ECHO

EUROPEAN COLLABORATION FOR HEALTHCARE OPTIMIZATION

Coronary revascularisation in Portugal

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 a critical view on how healthcare organizations provide care to patients.

I. EXECUTIVE SUMARY

- 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 proved to be a better option at reducing the risk of death; particularly, primary PCI supersedes any other alternative. Nevertheless, CABG is still considered more effective when dealing with a 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 shows that exposure to revascularisation interventions varies across *concelhos* regardless the burden of disease or the socioeconomic status of the area.
  - In 2009, 14,526 CID admissions occurred in Portugal, representing 1 admission per 596 adult inhabitants. Up to 3.4-fold difference was found between *concelhos* with extreme high and low CID rates and systematic variation was moderate: 10% above that randomly expected. Nevertheless, Portugal showed the lowest CID rate compared with other countries.
  - Around 78% of those CID admissions were labelled as AMI and difference between healthcare areas with extreme rates of AMI admissions (EQ_{5-95}) was up to 4.2-folded
  - The same year, 10,587 PCI interventions and 2,446 CABG surgeries were performed in Portugal, being the lowest PCI rate and the second lowest CABG rate among ECHO countries. That represented almost three times less the PCI rate found in Slovenia and half the Danish CABG rate.

- The ratio across *concelhos* with extremes rates reached 4.6-fold difference in PCI and 8.8-fold in CABG, and variation not deemed random was 10% and 19% above what could be randomly expected respectively. Region effect affecting variation in both procedures was low: explaining 10% of variation in PCI and 14% in CABG.

- There was certain positive correlation between CID admissions (considering CID admission as a proxy of burden of coronary disease) and PCI procedures, implying that areas with higher CID admission rates exhibit higher PCI rates. Correlation with CABG procedures was less marked and in regions such as *Algarve* and *Norte* the risk of CID hospitalisation was inversely related to the revascularisation procedure rate.

- In *Lisbon* region both PCI and CABG interventions were higher than expected, whereas in *Algarve* and *Norte* opposed patterns in utilisation of these procedures were detected. This last observation may suggest a certain degree of compensation across procedures.

- From 2002 to 2009, PCI utilisation sharply increased from 1 admission per 1,046 to 1 admission per 495 inhabitants. This rise in PCI exposure was similar across the territory, while systematic variation decreased over time. In turn, CABG utilisation rates have scarcely changed.

- Despite the doubling in PCI utilisation, CID admissions have remained stable and AMI has even increased a little.

- Interestingly, significantly more CID admissions occurred in more affluent *concelhos* compared to deprived ones; the same happened when analysing specifically AMI admissions. Thus, the variation in CID admissions across *concelhos* described in previous sections could be related to area income level.

- At the same time, wealthier areas showed significantly higher PCI and CABG utilisation than those less affluent over the period 2002-2009.

- On the other hand, when performing the analysis on provider basis, different meso and micromanagement approaches towards cardiovascular ischaemic disease could explain an important part of the *unwarranted variation in outcomes*. Differences in the risk-adjusted case fatality rates (CFR) after both revascularisation procedures are noticeable, with considerable variation across hospitals; “volume” (amount of interventions carried out in a year) has been argued as a plausible factor underpinning these differences:

- Portuguese Risk-adjusted CFR for AMI, in 2009, was 109.6 per 1,000 patients aged 18 and older; the third highest rate among ECHO countries and 10.5 per thousand points above the ECHO average. In terms of exposure, almost 22% of all Portuguese AMI patients were treated at poor performing hospitals –the second highest share of patients among ECHO countries. On the other hand, 28.5% of AMI patients were admitted to hospitals flagged as "good" or even "excellent" performers.
- Regarding the revascularisation procedures, in 2009, in-hospital mortality after PCI in Portugal was 20.8 per 1,000 patients aged 40 and older, the third highest among ECHO countries, but close to the ECHO average. Besides, 11.5% of patients undergoing a PCI were treated at "alarm" performer hospitals (the second lowest proportion among ECHO countries), while 9.8% of patients were intervened at hospitals pointed out as "good performers" (the second highest share for this procedure among ECHO countries even though far from England, the country with the highest).
- The risk-adjusted CFR after CABG surgery in Portugal, in 2009, was also the second lowest among ECHO countries -33.6 per 1,000 patients aged 40 and older, almost 17 per thousand points below ECHO average rate. All Portuguese hospitals were labelled as high volume (above 250 CABG procedures per year). In addition, almost 50% of patients were intervened at "*good/excellent performers*" hospitals, again the second 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 Portugal 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 Portuguese 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 Portugal 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, Portugal has the lowest CID admission rate among ECHO countries– 1 admission per 560 adult inhabitants. That means almost half the rate found in Denmark, the country with the highest rate (see table 1 in appendix 1.a).

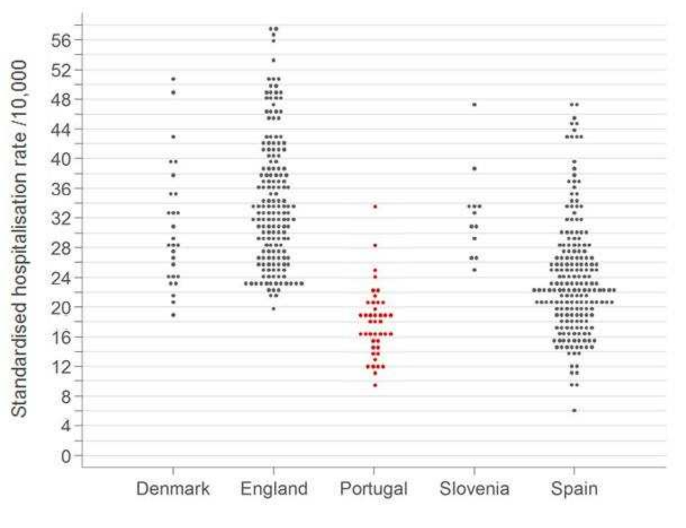

Figure 1.a. Age-sex standardised hospitalisation rates of CID per 10,000 inhabitants (natural scale to compare actual rates). Year 2009

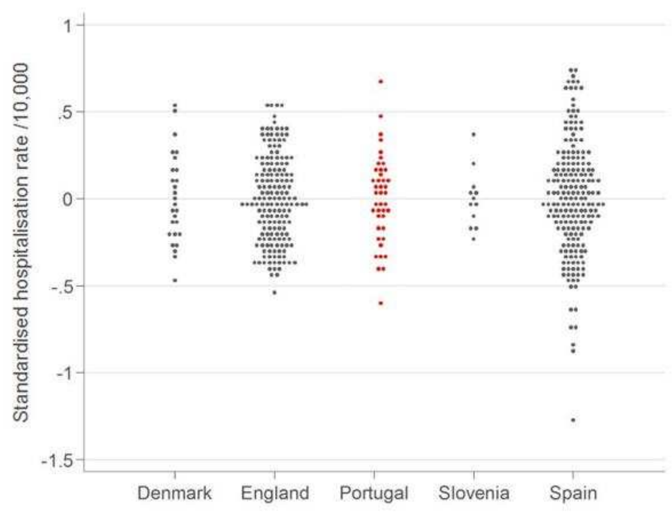

Figure 1.b. Age-sex standardised hospitalisation rates of CID per 10,000 inhabitants (normalised scale to compare degree of variation). Year 2009

** Each dot represents the relevant healthcare administrative area in each ECHO country (Concelhos in Portugal). 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 Portugal, England, Denmark and Slovenia: 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. On the other hand, systematic variation not deemed random is moderate/low in all countries, ranging from 9% (Slovenia) to 24% (England) beyond that randomly expected.

Acute Myocardial Infarction (AMI)

AMI admission rate in Portugal is also the lowest together with Spain, 1 hospitalisation per 725 adults. Slovenia stands out showing the highest rate, 1 admission per 449 adult inhabitants. In all ECHO countries, differences between areas with extreme rates are around 2-folded.

In Portugal only 5% of this variation exceeds what could be randomly expected. In the other countries, the part of the variation observed not amenable to chance is also low, except in Slovenia where reaches 34% above that expected (see table 2 in appendix 1.a).

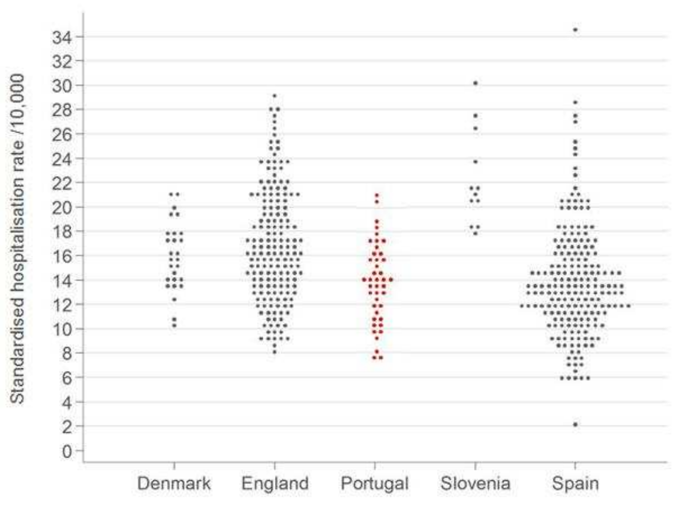

Figure 2.a. Age-sex standardised hospitalisation rates of AMI per 10,000 inhabitants (natural scale to compare actual rates). Year 2009

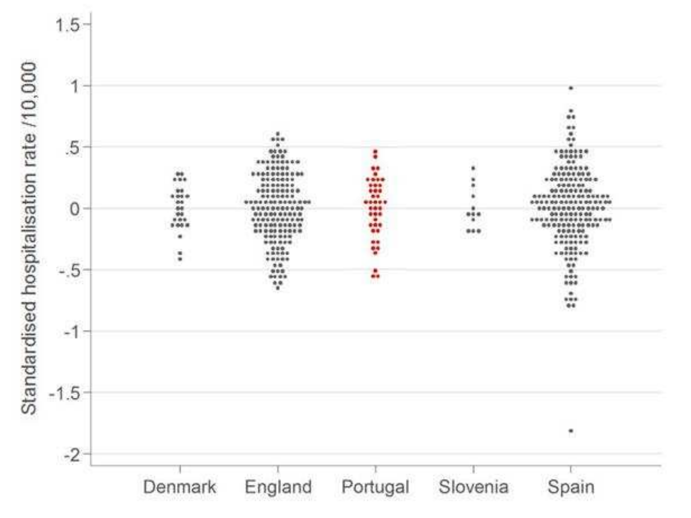

Figure 2.b. Age-sex standardised hospitalisation rates of AMI per 10,000 inhabitants (normalised scale to compare degree of variation). Year 2009

** Each dot represents the relevant healthcare administrative area in each ECHO country (Concelhos in Portugal). 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)

Portugal has the lowest PCI rate among ECHO countries, 1 admission per 468 inhabitants aged 40 or older. This rate is almost 2.8 times lowest than that found in Slovenia, the country with the highest rate. The ratio between highest and lowest PCI utilisation found at local level is similar in Portugal, England, Denmark 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 Portugal and England to 1.8 times larger than expected in Slovenia (see table 3 in appendix 1.a).

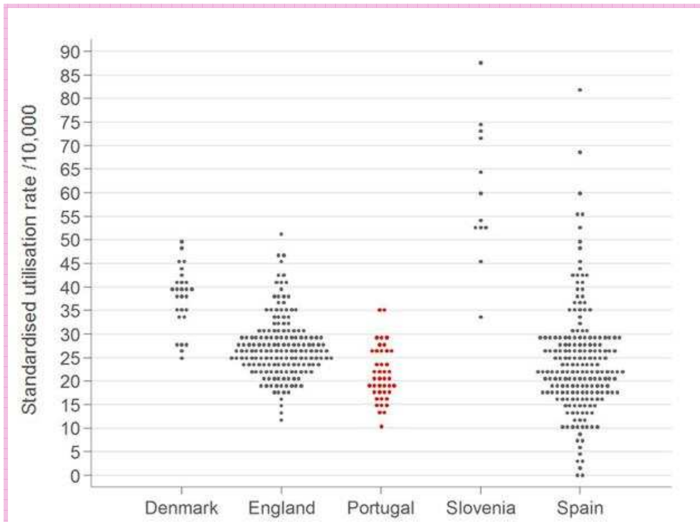

Figure 3.a. Age-sex standardised utilisation rates in PCI per 10,000 inhabitants (natural scale to compare actual rates). Year 2009

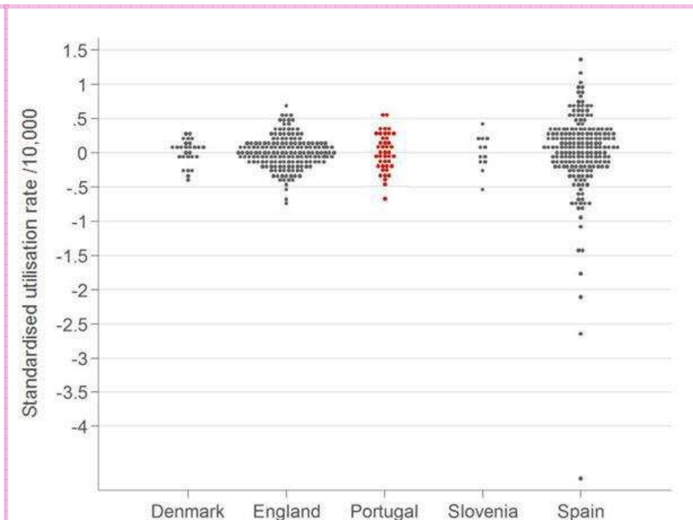

Figure 3.b. Age-sex standardised utilisation rates in PCI per 10,000 inhabitants (normalised scale to compare degree of variation). Year 2009

** Each dot represents the relevant healthcare administrative area in each ECHO country (Concelhos in Portugal). 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)

Portugal has the fourth CABG rate among ECHO countries – 1 admission per 2,096 inhabitants aged 40 or older. This figure is 41% higher than the Spanish one, the country with the lowest rate, but half the rate found in Denmark-the country with the highest rate.

Residents living in concelhos with the highest rates faced up to 7.4 more chances of getting a CABG procedure than population living in those with the lowest rates. This is a high figure, only exceeded by Spain, where some residents have almost 10 times more probability of getting a CABG procedure depending in their area of residence. In turn, In Denmark and England this ratio is close to 2 folded.

The systematic part of this variation is high in all countries, going up to 19% above that randomly expected in Portugal (see table 4 in appendix 1.a).

