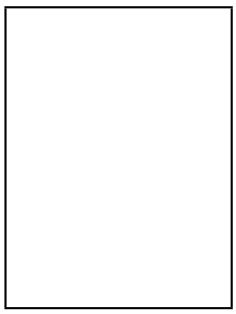
Journal Pre-proof



Portuguese National Registry of Interventional Cardiology: Official report of percutaneous coronary angiography and intervention from 2014 to 2023

Rita Calé Hélder Pereira André Luz Rui Campante Teles Marco Costa João Carlos Silva Pedro Braga Pedro Pinto Cardoso Rui Cruz Ferreira Filipe Seixo João Costa Hélder Ribeiro João Brum da Silveira Pedro Costa Ferreira Jorge Guardado Pedro Farto e Abreu Renato Fernandes Hugo Vinhas Dinis Martins Graça Caires Tiago Adrega Rui Caria Luís Bernardes José Baptista Pedro de Araújo Gonçalves Eduardo Infante Oliveira Paulino Sousa Carlos Braga Pedro Jerónimo Sousa Manuel Almeida, em nome dos investigadores do Registo Nacional de Cardiologia de Intervenção

PII: S0870-2551(25)00067-8

DOI: https://doi.org/doi:10.1016/j.repc.2024.12.003

Reference: REPC 2415

To appear in: *Revista Portuguesa de Cardiologia*

Received Date: 13 December 2024

Accepted Date: 26 December 2024

Please cite this article as: Calé R, Pereira H, Luz A, Teles RC, Costa M, Silva JC, Braga P, Cardoso PP, Ferreira RC, Seixo F, Costa J, Ribeiro H, Silveira JBd, Ferreira PC, Guardado J, Abreu PFe, Fernandes R, Vinhas H, Martins D, Caires G, Adrega T, Caria R, Bernardes L, Baptista J, de Araújo Gonçalves P, Oliveira EI, Sousa P, Braga C, Sousa PJ, Almeida M, Portuguese National Registry of Interventional Cardiology: Official report of percutaneous coronary angiography and intervention from 2014 to 2023, *Revista Portuguesa de Cardiologia* (2025), doi: https://doi.org/10.1016/j.repc.2024.12.003

This is a PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article. Please note that, during the production process, errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

© 2025 Sociedade Portuguesa de Cardiologia. Published by Elsevier España, S.L.U.

Journal Pre-proof

Portuguese National Registry of Interventional Cardiology: Official report of percutaneous coronary angiography and intervention from 2014 to 2023.

Rita Calé[a,*], Hélder Pereira[a], André Luz[b], Rui Campante Teles[c], Marco Costa[d], João Carlos Silva[e], Pedro Braga[f], Pedro Pinto Cardoso[g], Rui Cruz Ferreira[h], Filipe Seixo[i], João Costa[j], Hélder Ribeiro[k], João Brum da Silveira[b], Pedro Costa Ferreira[l], Jorge Guardado[m], Pedro Farto e Abreu[n], Renato Fernandes[o], Hugo Vinhas[p], Dinis Martins[q], Graça Caires[r], Tiago Adrega[s], Rui Caria[t], Luís Bernardes[u], José Baptista[v], Pedro de Araújo Gonçalves[w], Eduardo Infante Oliveira[x], Paulino Sousa[z], Carlos Braga[j], Pedro Jerónimo Sousa[m], Manuel Almeida[c], em nome dos investigadores do Registo Nacional de Cardiologia de Intervenção

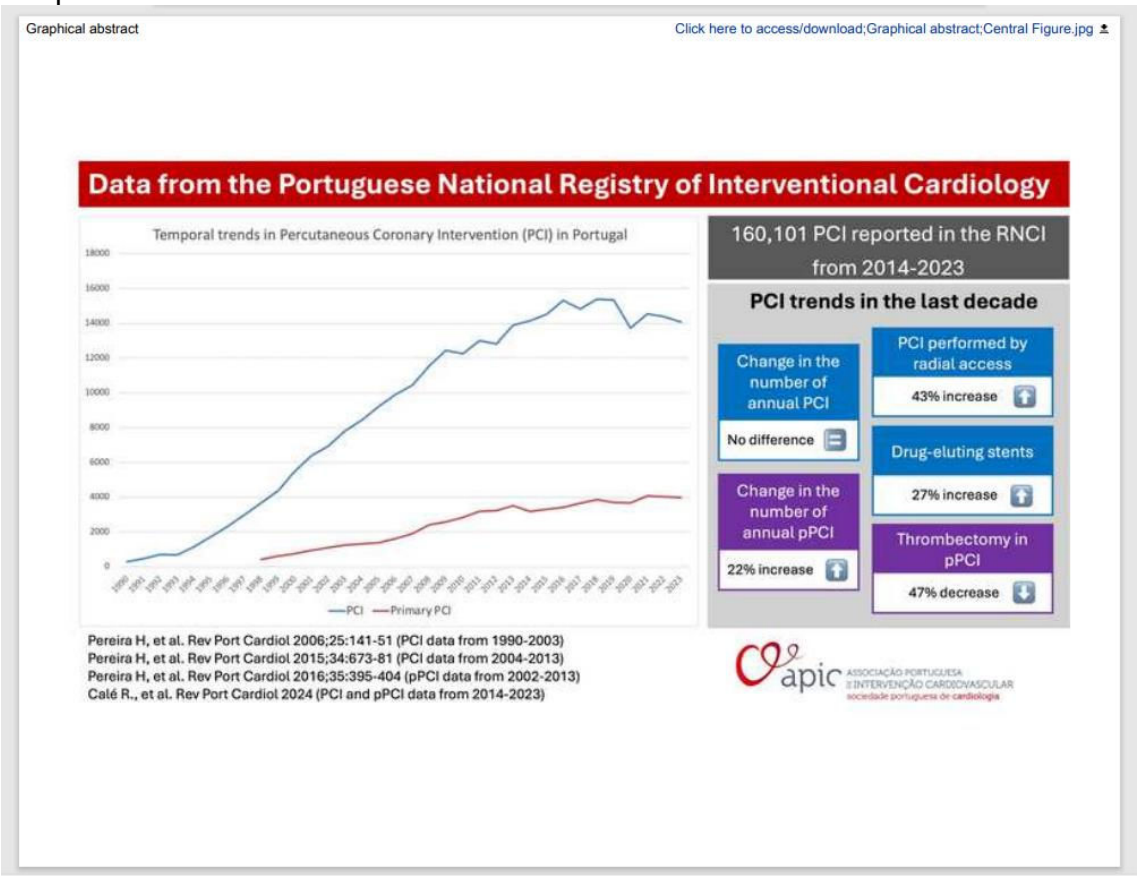
a *Hospital Garcia de Orta EPE, Almada, Portugal*
b *Centro Hospitalar do Porto - Hospital de Santo António, Porto, Portugal*
c *Centro Hospitalar de Lisboa Ocidental - Hospital de Santa Cruz, Carnaxide, Portugal*
d *Centro Hospitalar e Universitário de Coimbra - CHC, Coimbra, Portugal*
e Centro Hospitalar de São João EPE, Porto, Portugal
f *Centro Hospitalar de Vila Nova de Gaia/Espinho - Hospital Eduardo Santos Silva, Vila Nova de Gaia, Portugal*
g Centro Hospitalar de Lisboa Norte, EPE - Hospital de Santa Maria, Lisboa, Portugal
h *Centro Hospitalar Lisboa Central, EPE - Hospital de Santa Marta, Lisboa, Portugal*
i *Centro Hospitalar de Setúbal EPE - Hospital de São Bernardo, Setúbal, Portugal*
j *Hospital de Braga,* EPE, Braga, *Portugal*
k Centro Hospitalar de Trás-os Montes e Alto Douro EPE - Hospital de Vila Real, Vila Real, Portugal
l *Hospital de São Teotónio - Viseu, Portugal*
m Centro Hospitalar de Leiria, EPE – Hospital Santo André, Leiria, Portugal
n *Hospital Professor Doutor Fernando da Fonseca EPE, Amadora, Portugal*
o Hospital do Espírito Santo - Évora, Évora, Portugal
p *Hospital de Faro EPE, Faro, Portugal*
q *Hospital do Divino Espírito Santo de Ponta Delgada, EPE, São Miguel, Portugal*
r *Hospital* Central *do Funchal, Funchal, Madeira, Portugal*
s Centro Hospitalar do Baixo Vouga, EPE, Aveiro, Portugal
t *Hospital da Cruz Vermelha Portuguesa, Lisboa, Portugal*
u *Hospital CUF Tejo, Lisboa, Portugal*
v Unidade de Intervenção Cardiovascular - Alvor, Algarve, Portugal
w *Hospital da Luz, Lisboa, Portugal*
x Hospital Lusíadas, Lisboa, Portugal
z Hospital CUF Porto, Porto, Portugal

*Corresponding author
Adress: ritacale@hotmail.com; rita.theotonio@ulsas.min-saude.pt (R. Calé)

Journal Pre-proof

Registo Nacional de Cardiologia de Intervenção: Relatório Oficial de Angiografia e Intervenção Coronária Percutânea de 2014 a 2023.

