INSTITUTO POLITÉCNICO DE SANTARÉM
Escola Superior de Gestão e Tecnologia de Santarém

Diagnosis of Stable Coronary Disease by Computed Tomography Angiography as a first-line test: Cost Analysis in an Integrated Responsibility Center

Project work

Master's Degree in Health Unit Management

Cláudia Sofia Mendes Magro Russo

Supervisor: Professor Lino Patrício
Professor Sandra Oliveira

May, 2025

Acknowledgements

I would like to express my sincere thanks to everyone who contributed to the completion of this project to obtain a master's degree.

I would like to thank the coordinator of the Alentejo Cardiovascular Integrated Responsibility Center, Professor Lino Patrício, for his valuable insights and help with decision-making, for his support at all times and for the way in which he sponsored this project from an early stage.

I would like to thank Professor Sandra Oliveira for her guidance and encouragement throughout this process. Her dedication, understanding and collaboration were fundamental to the development of this work.

To the cardiologists Dr. David Neves and Dr. Diogo Brás for their important contributions.

I would also like to thank my family and friends for their unconditional support throughout this period.

Dedication

I dedicate this project to all those who have supported and encouraged me throughout this academic journey.

I dedicate it to my children Gonçalo and Carolina, my source of inspiration. I hope I can always pass on to them the power of knowledge, the importance of persistence, resilience and perseverance. May they learn that it's never too late to fight for your dreams/goals.

I dedicate this to my husband Rui, for his support and for understanding my absence. For his encouragement and infinite patience during all the nights I dedicated to my studies.

To my dear parents, for their love and unconditional support, they will always be the pillars of my success. Without them, nothing would be possible. I dedicate this to them for the sacrifices they make for me, for us, for their emotional support and for the trust they place in every decision I make.

To my dear grandparents who have left this plane and have not seen this journey. They will always be my safe haven in everything. I know that wherever they are, they will be proud.

To my great friends and colleagues who have always been there for me in times of doubt.

Finally, to all those who believe in the importance of knowledge and the positive impact it can have on society.

Thank you.

“Health has no price, but it does have costs.”

Ana Cristina Reis & Ana Macedo

Acronyms/Acronyms

ACS - Acute Coronary Syndrome

AMI - Acute Myocardial Infarction

AO - Operational Assistants

CA - Board of Directors

CAD - Coronary Artery Disease

CHD - Coronary Heart Disease

CMR - Cardiac Magnetic Resonance Imaging

CTA - Cardiac computed Tomography Angiography

CRI - Integrated Responsibility Centre

CRIA - Alentejo Integrated Cardiovascular Responsibility Centre

ECG - Electrocardiogram

ECHO - Echocardiogram

HR - Human Resources

ESC - European Society of Cardiology

MCDT - Complementary Means of Diagnosis and Therapy

MGF - General and Family Medicine

MRI - Magnetic Resonance Imaging

Stress Echo - Pharmacological Stress Echocardiography

TMRG - Maximum Guaranteed Response Time

TSDT - Senior Diagnostic and Therapeutic Technician

ULSAC - Alentejo Central Local Health Unit

WHO - World Health Organisation

Resumo

A melhoria da eficiência no setor da saúde é essencial para reduzir falhas nos serviços e assegurar cuidados de qualidade aos utentes do Serviço Nacional de Saúde (SNS), otimizando os recursos limitados. Em Portugal, a incidência de enfarte agudo do miocárdio (EAM) tem aumentado devido à prevalência de fatores de risco cardiovascular, muitos dos quais poderiam ser prevenidos com uma gestão adequada, adoção de hábitos saudáveis e um diagnóstico precoce por imagem. A angiografia por tomografia computorizada cardíaca (Angio TC) tem-se revelado uma ferramenta eficaz no diagnóstico da doença coronária (DC), permitindo calcular o score de cálcio das artérias coronárias e identificar outras patologias importantes. Este exame não invasivo pode substituir métodos convencionais, avaliando o fluxo arterial em tempo real. Este projeto avalia a viabilidade económica de implementar a Angio TC como exame de primeira linha para diagnóstico de DC estável na Unidade Local de Saúde do Alentejo Central (ULSAC), com uma poupança anual estimada de 344 991,16 €/ano

Palavras-chave: Angio TC cardíaca; Doença coronária estável; MCDT; Poupança.

Abstract

Improving efficiency in the health sector is essential to reduce service failures and ensure quality care for users of the National Health Service (SNS), optimizing limited resources. In Portugal, the incidence of acute myocardial infarction (AMI) has increased due to the prevalence of cardiovascular risk factors, many of which could be prevented through proper management, adoption of healthy habits and early diagnosis by imaging. Cardiac computed tomography angiography (CT angiography) has proven to be an effective tool in the diagnosis of coronary heart disease (CHD), allowing the calculation of the calcium score of the coronary arteries and the identification of other important pathologies. This non-invasive exam can replace conventional methods by assessing arterial flow in real time. The project evaluates the economic viability of implementing CT Angiography as a first-line exam for diagnosing stable CAD in the Alentejo Central Local Health Unit (ULSAC), with an estimated annual saving of 344 991,16€/year.

Keywords: Cardiac CT angiography; Stable coronary disease; MCDT; Savings.

General Index

Table of contents:

Index of figures

Chapter I – Introduction

Cardiovascular diseases (CVDs), including coronary artery disease (CAD), represent a significant global health burden, with millions of cases annually and a considerable impact on healthcare systems (World Heart Federation, 2023). In Portugal, the National Health Service (NHS) is confronted with an increasing number of challenges in addressing the rising prevalence of CAD. This is due to a number of factors, including an ageing population, unhealthy lifestyle choices, and an increasing incidence of risk factors such as hypertension, smoking, and obesity. Furthermore, inefficiencies in existing diagnostic pathways contribute to this burden. Reliance on conventional methods often results in delays, increased costs, and suboptimal allocation of resources (Roth et al., 2020).

A substantial contributor to these inefficiencies in Portugal is the restricted capacity of general practitioners (GPs) to prescribe advanced diagnostic procedures, such as Cardiac Computed Tomography Angiography (CT-angio). The current regulatory framework necessitates hospital-level authorisation for these tests, which forces GPs to rely on a cascade of traditional diagnostic methods, many of which are redundant and inconclusive. This process has the effect of increasing costs and prolonging patient waiting times, which serves to compound the diagnostic bottleneck. Furthermore, although international guidelines, such as those set forth by the European Society of Cardiology (ESC) (European Society of Cardiology, 2019), still include traditional frameworks involving multiple diagnostic steps, the potential of CT Angiography as a first-line diagnostic tool is gaining recognition (ESC, 2019).

Coronary computed tomography angiography (CCTA) has emerged as a cost-effective first-line test for diagnosing coronary artery disease (CAD), particularly in low to intermediate-risk patients (Moss et al., 2017; Zeb et al., 2014). The implementation of CCTA as recommended by the National Institute for Health and Care Excellence guidelines has been associated with reduced cardiovascular mortality and fewer hospitalizations for myocardial infarction (Weir-McCall et al., 2022). Combined strategies using CCTA and stress imaging tests have proven cost-effective for selecting candidates for invasive coronary angiography and early revascularization (Lorenzoni et al., 2019; Ferreira et al., 2014). CT-fractional flow reserve (CT-FFR) has shown superior diagnostic utility in intermediate to high-risk patients with stenosis of uncertain clinical significance (Burch et al., 2023). Recent advancements in CCTA techniques, including quantitative plaque assessment and evaluation of coronary physiology, have further improved its clinical impact in CAD management (Manubolu et al., 2024).

In this context, developments in diagnostic imaging, particularly CCTA has emerged as a

powerful non-invasive technique for CAD assessment, offering high-resolution visualization of coronary anatomy and enabling comprehensive cardiovascular risk evaluation (Pugliese et al., 2023; Ngam et al., 2020). CTCA demonstrates superior diagnostic accuracy compared to conventional methods, effectively ruling out CAD in low to intermediate-risk patients (Juárez-Orozco et al., 2019; Knuuti et al., 2018). Recent advancements in CTCA technology have improved image quality while reducing radiation exposure (Pugliese et al., 2023). Additionally, CTCA provides unique insights into plaque characteristics and perivascular inflammation (Dwivedi et al., 2018). Cardiac magnetic resonance imaging (CMR) complements CTCA by offering functional assessment and tissue characterization (Weberling et al., 2022; Bhatia & Kumar, 2022). The integration of artificial intelligence in cardiac imaging shows promise in enhancing diagnostic capabilities and risk stratification (Doolub et al., 2023).

