13.62	12.11	40.52	15.10		*	44.51	11.10		

(i) Total amount of interventions per hospital accumulated during the period of analysis.

** The national benchmarking is based on the average outcomes obtained using just the 6 Danish hospitals while the ECHO benchmarking uses the average across all hospitals in ECHO performing this type of intervention. Hospitals performing less than 30 interventions per year are dropped form the anlysis*

CFR: Crude case fatality rate per 1,000 patients undergoing CABG surgery; sCFR: Risk-adjusted Case Fatality Rate per 1,000 patients undergoing CABG surgery. Hospitals above the CI-99 control limit are considered in "Alarm position"; hospitals above the CI-95 control limit are considered in an "Alert position"; hospitals below the CI-95 control limit are considered "Good performers" and hospitals below the CI-99 control limit are considered "Excellent performers".

APPENDIX 3.a:

Tables England

Evolution over time

GEOGRAPHICAL APPROACH

Period of analysis: 2002-2009

Table 15. England descriptive statistics over time for burden of disease: CID.

	CORONARY ISCHAEMIC DISEASE							
	2002	2003	2004	2005	2006	2007	2008	2009
Cases	174620	170502	167366	163373	159466	152609	149216	141167
Stand. Rate	42.77	41.92	41.14	40.53	39.98	38.06	36.98	35.18
sR Q1.	48.83	46.91	46.10	44.41	43.09	41.82	41.28	39.15
sR Q5.	33.92	33.73	33.22	33.51	33.05	31.64	29.98	28.33
SCV	0.06	0.06	0.06	0.06	0.07	0.07	0.08	0.08

**sR: Age-sex Standardised Rate per 10,000 inhabitants (Reference population: national 2002); sR Qx: quintile x of sR distribution; SCV: Systematic Component of Variation;*

Table 16. England descriptive statistics over time for burden of disease: AMI

	ACUTE MYOCARDIAL INFARCTION							
	2002	2003	2004	2005	2006	2007	2008	2009
Cases	78406	77862	79083	78557	78040	75849	73710	69713
Stand. Rate	19.53	19.46	20.02	20.14	20.12	19.34	18.71	17.59
sR Q1.	21.64	20.72	20.78	20.37	20.02	20.04	19.57	18.98
sR Q5.	16.07	16.19	17.12	17.89	18.12	17.55	16.68	15.44
SCV	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09

** sR: Age-sex Standardised Rate per 10,000 inhabitants (Reference population: national 2002); sR Qx: quintile x of sR distribution; SCV: Systematic Component of Variation;*

Table 17. England descriptive statistics over time for procedure utilisation: PCI

	PERCUTANEOUS CORONARY INTERVENTION							
	2002	2003	2004	2005	2006	2007	2008	2009
Cases	30351	38592	46709	51948	57264	57161	60304	63220
Stand. Rate	12.47	16.1	19.41	21.53	24.25	24.17	25.51	26.96
sR Q1.	14.58	19.05	22.79	24.66	27.67	28.47	28.65	29.66
sR Q5.	11.90	15.22	18.01	20.37	22.88	22.65	24.15	25.56
SCV	0.16	0.13	0.13	0.11	0.09	0.1	0.09	0.07

** sR: Age-sex Standardised Rate per 10,000 inhabitants (Reference population: national 2002); sR Qx: quintile x of sR distribution; SCV: Systematic Component of Variation;*

APPENDIX 3.a:

Tables England

Evolution over time

GEOGRAPHICAL APPROACH

Period of analysis: 2002-2009

Table 18. England descriptive statistics over time for procedure utilisation: CABG

	CORONARY ARTERY BYPASS GRAFT							
	2002	2003	2004	2005	2006	2007	2008	2009
Cases	24188	22994	23117	21169	21436	22801	22483	20434
Stand. Rate	9.98	9.63	9.85	9.07	9.26	9.89	9.64	8.84
sR Q1.	21.64	20.72	20.78	20.37	20.02	20.04	19.57	18.98
sR Q5.	16.07	16.19	17.12	17.89	18.12	17.55	16.68	15.44
SCV	0.09	0.06	0.06	0.05	0.06	0.07	0.06	0.07