Graphical Abstract



Introdução e objetivos: Apresentar o relatório de atividade do Registo Nacional da Cardiologia de Intervenção (RNCI) com os dados da angiografia e intervenção coronária percutânea em Portugal na última década (de 2014 a 2023).
Métodos: Os dados foram baseados no RNCI e os números dos últimos anos foram comparados e complementados com a informação do Atlas ESC em Cardiologia de Intervenção (CI) de 2023, com um questionário que foi aplicado aos responsáveis de cada departamento de Cardiologia de Intervenção. Foi utilizada uma análise de regressão linear para avaliar as tendências de atividade ao longo do tempo.

Journal Pre-proof

Resultados: De 2014 a 2023, foram reportadas 160.101 intervenções coronárias percutâneas (ICP) no RNCI. O número anual de ICP na última década manteve-se constante (1360/milhão de habitantes em 2014 para 1322/milhão em 2023; R^2=0,039, p=0,276). Por outro lado, verificou-se um aumento de 22% nas ICP primárias (306/milhão de habitantes em 2014 para 374/milhão de habitantes em 2023; R^2=0,759, p<0,001) e uma redução, embora não eliminação, das disparidades geográficas na penetração da ICP primária em todo o território nacional.
As seguintes tendências em ICP foram observadas: um aumento de 43% nas ICP realizadas por acesso radial (57,4% em 2014 para 82,1% em 2023; R^2=0,908, p<0,001), um aumento de 27% no uso de *stents* farmacológicos (78,4% em 2014 para 99,2% de todas as ICP com *stents* em 2023; R^2=0,638, p=0,003) e uma redução de 47% na trombectomia durante ICP primária (35,0% em 2014 para 18,6% em 2023; R^2=0,649, p=0,003). Verificou-se um ligeiro aumento na utilização de dispositivos de diagnóstico intracoronário durante a ICP, com a imagiologia intravascular e as avaliações fisiológicas a atingirem 7,6% e 4,2%, respetivamente, em 2023.
Conclusão: O Registo Nacional de Cardiologia de Intervenção mostrou que a atividade da Cardiologia de Intervenção atingiu um *plateau* em termos do número de ICP realizadas anualmente. Por outro lado, continuou a verificar-se um crescimento na ICP primária e uma redução nas assimetrias geográficas.

Palavras-chave: Registo; Cardiologia de intervenção; Angiografia coronária; Angioplastia; *Stent*; Radial

Journal Pre-proof

Abstract

Introduction and objectives: To present the report on the trends in percutaneous coronary activity data in Portugal from the last decade (from 2014 to 2023).

Methods: Data were extracted from the Portuguese National Registry of Interventional Cardiology (RNCI) and the numbers in recent years were compared and complemented by information from the 2023 European Society of Cardiology Atlas in Interventional Cardiology (IC) survey, which was administered to the director of every IC department. Linear regression analysis was used to assess trends in activity over time.

Journal Pre-proof

Results: From 2014 to 2023, there were 160 101 percutaneous coronary interventions reported in the RNCI. The number of annual PCI in the last decade remained constant (1360/million inhabitants in 2014 to 1322/million in 2023; R^2=0.039, p=0.276). In contrast, there was a 22% increase in primary PCI (306/million inhabitants in 2014 to 374/million inhabitants in 2023; R^2=0.759, p<0.001) and there was a decrease, although it did not lead to an elimination, in the geographical disparities in primary PCI across Portugal.
The following PCI trends were noted: a 43% increase in PCI performed by radial access (57.4% in 2014 to 82.1% in 2023; R^2=0.908, p<0.001), a 27% increase in drug-eluting stents (78.4% in 2014 to 99.2% of all PCI with stents in 2023; R^2=0.638, p=0.003), and a 47% decrease of thrombectomy in primary PCI (35.0% in 2014 to 18.6% in 2023; R^2=0.649, p=0.003). There was a slight increase in the use of intracoronary diagnostic devices during PCI, with intravascular imaging and physiological assessments reaching 7.6% and 4.2%, respectively, in 2023.
Conclusion: The RNCI showed that IC activity has reached a plateau in terms of the number of PCIs performed per year. In contrast, there is continued growth in primary PCI and a reduction in geographical asymmetries.

Keywords: Registry; Interventional Cardiology; Coronary Angiography; Angioplasty; stent; radial

Introduction

The Portuguese National Registry of Interventional Cardiology (RNCI) is a multicentric prospective voluntary registry that includes all consecutive percutaneous coronary intervention procedures since it was created in 2002[1] by the Portuguese Society of Cardiology (SPC).
The RNCI is headquartered at the National Center for Data Collection in Cardiology (CNCDC) and aims to continuously collect all activity within the scope of Interventional Cardiology occurring in all cardiac catheterization laboratories (cath labs) nationwide from public and private centers in mainland Portugal and the islands. It is the responsibility of Portuguese Association of Interventional Cardiology (APIC) to design, implement, develop, monitor, and support the RNCI. To unify and standardize the collection, storage, and exchange of clinical data between our RNCI and other countries within Europe, the clinical data was collected based on the *European Data Standards for Clinical Cardiology Practice* (CARDS) developed by the European Society of Cardiology (ESC).[2] The primary goal of these standards is to improve the quality and consistency of clinical data, facilitating research, clinical practice, and evidence-based decision making.
Previous studies have documented the activity trends in National Interventional Cardiology during the periods 1992–2003 and 2004–2013, indicating a progressive increase in procedural volume over these years.[3,4] A more specific analysis of primary angioplasty data from 2002-2013 showed that the rate per million inhabitants tripled during these years.[5]

Objectives

Journal Pre-proof

We aim to present the most recent results of the RNCI activity over the past ten years (2014-2023) as a continuity of the previously published data. The results of the present analysis will be discussed and compared with previous years and with data from other European registries.[6,7]

Methods

The data collection for the RNCI is a process that involves the initial systematic collection of data at each catheterization laboratory (cath lab) by healthcare professionals, who are doctors, nurses, or technicians working in their respective units. This collection includes all percutaneous coronary intervention (PCI) procedures. Periodically, these data are sent to a centralized database in an anonymized format. In t 2023, the data were extracted from 28 national cath labs, 20 public (one of them began activity and started submitting data in 2023) and eight private one (Supplementary table 1), distribuged geographically as per Supplementary figure 1.

To assess the representativeness of gathered data and ensure they reflect the reality of the entire population, the RNCI figures for the year 2022 were compared with the information from the ESC Atlas in Interventional Cardiology (IC) survey 2023 (Supplementary table 2 – data from procedures and resources for coronary intervention section), performed in the same year, with data sent by each cathlab in Portugal. This survey gathers information from 26 hospitals, of which 19 are public and seven are private.

In 2022, data began to be collected data from diagnostic procedures. The data from diagnostic procedures from 2022 in the RNCI were also compared with the information from the ESC Atlas in IC survey for the same year.

Statistical analysis

Continuous variables were presented as mean±standard deviation, and a comparison between variables was performed with an independent t-student test. Categorical variables were presented by numbers (n) and percentages (%) and a comparison between groups was performed using Qui-square test or Fisher´s exact test, when appropriate.

The percentage difference of activity or devices used between the last and the first year was calculated using the following formula: % increase=100x (final absolute number-initial absolute number /initial).

Linear regression analysis was used to assess trends over time. The results are presented as the adjusted R-squared (R^2).

All reported p values were 2-sided and a p value < 0.05 was considered statistically significant.

Statistical analysis was performed with IBM SPSS Statistics 29.0.2.0 (IBM Corp, Armonk, NY, USA).

Results

Over the past decade, all public IC centers have submitted their data to the RNCI. In 2014, there were 19 participating centers, with the addition of Centro Hospitalar Baixo Vouga in 2023, bringing the total to 20 centers. As for private centers, the number of exporting centers has been increasing over the years, with eight private centers exporting data in 2023 (Supplementary Table 1).