Considering the potential benefits of CT-angio, the *Alentejo Central Local Health Unit* (ULSAC) has identified its integration as a priority within the scope of its Integrated Responsibility Centre for Cerebro-Cardiovascular Care (CRIA). The initiative aims to address significant shortcomings in current diagnostic practices by adopting CCTA as the primary diagnostic test for stable CAD. The aim of the CRIA initiative is to overcome the limitations imposed by GP prescription restrictions and to align the diagnostic workflows with contemporary recommendations by empowering hospital-level systems to use this technology more efficiently.

Such an initiative has the potential to have profound clinical and economic implications. From a clinical perspective, the high diagnostic accuracy and negative predictive value of CCTA reduce the necessity for superfluous invasive procedures and repetitive tests. This has the effect of accelerating the diagnostic timeline, thereby enabling earlier interventions and improved patient outcomes. From an economic perspective, the adoption of CCTA has the potential to significantly reduce healthcare costs by minimising resource-intensive procedures and reducing dependency on external diagnostic facilities. For example, the implementation of this protocol at ULSAC is projected to result in significant annual savings while simultaneously enhancing the quality of care provided to patients.

This study examines the feasibility and impact of adopting CT-angio at ULSAC, with a particular focus on its potential to address existing inefficiencies in the diagnosis of coronary artery disease (CAD). By analysing current diagnostic practices, associated costs, and anticipated savings, the research presents a comprehensive framework for the integration of CT angiography into standard care protocols. Furthermore, the study assesses potential challenges, including resource allocation, training requirements, and regulatory barriers, to guarantee successful implementation and long-term sustainability. In conclusion, this research

endeavours to contribute to a more comprehensive understanding of the ways in which innovative diagnostic methodologies can enhance healthcare efficiency, improve patient outcomes and align with the strategic objectives of national health systems such as the SNS.

Chapter II - Theoretical framework

The provision of quality healthcare is a critical issue that reflects an essential requirement within healthcare systems. It is of the utmost importance that these systems are designed in a manner that ensures effective and humane service provision to users. This entails addressing their needs and expectations in a manner that guarantees their well-being and satisfaction. In order to fulfil their purpose, healthcare services must be aligned with the expectations of those who rely on them.

From a philosophical standpoint, health is frequently regarded as a priceless commodity, justifying considerable investment to attain it. However, practical considerations reveal a more complex reality, particularly with regard to the increasing importance of healthcare expenditure and resource management. As Simões et al. (2010) observe, the Portuguese National Health Service (NHS) is confronted with considerable challenges in terms of controlling public expenditure and reducing the budget deficit. These challenges have had a significant impact on the nation's public finances in recent years.

Furthermore, Simões et al. (2010) highlight that healthcare is an ongoing and growing demand, which has resulted in a significant increase in expenditure. A comparison between the European Union's gross domestic product (GDP) and the proportion allocated to healthcare reveals a consistent increase in both metrics. In Portugal, this trend is particularly noteworthy, as healthcare expenditure exceeds the EU average. Consequently, the management of public health expenditure represents a critical challenge for the Portuguese NHS. This task requires incremental decisions aimed at promoting resource efficiency and improving population health outcomes. However, implementing these measures remains challenging due to the limited tools available, which primarily influence the supply of healthcare services rather than the demand (Barros, 2013).

The objective of the literature on this project in recent years has been to: The objective is to ascertain the current state of knowledge regarding stable coronary disease and the significance of CT-angio in its diagnosis and treatment, as well as its economic impact.

2. Coronary Heart Disease: concept

2.1 Current protocol for diagnosing stable coronary heart disease

Despite the considerable advances that have been made in the field of medical science, the Medical Complementary Diagnostic Tests (MCDTs) provided by the Portuguese National Health Service (NHS) for the diagnosis and risk stratification of stable CAD have remained static for decades. Following an initial clinical assessment, the probability of obstructive CAD

can be inferred based on the pre-test probability, which considers factors such as age, gender, symptomatology, and other risk indicators. The current guidelines for chronic coronary syndromes indicate that patients with a pre-test probability of ≤5% may be managed conservatively without further diagnostic testing, given their very low risk of obstructive CAD. In instances where the pre-test probability exceeds 5%, it is recommended that additional diagnostic procedures be undertaken. Anatomical imaging modalities, such as CCTA, are effective in determining the extent and severity of CAD, whereas functional tests assess myocardial ischaemia (Boerhout et al., 2021).

The 2019 guidelines from the European Society of Cardiology (ESC), as published in the European Heart Journal, synthesise and evaluate existing evidence in order to provide healthcare professionals with guidance on the optimal treatment strategies for specific conditions. These guidelines provide a framework for clinical decision-making in daily practice, while emphasising the importance of personalising final decisions through a collaborative approach between healthcare professionals, patients and/or caregivers (ESC, 2020). The ESC and other international organisations have developed transparent criteria for the production of guidelines, which are of great importance given their significant influence on clinical practice. Moreover, the ESC oversees the implementation of registries with the objective of evaluating diagnostic and therapeutic processes, resource utilisation, and adherence to guidelines. This facilitates a deeper comprehension of medical practice within Europe and globally, through the data collected in clinical settings (Juhani et al., 2020).

Adherence to these guidelines enables clinicians to risk-stratify patients, distinguish between stable and unstable angina, and differentiate symptoms caused by epicardial disease from those due to microvascular or vasospastic disease. Moreover, comorbidities and alternative aetiologies of symptoms are also evaluated. Clinical risk stratification comprises a series of fundamental investigations, including standard laboratory tests, resting electrocardiograms (ECGs), 24-hour Holter monitoring (where feasible), resting echocardiograms, and stress testing (ESC, 2020).

In Portugal, the response to these guidelines prompted joint reflection among study groups of the Portuguese Society of Cardiology, including the Nuclear Cardiology, Magnetic Resonance Imaging (MRI), and Cardiac Computed Tomography (CT) Study Group; the Echocardiography Study Group; and the Pathophysiology of Effort and Cardiac Rehabilitation Study Group. The objective of these groups was to identify the limitations of existing methodologies and to propose the incorporation of additional diagnostic modalities, such as stress or overload echocardiography, CT, and cardiac MRI, into the SNS portfolio, alongside traditional stress tests and myocardial perfusion scintigraphy. The adoption of these recommendations is

consistent with European guidelines and optimises the utilisation of resources in accordance with clinical contexts and local needs. Such a transition has the potential to enhance the quality of patient care, improve resource management, and generate potential health benefits and cost savings.

General practitioners (GPs) occupy a pivotal position in the early detection and management of cardiovascular diseases (CVDs) within the context of primary healthcare. It is the responsibility of general practitioners (GPs) to perform screening and identify patients who are at elevated risk of developing cardiovascular disease. It is of the utmost importance to ensure the efficient utilisation of multi-detector computed tomography (MDCT) in order to achieve optimal diagnostic and therapeutic effectiveness while simultaneously optimising the utilisation of healthcare resources. In the extant primary healthcare framework, general practitioners (GPs) have access to diagnostic tools, including simple electrocardiograms (ECGs), stress tests, and myocardial perfusion scintigraphy, which are used to evaluate stable CAD and to stratify cardiovascular risk. These tests are available at contracted centres under the SNS framework. However, MCDTs, including cardiac CT-angio, stress echocardiography, and stress cardiac MRI, are not accessible to GPs within the SNS framework. The requirement for hospital-level authorisation to access these advanced MCDTs has resulted in an increased demand for cardiology consultations and a consequent exacerbation of waiting lists. Prolonged delays in cardiology evaluations pose a significant risk in a specialty where timely care is of paramount importance.