** sR: Age-sex Standardised Rate (Reference population: national 2002); sR Qx: quintile x of sR distribution; SCV: Systematic Component of Variation;*

APPENDIX 3.b:

Tables England

Evolution over time

HOSPITAL APPROACH

Period of analysis: 2002-2009

Table 19. Evolution of English hospitals' relative performance for AMI admissions. (In-country benchmark estimation)

	ACUTE MYOCARDIAL INFARCTION							
	2002	2003	2004	2005	2006	2007	2008	2009
Discharges	79585	79176	80525	80248	79684	77874	75286	70994
Deceased	11350	11087	10128	9370	8350	7620	7198	6281
Nº Hospitals	150	150	150	150	149	149	149	149
Hospitals > 250 (% patients treated)	132 (95.9%)	130 (95.8%)	128 (95.5%)	128 (95.37%)	130 (96.34%)	126 (94.75%)	127 (94.91%)	125 (93.93%)
Average expected Risk-adjusted CFR	142.23	143.62	132.86	121.13	111.52	103.87	103.32	94.41
hosp. Alarm position (% patients treated)	19 (13.05%)	15 (8.56%)	12 (6.36%)	17 (10.05%)	11 (6.25%)	14 (8.49%)	16 (8.57%)	14 (7.45%)
hosp. Alert position (% patients treated)	13 (8.13%)	4 (3.32%)	6 (4.2%)	10 (7.15%)	11 (6.13%)	9 (6.03%)	6 (2.92%)	5 (2.71%)
hosp. Good performers (% patients treated)	7 (3.9%)	11 (7.37%)	6 (3.86%)	10 (6.58%)	8 (4.86%)	7 (5%)	7 (3.87%)	10 (8.19%)
hosp. Excellent performers (% patients treated)	17 (8.83%)	17 (11.7%)	16 (13.59%)	16 (13.53%)	20 (19.52%)	17 (17.89%)	19 (19.57%)	18 (18.79%)

** Hospitals>250: Hospitals above the activity threshold of 250 AMI hospitalisations/year; Alarm position: hospitals above the CI-99 control limit; Alert position: hospitals above the CI-95 control limit; Good performers: hospitals below the CI-95 control limit; Excellent performers: hospitals below the CI-99 control limit. In brackets the percentage of AMI patients in the country hospitalised at those hospitals*

Table 20. Evolution of English hospitals' relative performance for patients undergoing PCI procedure. (In-country benchmark estimation)

	PERCUTANEOUS CORONARY INTERVENTION							
	2002	2003	2004	2005	2006	2007	2008	2009
Discharges	30959	39385	47679	52886	58567	58681	61606	64139
Deceased	251	324	420	499	573	631	760	924
Nº Hospitals	34	40	42	48	59	64	72	73
Hospitals > 250 (% patients treated)	31 (99%)	33 (98.03%)	35 (98.33%)	39 (97.9%)	45 (95.7%)	55 (97.53%)	61 (97.36%)	64 (97.17%)
Average expected Risk-adjusted CFR	9.87	10.79	8.72	10.85	10.02	9.59	11.37	13.70
hosp. Alarm position (% patients treated)	4 (10.52%)	3 (8.18%)	7 (10.08%)	5 (9.71%)	4 (8.28%)	12 (22.7%)	9 (16.15%)	10 (19.57%)
hosp. Alert position (% patients treated)	1 (1.97%)	1 (2.55%)	4 (8.38%)	4 (8.44%)	6 (11.31%)	3 (6.64%)	3 (5.73%)	8 (8.55%)
hosp. Good performers (% patients treated)	4 (13.92%)	1 (2.41%)	3 (8.17%)	4 (13.8%)	3 (3.77%)	1 (0.79%)	4 (4.19%)	7 (7.22%)
hosp. Excellent performers (% patients treated)	4 (19.26%)	6 (23.45%)	3 (14.34%)	5 (20.22%)	2 (8.02%)	2 (8.09%)	4 (10.50%)	4 (10.3%)