Coronary angiography

Journal Pre-proof

According to the ESC Atlas in IC survey, 32 519 diagnostic catheterization procedures were performed in 2022; the percentage of PCI relative to the number of diagnostic procedures was 43%. According to the RNCI, 23 427 coronary angiographies were recorded in 2022, representing 72% of the total diagnostic procedures performed that year.

Percutaneous coronary intervention

In 2014, a total of 14 142 PCI were performed across the the whole of continental Portugal and the islands, amounting to 1360 per million inhabitants. The numbers of PCI have remained constant over the past decade (R^2=0.039, p=0.276), totaling 14 070 PCI in 2023 (1322 per million inhabitants).
In 2022, PCI was performed in 14 386 cases. These figures are consistent with those reported by the ESC Atlas in IC survey (Supplementary table 2), demonstrating a high level of representativeness of the registry in relation to the total number of procedures performed annually in Portugal. By analyzing Figure 1, it is noticeable that there was a slight reduction in the total number of PCI in the year 2020 during the Covid-19 pandemic period (-10.6% compared to the year of 2019), which was followed by a recovery in the subsequent years.
In Figure 2, regional disparities in the use of PCI per million inhabitants are evident. Lisbon and the Tagus Valley has the highest numbers of PCI per million inhabitants in Portugal, with the numbers remaining stable from 2014 (2113 PCI/million inhabitants) to 2022 (2061 PCI/million inhabitants). The Southern region and islands saw the most significant growth in PCI over the past decade (from 940 to 1254 PCI/million inhabitants). The rates of PCI remained stable in Northern and Central regions at close to 1100 PCI per million inhabitants.

Primary percuntaneous coronary intervention

Figure 3 illustrates the progression of primary angioplasty (pPCI) in Portugal from 2014 to 2023, presented in both absolute numbers and pPCI per million inhabitants. We observed a slight increase in the number of pPCI per million inhabitants over the years, with an incremental rate of 22% from 306 per million inhabitants in 2014 to 374 per million inhabitants in 2023 (R^2=0.759, p<0.001). In 2022, we collected 4032 pPCI in the RNCI (385 pPCI per million inhabitants), representing 92% of the pPCI collected by the ESC Atlas in IC survey.
In 2014, the region with the lowest rate of primary PCI was the Central region at 178 pPCI per million inhabitants (Figure 4A). By 2022, this region had seen significant improvement, nearing the values of the Northern region at 296 pPCI per million inhabitants (Figure 4B). The region with the highest pPCI values over the last decade is Lisbon and Tagus Valley (525 per million inhabitants in 2022). In the Southern region, an increase in pPCI numbers was also observed from 2014 to 2022 (272 to 392 per million inhabitant).
In the last decade, there has been a slight overall increase in the absolute number of PCI conducted in the context of acute coronary syndromes, primarily due to a rise in procedures related to ST-elevation myocardial infarction (R^2=0.837, p<0.001). In contrast, the number of PCIs performed for non-ST acute coronary syndromes has remained stable (R^2=0.250, p=0.100). Notably, a significant change was observed during the COVID-19 pandemic and subsequent years,

Journal Pre-proof

marked by a reduction in the number of PCIs performed for chronic coronary syndromes (R^2=0.581, p=0.006) (figure 5).

Complex Percutaneous coronary intervention

Over the past decade, there has been an increase in multivessel disease in patients treated with PCI (Figure 6), accounting for 30.3% of intervention cases in 2014 compared to 55.8% in 2023 (R^2=0.875, p<0.001). Although, the number of procedures involving multivessel PCI has increased over the years (R^2=0.651, p=0.003), the percentage of its utilization in the same procedure remains low, averaging 9.5% overall years. The number of PCI for additional vessels that were deferred to a second procedure is unknown.
Over the years, the average use of angioplasty in complex anatomies registered in the RNCI were: 7.7% in bifurcations, 2.8% in left main, 1.0% in chronic total occlusions, 3.7% in stent restenosis.
In 2022, according to data from the RNCI, PCI was used in complex anatomies as follows: 5.6% in bifurcations (n=595/10554), 3.6% in left main (n=480/13252), 1.7% in chronic total occlusions (n=230/13252) and 3.5% in stent restenosis (n=462/13252). In the ESC Atlas IC survey, PCI was used for complex anatomies in 5.7% (594/10331) for chronic total occlusions, 5.1% (629/12307) for unprotected left main, 7.4% (713/9611) for in-stent restenosis.

Stents

Stents were used on average in 91.8% of cases, with a significant increase in the use of drug-eluting stents (DES) in the last decade (78.4% in 2014 to 99.2% of all PCI with stents in 2023; R^2=0.638, p=0.003), approaching almost 100% in recent years. In 2014, bioresorbable vascular scaffold (BVS) were used in 1% of angioplasties with a peak use in 2015 with 1.3% of cases, followed by a decrease in the following years. From 2018 to 2022, there are no records of use of BVS.
In 2022, stents were used in 88.5% of coronary angioplasties and according to data from the ESC Atlas IC survey PCI performed with the use of any drug-eluting balloon was 6.3%. No BVS was reported in this survey.

Other coronary intervention devices

Manual thrombectomy in primary angioplasty has declined significantly over the past decade from 35.0% in 2014 to 18.6% in 2023, (R^2=0.649, p=0.003; figure 7).
The rate of rotational atherectomy has remained <2% over the years. Although its application remains limited to a small proportion of PCI procedures performed annually, there has been a consistent upward trend in its use over the past decade, increasing from 1.0% in 2014 to 1.9% in both 2021 and 2022 (R^2=0.452, p=0.021; figure 7). In 2022, the percentage of atherectomy use in the RNCI was 1.9%, similar to the results reported in the ESC Atlas in IC survey (2.1%).
Left ventricular mechanical support devices were used in less than 1% of PCI (Figure 7); 0.9% were reported in 2022 according to the RNCI and 1.0% according to the survey. Their usage has remained stable over the years (R^2=0.074, p=0.234).

Intracoronary diagnostic devices

Journal Pre-proof

The use of a pressure wire during PCI has seen a modest increase over the past decade (R^2=0.430, p=0.024), reaching a plateau in recent years at around 4.2%. In contrast, there has been a more marked growth in the use of intravascular ultrasound imaging both as a diagnostic tool and as a guide for angioplasty, with usage rates varying from 1.9% in 2014 to 7.6% in 2023 (R^2=0.907, p<0.001; Figure 8).
In the ESC Atlas in IC survey, in 2022, the PCI use rates with adjunctive intracoronary imaging techniques and physiology measurements were 7.8% and 5.7%, respectively. Additionally, the use of adjunctive intracoronary physiology measurements in procedures (coronary angiography and PCI) was 4.8%.

Antithrombotic treatment during PCI

Regarding the drugs used during PCI, glycoprotein IIb/IIIa inhibitors have been used less frequently (R^2=0.446, p=0.021); the highest usage rate was recorded in 2014 (5,8%) and the lowest in 2018 (2,4%) – see Figure 7.
Regarding the anticoagulant used during PCI, unfractionated heparin is the most used. The use of low molecular weight heparins are minimal, averaging approximately 3.0%, and has declined in recent years from 4.1% in 2014 to 0.2% in 2023, (R^2=0.867, p<0.001; figure 7). There are no records of bivalirudin being use in the period of the study.

Vascular access for percutaneous intervention

Radial access has become the preferred access for PCI over the past decade, with rates progressively increasing to a peak of 82.1% in 2023 (R^2=0.908, p<0.001; Figure 9). The use of femoral access has evolved in the opposite direction, progressively decreasing over the past few years. The use of cubital access is minimal, with an average utilization rate of 0.3% over the past decade. In the year 2022, the number of coronary angiographies performed via radial access was 90.8%. In the ESC Atlas in IC survey, PCI performed via trans-radial access was 86.1%.