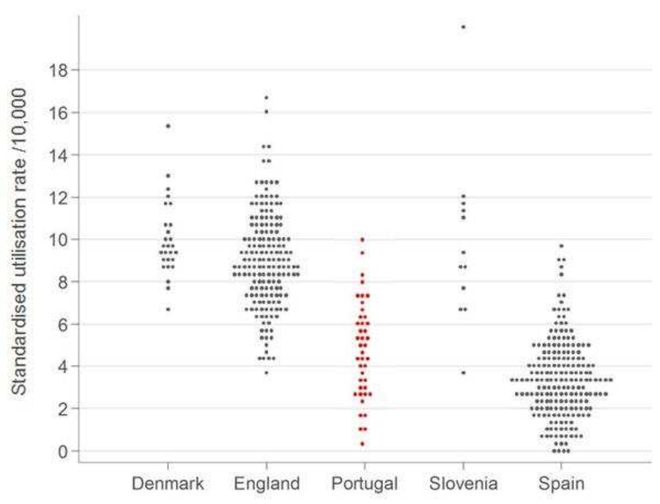

Figure 4.a. Age-sex standardised utilisation rates in CABG per 10,000 inhabitants (natural scale to compare actual rates). Year 2009

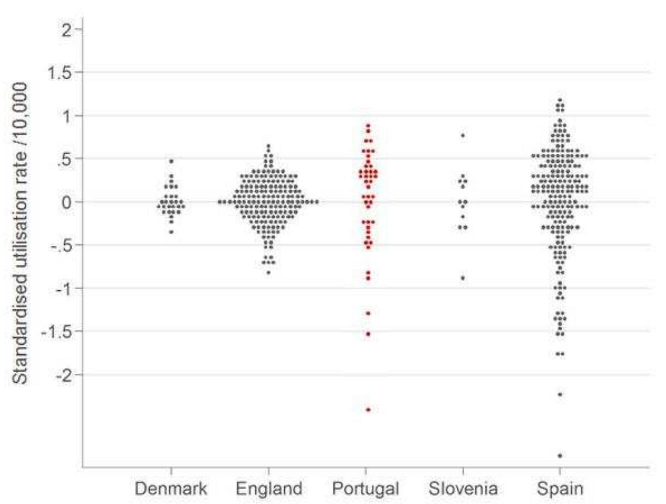

Figure 4.b. Age-sex standardised utilisation rates in CABG per 10,000 inhabitants (normalised scale to compare degree of variation). Year 2009

** Each dot represents the relevant healthcare administrative area in each ECHO country (Concelhos in Portugal). 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 arrangements, 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 the 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 *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.

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 each 10 AMI admissions died.

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

Regarding the Portuguese hospitals, 23 out of 40 centres were *high volume* hospitals in 2009, and took care of 79% of all AMI hospitalised patients; actually, Portugal showed the second highest proportion of AMI patients treated at high volume hospitals among ECHO countries (even though it is still 15 percentage points below the English, the highest share).

Eleven out of those 40 centres were flagged as “alert” or “alarm” performers. In terms of exposure, almost 22% of all Portuguese AMI patients were treated at those “alert”/ “alarm” hospitals, yielding the second highest percentage among all ECHO countries (16.6 percentage points above Spain, the lowest share).

It is also remarkable that 28.5% of all AMI patients were admitted to hospitals labelled as “good” or even “excellent” performers. Nevertheless, Portugal is the country treating the lowest percentage of AMI patients at “excellent performers” across ECHO countries (see table 6, appendix 1.b, for further details).

Overall, 1 in 9 AMI patients admitted to a Portuguese hospital died in 2009 (risk-adjusted CFR 109.57 per 1,000), slightly above the ECHO average.

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.

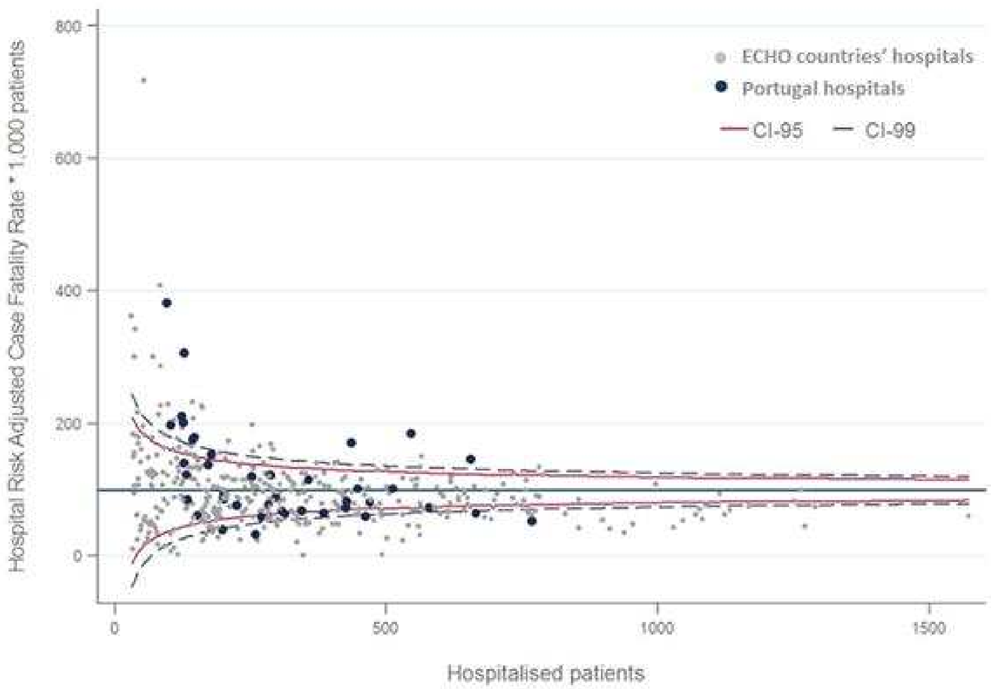

Figure 5. In-hospital case fatality rate for AMI admissions across hospitals in ECHO countries. Year 2009.

** 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.*

An important issue to consider is the variation in outcomes among hospitals, depending on the volume of AMI patients treated. The bulk of hospitals flagged as alarm and alert in all ECHO countries are mostly treating less than 250 AMI patients/year (the low-volume hospitals). There were some exceptions (like 3 centres out of the 10 "alert" Portuguese hospitals which had over 500 AMI patients in 2009) that would demand a closer look.

In-hospital mortality after Percutaneous Coronary Intervention (PCI)

In 2009, 132,737 patients aged 40 and older underwent PCI procedure at one of the hospitals in ECHO countries. 2,623 of them passed away, that is, 1 in each 51 intervened patients. These figures set the ECHO risk-adjusted CFR at 19.86 per 1,000 patients (aged 40+) undergoing PCI procedure. Portugal had that year the third highest risk-adjusted CFR, behind Spain and Denmark and slightly above ECHO benchmark.

Within the ECHO framework, 79.9% of the hospitals performing PCI procedures were *high volume* and took care of 95.44% of patients undergoing that procedure in 2009. In Portugal the share of high-volume hospitals dropped to 50%, taking care of 84% of PCI patients, by far the lowest share in ECHO countries *(see tables 5 and 7 in appendix 1b).*

Nevertheless, as shown in figure 6, Portuguese hospitals have rather good outcomes in performance according to ECHO benchmarking. Even though far from England, the country with best outcomes, Portugal showed the second lowest percentage in ECHO patients undergoing PCI at alert/alarm hospitals (11.45%) together with the second highest share intervened at good/excellent performing hospitals (9.8%). In this particular case, unlike what is generally observed, volume did not seem to have an outstanding impact in outcomes, only 2 of the lower volume Portuguese centres were flagged as poorer performers, in contrast with the other 2 high-volume centres also flagged as alarm (See table 7, appendix 1.b, for further details).

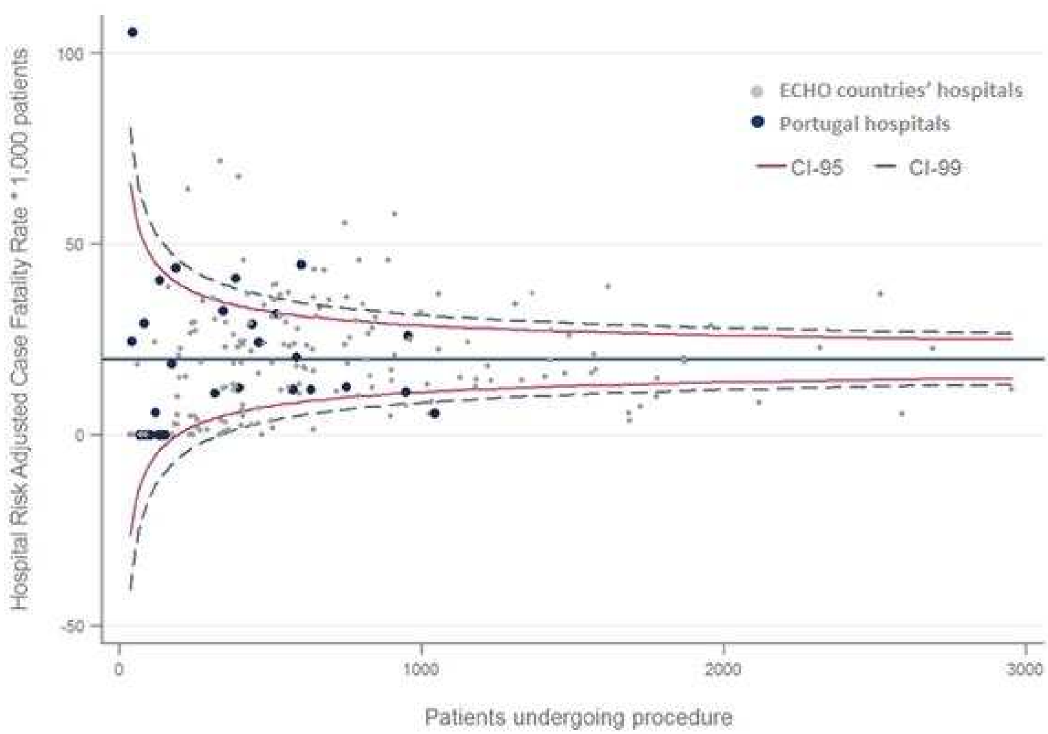

Figure 6. In-hospital case fatality rate after Percutaneous Coronary Intervention across hospitals in ECHO countries. Year 2009.

** 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 intervened at hospitals placed in the "*alert/alarm*" zone, versus the 5.61% treated at hospitals flagged as "*good/excellence performance*".

In the ECHO context, Portugal shows quite a different picture. The percentage of Portuguese patients undergoing CABG surgery treated at higher volume hospitals rises up to 100%. Only 6 hospitals in the country performed CABG surgery and only one of them was flagged as poor or less safe at performance. Nevertheless, this centre intervened 16.2% of CABG patients, the second highest share in ECHO, just behind Spain. Half of the hospitals, which treated also 50% of all CABG patients, were “good” or even “excellent” performers.

The scenario of the risk-adjusted case fatality rate after CABG shown in figure 7 placed Portugal at a rather high level of performance. Compared to the ECHO benchmark, the Portuguese risk-adjusted CFR for CABG is the second lowest, almost 17 per thousand points below the ECHO average and half the Spanish one, the country with the highest rate.

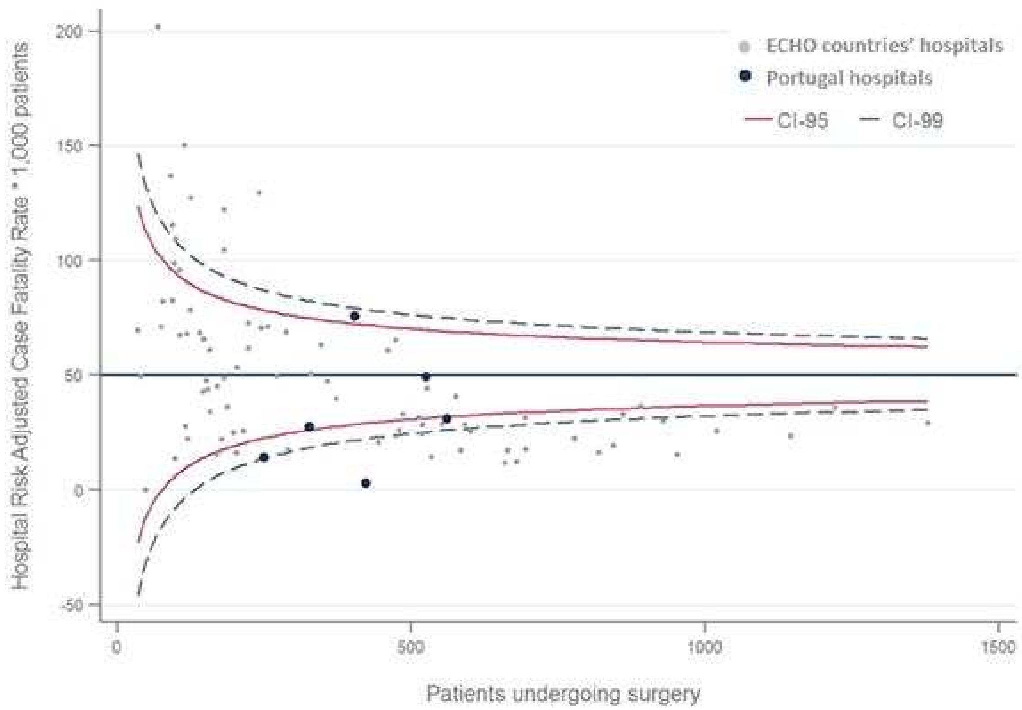

Figure 7. In-hospital case fatality rate after CABG across hospitals in ECHO countries. Year 2009.

** 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 Portugal 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 *concelhos* 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 Portuguese hospitals.

a. Geographic approach

The magnitude and the variation in coronary condition and/or revascularization procedures across the country will be mapped out following the two health relevant administrative tiers: 278 *concelhos* and 5 regions. While *concelhos* would represent local provision of care, regions are used as a surrogate for regional policies affecting all the *concelhos* within each one.

Coronary Ischaemic Disease admissions (CID)

In 2009, 14,526 CID admissions occurred in Portugal, which means 1 admission per 593 Portuguese adult inhabitants.

Up to 3.4-fold difference in chances to suffer a CID admission was found between concelhos with extreme high and low rates. Systematic variation was 10% above what could be randomly expected, and the effect of the region where the concelho belongs on this variation was almost negligible (see tables 9 and 10 at the appendix 2.a).