Non-invasive diagnostic techniques are fundamental for confirming the presence or absence of CAD and evaluating its functional implications at an early stage of the disease process. These techniques provide vital information for both diagnosis and prognosis, which directly influences the subsequent management of the patient. The most commonly employed techniques for the evaluation of cardiac function encompass stress echocardiography, myocardial perfusion scintigraphy, and magnetic resonance imaging (MRI). In the context of non-invasive anatomical evaluation, magnetic resonance angiography (MRA) and CT-angio are frequently employed, with CT-angio being the preferred option due to its superior spatial resolution in comparison to MRI (Neglia et al., 2015).

The selection of an appropriate diagnostic technique as the initial assessment for coronary artery disease (CAD) should consider a range of factors, including the pre-test probability, the limitations of interpreting baseline electrocardiograms (ECGs), the patient's exercise capacity, the availability of the test, the expertise of the clinician, and the associated costs. In order to reduce the incidence of cardiac events, it is essential that the first-line diagnostic test exhibits high diagnostic accuracy, robust risk stratification capabilities and integration into an efficient

and cost-effective clinical pathway (Bettencourt et al., 2022).

Non-invasive cardiac imaging modalities are an indispensable tool in the management of CAD, facilitating diagnosis, functional evaluation, risk stratification, and assessment of myocardial viability. These methods are supplementary to clinical scoring systems and assist in determining whether patients require catheterisation, revascularisation, or intensive medical therapy. It is widely accepted that non-invasive diagnostics are particularly advantageous for patients with an intermediate pre-test probability of CAD, while further testing is unwarranted in cases of very low pre-test probability.

In medical guidelines, recommendations are classified in a systematic way with the aim of guiding safe, effective clinical decisions based on scientific evidence. To do this, two main parameters are used: the class of recommendation and the level of evidence.

Medical guidelines use two main criteria to guide clinical conduct: the class of recommendation and the level of evidence. The class of recommendation indicates the strength with which an intervention is suggested:

- Class I means that the procedure should be done, because there is proven benefit;
- Class IIa indicates that it can be considered, with probable benefit;
- Class IIb also allows consideration, but with more uncertain benefit;
- Class III recommends that it should not be done, because there is no benefit or because there is a risk.

The level of evidence reflects the quality of the data supporting the recommendation:

- Level A is based on strong studies, such as clinical trials and meta-analyses;
- Level B, on moderate studies, such as cohorts and case-controls;
- Level C, on expert opinion or limited data.

These two parameters help guide safe and informed clinical decisions.

Figure 1 illustrates the European recommendations published in 2019 for the utilisation of imaging techniques for the initial diagnosis of symptomatic patients with suspected CD. These recommendations assist the family physician in determining whether to prescribe dual antiplatelet medications (DCMs). Additionally, it demonstrates that CTA is a Class I recommendation with Level of Evidence B.

Figure 1 - Recommendations for the use of imaging methods for diagnosing CD

Source: ESC2019

Recommendations on risk assessment		
Risk stratification is recommended based on clinical assessment and the result of the diagnostic test initially employed to diagnose CAD.	I	B
Resting echocardiography is recommended to quantify LV function in all patients with suspected CAD.	I	C
Risk stratification, preferably using stress imaging or coronary CTA (if permitted by local expertise and availability), or alternatively exercise stress ECG (if significant exercise can be performed and the ECG is amenable to the identification of ischaemic changes), is recommended in patients with suspected or newly diagnosed CAD.	I	B
In symptomatic patients with a high-risk clinical profile, ICA complemented by invasive physiological guidance (FFR) is recommended for cardiovascular risk stratification, particularly if the symptoms are responding inadequately to medical treatment and revascularization is considered for improvement of prognosis.	I	A
In patients with mild or no symptoms, ICA complemented by invasive physiological guidance (FFR/iwFR) is recommended for patients on medical treatment, in whom non-invasive risk stratification indicates a high event risk and revascularization is considered for improvement of prognosis.	I	A
ICA complemented by invasive physiological guidance (FFR) should be considered for risk-stratification purposes in patients with inconclusive or conflicting results from non-invasive testing.	IIa	B
If coronary CTA is available for event risk stratification, additional stress imaging should be performed before the referral of a patient with few/no symptoms for ICA.	IIa	B
Echocardiographic assessment of global longitudinal strain provides incremental information to LVEF and may be considered when LVEF is >35%.	IIb	B
Intravascular ultrasound may be considered for the risk stratification of patients with intermediate LM stenosis.	IIb	B
ICA is not recommended solely for risk stratification.	III	C

2.2 Factors influencing the prescription of MCDTs

The European Society of Cardiology (ESC) recommends the utilisation of stress tests (PE) or non-invasive cardiac imaging techniques, including stress echocardiography, myocardial perfusion scintigraphy, and CT-angio, as diagnostic tools for stable coronary artery disease (CAD). These medical complementary diagnostic tests (MCDTs) are used to diagnose, stratify risk, and inform therapeutic decisions for patients presenting with low to intermediate probabilities of stable coronary artery disease (Forc et al., 2013).

A number of factors are taken into account when determining whether to prescribe an MCDT for the diagnosis of coronary heart disease (CHD). The primary factor influencing the decision to perform a particular test is the clinical indication, which is based on the patient's symptoms and complaints. However, the availability of resources, equipment, and healthcare

professionals with the requisite skills to perform and interpret these tests is also a crucial factor. Clinical guidelines and protocols, both national and international, provide essential frameworks that guide clinicians in selecting the most appropriate diagnostic tests for specific scenarios. Furthermore, the personal preferences and experience of the physician with specific MCDTs can also influence their clinical decisions. Furthermore, economic factors, such as the cost of MCDTs and their accessibility to both clinicians and patients, exert a significant influence on the diagnostic process. In Portugal, the prescription of complementary tests is frequently constrained by the reimbursement policies of the National Health Service (SNS) or the availability of private health insurance coverage (Ferreira et al., 2014).

Another factor contributing to the increased utilisation of MCDTs in Portugal is the phenomenon of defensive medicine. Similarly, Portuguese physicians may request these tests not only for the benefit of their patients but also as a precaution against potential legal ramifications. This practice has a considerable impact on the rising costs of healthcare. In Portugal, the financial burden of MCDTs represents a significant proportion of the healthcare budget, reflecting both the necessity for precise diagnoses and the legal concerns of medical practitioners (Minossi et al., 2013).

A comparison of Portugal with other European Union (EU) countries reveals a similar prevalence of defensive medicine. However, the associated costs vary depending on the structure of the healthcare system and the degree of public funding. In centralized systems, such as that of Portugal and other southern European nations, cost management is primarily government-led. In contrast, in northern European countries, private healthcare systems often exert a greater influence on resource allocation and cost containment strategies (Sakellarides, 2019).

A systematic review by Goetz et al. (2015) demonstrated that the provision of real-time cost information to physicians has a significant impact on their prescribing behaviours with regard to MCDTs. Of the nine studies analysed, seven demonstrated statistically significant reductions in healthcare expenditure. However, only three observed a decrease in the number of MCDTs requested. These findings indicate that physicians are more likely to select cost-effective tests than to reduce the overall number of tests requested. This underscores the necessity of incorporating cost considerations into the clinical decision-making process to facilitate more economical and efficient healthcare practices (Goetz et al., 2015).

The physician's role is one of considerable complexity, with the need to balance their duty to the patient with the financial expectations of the healthcare payer. Sehgal and Gorman (2011) and Ginsburg et al. (2000) found that, while many physicians concur on the significance of

cost-effectiveness in selecting MCDTs, they are frequently reluctant to engage in financial discourse with patients. Tilburt et al. (2013) expressed a similar viewpoint, noting that physicians tend to prioritize the welfare of their patients over financial considerations and are reluctant to deny access to costly diagnostic services. Concurrently, they recognise the necessity to restrict the utilisation of superfluous MCDTs.