Discussion

The RNCI remains a valuable tool for a comprehensive national perspective on the development of IC practices, regional trends, and benchmarking each catheterization laboratory in Portugal against national and international standards. These data are crucial for healthcare professionals and policymakers in their process of decision making, thereby driving initiatives aimed at reducing disparities in cardiovascular disease burden.
The registry, which began in 2002, has been continuously improved over the last 20 years thanks to the efforts of successive APIC boards, and since 2013, all existing public centers have been incorporated into the registry.[4] Currently, it includes consecutive data on PCI procedures from 28 centers (both public and private).
When comparing the total number of PCI and primary PCI in 2022, from two different sources, the RNCI and data from the ESC Atlas in IC survey sent to all

Journal Pre-proof

coordinators of national public and private cath labs, the numbers are very similar (102% and 92%, respectively). The representiveness of the presented figures is reinforced by the fact that data from consecutive coronary interventional procedures were received from all public centers nationwide and most private centers; most data were sent automatically and digitally.
Regarding coronary angiographies, the data are not as representative as for PCI. Currently, the RNCI have approximately three-quarters of all diagnostic procedures from 2022, when compared to the 2022 ESC Atlas IC survey. Routine transfer for diagnostic procedure data started later and is currently in a phase of progressive implementation.
It is important to have data on coronary diagnostic procedures for several reasons. It is the only way to assess whether patients with acute myocardial infarction proposed for invasive strategy are being treated with angioplasty versus medical or surgical therapy. Additionally, it enables us to evaluate the percentage use of invasive diagnostic methods such as physiological assessments for diagnosing functionally significant coronary artery disease (CAD).

Regarding PCI, the observed growth at the beginning of the 21st century reached a plateau in the last decade. From 2004 to 2008, growth was at 37%, compared to 20% between 2009-2013, and a decrease of 0.5% from 2014-2023.[4] There was a slight reduction in the number of PCI in 2020 due to the lockdown period of the COVID-19 pandemic (-10,6% compared to the year of 2019), explained by the temporary suspension of some elective activities and redeployment of cardiovascular resources to the care of Covid-19 patients. The reduction in PCI is similar to preliminary results from the ESC Atlas project, which reported a median change in PCI of between 2019 and 2020 of -9.0% across 31 ESC members.[6]
In the subsequent years, the total number of PCI were similar to numbers from 2014.
Similarly to the COURAGE[8] study published in 2007, the ISCHEMIA trial[9], published in 2020, did also not affect the total number of PCIs performed nationwide. However, it may have contributed to the observed reduction in PCIs for chronic coronary syndromes beginning that year and which persisting over the following years. If this reduction were solely attributable to the Covid-19 pandemic, a recovery in the volume of procedures for this specific context would have been expected in the subsequent years; however, this recovery was not observed.

The 1322 PCI per million inhabitants performed in 2023 were similar to 1333 PCI per million inhabitants performed ten years earlier, in 2013. Both figures are markedly lower than the median of 2186 PCI procedures per million inhabitants reported for ESC member countries (IQR 1383-2494) reported in the 2023 ESC Atlas Project,[10] as well as Spain, with 1573 PCI per million inhabitants in 2022.[7]

Data on primary PCI indicate a more attenuated growth in the last decade, a 22% increase from 2014 to 2023, compared to a 62% increase from 2004 to 2013, but still, in 2023, the rate stood at only 374 pPCI per million inhabitants, significantly below the median of 498.5 (IQR 420.2–636.3) pPCI procedures per million inhabitants in ESC member countries as reported by 2023 ESC Atlas survey;[10]

Journal Pre-proof

and the target of 600 pPCI per million inhabitants per year recommended by the European Association of Percutaneous Cardiovascular Interventions.[11] The figures are close the median of 311.8 (IQR 37.0–650.1) pPCI procedures per million inhabitants observed in middle-income countries, yet remain considerably below the rates in high-income countries (533.7; IQR 429.8–661.0).[6] Despite the robust growth over the last 20 years, aligning with trends in Southern European countries, which often report values significantly lower than 600 pPCI per million inhabitants, the rates of pPCI in Portugal remain lower than those reported in Spain, which had 452 per million inhabitants in 2022.[7]

Despite all the efforts in the last decade, such as community campaign actions and improvement of interinstitutional cooperation, the numbers are still below the European average and those of our neighbor, Spain. This strongly indicates that there are still areas for improvement in the coming years.

Several factors contribute to Portugal's lower rates of pPCI compared to Northern European countries and Spain, including differences in disease prevalence, the availability of healthcare resources, and levels of healthcare literacy among the population. Regional disparities and demographic factors within Portugal, such as urban-rural divides and population density, impact the equitable distribution and accessibility of healthcare services, including primary angioplasty. This report demonstrates these disparities, with the Central region showing lower pPCI rates per million inhabitants. However, these regional asymmetries have diminished over the past decade. The Lisbon and Tagus Valley region, with the highest pPCI rates, reported 473 per million inhabitants in 2014 and 525 per million inhabitants in 2022. The Central region, which had the lowest rate of 178 per million inhabitants in 2014, improved to 296 per million inhabitants in 2022, approaching the Northern region's values. The pPCI numbers in the Central region may improve further in the coming years with the recent opening of a new cath lab in the interior central region (Guarda district) at the beginning of 2024. The Southern region and islands also showed growth from 272 per million inhabitants in 2014 to 392 per million inhabitants in 2022. The improved rates in the Central region may be attributed to the opening of new catheterization laboratories, particularly at the Leiria Hospital Center. In the South, population growth due to the influx of non-resident foreigners and tourism may have contributed to the increase in pPCI rates.

Regarding the complex procedures, despite operators having more experience in treating complex disease, the number of procedures involving bifurcations (7.7%), the left main coronary artery (2.8%), chronic occlusions (1.0%), and restenosis (3.7%) has remained low over the years. These low numbers may be underestimated compared to the actual figures due to the potential influence of missing data in the database entries at each local cath lab. This statement is supported by the slightly higher numbers of complex PCI reported in the ESC Atlas in IC survey, although these are still below 10%. While operators are increasingly skilled in managing complex coronary disease, the low percentage of PCIs in complex anatomies, could reflects both strategic decisions in patient care due to anticipated technical challenges and recent scientific data reporting privileging a more conservative approach for stable coronary disease as there are a higher risk associated with procedures in these anatomical settings and a higher risk of target lesion failure on the long-term. This may influence the decision-making process, leading to conservative management approaches or

Journal Pre-proof

alternative treatment strategies, such as cardiac bypass surgery. On the other hand, the reported low percentages may also be influenced by missing or incomplete data in the RNCI or in the survey, which could underestimate the actual prevalence of these procedures. The level of detail collected in the RNCI may be insufficient to capture specific aspects of procedural complexity, such as PCI in the setting of complex calcified coronary disease or the use of advanced techniques, such as lithotripsy.

Stents remain the predominant therapeutic modality for managing obstructive CAD, with DES being increasingly favored in recent years, eliminating conventional bare-metal stents. BVS were utilized in a minority of cases from 2014 to 2017; however, following the publication of the three-year follow-up of ABSORB III trial,[12] which highlighted a heightened risk of stent thrombosis with BVS compared to conventional DES, their use was discontinued in 2018.

Registry data do not include information on the utilization of drug-coated balloons. Survey data suggest their occasional use as a substitution for stents, albeit in a limited proportion of cases. Nevertheless, extracting these specifics from the RNCI is challenging.

Regarding other adjunctive coronary intervention devices, the last decade has seen a significant decrease in the use of manual thrombectomy in primary angioplasty, as a result of the findings from the TASTE[13,14] and TOTAL[15] trials, which found no significant differences in 30-day mortality and major adverse cardiovascular events in the routine use of thrombus aspiration before PCI as compared with PCI alone. Additionally, the TOTAL trial even indicated an increased risk of stroke in patients undergoing the technique.[15] These results led to a revision of clinical guidelines. Currently, routine use of thrombus aspiration is not recommended and the technique should be reserved for specific cases, such as in situations with large amounts of visible thrombus.[16]

The use of image-guided angioplasty has slightly increased over the past decade, though it remains lower than in Spain, where imaging techniques (IVUS and OCT) were used in 14.7% of PCIs in 2022.[17] The use of physiology has also gradually increased over the years; however, in the past year, it showed no growth, in contrast to Spain, where the use of physiology rose by 6.3% in 2022 compared to 2021.[17] Despite the increasing body of evidence supporting the use of imaging and physiological assessments to guide PCI, several barriers continue to hinder the widespread adoption of these technologies in national cath labs. A significant barrier is the perception of time constraints; integrating intravascular imaging or physiological assessments may prolong the duration of interventions, thereby potentially reducing the number of procedures that can be performed within a given timeframe. Additionally, the lack of adequate training or expertise and the associated costs of these technologies further hinders their adoption. To enhance the utilization of these cost-benefit devices, there is a need to integrate them into cath lab workflows and to provide education to healthcare professionals of all categories.

Regarding vascular access for PCI, the radial approach has gained prominence over the past decade, becoming the preferred access route for most procedures.