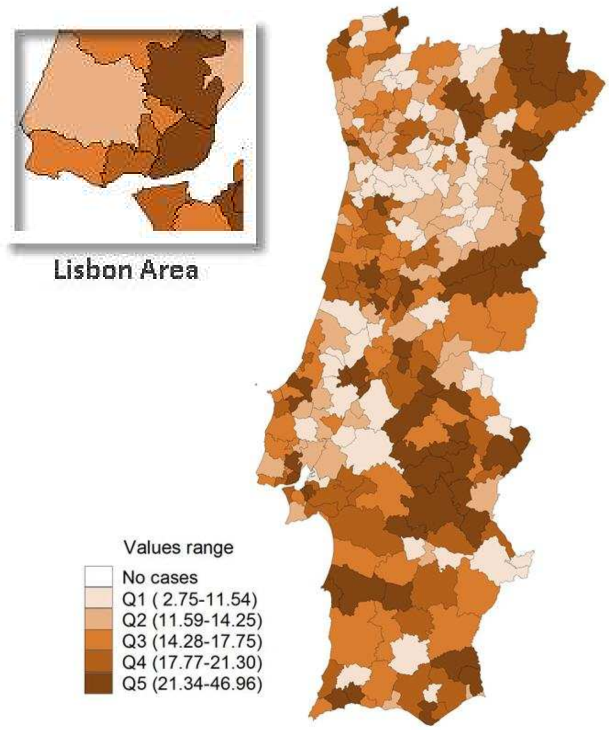

Figure 8. Age-sex standardised CID hospitalisation rate per 10,000 inhabitants by *concelhos*. Year 2009

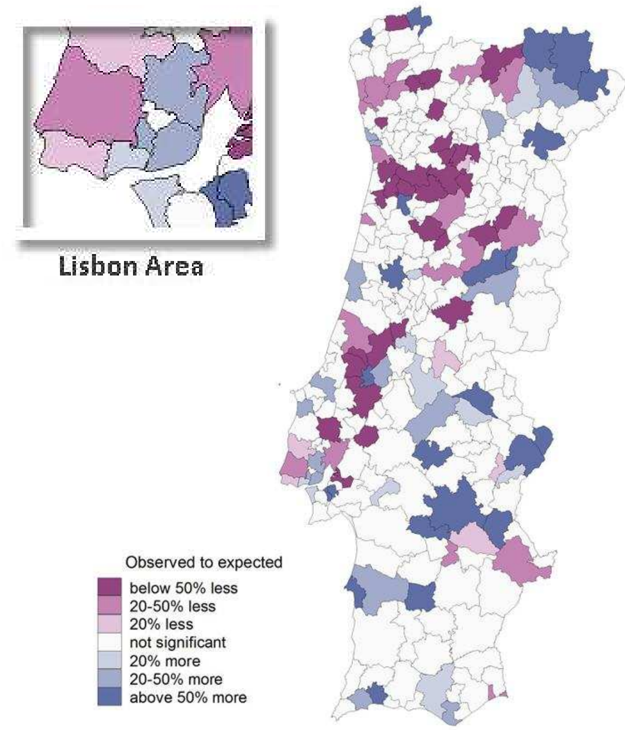

Figure 9. CID Admission Ratio *observed/expected* by *concelhos*. Year 2009

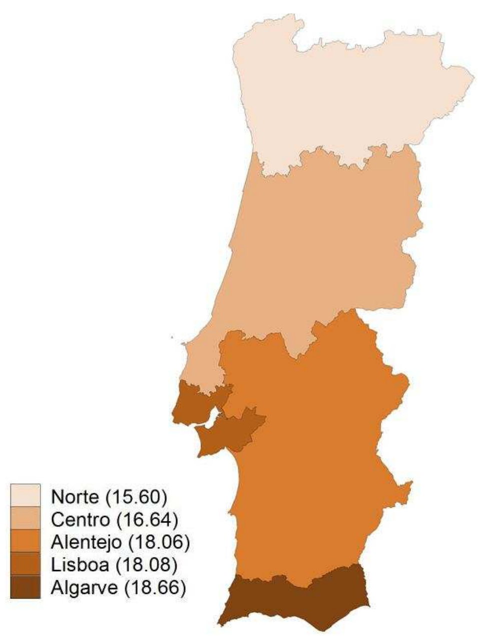

Figure 10. Age-sex standardised CID hospitalisation rate per 10,000 inhabitants by regions. Year 2009

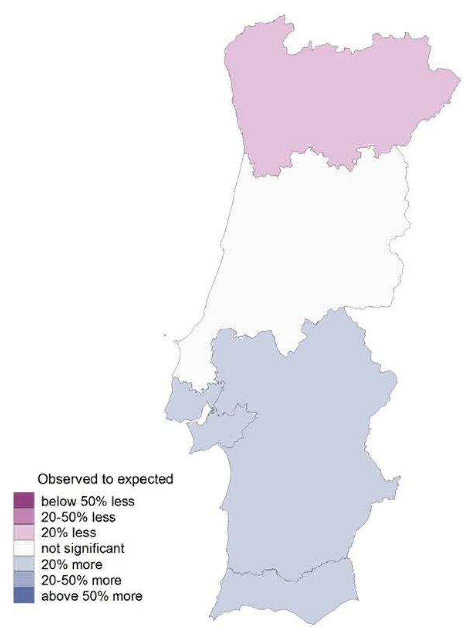

Figure 11. CID Admission Ratio *observed/expected* by regions. Year 2009

** 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.*

Concelhos with high CID rates are found along the western half of the country (figure 8). Residents in most of theses *concelhos* bear at least 20% more risk of CID admission than national average (bluish areas in figure 9).

At regional level, population living in *Algarve, Alentejo* and *Lisbon* regions stand more relative risk of undergoing CID hospitalisation than national average. In turn, population living in *Norte* has at least 20% less risk than average (figures 10 and 11).

Percutaneous Coronary Interventions (PCI) and its comparison with the burden of Coronary Ischaemic Disease (CID).

Along 2009, 10,587 PCI interventions were performed in Portugal- 1 procedure per 527 inhabitants aged 40 or older.

A 4.6-folded difference in exposure to this procedure was found between *concelhos* with extreme rates. Systematic variation was moderate, 10% above that randomly expected, and the region where the concelho belongs explains 10% of it (see tables 9 and 10 in appendix 2.a).

As expected, there was some overlapping between PCI rates and risk of CID admission, considering CID admission as a proxy of burden of coronary disease. There is a strong pattern of high PCI rates in the southern part of the country and this pattern matched with regions where residents bear an increased relative risk of CID admissions: *Algarve, Alentejo* and *Lisbon* regions. Just the opposite dynamic is detected in *Norte* where population has less risk than expected of undergoing CID admissions and also exhibited the lowest PCI intensity (figures 12 - 15).

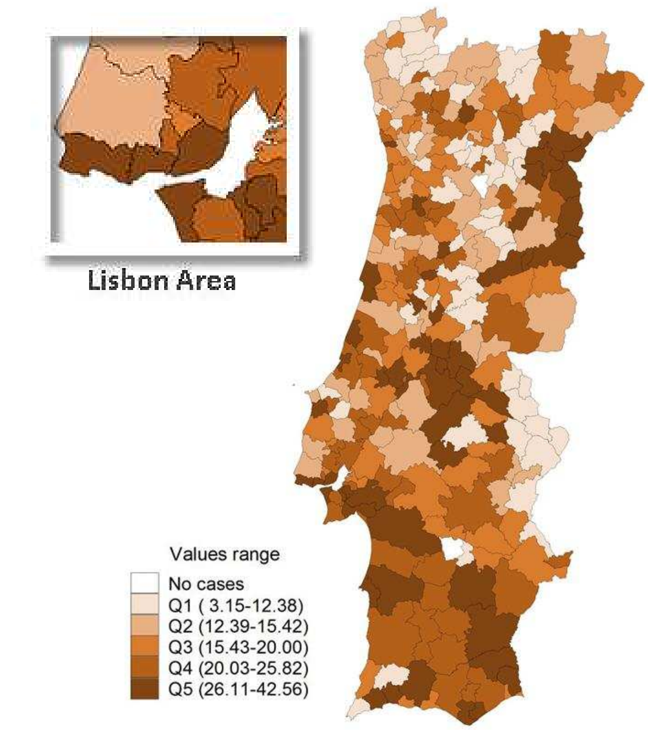

Figure 12. Age-sex standardised PCI utilisation rate per 10,000 inhabitants by *concelhos*. Year 2009

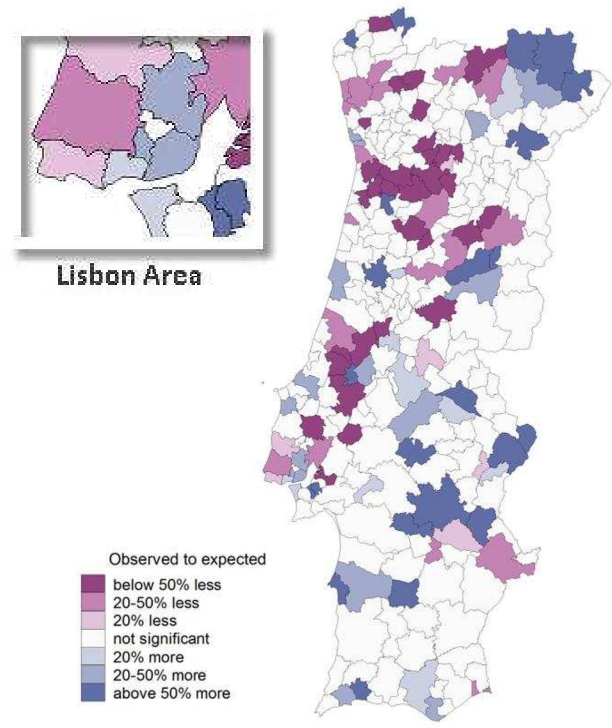

Figure 13. CID Admissions Ratio *observed/expected* by *concelhos*. Year 2009

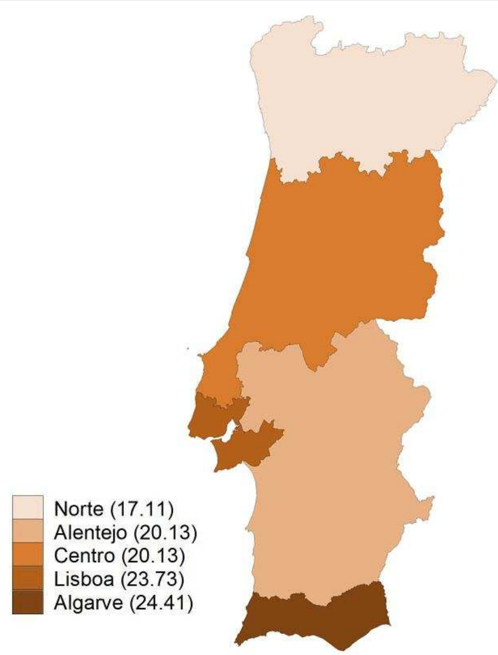

Figure 14. Age-sex standardised PCI utilisation rate per 10,000 inhabitants by regions. Year 2009

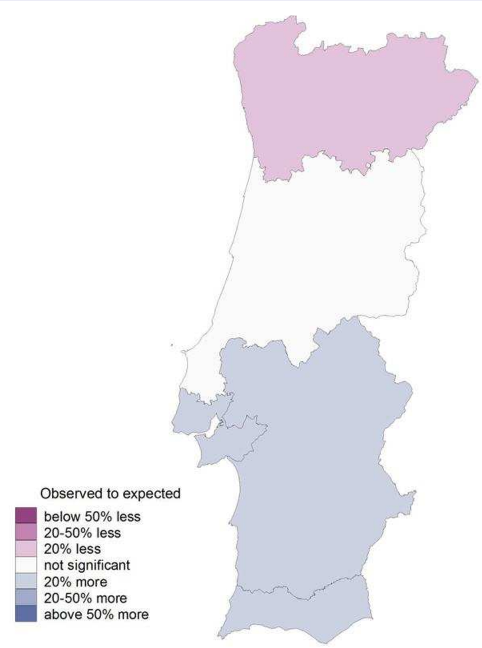

Figure 15. CID Admissions Ratio *observed/expected* by regions. Year 2009

** 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) and its comparison with the burden of Coronary Ischaemic Disease (CID).

During 2009, 2,446 CABG procedures were performed in Portugal, which represents 1 surgery per 2,066 inhabitants aged 40 or older.

The ratio across concelhos with extremes rates reached 8.8-fold difference, and up to 19% of this variation cannot be deemed random. As observed with PCI utilisation, variation in CABG surgery was poorly explained by the regional level, just a 14% of the observed variation could be related to the region where *concelho* belongs (see tables 9 and 10 in appendix 2.a).

Most *concelhos* with high rates are spread out over the southern half of Portugal. But, in this case, CABG utilisation correlated less with burden of disease than the association observed with PCI. Thus, in *Norte* and *Algarve,* CABG procedures and the risk of CID hospitalisation seems inversely related. In *Norte,* CABG utilisation is relatively high but the risk of having CID is below expected. Conversely, in *Algarve,* CABG rates are the lowest detected in the country (close to zero), while population have more risk of undergoing a CID admission than average. Some correlation was found only in *Alentejo* and *Lisbon,* where high CABG rates coexisted with higher relative risk of CID admissions (figures 18 and 19).