Silvestri et al. (2018) investigated the impact of providing physicians with real-time information on patient co-payment amounts on their decisions regarding the prescription of MCDTs. A reduction in the likelihood of prescribing both laboratory and imaging tests was observed, which resulted in shorter waiting lists and reduced costs. However, the impact was more pronounced for laboratory tests in comparison to imaging tests. This discrepancy may be attributed to the perception of laboratory tests as more discretionary by physicians, which may result in the prioritisation of cost-effective alternatives or imaging tests.

2.3 Costs of atherosclerosis in Portugal

In Portugal, the economic burden of atherosclerosis is considerable, with total costs estimated at 1.9 billion€. Of the total costs, 58% can be attributed to direct costs, while indirect costs account for the remaining 42% (NHS). The largest proportion of direct costs is associated with outpatient treatments (58%), followed by hospitalisations (42%). The indirect costs are primarily attributable to the loss of productivity resulting from patient absenteeism due to the disease. Atherosclerosis represents a substantial financial impact, accounting for approximately 1% of the country's gross domestic product (GDP) and 11% of total health expenditure. These costs, both direct and indirect, encompass hospitalisations, medications, and the utilisation of medical complementary diagnostic tests (MCDTs). This economic burden represents a significant challenge to the long-term sustainability of the Portuguese National Health Service (NHS).

The evaluation of new-onset stable chest pain, commonly referred to as angina pectoris, frequently remains inconclusive despite the application of multiple MCDTs. In such cases, cardiac catheterisation – a procedure that is invasive, costly and not without potential complications – often becomes necessary to achieve diagnostic certainty (Hamm et al., 2008).

2.4 Recommendations for the use of coronary CT-angio in the diagnosis of stable coronary disease

CT angio has emerged as a non-invasive and highly effective imaging technique for the evaluation of patients presenting with chest pain and an intermediate probability of CAD. This modality is employed for the diagnosis and characterisation of CAD, as well as for the guidance

of the initiation or intensification of medical therapy. Recent technological advancements have significantly enhanced the data yield of CT angio, rendering it a crucial tool for analysing atherosclerotic plaques within the coronary arteries. This encompasses the identification, characterisation and quantification of atherosclerosis, which is of significant importance in patient risk stratification (Gianluca et al., 2022). Moreover, CT-angio is capable of detecting both calcified and non-calcified plaques, which are early indicators of CAD. It also serves as a valuable prognostic tool for assessing cardiovascular risk (Finck et al., 2019).

The abundance of data yielded by CT-angio poses a challenge in selecting the information to include in diagnostic reports. This imaging modality provides more detailed insights than cardiac catheterisation, including the visualisation of atherosclerotic disease, tissue characteristics, remodelling patterns, coronary flow patterns and inflammatory activity. The comprehensive nature of the data facilitates enhanced risk stratification and patient management, thereby advancing the pursuit of precision medicine. Nevertheless, reports should concentrate on the most recent evidence and give priority to coronary anatomy until definitive data become available to support the integration of additional parameters into decision-making algorithms (Arbab, 2018).

In their 2019 guidelines for chronic coronary syndromes, the European Society of Cardiology (ESC) recommend that CT-angio or non-invasive functional imaging should be used as the initial diagnostic approach, rather than traditional stress testing (ESC, 2019). Notable studies, including ACCURACY, CONFIRM, and SCOT-HEART, have highlighted the significance of CT angiography. In 2016, the National Institute for Health and Care Excellence (NICE) recommended computed tomography angiography (CTA) as the initial diagnostic test for suspected CAD, citing its efficacy in reducing coronary events, particularly non-fatal acute myocardial infarctions (NICE, 2016).

The NICE guidelines place particular emphasis on the use of CT-angio as an efficient and accurate diagnostic tool for stable CAD. This recommendation is consistent with the current evidence base, which supports the efficacy of CT-angio in improving diagnostic accuracy and patient outcomes. Prioritising CT-angio in diagnostic protocols may result in improved clinical outcomes and more efficient utilisation of resources (Moss et al., 2019). Furthermore, CT angiography is acknowledged for its cost-effectiveness, exhibiting the lowest cost per accurate diagnosis while maintaining high sensitivity and a low complication risk (Newby et al., 2015).

Computed tomography angiography provides rapid, detailed images of the coronary anatomy in a non-invasive manner, with progressively lower radiation doses. This procedure makes use of iodinated contrast agents, nitrates and beta-blockers with the objective of enhancing image

quality through the induction of bradycardia and coronary vasodilation. Its high negative predictive value (NPV) frequently permits clinicians to commence treatment without further investigation, particularly in patients with a low probability of CAD. Nevertheless, there are certain limitations to the procedure. For instance, it can be challenging to visualise vascular lumens in cases of extensive calcifications (Agatston scores >400) and the image quality may be reduced in patients with arrhythmias or elevated heart rates (>60 bpm) (Gerber et al., 2009).

The CONFIRM observational study followed 2,506 patients who underwent CT-angio for an average of two to three years. The study focused on individuals with an intermediate probability of coronary artery disease (CAD) based on the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III), Framingham, and Morise risk scores. The study, which excluded patients with known CAD, demonstrated a significant correlation between risk scores and clinical outcomes. The NCEP ATP III score exhibited the best predictive performance (c-index 0.706), followed by the Framingham score (c-index 0.623) and the Morise score (c-index 0.618) (Hadamitzky et al., 2013).

Technological advancements have enhanced the diagnostic and prognostic value of CT-angio. The CONFIRM2 study investigated the quantification of cardiac, coronary, non-coronary, and extracardiac findings and their relationship to clinical outcomes (Van Rosendael et al., 2023). Furthermore, the increased utilisation of CT-angio has underscored the prevalence of incidental extracardiac findings, predominantly pulmonary nodules, which are often associated with overlapping risk factors such as age and smoking. While the majority of findings are clinically insignificant, follow-up investigations can result in significant financial burden (Pinto et al., 2022).

The SCOT-HEART trial, a multicentre study conducted in 2023, provided further validation of the efficacy of CT-angio in comparison to traditional diagnostic approaches. The trial's findings informed updates to the NICE and ESC guidelines, which now prioritize CT-angio as a first-line diagnostic tool and demonstrate its role in improving clinical outcomes (Mumtaz et al., 2024). Despite the proven benefits of CT-angio, its utilisation in Portugal remains below expectations, likely due to constraints in accessibility. It is imperative that greater efforts be made to educate cardiologists and general practitioners about the advantages of this technique in order to promote its more effective use in clinical practice.

Randomised clinical trials and studies such as FFRCT have demonstrated that CT-angio is superior to other techniques for the assessment of specific lesions. A high negative predictive value (NPV) of greater than 95% may result in a reduction in the reliance on invasive procedures, such as coronary angiography. Nevertheless, the existing literature does not

support the use of this technique in patients with pre-existing cardiovascular disease, prior cardiac interventions, or arrhythmias, as these groups were excluded from the majority of the relevant studies (Boerhout et al., 2021).

Computed tomography angiography is an effective method for accurately detecting coronary artery calcium using the Agatston calcium score, which correlates well with non-contrast CT calcium scores. Notwithstanding its high reproducibility, the technique may yield systematically lower Agatston scores when derived from CT-angio images (Van der Bijl et al., 2010).

In conclusion, computed tomography angiography has become a reliable and non-invasive alternative to coronary angiography for the diagnosis of stable coronary artery disease. Technological advances have enhanced the capacity of this technique to assess coronary stenosis and quantify atherosclerotic plaques, while it is evolving towards functional stenosis evaluation. The results of multicentre trials have demonstrated the efficacy of this approach in reducing cardiac mortality and improving outcomes. However, further long-term studies are required to confirm these findings. As technology advances, CT-angio is becoming an increasingly pivotal tool in the early detection and prevention of severe cardiac events, improving treatment strategies and aligning with the goals of precision medicine (Sun, 2016).

2.5 Cost-effectiveness analysis of the use of CT angio as a first-line test

The number of studies addressing the costs associated with atherosclerosis and the cost-effectiveness of CT-angio remains limited. The evaluation of cost-effectiveness in imaging techniques is inherently complex, as it is influenced by a number of factors, including economic considerations, the availability of the technology in question, the expertise of the physicians involved, and the prevalence of the disease in question. There is a paucity of comparative analyses that encompass all imaging modalities and their long-term implications. This includes the necessity for additional testing and the optimisation of clinical outcomes (Nelson, 2019).