Journal Pre-proof

This shift coincided with a decline in the use of femoral access. In the last decade, randomized studies that compared radial access with femoral access, such as the RIVAL[18], RIFLE-STEACS[19] and MATRIX[20] trials, have reinforced the importance of prioritizing radial access as the default approach, as it is considered safer with a lower risk of vascular and hemorrhagic complications and hard end points during follow-up.

Conclusion

The RNCI achieved robustness in the data on intervention procedures, but there is still room for improvement regarding the data on diagnostic procedures and complex angioplasty, including the use of adjuntive devices to diagnose and treat coronary disese.

In the last 10 years, IC has reached a plateau in terms of the number of PCIs performed per year. In contrast, there has been a steady increase in primary PCI and a reduction in geographical asymmetries, although it remains below the median of European countries. In several instances, it has been observed that national IC has followed clinical evidence, with increased utilization of radial access and DES, and a reduced use of manual thrombectomy in primary angioplasty. In other fields, such as intravascular imaging and physiology, there is potential for improvement in the following years.

Journal Pre-proof

Ethical disclosures

Protection of human and animal subjects.
The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data.

The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent.

The authors declare that no patient data appear in this article.

Conflicts of interest

The authors have no conflicts of interest to declare.

Acknowledgments

We would like to thank Maria Fátima Loureiro, who was the biostatistician at the National Center for Data Collection in Cardiology (CNCDC) at the time of the study, for her collaboration in processing the data from the Portuguese National Registry of Interventional Cardiology.

Journal Pre-proof

Additionally, we extend our gratitude to all healthcare professionals who diligently record data in the registry at their respective centers.

Ethics in publishing
1. Does your research involve experimentation on animals?:
No
2. Does your study include human subjects?:
Yes
If yes; please provide name of the ethical committee approving these experiments and the registration number. :
The data for this article is derived from the National Registry of Interventional Cardiology (RNCI), which is centralized at the National Center for Data Collection in Cardiology (CNCDC) and operates under the aegis of the Portuguese Association of Cardiovascular Intervention (APIC-SPC). All centers contribute data that is fully anonymized, ensuring patient confidentiality. As a result, ethics committee approval was not required.
If yes; please confirm authors compliance with all relevant ethical regulations. :
Yes
If yes; please confirm that written consent has been obtained from all patients. :
Yes
3. Does your study include a clinical trial?:
No
4. Are all data shown in the figures and tables also shown in the text of the Results section and discussed in the Conclusions?:
Yes

References

1. Pereira H. The 2002 Portuguese Interventional Cardiology Registry. Rev Port Cardiol 2004;23:7-14.

2. Flynn MR, Barrett C, Cosio FG, et al. The Cardiology Audit and Registration Data Standards (CARDS), European data standards for clinical cardiology practice. Eur Heart J 2005;26:308-13.

3. Pereira H, Patricio L, Magalhaes D, Portuguese Working Group of Interventional Cardiology PSoC. The Portuguese Interventional Cardiology Registry from 1992 to 2003. Rev Port Cardiol 2006;25:141-51.

4. Pereira H, Teles RC, Costa M, et al. Trends in percutaneous coronary intervention from 2004 to 2013 according to the Portuguese National Registry of Interventional Cardiology. Rev Port Cardiol 2015;34:673-81.

Journal Pre-proof

5. Pereira H, Campante Teles R, Costa M, et al. Trends in primary angioplasty in Portugal from 2002 to 2013 according to the Portuguese National Registry of Interventional Cardiology. Rev Port Cardiol 2016;35:395-404.

6. Timmis A, Vardas P, Townsend N, et al. European Society of Cardiology: cardiovascular disease statistics 2021. Eur Heart J 2022;43:716-99.

7. Jurado-Roman A, Freixa X, Cid B, et al. Spanish cardiac catheterization and coronary intervention registry. 32nd official report of the Interventional Cardiology Association of the Spanish Society of Cardiology (1990-2022). Rev Esp Cardiol (Engl Ed) 2023;76:1021-31.

8. Boden WE, O'Rourke RA, Teo KK, et al. Optimal medical therapy with or without PCI for stable coronary disease. N Engl J Med 2007;356:1503-16.

9. Maron DJ, Hochman JS, Reynolds HR, et al. Initial Invasive or Conservative Strategy for Stable Coronary Disease. N Engl J Med 2020;382:1395-407.

10. Timmis A, Aboyans V, Vardas P, et al. European Society of Cardiology: the 2023 Atlas of Cardiovascular Disease Statistics. Eur Heart J 2024;45:4019-62.

11. Widimsky P, Wijns W, Fajadet J, et al. Reperfusion therapy for ST elevation acute myocardial infarction in Europe: description of the current situation in 30 countries. Eur Heart J 2010;31:943-57.

12. Kereiakes DJ, Ellis SG, Metzger C, et al. 3-Year Clinical Outcomes With Everolimus-Eluting Bioresorbable Coronary Scaffolds: The ABSORB III Trial. J Am Coll Cardiol 2017;70:2852-62.

13. Frobert O, Lagerqvist B, Olivecrona GK, et al. Thrombus aspiration during ST-segment elevation myocardial infarction. N Engl J Med 2013;369:1587-97.

14. Lagerqvist B, Frobert O, Olivecrona GK, et al. Outcomes 1 year after thrombus aspiration for myocardial infarction. N Engl J Med 2014;371:1111-20.

15. Jolly SS, Cairns JA, Yusuf S, et al. Randomized trial of primary PCI with or without routine manual thrombectomy. N Engl J Med 2015;372:1389-98.

16. Neumann FJ, Sousa-Uva M, Ahlsson A, et al. 2018 ESC/EACTS Guidelines on myocardial revascularization. Eur Heart J 2019;40:87-165.

17. Freixa X, Jurado-Roman A, Cid B, Cruz-Gonzalez I, Aci SEC. Spanish cardiac catheterization and coronary intervention registry. 31st official report of the Interventional Cardiology Association of the Spanish Society of Cardiology (1990-2021). Rev Esp Cardiol (Engl Ed) 2022;75:1040-9.

18. Jolly SS, Yusuf S, Cairns J, et al. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes

Journal Pre-proof

(RIVAL): a randomised, parallel group, multicentre trial. Lancet 2011;377:1409-20.

19. Romagnoli E, Biondi-Zoccai G, Sciahbasi A, et al. Radial versus femoral randomized investigation in ST-segment elevation acute coronary syndrome: the RIFLE-STEACS (Radial Versus Femoral Randomized Investigation in ST-Elevation Acute Coronary Syndrome) study. J Am Coll Cardiol 2012;60:2481-9.

20. Valgimigli M, Frigoli E, Leonardi S, et al. Radial versus femoral access and bivalirudin versus unfractionated heparin in invasively managed patients with acute coronary syndrome (MATRIX): final 1-year results of a multicentre, randomised controlled trial. Lancet 2018;392:835-48.

Figure legends

Figure 1: Absolute number of PCI and PCI per million inhabitants between 2014-2023.

Figure 2: Geographic distribution of PCI per million inhabitants by region in Portugal in the years 2014 (A) and 2022 (B).

Figure 3: Absolute number of primary PCI and pPCI per million inhabitants between 2014-2023.

Figure 4: Geographic distribution of pPCI per million inhabitants by region in Portugal in the years 2014 (A) and 2022 (B).

Figure 5: Distribution of PCI Indications from 2014 to 2023 (indication documented in 85.8% of cases).
STEMI – ST-elevation myocardial infarction; NSTEMI – non-ST elevation myocardial infarction; UA – unstable angina; CCS – chronic coronary syndrome

Figure 6: Presence of multivessel disease in PCI and of multivessel PCI in the same procedure between the years 2014-2023.

Figure 7: Evolution of devices and drugs between the years 2014-2023; MCS – mechanical circulatory support; LMWH – low molecular weight heparin during PCI.

Figure 8: Adjuvant diagnostic devices used during PCI between the years, 2014-2023.