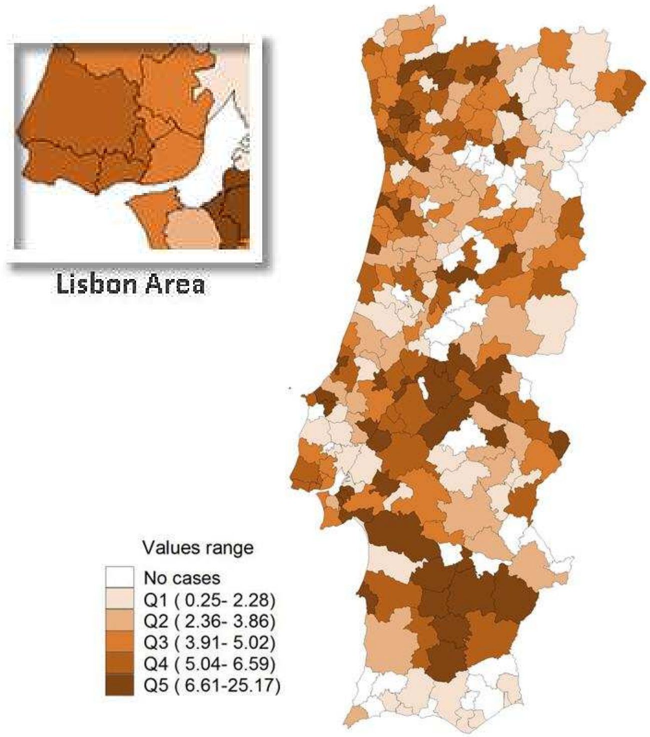

Figure 16. Age-sex standardised CABG utilisation rate per 10,000 inhabitants by *concelhos*. Year 2009

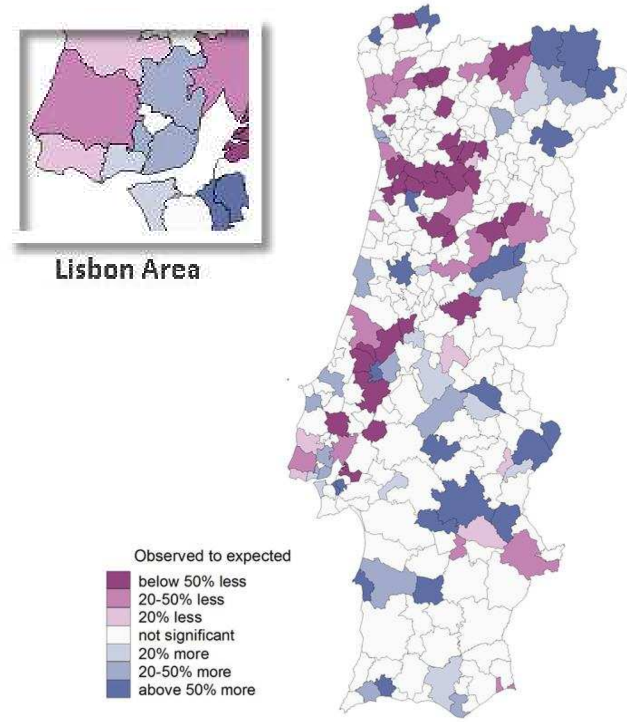

Figure 17. CID Admissions Ratio *observed/expected* by *concelhos*. Year 2009

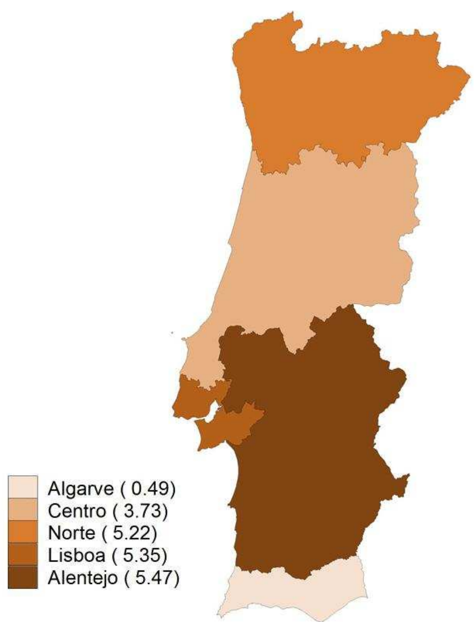

Figure 18. Age-sex standardised CABG utilisation rate per 10,000 inhabitants by regions. Year 2009

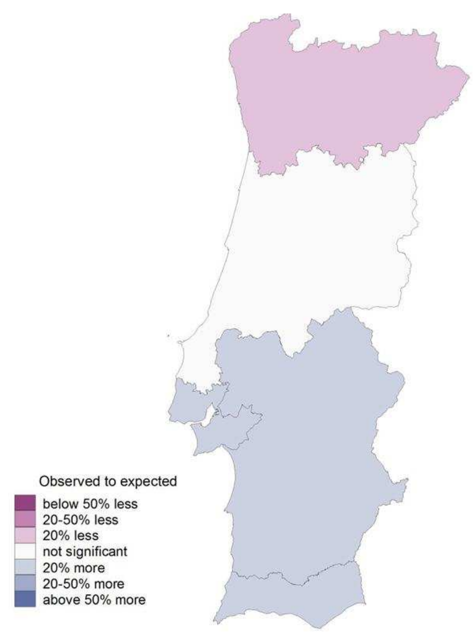

Figure 19. CID Admissions Ratio *observed/expected* by regions. Year 2009

** 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. On the other hand, relative under-exposure to PCI could be increasing the proportion of severe cases and, thus, the need for CABG.

Comparing the relative risk of exposure to both interventions, some *concelhos* showed concomitant higher risk for PCI and CABG procedures. At regional level that resulted in Lisbon region population being more exposed to both procedures (figures 22 and 23).

On the contrary, a certain substitution between these two procedures can be observed in a few *concelhos*. This results in *Algarve* residents standing below average risk of undergoing CABG, but more than the national average risk of having PCI. And in a opposite way, population in *Norte* bear more than average risk of undergoing CABG but less of PCI (figures 20 - 23).

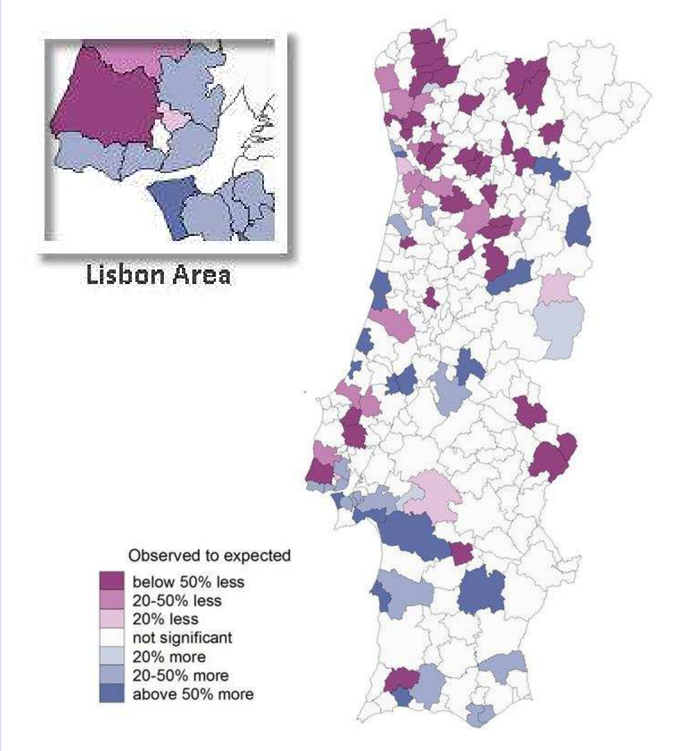

Figure 20. PCI utilisation ratio *observed/expected* by *concelhos*. Year 2009

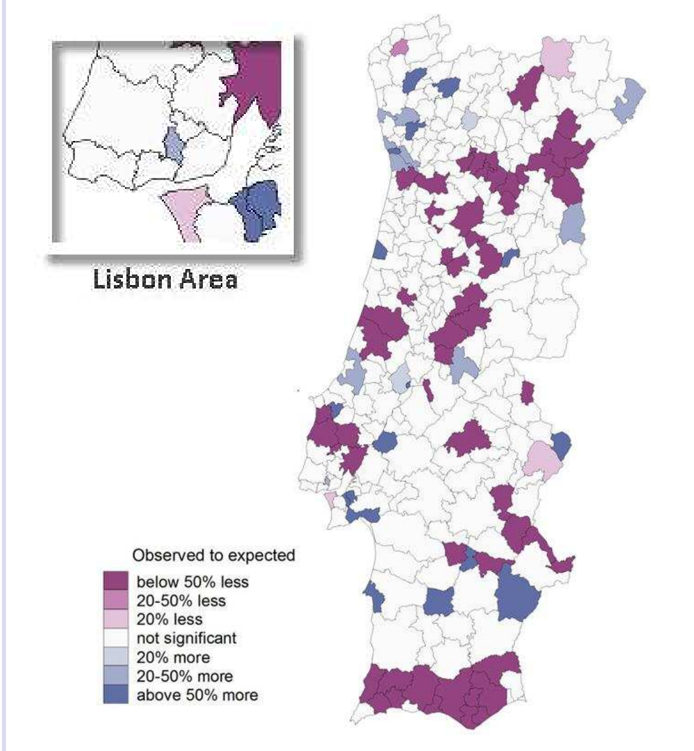

Figure 21. CABG utilisation ratio *observed/expected* by *concelhos*. Year 2009

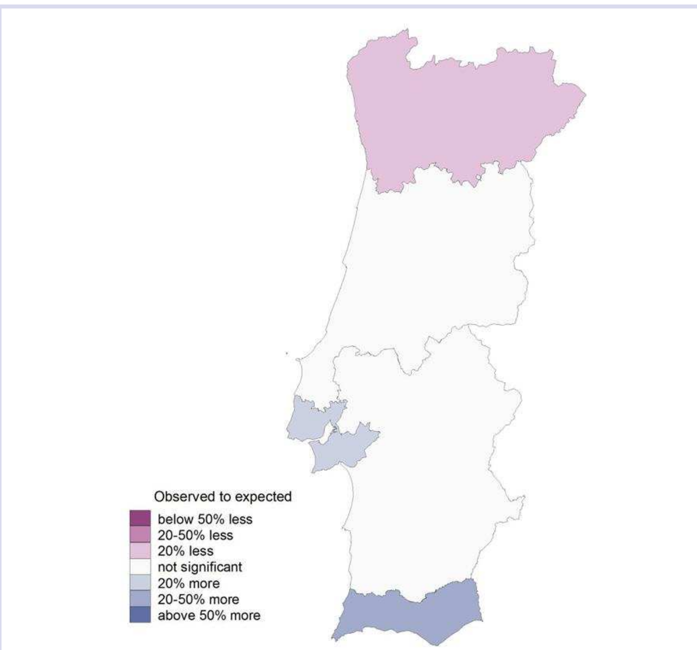

Figure 22. PCI utilisation ratio *observed/expected* by regions. Year 2009

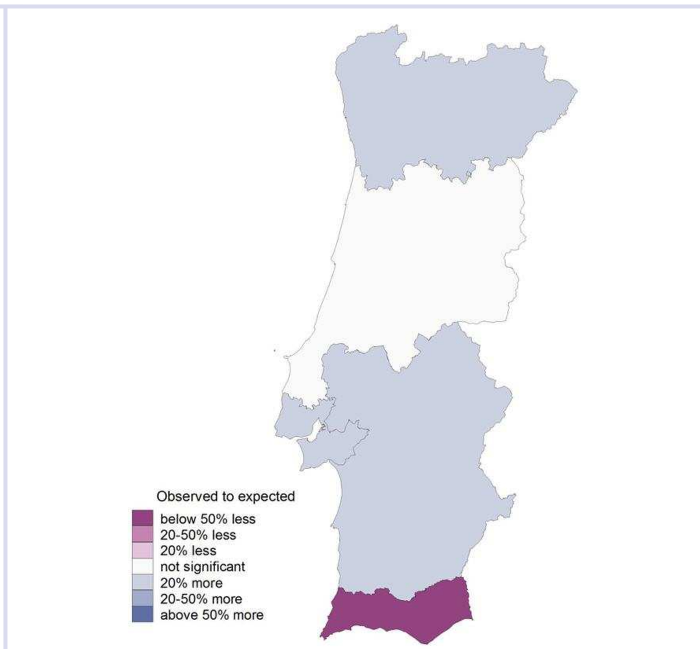

Figure 23. CABG utilisation ratio *observed/expected* by regions. Year 2009

** 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 and after one of the revascularization procedures, percutaneous coronary intervention (PCI) or coronary bypass surgery (CABG), across Portuguese 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 Portuguese hospitals performance against their national standard or benchmark. When the number of relevant hospitals was too small to reliably establishing a national benchmark, we have also kept the ECHO standard as term of reference.

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 Portuguese hospitals average CFR (risk-adjusted) and its 95% and 99% CIs. The solid grey line represents the Portuguese 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, 12,356 admissions were flagged as Acute Myocardial Infarction across 40 Portuguese hospitals; of those, 1,183 patients died –around 1 in 10.5 patients. The overall risk-adjusted CFR adds up to 1 death per 9 AMI admissions, setting the Portuguese average at 109.57 per 1,000 patients (+18), 10.5 per thousand points above the ECHO benchmark.

Individual hospitals' risk-adjusted CFR ranged from 32.34 (minimum CFR) to 335.89 (maximum CFR) per 1,000 AMI patients; thus, depending on the centre where they were treated, AMI patients could bear up to a 9.3-folded probability of dying. (See table 11 at the appendix 2.b for further details).

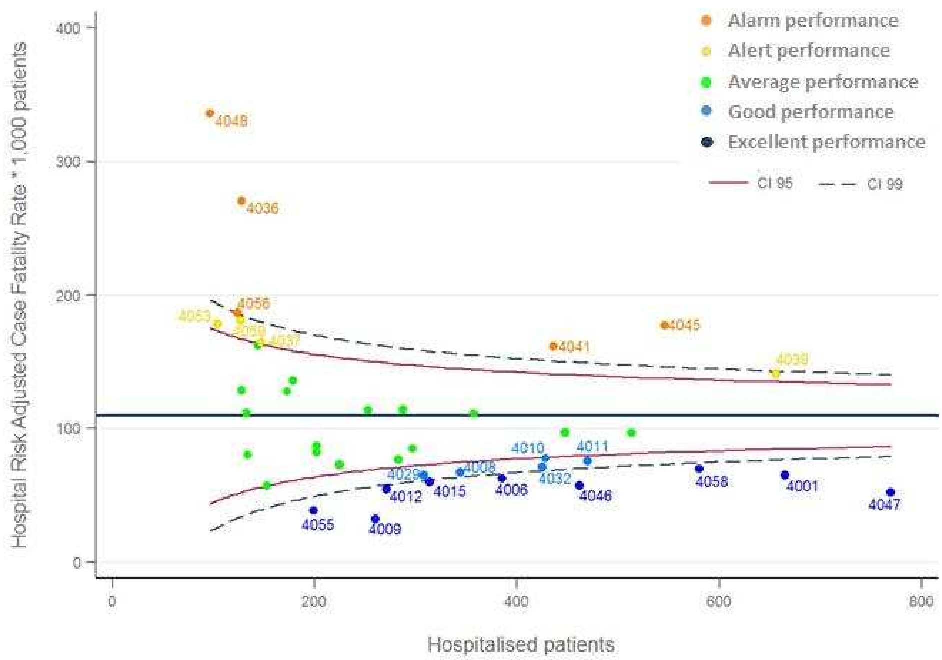

Figure 24. In-hospital mortality after AMI admission at Portuguese hospitals. Year 2009.

**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 Portuguese 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 higher than ECHO's, Portuguese hospitals' performance as assessed per this in-country funnel shows a different scenario, where 9 hospitals are flagged as alert/alarm (instead of the 11 by ECHO standards) and 14 as good/excellent performers (instead of 8).

In 2009, more than half of the Portuguese hospitals showed an annual volume of AMI patients above 250 (58% 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 still be observed as the number of patients treated increases. Actually, excluding 3 of the high-volume centres, the poorest performers (showing risk-adjusted CFR up to 3 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 19% of patients were hospitalised at alert/alarm centres while 48% of patients were at good or excellent centres. 43% of hospitals were average performers.

In-hospital case fatality rate for Percutaneous Coronary Interventions.

In 2009, 10,661 PCI procedures were performed across 30 Portuguese hospitals, yielding a risk-adjusted CFR of 1 death per each 48 interventions in patients aged 40 or older.