A comprehensive cost analysis of diagnostic strategies must encompass both direct and indirect costs. The direct costs are determined by the expenses incurred for the diagnostic tests performed, which are typically based on the price list provided by the National Health Service (NHS). Among the available medical complementary diagnostic tests (MCDTs), computed tomography angiography (CTA) has emerged as a highly promising option in cardiology and is increasingly the preferred diagnostic modality for evaluating patients with symptoms of stable angina. (Newby et al., 2015).

Recent advances in computed tomography, particularly in spatial resolution, acquisition speed, and radiation reduction, have markedly enhanced the diagnostic accuracy of CT-angio nabling

precise detection of an expanding range of cardiac pathologies. CT-angio has been identified as the imaging modality with the lowest cost per accurate diagnosis, combining high sensitivity with a low probability of complications (Newby et al., 2015).

In a comparative cost-effectiveness analysis of CT-angio versus other non-invasive imaging modalities for suspected CAD, Carmo et al. (2022) found that... The study concluded that CT-angio was the most effective and the least expensive option in comparison to other available alternatives, such as myocardial scintigraphy and stress echocardiography. These findings indicate that CT-angio is a viable and economically advantageous diagnostic tool for CAD, offering precise diagnostic information while reducing disease management costs.

Further evidence from the PROMISE trial lends further support to the economic benefits of CT-angio. The study, published subsequent to the 2019 ESC Guidelines, demonstrated that an anatomical approach utilising CT-angio is a more cost-effective strategy than functional imaging tests. The reduction in expenditure is attributable to the enhanced capacity to differentiate between obstructive and non-obstructive coronary artery disease (CAD), thereby facilitating a more tailored approach to therapeutic intervention (Boerhout et al., 2021).

CT-angio has become the diagnostic test of choice for evaluating patients with stable angina (Corballis et al., 2023). This trend confers benefits upon patients, healthcare providers, and institutions such as the ULSAC. The adoption of coronary CT-angio as a primary diagnostic tool for stable CAD holds the potential for considerable benefits, including cost savings, enhanced service quality, and improved patient outcomes. Implementing this strategy within organisations such as the CRIA could result in significant gains while maintaining or even improving the quality of care provided.

Chapter III - Project Presentation

3. Project

The 2023 World Heart Federation Report highlights a concerning 60% increase in cardiovascular disease-related deaths over the past three decades. This trend underscores the urgent need for effective prevention and treatment strategies to address the growing public health challenge. Cardiovascular diseases remain a leading cause of mortality globally, necessitating concerted efforts to mitigate their impact.

In Portugal, the NHS faced a deficit of approximately 1.066 billion € in 2022, as reported by the Public Finance Council in June 2023. This financial shortfall reveals critical risks to the sustainability of the SNS, which could impair its performance in both the short and medium terms. Strengthening the SNS requires increased investment in its sustainability and efficiency to ensure quality healthcare delivery (NHS).

The NHS has long faced numerous challenges, with urgent reforms needed to overcome its systemic difficulties. As Sakellarides (2020) noted, the NHS requires significant public investment to enhance its infrastructure and operational capabilities. Key transformations include improving system efficiency and increasing available resources to uphold service quality for the population. Hospital care, a vital component of the NHS, is central to cost reduction and organizational improvements. Silva et al. (2015) emphasize the need to integrate several healthcare interventions within a cohesive framework to continuously enhance service quality while ensuring sufficient resources for planning and executing quality improvement initiatives.

Cardiovascular disease remains a significant global burden, with a prevalence of 523 million cases and 18.6 million deaths annually. Risk factors such as hypertension, smoking, and obesity are major contributors to this burden. Among these cases, ischemic heart disease accounts for approximately 182 million cases and 9.14 million deaths annually. Addressing these risk factors is essential to reducing the global impact of cardiovascular disease.

In diagnosing coronary artery disease (CAD), numerous complementary diagnostic and therapeutic methods (CDTMs) are employed. Non-invasive tests, including treadmill stress tests, myocardial perfusion scintigraphy, pharmacological stress echocardiography, and cardiac magnetic resonance imaging, provide crucial information about the presence and severity of CAD. These Medical Complementary Diagnostic Tests (MCDTs) aid therapeutic decisions, particularly in determining the necessity of invasive procedures such as coronary angiography, which remains the "gold standard" for detecting CAD.

Coronary CT angio, an advanced non-invasive radiological technique, has revolutionized the diagnostic landscape for stable CAD. Offering high-definition imaging within minutes, it enables precise identification of plaques and coronary obstructions. This technique is especially valuable for patients with intermediate or low pre-test probabilities of CAD, facilitating quicker and more informed medical decision-making (Taylor et al., 2010).

Countries with public health systems, such as the United Kingdom, Sweden, and Canada, underscore the importance of cost-effectiveness analyses and economic studies in healthcare decision-making. Implementing guidelines and protocols for specific pathologies optimizes resource allocation and improves healthcare quality. Cost-effectiveness analysis compares the costs of various interventions relative to their health outcomes, while cost-benefit analysis monetizes these effects. Bleichrodt and Quiggin argue that preferences, which evolve over an individual's life due to factors such as age, income, and health, also influence the application of these analyses.

In health economics, cost-effectiveness is a critical criterion for selecting diagnostic tests and therapeutic options (Ferreira et al., 2014). Recognizing this, the Portuguese government initiated a comprehensive reorganization of the SNS in 2024, aiming to enhance the quality and efficiency of healthcare across multiple levels. The creation of specialized functional units, such as Integrated Responsibility Centres (CRIs), plays a pivotal role in advancing healthcare quality (ACSS).

The Alentejo Cerebro-cardiovascular Integrated Responsibility Centre (CRIA), established in 2020 within the Alentejo Central Local Health Unit (ULSAC), exemplifies this focus on specialized care. CRIA's commitment to specialized care is rooted in a multidisciplinary approach, involving hospital administrators, cardiologists, cardiac and vascular surgeons, neuroradiologists, interventional radiologists, anesthesiologists, nurses, and TSDTs in cardiopneumology and radiology. Administrative technicians and operational assistants complete this pioneering team.

CRIA is Portugal's first integrated center dedicated to cerebro-cardiovascular care, setting a benchmark for collaborative, multidisciplinary healthcare. Its ongoing quest for continuous improvement reflects its mission to provide comprehensive, specialized care to the Alentejo population.

3.1 Steps towards change

The gap between our reality and international recommendations is evident and makes it inevitable that decisions need to be taken to change this reality. Various strategies can be

analysed to correct this mismatch. The project suggested here is just one of the possible solutions.

Despite evidence of cost-effectiveness from other contexts, a cost analysis based on specific data is considered essential. This analysis should be encouraged by senior management at hospital level, so that future decisions are based on both scientific evidence and local feasibility. In some countries, the paradigm shift has been accompanied by a promise not to increase the costs of diagnosing CD. We can adopt these good practices and look for the best strategy to achieve the same results, improving the quality of care without putting a financial burden on the NHS.

This project aims to justify the importance of implementing a protocol for diagnosing and ruling out stable coronary disease using CT angio as a first-line test.