Figure 9: Vascular access for percutaneous coronary intervention between 2014-2023

Journal Pre-proof

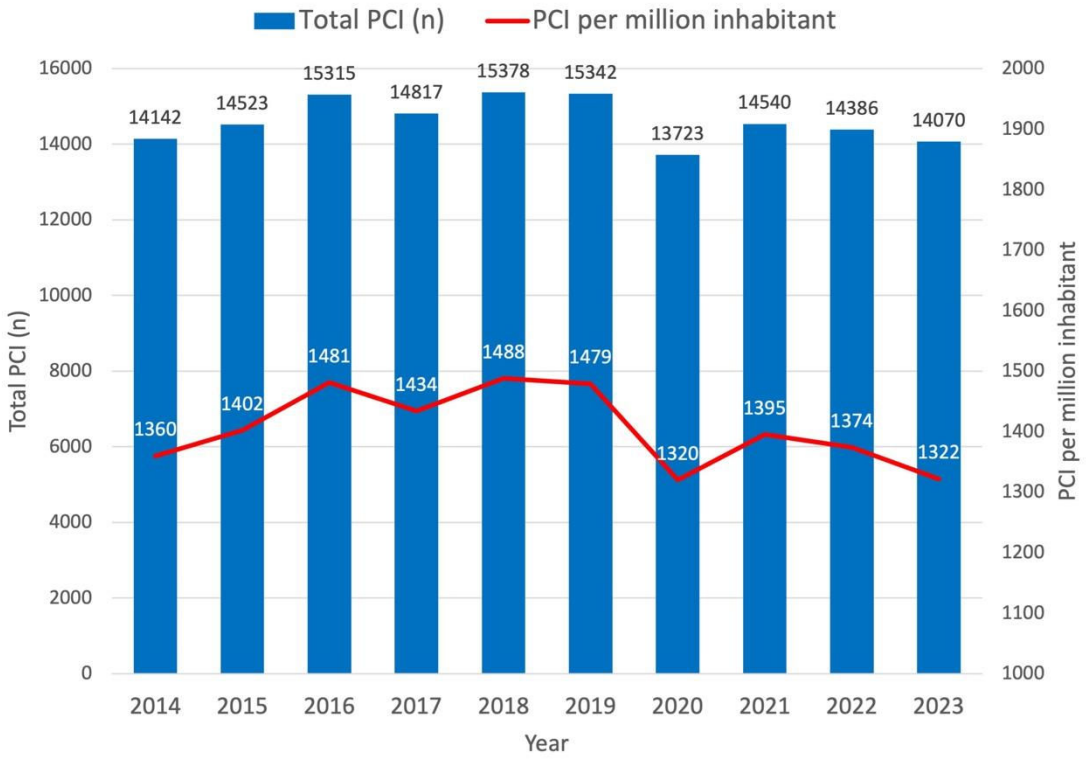


Figure 1. Absolute number of percutaneous coronary intervention (PCI) and PCI per million inhabitants between 2014-2023.

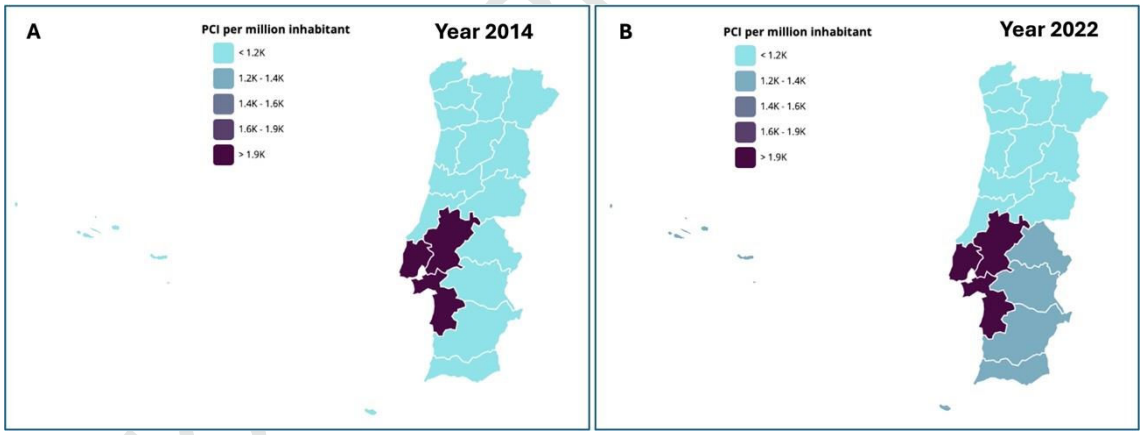


Figure 2. Geographic distribution of percuntaneous coronary intervention per million inhabitants by region in Portugal in the years 2014 (A) and 2022 (B).

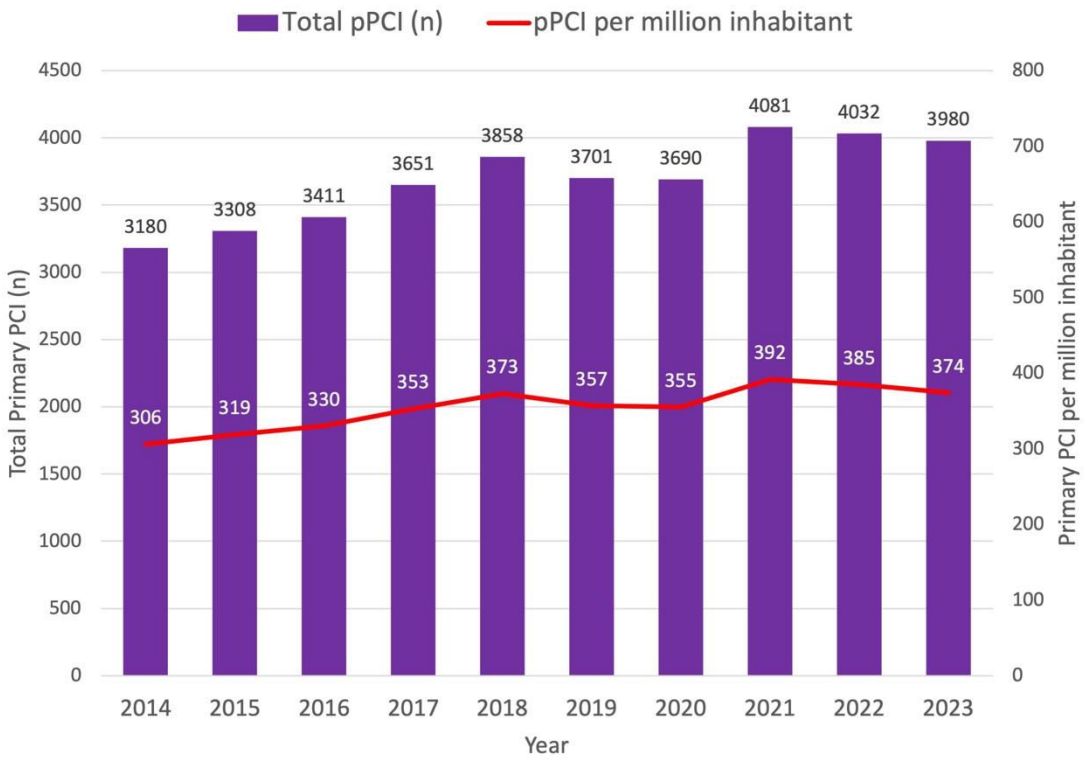


Figure 3. Absolute number of primary percutaneous coronary intervention (pPCI) and pPCI per million inhabitants between 2014-2023.

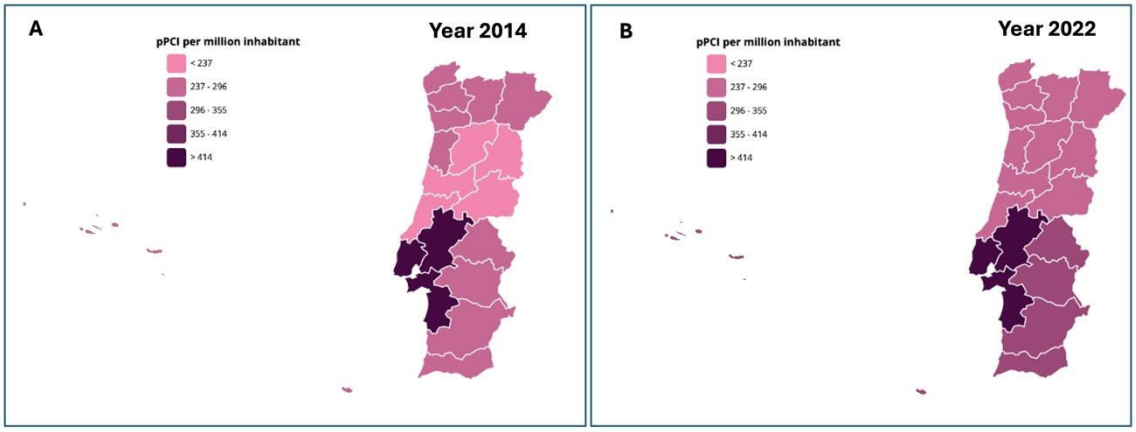


Figure 4. Geographic distribution of pPCI per million inhabitants by region in Portugal in the years 2014 (A) and 2022 (B).