PCI CFRs varied widely across hospitals in a range from cero to 118 deaths in 1,000 patients, i.e. depending on the hospital where the procedure was performed, excluding extreme values, patients faced almost 9-times higher probability of dying (see table 13 at the appendix 2.b for further details).

As with AMI outcomes, Portuguese in-country benchmark for PCI was slightly higher than ECHO's; however, the resulting scenario did not substantially changed. Figure 25 shows how, when nationally benchmarked, 5 hospitals were flagged as alert/alarm (instead of the 4 in the ECHO benchmarking), while 2 were assessed as good or excellent performers (instead of 1).

Those hospitals in the alert/alarm position (17% of the total), took care of 13% of all patients undergoing PCI, while hospitals flagged as good/excellent provided PCI for 18.7% of patients.

The direction of the "volume effect" observed for PCI admission outcomes was as expected. Figure 25 shows how the larger the number of PCIs per year in a hospital, the more likely is to improve performance; with only two exceptions, which, with a number of procedures between 400-600 PCIs/year, remained within the alarm performance area.

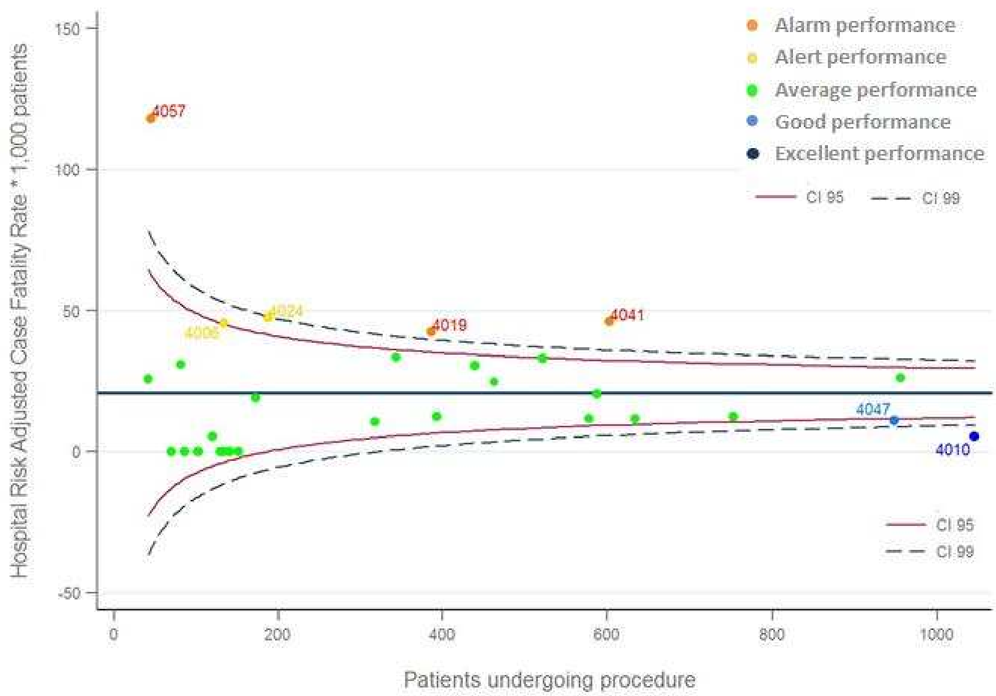

Figure 25. In-hospital mortality after going through PCI procedure at Portuguese hospitals. Year 2009.

** 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.*

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

In 2009, 2,492 CABG surgeries were performed at 6 Portuguese hospitals, of which 3.5% resulted in death. As for risk-adjusted hospital CFR, this means 1 death in 30 interventions for patients aged 40 or older.

In terms of individual hospitals, CABG CFRs took values from 3 to 78 deaths per 1,000 interventions, so patients undergoing CABG surgery could be bearing 26 times higher probability of death (risk-adjusted), depending on the hospital (See table 14 at the appendix 2.b for further details).

Since the national average risk-adjusted CFR for CABG is lower than ECHO countries' (16.8 per thousand points below ECHO's, as seen in section II.b), Portuguese hospitals' performance as assessed per this in-country funnel yield a different scenario, more demanding than international comparison. Two hospitals were flagged alert/alarm (instead of 1 by ECHO standards) and only 1 as good/excellent performer (instead of 3). 50% of hospitals were at the average level of performance, indicating risk-adjusted in-hospital mortality not significantly different from benchmark.

It is worth noting that 37.3% of patients were intervened at alert/alarm centres, while another 17% underwent their surgery at good or excellent hospitals.

The forerunner, flagged as excellent by both national and international standards, showed a lower than expected risk-adjusted CFR at 95% level of confidence, actually, almost 13 times smaller than the benchmark. (See table 14 at the appendix 2.b for further details).

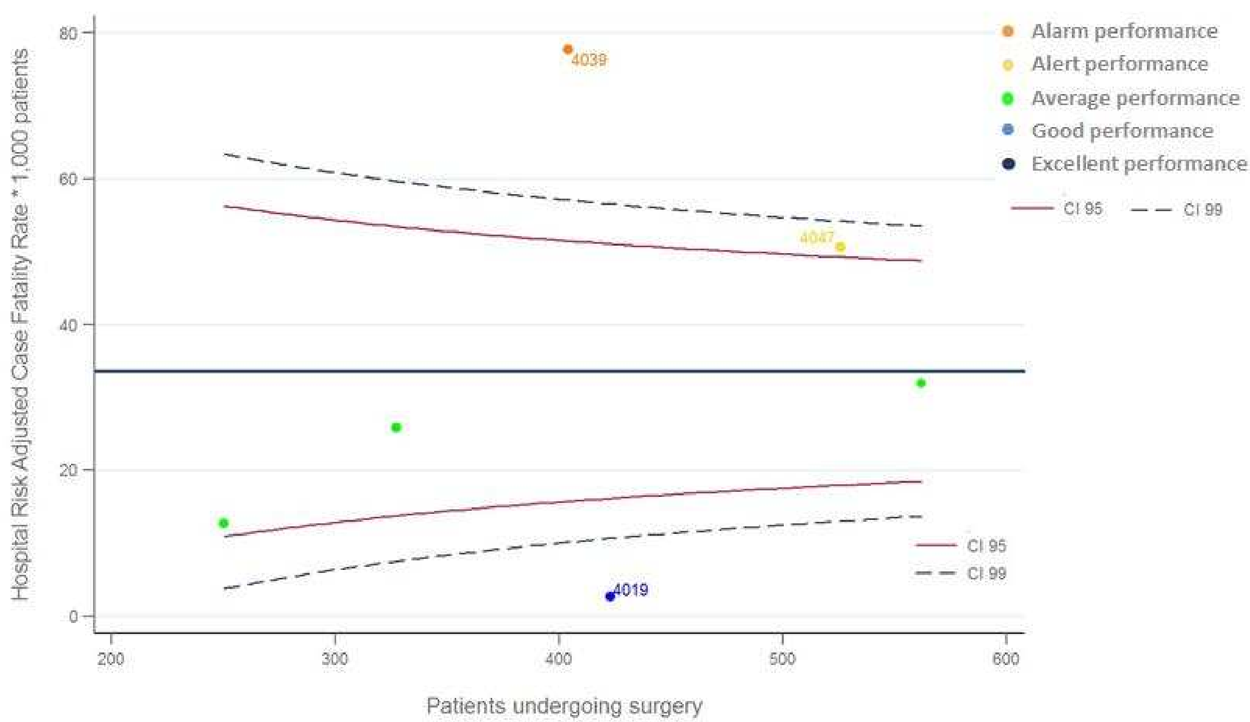

Figure 26. In-hospital mortality after going through CABG surgery at Portuguese hospitals. Year 2009.

** 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 remained quite stable; despite the huge increase in PCI utilisation.

By and large, in terms of hospital outcomes, risk-adjusted CFRs for AMI and following CABG have been improving over the period; but not so much for PCI. Nevertheless there are specific cases whose evolution warrants further investigation to identify both success and failure factors.

a. Geographic approach

From 2002 to 2009, coronary ischaemic disease admissions remained quite stable ranging from 1 admission per 550 to 1 admission per 497 adult inhabitants. Moreover, its systematic variation slightly decreased over the period, from moderate values around 12% above that randomly expected in 2002, to lower ones around 9% in 2009 (see table 15 in appendix 3.a).

Analysing only AMI admissions, we found that rates have increased by 12%- from 1 admission per 785 to 1 admission per 700 adult inhabitants. In this case, variation not deemed random remained low and stable along the period (see table 16 in appendix 3.a)

In the same period, PCI utilisation doubled their rates from 10 to 20 admissions per 10,000 inhabitants aged 40 or older – that is, from 1 admission per 1,046 to 1 admission per 495 inhabitants. At the same time, systematic variation halved their values (from 25% above what would be expected by chance to just 10%), pointing out that PCI exposure has grown more similar across the territory (see table 17 in appendix 3.a).

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 *concelhos*.

In turn, CABG utilisation barely increased by 19% over the same period, – from 1 admission per 2,674 to 1 admission per 2,242 inhabitants aged 40 or older. Besides, its systematic variation had a bumpy evolution along the period, moving up and down between 8% and 18% above that randomly expected.

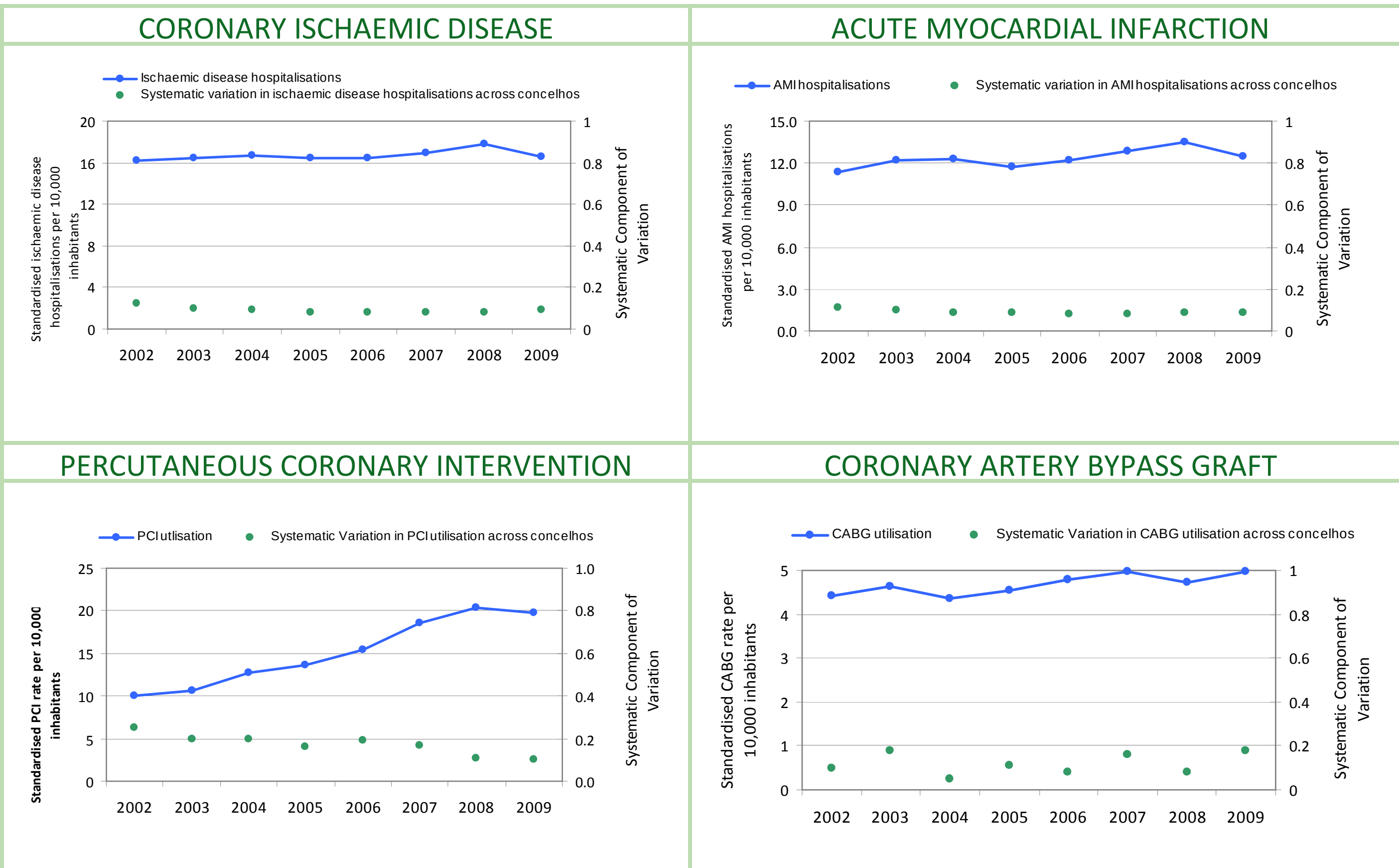

Figure 27. Temporal evolution of cardiovascular indicators from a geographical approach

Trends at those healthcare administrative areas within the lowest and highest quintiles – utilisation rates of PCI and CABG.

This section offers only a few selected examples, but Individual *concelhos*' evolution over time can be tracked in their original dynamic charts at

http://echo-health.eu/handbook/quintiles_cv_por.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 *concelhos*.

Analysing evolution of *concelhos* whose PCI rates were among the lowest at the beginning of the period (Q1), we see that most of them were small with less than 10,000 inhabitants. Moreover as shown in figure 28, they showed quite an uneven evolution spreading across the utilisation range in 2009. For example, in *Sabugal* utilisation has increased over time until it reached the top utilisation quintile (Q5) in 2009. Instead, ***Bãiao*** remained among the lowest rates for the whole period. Figure 29 portraits the evolution for *concelhos* starting at the top of the utilisation range (Q5). Those *concelhos* are bigger in terms of population and most of them stayed in the fifth and fourth utilisation quintile, for example *Lourinhã*. While, others, as *Elvas*, have had their rates decreased to the lowest quintile of PCI utilisation. Such decreases in the rate corresponded to Concelhos with less than 11,500 inhabitants.

Similar behaviour was observed in CABG. *Concelhos* with lowest CABG rates are less populated than those in higher utilisation quintiles. Again, *concelhos* in Q1 spread across all utilisation quintiles over time. Taking as an example *Lagos* and *Trofa*, both areas showed low rates in 2002 but while *Lago**s*** remained among the lowest quintiles, *Trofa* reached the highest utilisation levels by the end of the period (figure 30).

Moreover, it can be observed that most *concelhos* with highest CABG utilisation in 2002 (Q5 in orange) experienced a bumpy evolution going up and down, for example *Bombarral* or *Santa Comba Dão*. A few areas, for example *Setúbal,* remained **in** the same quintile in almost all years (figure 31).