** Hospitals>250: Hospitals above the activity threshold of 250 PCI performed/year; Alarm position: hospitals above the CI-99 control limit; Alert position: hospitals above the CI-95 control limit; Good performers: hospitals below the CI-95 control limit; Excellent performers: hospitals below the CI-99 control limit. In brackets the percentage of patients in the country undergoing PCI procedure at those hospitals*

APPENDIX 3.b:

Tables England

Evolution over time

HOSPITAL APPROACH

Period of analysis: 2002-2009

Table 21. Evolution of English hospitals' relative performance for patients undergoing CABG surgery. (In-country benchmark estimation)

	CORONARY ARTERY BYPASS GRAFT							
	2002	2003	2004	2005	2006	2007	2008	2009
Discharges	24806	23302	23625	21702	21952	23511	23087	21006
Deceased	700	638	652	658	678	639	615	571
Nº Hospitals	28	28	28	28	28	29	29	29
Hospitals > 250 (% patients treated)	27 (99.7%)	27 (99.81%)	28 (100%)	28 (100%)	28 (100%)	29 (100%)	29 (100%)	29 (100%)
Average expected Risk-adjusted CFR	33.28	27.67	28.51	31.16	31.89	28.35	26.71	27.81
hosp. Alarm position (% patients treated)	2 (3.39%)	4 (15.43%)	1 (2.39%)	--- ---	1 (3.16%)	1 (2.35%)	3 (10.28%)	1 (2.51%)
hosp. Alert position (% patients treated)	--- ---	1 (6.14%)	1 (3.03%)	3 (7.9%)	1 (3.65%)	2 (5.04%)	2 (6.79%)	3 (8.76%)
hosp. Good performers (% patients treated)	3 (10.01%)	3 (10.47%)	2 (7.26%)	3 (9.97%)	1 (5%)	1 (3.93%)	1 (3.07%)	3 (10.92%)
hosp. Excellent performers (% patients treated)	4 (15.44%)	2 (7.84%)	1 (3.76%)	1 (4.99%)	2 (8.42%)	--- ---	1 (3.3%)	--- ---

** Hospitals>250: Hospitals above the activity threshold of 250 CABG performed/year; Alarm position: hospitals above the CI-99 control limit; Alert position: hospitals above the CI-95 control limit; Good performers: hospitals below the CI-95 control limit; Excellent performers: hospitals below the CI-99 control limit. In brackets the percentage of patients in the country undergoing CABG surgery at those hospitals*

APPENDIX 4:

Technical note

Cardiovascular Ischaemic Disease and AMI, as well as the revascularisation procedures, PCI and CABG, are conceived as geographical and hospital-specific indicators, within the ECHO performance model.

First of all, from a geographical basis, this approach entails some implications, both for methodology and in interpreting results. The report is based on ecologic analyses –data aggregated at a certain geographical level which becomes the unit of analysis; thus, the correct interpretation of the findings highlights the risk of being exposed to hospitalisations due to cardiovascular conditions or revascularisation procedures for the population living in a certain area (as opposed to the risk for an individual patient). Afterwards, from a provider perspective, individual data is analysed and risk-adjusted within multivariate logistic 2-level hierarchical modelling, so then clustered into hospitals, where the interpretation would be the risk of dying after being hospitalised and/or intervened in a specific hospital compared to the national average or the ECHO benchmark.

Main endpoints:

This report maps out standardised utilisation rates per geographical area as well as the risk-adjusted case fatality rates per each provider, analysing events amenable to healthcare quality. As a summary measure of variation, the report includes the classical statistics Ratio of Variation between extremes, Component of Systematic Variation and Rho Statistic or cluster effect.

Instruments:

In the geographical approach, being an ecologic study, each admission was allocated to the place of residence of the patient, which in turn was referred to a policy relevant geographic unit – the 326 Local authorities and the 9 Regions building up the English National Health Service.