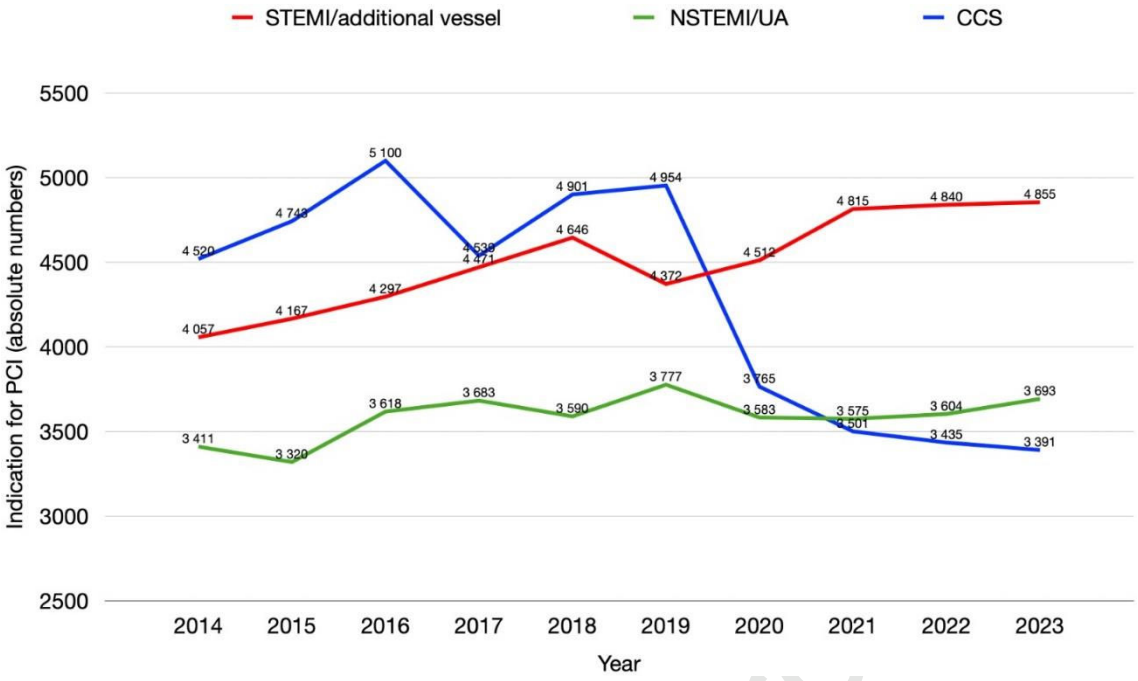


Figure 5. Distribution of PCI Indications from 2014 to 2023 (indication documented in 85.8% of cases).
STEMI – ST-elevation myocardial infarction; NSTEMI – non-ST elevation myocardial infarction; UA – unstable angina; CCS – chronic coronary syndrome

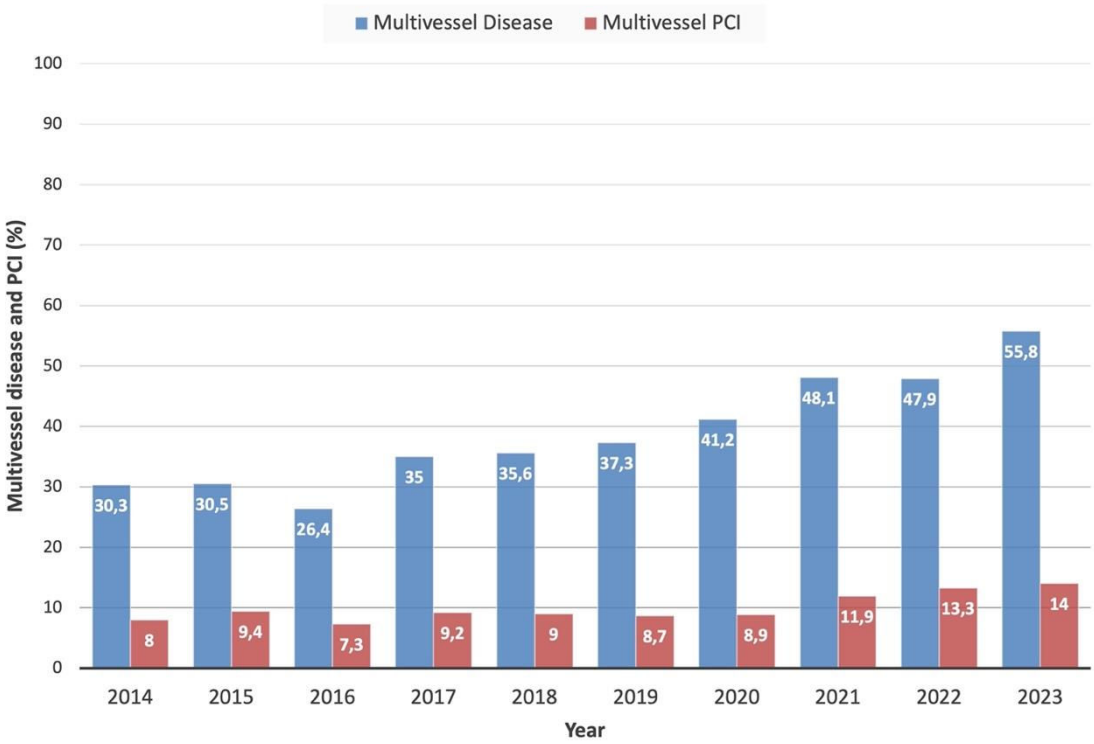


Figure 6. Presence of multivessel disease in percutaneous coronary intervention (PCI) and performance of multivessel PCI in the same procedure between the years 2014-2023

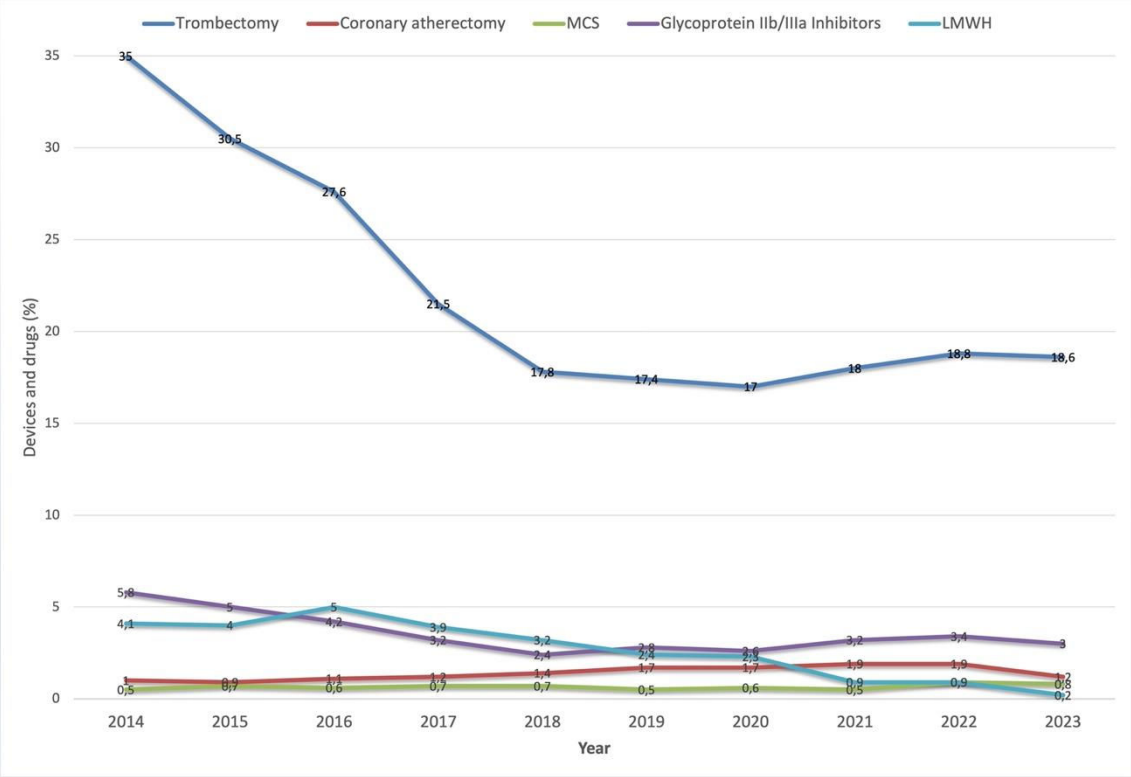


Figure 7: Evolution of devices and drugs between the years 2014-2023;

MCS: mechanical circulatory support; LMWH: low molecular weight heparin during percutaneous coronary intervention.