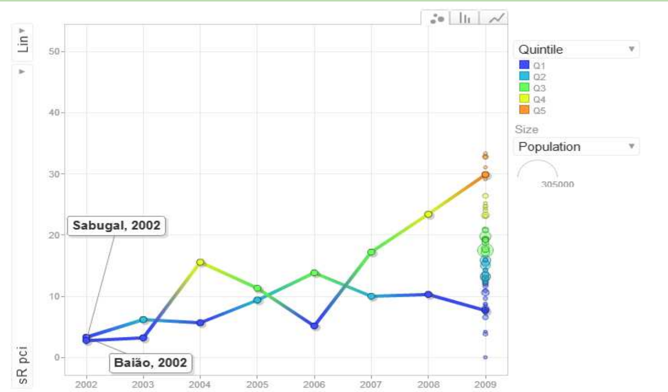

Figure 28. Trends in utilisation rates of PCI across *concelhos* showing the lowest rates at the beginning of the period.

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

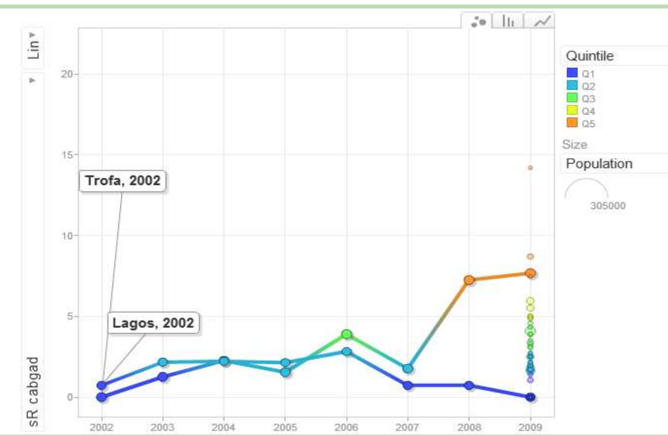

Figure 30. Trends in utilisation rates of CABG across *concelhos* , showing the lowest rates at the beginning of the period.

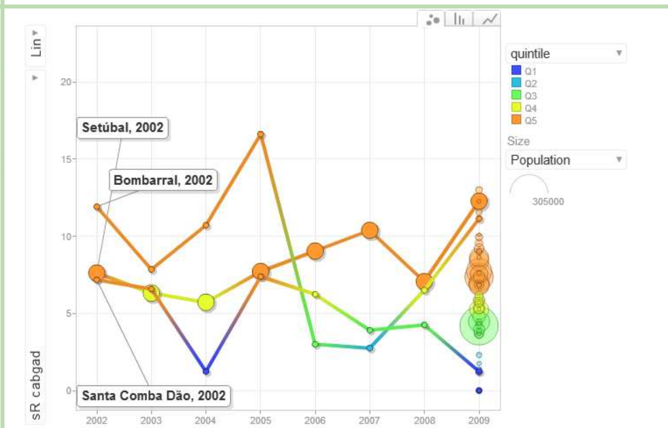

Figure 31. Trends in utilisation rates of CABG across *concelhos* , showing the highest rates at the beginning of the period.

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_por.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.

Note that the distribution of hospital outcomes was performed according to the most recent designation of hospitals, following the current list of hospitals, once merging processes have been taken into account.

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

Throughout the period reviewed, the proportion of high-volume hospitals increased as well as the share of AMI patients treated in these hospitals. The percentage of patients attended in “alarm” hospitals decreased substantially, while the share treated in “alert” hospitals increased. It was also remarkable the upwards trend in the percentage of AMI patients treated at “excellent performing" hospitals. All together drove to a net reduction in the average in-hospital risk-adjusted CFR. Further details of the evolution of Portuguese hospitals' relative performance for AMI admissions along this period in table19, appendix 3.b.

None of the individual hospitals seems to improve or worsen radically their risk-adjusted CFR for AMI patients along the analysed period. As shown in figure 32, good performing hospitals tend to remain as such or even improve to “*excellent performance*”, i.e. ***Centro Hospitalar Lisboa Ocidental EPE*** and ***Hospital Sco Joco EPE – Porto***. Hospitals starting in an "*alarm position*", on the other hand, could fluctuate through the area of average but, then again tend to return to a "*less safe*" performance position, i.e. ***Centro Hospitalar de Lisboa norte EPE*.** There are a few exceptions to the general trend: **Centro hospitalar de Cascais** is a clear example of a low-volume hospital (note that the size of the bubble is proportional to the amount of cases treated) with an erratic evolution of its performance.

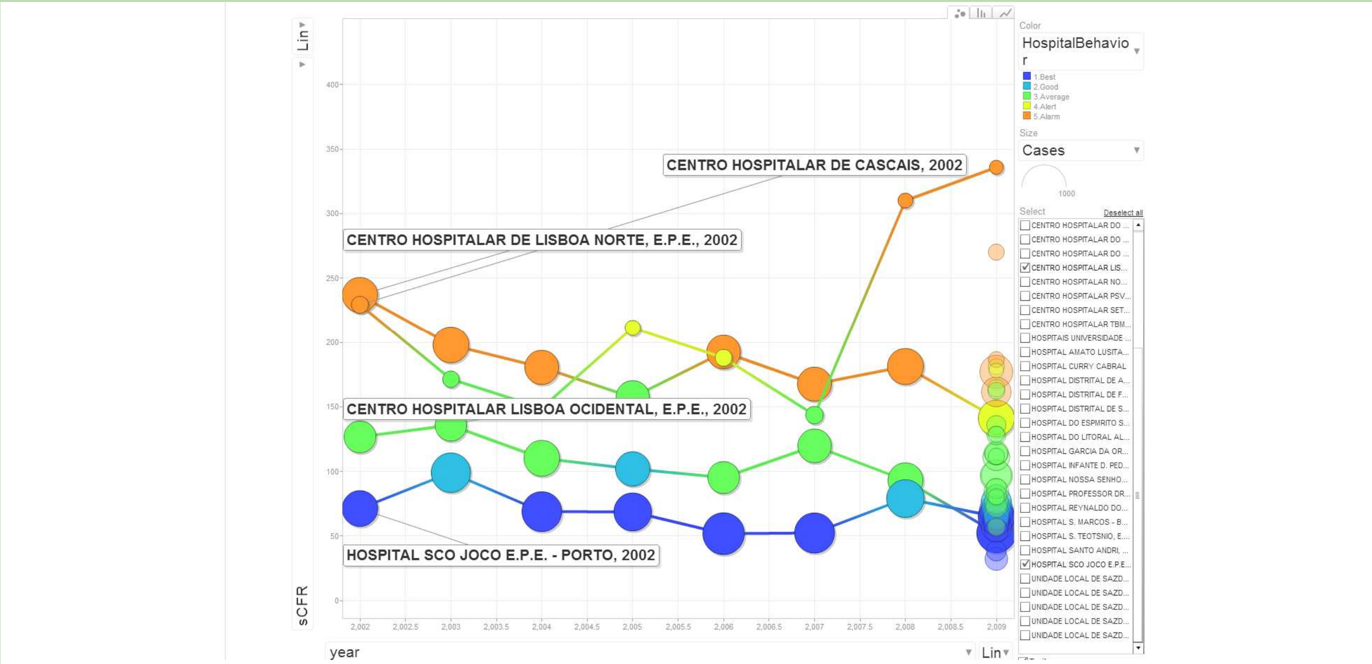

Figure 32. In-Hospital mortality trends of AMI, 2006-2009, showing some of the highest and lowest CFRs and their evolution.

** 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.

The proportion of high-volume hospitals also increased for PCI as well as the share patients intervened at those hospitals along the analysed period. The percentage of “alarm performer” hospitals decreased as did the share of patients intervened at them.

From an individual hospital perspective, as shown in figure 33, we find centres starting and ending at an “alert/alarm performance” (***Centro Hospitalar de Lisboa central, EPE***), hospitals fluctuating between the areas of average and “alarm performance” (***Centro Hospitalar de Lisboa norte, EPE***), but, also, hospitals improving from average to an “excellent performance” (***Centro Hospitalar de Vila Nova de Gaia/Espinho, E.P.E.***). ***Hospital do litoral Alentejano-Santiago do Cacim*** is an example of a lower-volume hospital worsening drastically its performance along the period. Further details of the evolution of Portuguese hospitals' relative performance for PCI along this period in table 20, appendix 3.b

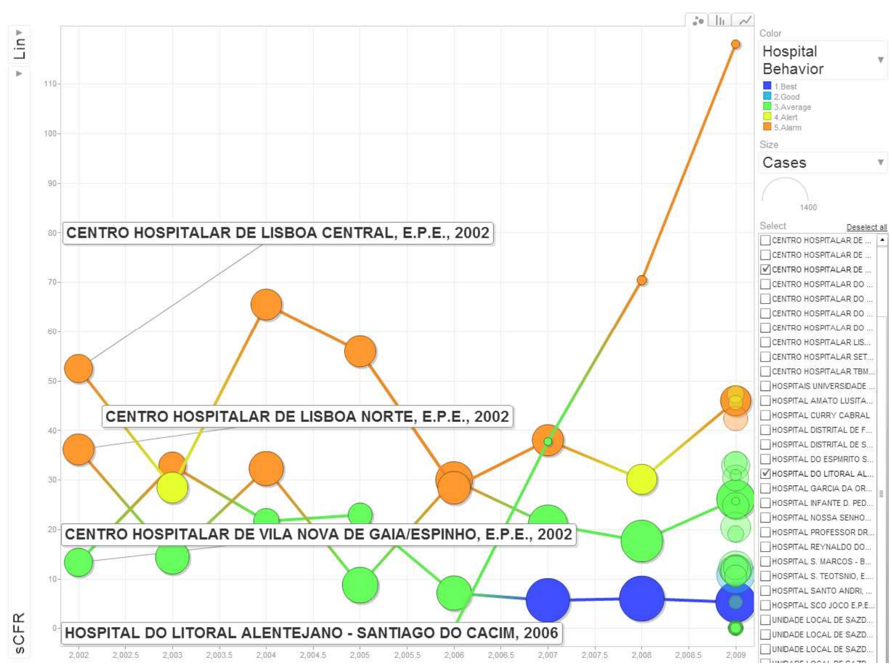

Figure 33. In-Hospital mortality trends of PCI -2002-2009, showing some of the highest and lowest CFRs and their evolution

** 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 graft, the number of hospitals performing this surgery did not change along the analysed period and all of them were constantly high-volume. Nevertheless, after some years of improvement, the percentage of patients undergoing CABG surgery in alarm/alert performing hospitals increased (almost 20 percentage points for the last year) while the percentage of CABG patients intervened at excellent performing hospitals remained more or less the same, between 16.5 and 17.5% since2005. There is a net decrease in the average in-hospital risk-adjusted CFR.

When considering the evolution of individual Hospitals, there are no extreme remarkable changes during the period, even though the evolution in performance (in terms of risk-adjusted CFR) is more erratic than previous analysed trends. Figure 34 shows the four out of six hospitals performing GABG in Portugal which did not remain at average position. The first one (***Centro Hospitalar de Lisboa Norte ,EPE***) fluctuates around the areas of average performance and "*alert/alarm*" while increasing its risk-adjusted case fatality rate. ***Centro Hospitalar de Lisboa central EPE*** instead, seems to improve going from alert to average performance while reducing drastically its risk-adjusted CABG fatality rate. ***Hospitais universidade de Coimbra*** is an example of steady evolution remaining as excellent performer along the period analysed. Further details of the evolution of Portuguese hospitals' relative performance for CABG along this period in table 21, appendix 3.b.

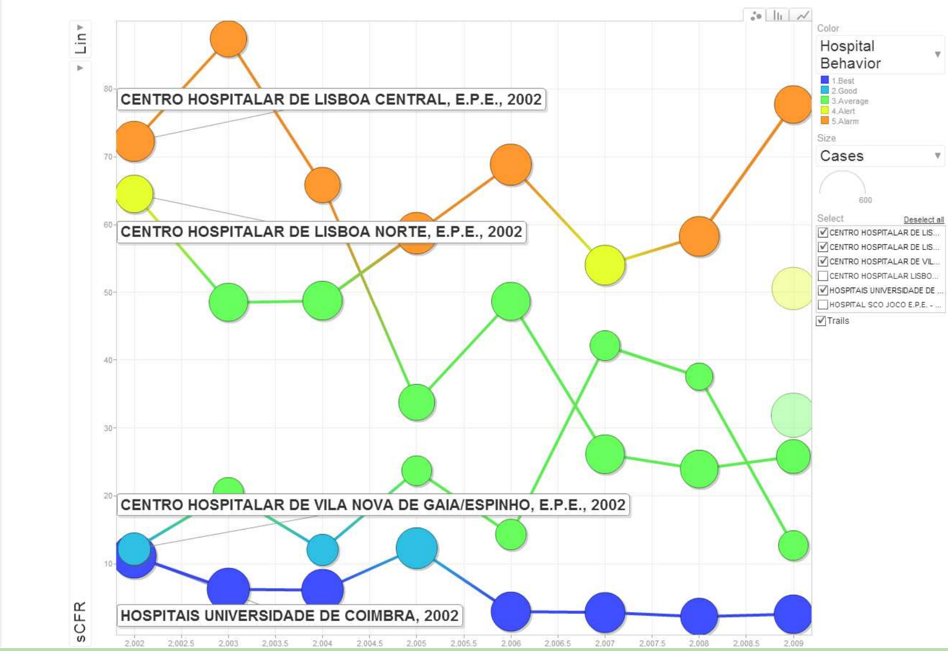

Figure 34. In-Hospital mortality trends of CABG -2002-2009, showing some of the highest and lowest CFRs and their evolution

** 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

PCI and CABG exposure was higher for population living in most affluent *concelhos*. As CID admissions were also more frequent in wealthier areas, differences in revascularisation across wealth levels might be driven by need.

Significantly more CID admissions took place in affluent *concelhos* than in deprived ones. The same happened when analysing specifically AMI admissions. Thus, the variation in CID admissions across *concelhos* described in previous sections could be related to area income level.

At the same time, wealthier areas showed significantly higher PCI and CABG utilisation than those less affluent over the period 2002-2009. But whereas, PCI utilisation has increased in all *concelhos*, regardless their income level, CABG utilisation rates have only scarcely raised in the most deprived areas.

One possible conclusion is that, though residents at better-off municipalities are exposed to higher PCI and CABG intensity, this might be justified by need, since this population seems to also bear a higher burden of coronary disease (at least in terms of CID hospital admissions). This seems a bit counter-intuitive from the epidemiological point of view: there is much evidence outlining lower socioeconomic level and more often associated life styles as a risk factors for CID.