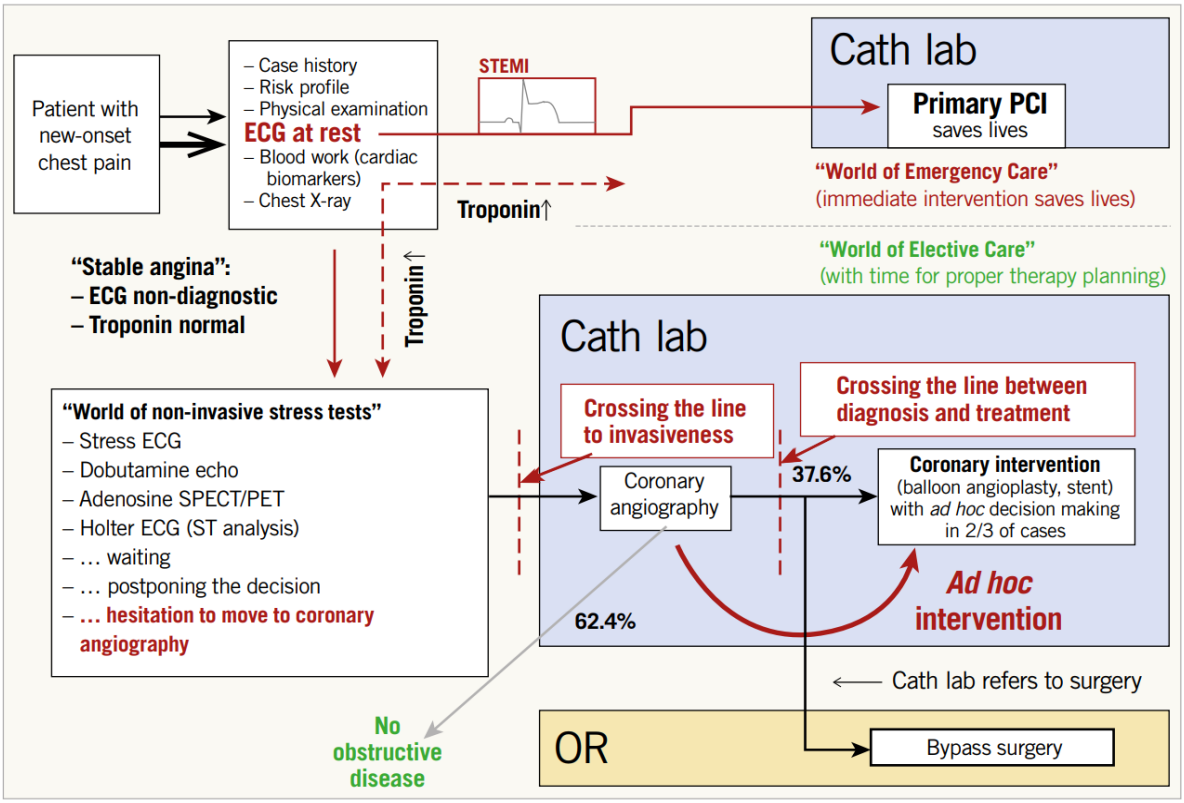
3.2 Obstacles and resistance

Initial resistance is expected, which is common in any process of change, and in healthcare it's no different, usually caused by a lack of familiarity with the indications, contraindications, advantages and disadvantages of the new techniques for diagnosing coronary heart disease, but it is expected that there will be rapid acceptance of the new recommendations by NHS FGM doctors. Many already follow international guidelines, such as the European ones, especially for patients with health subsystems such as ADSE, which cover tests such as overload echocardiography, cardiac CT angio and MRI. However, centres contracted with the SNS might resist replacing traditional tests such as stress tests and myocardial perfusion scintigraphy, which will lose relevance in the initial diagnosis of stable coronary disease.

It will be necessary to increase the availability of CT machines and trained professionals. As the volume of cardiac CT scans grows, it is crucial to maintain quality to guarantee diagnostic accuracy, optimising images and minimising radiation exposure. Without adequate support from the managing organisations, the project could fail. Staff dissatisfaction over issues such as pay and lack of training can also demotivate, making a continuous training plan and effective communication of objectives essential. Adjustments to the strategic plan should be made throughout implementation to ensure that targets are met.

3.3 A brief presentation of current practice

Figure 2 - Current conceptual map



3.4 General Objectives

The main objective of this study is to carry out a cost analysis of CT angio if it is implemented as a first-line test for diagnosing stable CD.

3.5 Specific objectives

- To analyse the costs of implementing CT angio as a first-line test for the diagnosis of stable coronary artery disease (CAD) at ULSAC.
- Determine the potential annual savings from adopting CT angio at ULSAC.
- To compare the costs associated with CT angio with the diagnostic methods currently used by the ULSAC to diagnose stable coronary artery disease (CAD).
- Determine the direct financial benefits of reducing other MCDTs for diagnosing stable coronary heart disease (CHD).
- To assess the long-term sustainability of the continued use of CT angio at ULSAC.

The project also aims to improve the perspective of the user, the health professional, learning and the financial perspective, as shown in table 1 below.

Table 1- Project Perspectives

User perspective	Increasing user satisfaction Increase the speed and accuracy of diagnosis
Professionals' perspective	Reduce internal and external waiting times for a diagnosis of CD and other clinical situations by freeing up time in other centres Increasing efficiency and profitability at CRIA Opportunities for professional development Updating healthcare procedures
Learning Perspective	Valuing health professionals Increasing the level of employee training Increasing scientific production Reference centre for training and innovation
Financial perspective	Optimising human and technological resources Reduce costs with inconclusive MCDTs Fundraising/partnerships

3.6 Project design

The aspect that aroused the greatest interest and led to the development of this research project was the awareness of the huge geographical area to which CRIA responds. Waiting lists for the various MCDTs to detect CD tend to increase, thus delaying the diagnosis of CD, which can consequently lead to a late start to treatment, thus increasing the number of hospitalisations and hospital stays that tend to be longer, worsening patients' prognosis.

The project is to be carried out in two distinct phases, phase 1 will be studied and developed in this academic work, but phase 2 will not be studied in this particular work.

3.7 Phase 1 project

CRIA aims to become not only a regional but also a national referral centre in a global referral network and to implement methodologies that contribute to the effective management of health resources, responding to the needs of users. CRIA's values and principles are user-centred orientation and health promotion, humanisation and empathy, professionalism, ethics and transparency, innovation and safety, as well as efficiency and sustainability. Its long-term goals

are to increase its capacity to diagnose and treat patients with coronary heart disease, reduce waiting times for treatment and cut healthcare costs, while maintaining the quality of its services.

The starting point for this project was the identification of the CRIA's problems in managing waiting lists and prioritising patients for diagnosis and treatment of stable CD. CRIA must provide a timely response to all patients referred to the centre. In our daily practice, we noticed that patients referred by FGM doctors began their stable CAD studies many months before arriving at the haemodynamics laboratory for cardiac catheterisation, with numerous inconclusive ischaemia tests. It was also realised that the high number of requests for MCDTs to detect non-invasive CD increased the waiting list and the inability to respond to other pathologies. It was also realised that the delay in carrying out non-invasive tests led doctors to prescribe an invasive test that was not free of complications, cardiac catheterisation, at a very high cost to the NHS, becoming the "Gold Standard" test.

After identifying the problem, and given that CRIA has its own CT angio room, the idea was to implement a CT angio protocol as a first-line test for detecting stable CD, thus freeing up other MCDTs to detect other pathologies, reducing the time taken for diagnosis and intervention when CD is present.

In phase 1, after identifying the problem, requests for authorisation to carry out the project were made to the ULSAC Board of Directors and the institution's ethics committee.

Data is collected for the study and a literature review is carried out to support the feasibility of the project.