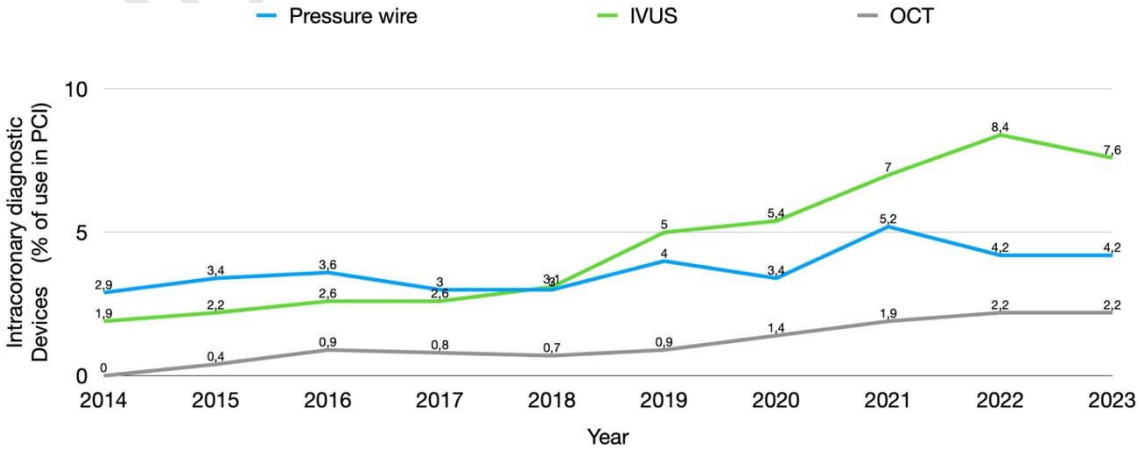


Figure 8. Adjuvant diagnostic devices used during percutaneous coronary intervention between the years 2014-2023.

Figure 9. Vascular access for PCI between the years 2014-2023.

Journal Pre

Journal Pre-proof

Supplement

Supplementary Table 1. Hospitals Participating in the Registry		
Region	Public hospitals	Private hospitals
North	Hospital de Braga Hospital de São João Centro Hospitalar de Santo António Centro Hospitalar Vila Nova de Gaia Centro Hospitalar de Trás os Montes e Alto Douro Centro Hospitalar de Tâmega e Sousa Centro Hospitalar Baixo Vouga*	Hospital Luz Arrábida Hospital CUF Porto
Central	Centro Hospitalar Tondela Viseu Centro Hospitalar Universitário de Coimbra Hospital de Santo André	Hospital Luz Coimbra
Lisbon and Tagus Valley	Centro Hospitalar de Lisboa Norte Centro Hospitalar de Lisboa Central Centro Hospitalar de Lisboa Ocidental Hospital Fernando Fonseca Hospital Garcia de Orta Hospital de São Bernardo	Hospital da Cruz Vermelha Portuguesa Hospital da CUF Tejo Hospital da Luz Hospital dos Lusíadas
South and Islands	Hospital Espírito Santo de Évora Centro Hospitalar do Algarve Hospital Divino Espírito Santo Hospital Dr. Nélio Mendonça	Unidade de Intervenção Cardiovascular do Algarve
Total (N)	20	8

*Data from 2023

Supplementary Table 2. European Society of Cardiology Atlas in Interventional Cardiology Survey 2023*

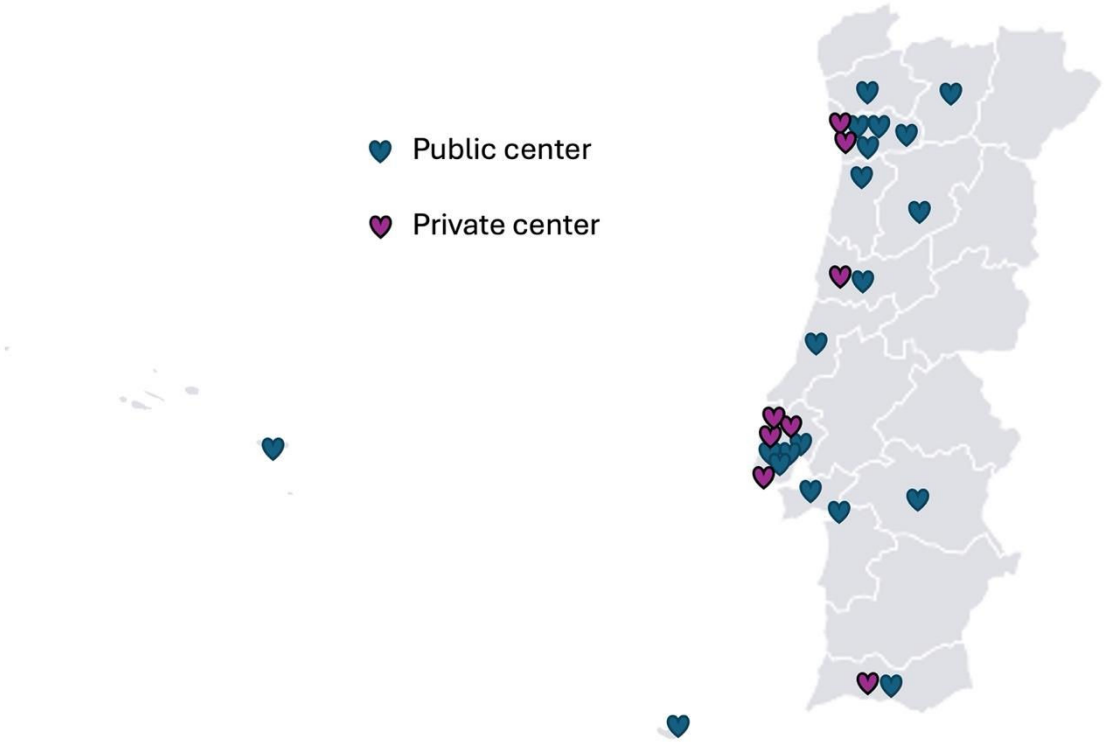
Journal Pre-proof

Section 2	Invasive coronary angiography and diagnostic cardiac catheterization	Value in Absolute number (% of PCI)
2.1	Invasive coronary angiography and diagnostic cardiac catheterization	32519
2.2	PCI	14093
2.3	PCIs performed via trans-radial access	12140/14093 (86.1%)
2.6	Primary PCI	4361/14093 (30.9%)
2.7	PCI in chronic total occlusions	594/10331 (5.7%)
2.8	PCI in left main (unprotected)	629/12307 (5.1%)
2.9	PCI for in-stent restenosis	713/9611 (7.4%)
2.11	PCI with drug-eluting balloons	790/12543 (6.3%)
2.12	PCI with coronary stents	11951/13502 (88.5%)
2.13	PCI with drug-eluting coronary stents	11939/13502 (99.9% of stents)
2.16	PCI with bio-resorbable vascular scaffolds	0
2.18	Procedures (coronary angiography and PCI) using adjunctive intracoronary imaging techniques	1290/31495 (4.1% of procedures)
2.19	PCI performed with adjunctive intracoronary imaging techniques	1056/13502 (7.8%)
2.20	Procedures (coronary angiography and PCI) using adjunctive intracoronary physiology measurements	1507/31495 (4.8% of procedures)
2.21	PCI performed with adjunctive intracoronary physiology measurements	768/13502 (5.7%)
2.22	PCI with rotational or orbital atherectomy	286/13502 (2.1%)
2.23	PCI with intravascular lithotripsy	290/13748 (2.1%)
2.24	Use of percutaneous hemodynamic support devices	144/13748 (1.0%)

*Data from procedures and resources for coronary interventions section; Year of the value: 2022; Search of the values were the head of each IC Department (26 hospitals – 19 public and seven private)

PCI: Percutaneous coronary intervention.

Journal Pre-proof



Supplementary Figure 1. Geographic distribution of centers with public or private cath labs that exported data to the RNCI from 2014 to 2023.

Journal Pre-proof