An alternative hypothesis, would consider whether there might be under or over exposure to hospitalisation in those areas as a result of differences in access to hospital services, rather than differences in burden of disease.

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 *concelhos*. 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 *concelhos* amenable to their wealth. As a second best, any eventual existing gap should disappear over time.

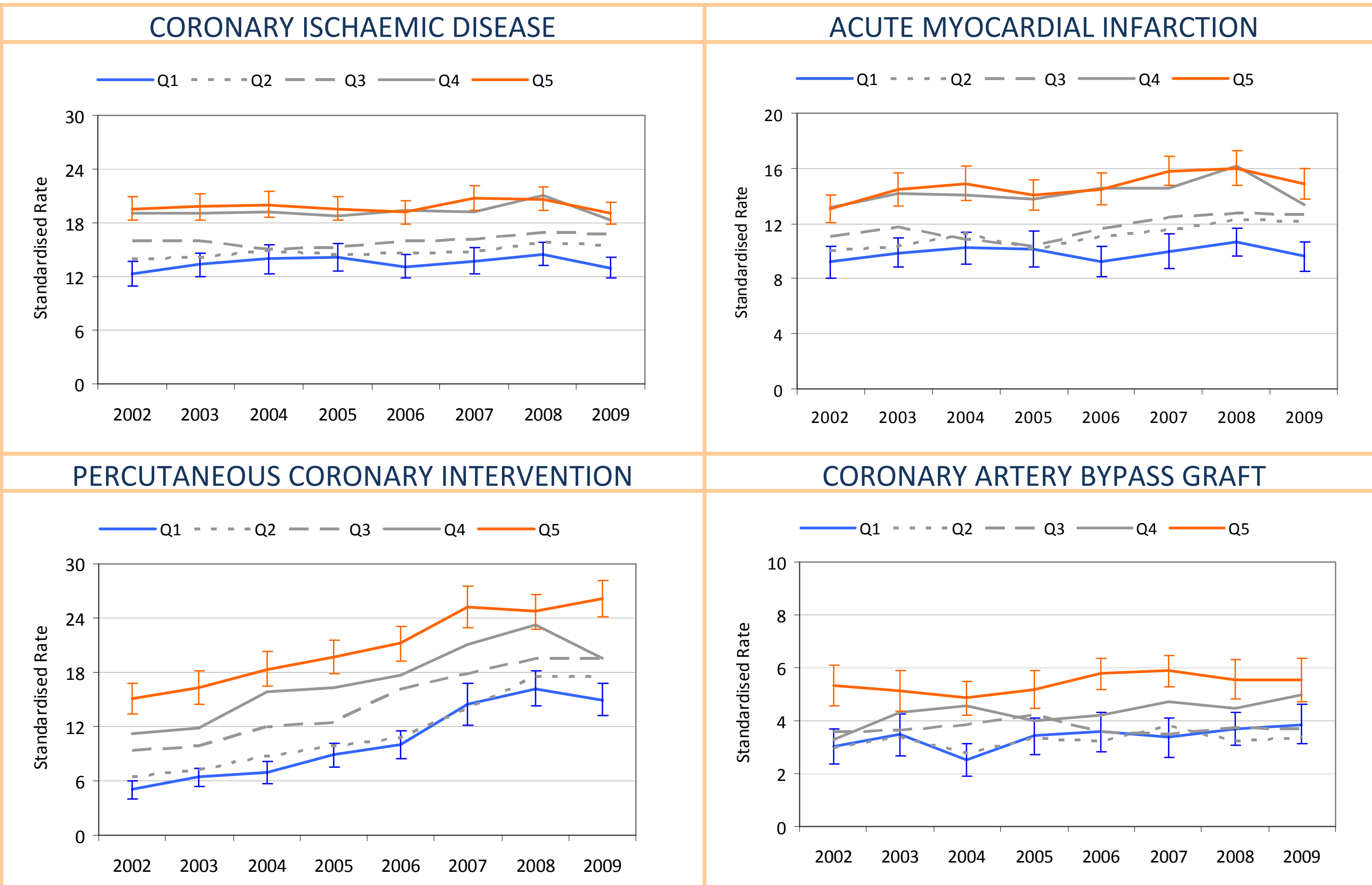

Figure 35. Trends in standardised rate by income quintile

** Areas are divided in 5 categories of wealth (average annual family income available per individual): 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 utilisation 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.*

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VI. POLICY IMPLICATIONS.

Coronary ischaemic disease is one of the leading causes of death, disability and decreased quality of life in Europe; particularly in Portugal, it was one of the main causes of death in 2009, together with cerebrovascular diseases and cancer. 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 in the north of Europe, rates from 2009 still showed higher figures in England and Denmark (in this order) than in Spain and Portugal (the country with the lowest rate). These differences should be taken into account in assessing and comparing 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 of burden of disease and PCI intensity of use showed some overlapping, though it also highlighted some discrepancies: *Concelhos* 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.

CABG utilisation did not correlate with the burden of disease either in many concelhos.

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 the observed revascularisation rates and its variation across the territory.

Some literature points out the concern over regional disparities and inequality in Portugal. The within-country analysis showed how significantly more CID, and specifically AMI admissions took place in more affluent *concelhos* compared to the deprived ones. At the same time, wealthier areas showed significantly higher rates for both revascularisation procedures all along the period of analysis. The fact that more affluent areas bear more CID admissions together with a higher PCI and CABG utilisation rates, jointly considered, seem to suggest an intensity of utilisation driven by need, as this population could be more affected by/exposed to coronary diseases (or at least more prone to hospitalisation from coronary ischaemic diseases. This phenomenon may require further exploration, to discard differences in access to hospital as the underlying cause, which may be confounding the gradient of burden of disease

Looking now at the hospital case fatality rates for these patients and those procedures, Portuguese risk-adjusted in-hospital mortality rate for AMI patients has shown a slight net decrease since 2002, but it was still the third highest among ECHO countries in 2009. Detailed analysis reveals that the majority of Portuguese AMI patients were treated at hospitals providing care within the expected (average) levels of quality and safety or above. However, close to 19% of these patients were admitted to hospitals showing CFRs significantly higher than expected, and were consequently flagged as alert/alarm. Actually There was a 10.4–folded difference in the risk of dying depending on where the AMI patient was hospitalised, even though multilevel analysis showed that the hospitals barely explained this variation in outcomes (cluster effect just contributing a 4.1%). Volume has been argued as one of the plausible factors underpinning these differences; Though 58% of Portuguese hospitals registered a volume of annual patients beyond the ECHO threshold for high volume, the lower the volume the higher the probability of worse outcomes; Nevertheless, there must be other organisational factors that deserve further and closer look.

The literature recommends assessing a number of elements 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 Portuguese 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 all over the country, suggesting that in some areas factors other than need or technological change might be driving the revascularisation intensity.

The comparatively poorer results of some of the Portuguese hospitals, by national and international benchmarking, warrant some closer look. The fact that 37.3% of the patients undergoing CABG surgery 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 (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 (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 (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 (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	143.62	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 Portugal

WITHIN-Country analysis

GEOGRAPHICAL APPROACH

Year 2009

Table 9: Descriptive Statistics of burden of coronary disease and use of revascularisation procedures across *concelhos*.

	CID	AMI	PCI	CABG
Cases	14,526	11,365	10,587	2,446
Population	8,616,865	8,616,865	5,222,232	5,222,232
Crude Rate	18.95	14.35	19.41	4.29
Stand. Rate	16.86	12.76	18.98	4.84
sR Min.	2.75	1.26	3.15	0.25
sR Max.	46.96	37.37	42.56	25.17
sR. P5	8.41	5.37	7.51	1.17
sR. P25	12.26	9.23	13.55	2.78
sR. P50	15.92	12.07	17.25	4.4
sR. P75	19.89	15.82	24.13	6.05
sR. P95	28.8	22.5	34.32	10.25
EQ5-95	3.42	4.19	4.57	8.75
EQ25-75	1.62	1.71	1.78	2.17
ICC	0.01	0.04	0.10	0.14

** sR: Age-sex Standardised Rate (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 concelhos.

	CID	AMI	PCI	CABG
SUR Mín.	0.15	0.12	0.2	0.06
SUR Máx.	2.7	2.67	2.15	5.26
SUR P5	0.49	0.39	0.36	0.28
SUR P25	0.72	0.68	0.68	0.6
SUR P50	0.93	0.89	0.86	0.92
SUR P75	1.18	1.21	1.17	1.27
SUR P95	1.62	1.63	1.68	2.18
SCV	0.1	0.1	0.1	0.19

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

APPENDIX 2b:

Tables Portugal

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	1183	188	87
N. hospitals	40	30	6
Crude CFR	105.70	16.19	33.27
Risk-adjusted CFR	109.57	20.77	33.55
R-adj CFR MIN	32.34	0.00	2.62
R-adj CFR MAX	335.89	118.04	77.71
Rho Statistic	0.041	0.05	0.109

**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
4048	CENTRO HOSPITALAR DE CASCAIS	97	278.35	335.89	175.45	43.70	*		196.15	23.00	*	
4036	HOSPITAL AMATO LUSITANO - CASTELO BRANCO	128	226.56	270.16	166.92	52.23	*		184.94	34.21	*	
4056	UNIDADE LOCAL DE SAZDE DO NORTE ALENTEJANO E.	124	161.29	186.50	167.84	51.31	*		186.14	33.00	*	
4059	CENTRO HOSPITALAR BARLAVENTO ALGARVIO, E.P.E.	127	157.48	180.99	167.14	52.00	*		185.23	33.91		
4053	HOSPITAL DISTRITAL DE SANTARIM, E.P.E.	104	153.85	178.02	173.19	45.95	*		193.18	25.96		
4045	HOSPITAL PROFESSOR DR. FERNANDO DA FONSECA - /	546	168.50	177.06	137.34	81.81	*		146.06	73.08	*	
4037	CENTRO HOSPITALAR COVA DA BEIRA, E.P.E.	147	149.66	164.36	163.08	56.06	*		179.90	39.25		
4035	CENTRO HOSPITALAR DO OESTE NORTE	144	152.78	162.37	163.64	55.51			180.63	38.52		
4041	CENTRO HOSPITALAR DE LISBOA CENTRAL, E.P.E.	436	153.67	161.46	140.64	78.50	*		150.41	68.74	*	
4039	CENTRO HOSPITALAR DE LISBOA NORTE, E.P.E.	656	137.20	141.10	134.90	84.24	*		142.86	76.28		
4030	UNIDADE LOCAL DE SAZDE DA GUARDA, E.P.E.	179	122.91	135.92	158.07	61.08			173.30	45.84		
4014	CENTRO HOSPITALAR DO MIDIO AVE, E.P.E.	128	125.00	128.61	166.92	52.23			184.94	34.21		
4018	CENTRO HOSPITALAR NORDESTE, E.P.E.	173	121.39	127.81	158.90	60.25			174.40	44.75		
4002	CENTRO HOSPITALAR DO PORTO, E.P.E.	287	111.50	114.31	147.87	71.28			159.90	59.24		
4050	HOSPITAL NOSSA SENHORA DO ROSARIO, E.P.E. - BAR	253	110.67	113.83	150.36	68.78			163.18	55.97		
4057	HOSPITAL DO LITORAL ALENTEJANO - SANTIAGO DO C	133	105.26	111.66	165.83	53.32			183.51	35.64		
4042	HOSPITAL CURRY CABRAL	357	112.04	111.03	143.91	75.24			154.70	64.45		
4052	CENTRO HOSPITALAR SETUBAL, E.P.E	448	93.75	96.97	140.23	78.92			149.86	69.29		
4019	HOSPITAIS UNIVERSIDADE DE COIMBRA	513	95.52	96.66	138.22	80.93			147.22	71.93		
4023	HOSPITAL SANTO ANDRI, E.P.E. - LEIRIA	202	84.16	86.95	155.22	63.93			169.57	49.58		
4054	HOSPITAL DO ESPMRITO SANTO - IVORA	297	87.54	84.58	147.22	71.93			159.05	60.10		
4013	UNIDADE LOCAL DE SAZDE DO ALTO MINHO, E.P.E.	202	89.11	82.08	155.22	63.93			169.57	49.58		
4034	CENTRO HOSPITALAR DE TORRES VEDRAS	134	89.55	80.25	165.62	53.53			183.23	35.92		
4010	CENTRO HOSPITALAR DE VILA NOVA DE GAIA/ESPINH	428	77.10	77.52	140.93	78.21		*	150.79	68.36		
4024	HOSPITAL S. TEOTSNIO, E.P.E. - VISEU	283	84.81	76.65	148.14	71.01			160.26	58.89		
4011	HOSPITAL S. MARCOS - BRAGA	470	74.47	75.73	139.50	79.65		*	148.90	70.24		
4026	HOSPITAL INFANTE D. PEDRO, E.P.E. - AVEIRO	225	80.00	72.87	152.83	66.32			166.42	52.73		
4032	CENTRO HOSPITALAR DE COIMBRA	425	75.29	71.00	141.04	78.10		*	150.93	68.21		
4058	HOSPITAL DISTRITAL DE FARO	580	70.69	69.57	136.51	82.63		*	144.98	74.17		*
4008	CENTRO HOSPITALAR TBMEGA E SOUSA, E.P.E.	344	72.67	67.14	144.55	74.59		*	155.55	63.60		
4001	HOSPITAL SCO JOCO E.P.E. - PORTO	665	72.18	64.97	134.73	84.41		*	142.64	76.51		*
4029	CENTRO HOSPITALAR DO MIDIO TEJO, E.P.E.	308	68.18	64.93	146.54	72.61		*	158.16	60.99		
4006	UNIDADE LOCAL DE SAZDE DE MATOSINHOS, E.P.E.	385	67.53	62.36	142.64	76.51		*	153.03	66.12		*
4015	CENTRO HOSPITALAR DE TRAS-OS-MONTES E ALTO DC	314	63.69	59.63	146.19	72.96		*	157.69	61.46		*
4046	HOSPITAL GARCIA DA ORTA, E.P.E. - ALMADA	462	60.61	57.21	139.76	79.39		*	149.24	69.90		*
4049	HOSPITAL REYNALDO DOS SANTOS - VILA FRANCA DE	153	65.36	57.16	162.02	57.12			178.51	40.64		
4012	CENTRO HOSPITALAR DO ALTO AVE, E.P.E.	271	59.04	54.44	148.98	70.16		*	161.37	57.78		*
4047	CENTRO HOSPITALAR LISBOA OCIDENTAL, E.P.E.	769	55.92	52.31	132.97	86.18		*	140.32	78.83		*
4055	UNIDADE LOCAL DE SAZDE DO BAIXO ALENTEJO, E.P.E.	199	50.25	38.53	155.56	63.58		*	170.02	49.13		*
4009	CENTRO HOSPITALAR DE ENTRE O DOURO E VOUGA, E	260	42.31	32.34	149.81	69.34		*	162.45	56.69		*