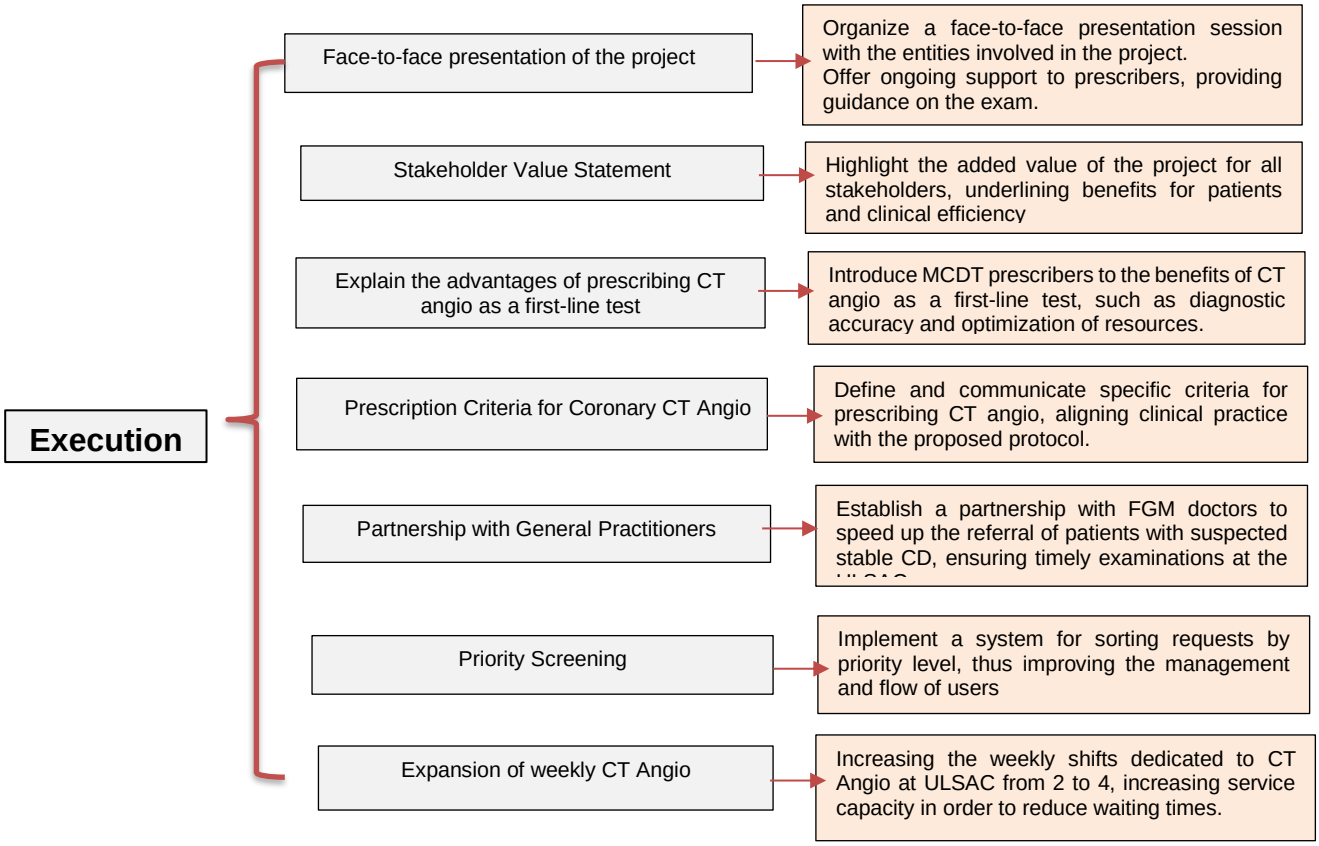
The data is processed and finally the results are projected.

3.8 Phase 2 of the project

The implementation of the project at the ULSAC, phase 2, must be carried out in a simplified and efficient manner, due to the need to control the waiting list, in order to obtain reliable results in good time.

The project is due to be implemented in March 2025, but phase 2 will not be the subject of this study.

Figure 3 - Project implementation phase



Budget/Resources

- Determine the increase in costs for healthcare professionals and consumables when performing CT angio.

After five years, the real impact of the project's implementation on the ULSAC economy should be assessed.

Waiting times for CD treatment should be evaluated after the project has been implemented.

3.9 Project schedule

A timetable was drawn up for this project, as shown in figure 4, in order to organise and manage the key stages and deadlines. The timetable also served as a strategic guide so that the project could be developed in a structured and efficient manner, to ensure that the proposed goals were met within the deadlines set.

The project began in December 2023 with the identification of the problem and the first phase ended in November 2024.

It is intended that this project will be implemented at ULSAC in March 2025 and that a final

evaluation and analysis of the project will be carried out in March 2030.

At 6 months into the project, the results should be evaluated and strategies readjusted if necessary.

Figure 4 - Project timetable

Tasks	Dec. 2023	Jan. 2024	Febr. 2024	Mar. 2024	April 2024	May 2024	June 2024	July 2024	August 2024	Sept. 2024	Oct. 2024	Nov. 2024	Dec. 2024	Jan. 2025	Febr. 2025	Mar. 2026
Identifying the problem																
Requests for authorization to prepare the project to the CA and Ethics Committee of ULSAC																
Project design																
Literature review / State of the art																
Collection of ordinance values for MCDTs carried out at ULSAC																
Collection of the number of MCDTs carried out at ULSAC to diagnose stable CD in the years to be studie																
Prospective economic study																
Analysis of results																
Discussion and results																
Final considerations																
Drafting the project																
Project implementation																
Analysis of the first 6 months																
5-year evaluation of results																

3.10 Project target population

The project's target population will be all symptomatic inpatients and outpatients without a diagnosis of stable CD, whose doctors believe, by clinical criteria, that CD is present.

Inclusion criteria

- Patients with a high probability of coronary heart disease due to risk factors:
- Symptoms of coronary heart disease (chest pain or discomfort suggesting ischaemia)
- Known heart disease;
- Detection of atherosclerosis;
- Kawasaki disease.
- Suspected calcifications in the coronary arteries (calcium score assessment);
- Verifying the effectiveness of a stent after coronary angioplasty;
- Coronary intervention planning;
- Patients with difficult vascular access.

Exclusion criteria

- Pregnant women;
- Acute renal failure;
- Unstable coronary disease;
- Arrhythmias;
- Cardiac catheterisation less than 12 months ago

- Chest pain with electrocardiogram showing acute CD changes

Chapter IV – Metodology

4. Methodology

In order to build new knowledge, it is essential to focus on scientific development. Only in this way can we understand phenomena and events. Only by understanding events and phenomena can we move forward, produce, refute and develop scientific knowledge (Fortin et al., 2006).

Scientific methodology is a process or method applied to science to achieve a specific end, according to the area of study, enabling the production of knowledge (Sarmento, 2013). To this end, this study was developed as an observational retrospective case study. It is characterised by being observational, without the direct intervention of the researcher, consisting of successive stages of data collection, recording, analysis and formulation of conclusions relating to a past period, focusing on a specific entity (Sarmento, 2013).

Yin (2009), quoted by Barroso (2015, p.20), argues that the use of various sources not only provides information but also allows for the validation of that information. To ensure maximum accuracy in this study, several sources of information were used for data selection and collection, including computer system databases, documentary analysis and direct observation.

Firstly, the problem that led to this project was identified, the project's objectives and keywords were established. Subsequently, authorisation to carry out this project was sought from the current ULSAC Board of Directors, as well as a request for an opinion from the ethics committee, which approved it.

Once the project had been approved, a literature review was started to support the project. The keywords defined were Cardiac CT Angio, Stable Coronary Disease, MCDTs and "saving". The keywords were researched in Portuguese and English, in publications, books and scientific articles that helped to clarify the concepts.

A search was made for the most cited articles and authors on the key concepts over the last five years, with the aim of finding the main visions and definitions of the concepts. A search was made for articles on the cost-effectiveness of CT Angio. Given the difficulty encountered, perhaps due to a lack of publications during the pandemic period, which might have led to few publications, it was decided to try to find bibliography from the last ten years. We realised that documents were scarce.

However, articles have been kept out of this time window because of the relevance of their vision.

We consulted the values of the MCDT ordinance in the SNS price tables published in the Official Gazette on 11 July 2017, and collected from the administrator of the Cardiology area, the number of MCDTs carried out in 2017, 2018 and 2019, as well as those carried out in 2023, excluding the years of the Covid-19 pandemic because they were atypical years.