For the risk-adjustment of the hospital approach within the multivariate logistic 2-level hierarchical modelling, the following variables have been included:

- Age and sex
- Having the patient a primary diagnosis of AMI, whether it was classified as transmural (with ST segment elevation, STEMI), non-STEMI or unclassified.

Whether the patient underwent heart valve replacement and/or implantation of a cardiac or circulatory assistance device.

Whether the intervention was a major structural surgery (including repair or revision of atrial and ventricular septa, cardiotomy, pericardiotomy, pericardiectomy and excision of a heart lesion).

- Another specific measures of the severity of the underlying condition (42 co-morbidities variables included in the Elixhauser index), such as:

Cardiac arrhythmias	Hypothyroidism
Valvular disease	Liver disease
Congestive heart failure	Obesity
Chronic lung disease	Alcohol abuse
Hypertension, uncomplicated	Drugs abuse
Hypertension, complicated	Lymphoma
Hypertension with congestive Heart failure	Solid tumor without metastasis
Hypertension without congestive Heart failure	Metastatic cancer
Hypertensive heart and renal disease with heart failure	Weight loss
Hypertensive heart and renal disease without heart failure	Psychoses
Hypertensive heart and renal disease with heart and renal failure	Depression
Hypertensive heart and renal disease without heart and renal failure	AIDS/HIV
Hypertensive renal disease with renal failure	Fluid and electrolyte disorders
Hypertensive renal disease without renal failure	Peptic ulcer disease excluding bleeding
Total hypertension disease	Deficiency anemia
Pulmonary circulation disorders	Blood loss anemia
Renal failure	Coagulopathy
Pre-existing hypertension complicating pregnancy	Rheumatoid arthritis/collagen vascular diseases
Other hypertension in pregnancy	Peripheral vascular disorders
Diabetes, without chronic complications	Paralysis
Diabetes, with chronic complications	Other neurological disorders

For both approaches, the operational definitions for each indicator are detailed in the coding table in appendix 5. Indicators are based on those in use in the international arena as proposed by AHRQ and OECD. For its use in the analysis of variations across countries they were subject to a construct validity process developed by the Atlas VPM project in Spain and cross-walking across different diseases and procedures classifications underwent a face-validation carried out as a task within the ECHO project.

This report is based on the hospital admissions registered in the National Health Service (NHS). Cross- and in-country sections were built upon 2009 discharges, whereas time-trends and social gradient analyses used 2002 to 2009 data.

Socioeconomic data and deprivation index were obtained from the UK National Statistics.

APPENDIX 5:

Definitions of indicators

	Diagnosis codes ICD10 and Procedures codes OPCS					
	Primary diagnosis		Secondary diagnosis2-30		Procedures	
	Inclusions	Exclusions	Inclusions	Exclusions	Inclusions	Exclusions
Ischaemic Disease +18 Age Type of admission unplanned	I21 I22 I20.0 I24.0 I24.8 I20.8 I20.1 I20.9 I25.10 (IF DX2-30= I20.0)					
Acute Myocardial Infarction (AMI) +18 Age Type of admission unplanned	I21* I22*					
Percutaneus Coronary Interventions (PCI) +40 Age					K49, K50.1, K75, K76	
Coronary Artery Bypass Grafting (CABG) +40 Age					K40, K41, K42, K43, K44, K45, K46	

APPENDIX 5:

Definitions of indicators

	Diagnosis codes ICD10 and Procedures codes OPCS					
	Primary diagnosis		Secondary diagnosis2-30		Procedures	
	Inclusions	Exclusions	Inclusions	Exclusions	Inclusions	Exclusions
Acute Myocardial Infarction in Hospital Mortality +18 Age	I21* I22*	O00*-O99*		O00*-O99*		
Percutaneus Coronary Interventions in Hospital Mortality +40 Age		O00*-O99*		O00*-O99*	K49, K50.1, K75, K76	
Coronary Artery Bypass Grafting in Hospital Mortality +40 Age		O00*-O99*		O00*-O99*	K40, K41, K42, K43, K44, K45, K46	