(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 Portugal

WITHIN-Country analysis

HOSPITAL APPROACH

Year 2009

Table 13: Hospital outcomes for Percutaneous Coronary Interventions*. 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
4057	HOSPITAL DO LITORAL ALENTEJANO - SANTIAGO DO C	45	44.44	118.04	62.88	-21.34	*		76.12	-34.57	*	
4024	HOSPITAL S. TEOTSNIO, E.P.E. - VISEU	188	37.23	47.33	41.38	0.17	*		47.85	-6.30		
4041	CENTRO HOSPITALAR DE LISBOA CENTRAL, E.P.E.	602	38.21	45.99	32.29	9.26	*		35.90	5.64	*	
4006	UNIDADE LOCAL DE SAZDE DE MATOSINHOS, E.P.E.	134	29.85	45.61	45.18	-3.63	*		52.84	-11.30		
4019	HOSPITAIS UNIVERSIDADE DE COIMBRA	386	31.09	42.39	35.15	6.39	*		39.67	1.88	*	
4045	HOSPITAL PROFESSOR DR. FERNANDO DA FONSECA - /	343	29.15	33.48	36.03	5.52			40.82	0.73		
4052	CENTRO HOSPITALAR SETUBAL, E.P.E	521	26.87	32.82	33.15	8.40			37.04	4.51		
4036	HOSPITAL AMATO LUSITANO - CASTELO BRANCO	82	24.39	30.98	51.97	-10.42			61.77	-20.22		
4002	CENTRO HOSPITALAR DO PORTO, E.P.E.	439	27.33	30.41	34.26	7.29			38.49	3.05		
4039	CENTRO HOSPITALAR DE LISBOA NORTE, E.P.E.	955	24.08	26.12	29.91	11.63			32.79	8.76		
4059	CENTRO HOSPITALAR BARLAVENTO ALGARVIO, E.P.E.	42	23.81	25.69	64.36	-22.82			78.06	-36.51		
4042	HOSPITAL CURRY CABRAL	462	21.65	24.78	33.92	7.63			38.04	3.50		
4058	HOSPITAL DISTRITAL DE FARO	587	18.74	20.42	32.43	9.11			36.10	5.45		
4054	HOSPITAL DO ESPMRITO SANTO - IVORA	173	17.34	19.09	42.25	-0.70			49.00	-7.45		
4011	HOSPITAL S. MARCOS - BRAGA	393	12.72	12.30	35.02	6.52			39.50	2.05		
4032	CENTRO HOSPITALAR DE COIMBRA	753	13.28	12.21	31.07	10.48			34.30	7.24		
4001	HOSPITAL SCO JOCO E.P.E. - PORTO	633	14.22	11.74	32.00	9.55			35.53	6.02		
4046	HOSPITAL GARCIA DA ORTA, E.P.E. - ALMADA	577	12.13	11.64	32.53	9.01			36.23	5.32		
4047	CENTRO HOSPITALAR LISBOA OCIDENTAL, E.P.E.	948	11.60	10.92	29.95	11.60		*	32.83	8.72		
4015	CENTRO HOSPITALAR DE TRAS-OS-MONTES E ALTO DC	317	12.62	10.56	36.64	4.91			41.62	-0.08		
4010	CENTRO HOSPITALAR DE VILA NOVA DE GAIA/ESPINH	1045	6.70	5.32	29.51	12.03		*	32.26	9.29		*
4012	CENTRO HOSPITALAR DO ALTO AVE, E.P.E.	120	8.33	5.31	46.56	-5.01			54.66	-13.12		
4008	CENTRO HOSPITALAR TBMEGA E SOUSA, E.P.E.	152	0.00	0.00	43.69	-2.14			50.89	-9.34		
4023	HOSPITAL SANTO ANDRI, E.P.E. - LEIRIA	129	0.00	0.00	45.64	-4.10			53.46	-11.91		
4026	HOSPITAL INFANTE D. PEDRO, E.P.E. - AVEIRO	103	0.00	0.00	48.61	-7.06			57.35	-15.81		
4029	CENTRO HOSPITALAR DO MIDIO TEJO, E.P.E.	141	0.00	0.00	44.56	-3.02			52.04	-10.49		
4030	UNIDADE LOCAL DE SAZDE DA GUARDA, E.P.E.	86	0.00	0.00	51.23	-9.69			60.81	-19.26		
4037	CENTRO HOSPITALAR COVA DA BEIRA, E.P.E.	102	0.00	0.00	48.74	-7.20			57.53	-15.99		
4049	HOSPITAL REYNALDO DOS SANTOS - VILA FRANCA DE	70	0.00	0.00	54.54	-12.99			65.15	-23.60		
4055	UNIDADE LOCAL DE SAZDE DO BAIXO ALENTEJO, E.P.E.	133	0.00	0.00	45.27	-3.72			52.96	-11.42		

(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 from 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".

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
4039	CENTRO HOSPITALAR DE LISBOA NORTE, E.P.E.	404	71.78	77.71	51.41	15.69	*		57.03	10.08	*	
4047	CENTRO HOSPITALAR LISBOA OCIDENTAL, E.P.E.	526	47.53	50.56	49.21	17.90	*		54.12	12.98		
4001	HOSPITAL SCO JOCO E.P.E. - PORTO	562	32.03	31.88	48.70	18.41			53.45	13.65		
4041	CENTRO HOSPITALAR DE LISBOA CENTRAL, E.P.E.	327	27.52	25.81	53.41	13.70			59.64	7.46		
4010	CENTRO HOSPITALAR DE VILA NOVA DE GAIA/ESPINH	250	16.00	12.73	56.26	10.85			63.39	3.71		
4019	HOSPITAIS UNIVERSIDADE DE COIMBRA	423	4.73	2.62	51.01	16.10		*	56.49	10.61		*

(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 from the analysis.*
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 Portugal

Evolution over time

GEOGRAPHICAL APPROACH

Period of analysis: 2002-2009

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

	CORONARY ISCHAEMIC DISEASE							
	2002	2003	2004	2005	2006	2007	2008	2009
Cases	15374	15831	15946	15573	15285	15531	15648	14526
Stand. Rate	18.18	18.31	18.55	18.3	18.49	18.99	20.11	18.82
sR Q1.	12.29	13.33	13.96	14.12	13.14	13.72	14.49	12.97
sR Q5.	19.57	19.81	20.06	19.57	19.20	20.80	20.69	19.04
SCV	0.12	0.1	0.09	0.08	0.08	0.08	0.08	0.09

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

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

	ACUTE MYOCARDIAL INFARCTION							
	2002	2003	2004	2005	2006	2007	2008	2009
Cases	10865	11802	11824	11471	11510	11852	12009	11365
Stand. Rate	12.74	13.57	13.73	13.06	13.88	14.49	15.35	14.28
sR Q1.	9.21	9.89	10.21	10.17	9.24	9.99	10.65	9.63
sR Q5.	13.08	14.46	14.91	14.08	14.52	15.81	16.02	14.88
SCV	0.11	0.1	0.09	0.09	0.08	0.08	0.09	0.09

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

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

	PERCUTANEOUS CORONARY INTERVENTION							
	2002	2003	2004	2005	2006	2007	2008	2009
Cases	6072	6921	7711	8327	8911	10529	10922	10587
Stand. Rate	9.56	10.53	12.6	13.8	15.59	19.01	20.8	20.2
sR Q1.	5.03	6.42	6.94	8.86	9.99	14.45	16.21	14.97
sR Q5.	15.07	16.32	18.38	19.73	21.16	25.25	24.75	26.15
SCV	0.25	0.2	0.2	0.16	0.19	0.17	0.11	0.1

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

APPENDIX 3.a:

Tables Portugal

Evolution over time

GEOGRAPHICAL APPROACH

Period of analysis: 2002-2009

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

	CORONARY ARTERY BYPASS GRAFT							
	2002	2003	2004	2005	2006	2007	2008	2009
Cases	2363	2269	2226	2347	2577	2541	2491	2446
Stand. Rate	3.74	4.06	3.78	4.18	4.18	4.36	4.31	4.46
sR Q1.	3.04	3.46	2.52	3.42	3.57	3.38	3.69	3.87
sR Q5.	5.33	5.11	4.85	5.19	5.78	5.87	5.56	5.54
SCV	0.1	0.18	0.05	0.11	0.08	0.16	0.08	0.18

** 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 Denmark

Evolution over time

HOSPITAL APPROACH

Period of analysis: 2002-2009

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

	ACUTE MYOCARDIAL INFARCTION							
	2002	2003	2004	2005	2006	2007	2008	2009
Discharges	11367	12321	12183	11755	11874	12358	12739	12356
Deceased	1438	1547	1497	1425	1340	1355	1289	1183
Nº Hospitals	41	41	39	41	40	40	40	40
Hospitals > 250 (% patients treated)	20 (70.79%)	22 (74.7%)	20 (71.56%)	22 (75.64%)	21 (71.53%)	22 (74.33%)	22 (75.52%)	23 (78.97%)
Average expected Risk-adjusted CFR	126.94	131.16	127.34	131.84	121.34	118.3	105.54	109.57
hosp. Alarm position (% patients treated)	8 (24.08%)	8 (22.2%)	5 (17.2%)	5 (13.72%)	5 (11.83%)	5 (13.55%)	4 (11.52%)	5 (10.77%)
hosp. Alert position (% patients treated)	--- ---	1 (1.13%)	2 (4.08%)	2 (3.25%)	3 (4.15%)	3 (4.82%)	2 (2.87%)	4 (8.37%)
hosp. Good performers (% patients treated)	5 (13.35%)	6 (16.24%)	4 (10.1%)	7 (17.65%)	2 (6.56%)	2 (8.81%)	4 (9.71%)	5 (15.98%)
hosp. Excellent performers (% patients treated)	5 (14.82%)	8 (21.82%)	5 (19.31%)	7 (26.03%)	7 (23.68%)	8 (25.09%)	6 (18.01%)	9 (31.6%)

**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 Portuguese hospitals' relative performance for patients undergoing PCI procedure. (In-country benchmark estimation)

	PERCUTANEOUS CORONARY INTERVENTION							
	2002	2003	2004	2005	2006	2007	2008	2009
Discharges	6001	7047	7726	8361	8966	10623	10977	10661
Deceased	124	132	157	149	171	188	177	188
Nº Hospitals	26	34	33	34	34	34	31	30
Hospitals > 250 (% patients treated)	9 (71.09%)	9 (65.9%)	11 (68.78%)	12 (68.84%)	13 (74.82%)	14 (82.89%)	15 (84.02%)	15 (84.05%)
Average expected Risk-adjusted CFR	16.01	15.73	15.48	13.28	13.99	17.47	17.24	20.77
hosp. Alarm position (% patients treated)	6 (34.31%)	5 (22.25%)	5 (27.76%)	4 (20.08%)	6 (35.89%)	5 (30.3%)	5 (11.49%)	3 (9.69%)
hosp. Alert position (% patients treated)	--- ---	2 (15.52%)	--- ---	4 (19%)	--- ---	--- ---	1 (5.47%)	2 (3.02%)
hosp. Good performers (% patients treated)	--- ---	--- ---	--- ---	--- ---	--- ---	2 (20.07%)	1 (2.83%)	1 (8.89%)
hosp. Excellent performers (% patients treated)	--- ---	--- ---	--- ---	--- ---	--- ---	1 (11.74%)	1 (12.05%)	1 (9.80%)

** 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 Denmark

Evolution over time

HOSPITAL APPROACH

Period of analysis: 2002-2009

Table 21. Evolution of Portuguese 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	2389	2326	2268	2413	2621	2611	2541	2492
Deceased	96	89	81	78	97	82	73	87
Nº Hospitals	6	6	6	6	6	6	6	6
Hospitals > 250 (% patients treated)	6 (100%)	6 (100%)	6 (100%)	6 (100%)	6 (100%)	6 (100%)	6 (100%)	6 (100%)
Average expected Risk-adjusted CFR	40.83	39.2	38.27	31.64	36.3	33.27	29.98	33.55
hosp. Alarm position (% patients treated)	1 (19.42%)	1 (16.25%)	1 (15.83%)	1 (20.43%)	1 (18.54%)	--- ---	1 (17.91%)	1 (16.21%)
hosp. Alert position (% patients treated)	1 (16.87%)	--- ---	--- ---	--- ---	--- ---	1 (17.35%)	--- ---	1 (21.11%)
hosp. Good performers (% patients treated)	1 (12.72%)	--- ---	1 (12.35%)	1 (19.89%)	--- ---	--- ---	--- ---	--- ---
hosp. Excellent performers (% patients treated)	1 (22.81%)	1 (22.06%)	1 (21.87%)	--- ---	1 (16.75%)	1 (17.46%)	1 (15.47%)	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 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 (***Ministério de Saúde***). Cross- and in-country sections were built upon 2009 discharges, whereas time-trends and social gradient analyses used 2002 to 2009 data.

Social gradient data and data for *concelhos* on average family annual income (both based in transfers and available) were obtained from the National Statistics office (***INE Portugal***).

APPENDIX 5:

Definitions of indicators

	Diagnosis and procedures codes ICD9-CM					
	Primary diagnosis		Secondary diagnosis2-30		Procedures	
	Inclusions	Exclusions	Inclusions	Exclusions	Inclusions	Exclusions
Ischaemic Disease +18 Age Type of admission unplanned	410.*, 411.1, 411.8, 413.* 414.01 (IF DX2-30 411.1)*					410.*, 411.1, 411.8, 413.* 414.01 (IF DX2-30 411.1)*
Acute Myocardial Infarction (AMI) +18 Age Type of admission unplanned	410.*					410.*
Percutaneus Coronary Interventions (PCI) +40 Age					36.01, 36.02, 36.05, 36.06, 36.07, 36.08, 36.09, 00.66	
Coronary Artery Bypass Grafting (CABG) +40 Age					36.10, 36.11, 36.12, 36.13, 36.14, 36.15, 36.16, 36.17, 36.19	

APPENDIX 5:

Definitions of indicators

	Diagnosis and procedures codes ICD9-CM					
	Primary diagnosis		Secondary diagnosis2-30		Procedures	
	Inclusions	Exclusions	Inclusions	Exclusions	Inclusions	Exclusions
Acute Myocardial Infarction in Hospital Mortality +18 Age	410.*	630.*-677.*		630.*-677.*		
Percutaneus Coronary Interventions in Hospital Mortality +40 Age		630.*-677.*		630.*-677.*	36.01, 36.02, 36.05, 36.06, 36.07, 36.08, 36.09, 00.66	
Coronary Artery Bypass Grafting in Hospital Mortality +40 Age		630.*-677.*		630.*-677.*	36.10, 36.11, 36.12, 36.13, 36.14, 36.15, 36.16, 36.17, 36.19	