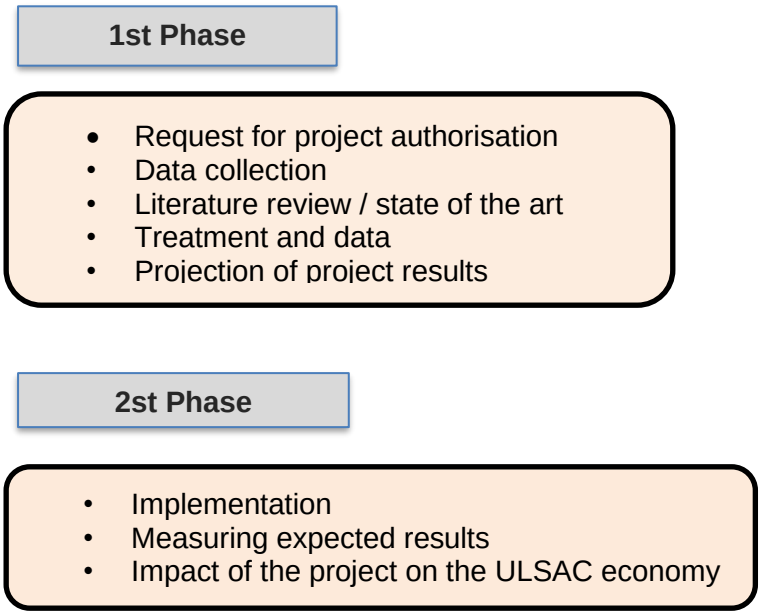
A prospective economic study was carried out with the aim of assessing the amount of "savings" produced if the project is implemented, if a protocol for diagnosing and/or excluding low- and intermediate-risk CD is implemented, using CT angio as the first-line test.

The amount spent per CT angiography performed, the amount spent on consumables per examination and on human resources were calculated, as well as all the costs associated with the possible implementation of the protocol.

The saving values per exam/year were calculated if there was a 50 per cent reduction in other MCDTs and a 100 per cent increase in CT angio. The values were worked out using the Excel tool.

In order to carry out this project, a methodological scheme was drawn up, which is presented below. The second phase of the scheme can only be evaluated 5 years after the project has been implemented.

Figure 5 - Methodological outline of the project



The project's methodological scheme seems to be the most effective for proper planning and for implementing/monitoring the project in order to achieve the proposed objectives.

This project has a retrospective component, as it reflects the costs per test (ordinance values) and the number of functional tests carried out at the now ULSAC, for the diagnosis of stable coronary disease in 2023

4.1 Literature review

The searches were carried out on various search engines, including Google Scholar, ResearchGat, b-on, ScienceDirect, MDPI, JBI Evidence Synthesis, Scopus, PubMed National Library of Medicine and Scielo.

All the selected articles were added to Mendely using the APA standard as a storage tool. The use of this tool was fundamental when writing the texts, especially when inserting bibliographical references.

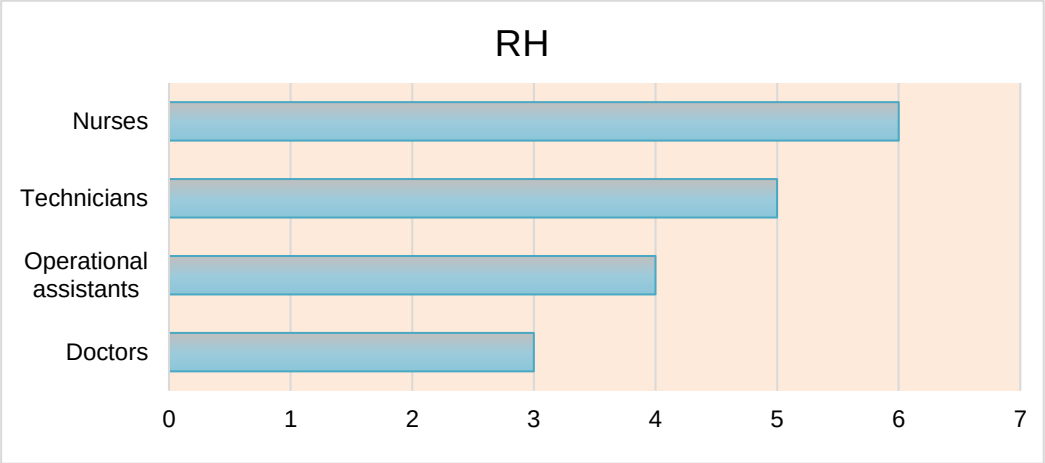
Mendely has 93 articles selected and arranged in order of publication.

4.2 Human Resources and Competence Management

The distribution of CRIA employees at CT Angio, by professional class, demonstrates 5 Radiology TSDTs, 6 Nurses, 3 cardiologists and 3 Operational Assistants, totalling 17 employees, as shown in figure 4.

Only one member of each professional class is present on each shift, and there are now four shifts a week for coronary CT angiography.

Figure 6 - HR distribution graph



Given the geographical area (all of Alentejo, except the Alentejo coast) to which ULSAC has to respond in terms of diagnosing and treating CD, waiting lists for coronary angiography tend to increase.

Coronary angiography is the end-of-line test for detecting CAD and should only be carried out when there is clear evidence of CAD, but it is often requested by doctors to clarify the presence or absence of CAD as the first test.

This study aims to reduce the number of invasive tests (coronary angiography), freeing up slots for patients who really need them. Because they are invasive tests, they are also more expensive.

4.3 Characterisation of the study site

Since 2009, ULSAC's Cardiovascular Intervention Unit has facilitated access to coronary revascularisation in the Alentejo, especially in the acute phase of acute myocardial infarction, thus reducing cardiovascular mortality in the region. The need to expand cardiovascular intervention (cardiac, peripheral vascular and aortic), together with the capacity to carry out structural and brain-vascular interventions in the south of the country, and the partnership for training and research with the University of Évora (UÉ), led to the creation of the current Alentejo Integrated Responsibility Centre (CRIA), focused on Brain-Cardiovascular Intervention. This CRI is unique in the country and stands out for its comprehensive approach to brain and cardiovascular intervention and its ability to invest in infrastructure, equipment, training and research.

CRIA focuses its attention on intervention and cardiac imaging (CT Angio).

The CRIA Production Programme Contract includes the clinical outcomes resulting from the clinical governance process implemented, namely mortality and readmissions. There is a clinical follow-up consultation for this purpose. Clinical outcomes are evaluated during the term of the IRB and through benchmarking against published medical literature.

CRIA's Human Resources are a fundamental pillar of CRIA's Mission, Vision and Values. The organisation of the structure is based on accountability and delegation of powers. The decision-making flowchart is flexible to allow free and spontaneous activity by all participants, with an "ad hoc" type of organisation.

Chapter V – Data analysis

5. CRIA's strategic positioning

5.1 CRIA's PESTL analysis

PESTL analysis is an essential tool for developing a systematic and proactive approach to this project. It is crucial for identifying the external factors that could influence the project, thus offering a broader vision that can help in making informed strategic decisions.

This analysis assesses the external variables, those that are outside CRIA's control and that could influence the project. This analysis allows CRIA to foresee risks and identify strategic opportunities. The analysis was carried out in order to study macro-environmental factors, politics, the economy, society, technology, the environment and legal issues.

The PESTL analysis carried out for this project is reflected in table 2 below.

Table 2 - Pestl analysis

P Politics	• Government instability; • Changing national health policies; • Changes in the administrative sector; • Outdated professional careers.
E Economy	• Hospital budget restrictions; • Inflation (7.8% in 2022 and 4.3% in 2023); • Alentejo unemployment rate (5.9% in 2023) • Recourse to European funds; • Growing tourist activity.
S Social	• Population in the Alentejo (704,707 individuals); • Ageing population (25.6% of the population >65 years); • School level (270,000 ≤ 1st cycle); • Increased migratory flows; • Overall perception and satisfaction of users in relation to CRIA; • Pressure from the media.
T Technology	• Constant technological advances; • Recent investment in technology; • Partnerships with technology companies.
L Legal	• Labour legislation; • Public procurement code; • General data protection regulation; • Budgetary rules and restrictions; • Litigation; • Informed consent.

5.2 SWOT analysis

The SWOT analysis was used to identify and assess the project's strengths, weaknesses, opportunities and threats. SWOT analysis has been adopted by numerous companies and institutions in strategic planning. Table 3 demonstrates the SWOT analysis of the proposed project.

Table 3 - SWOTs analysis

Strengths	**Weaknesses**
• Qualified/experienced staff • Innovative technology • Offering differentiated services • Ongoing research projects • Accreditation of the service and professionals • Research projects	• High staff turnover • Wear and tear on the teams • Loss of human resources • Human resources (radiologist) • Administrative procedures • Quality management • Limited facilities (changing rooms and recovery)
Opportunities	**Threats**
• Established partnerships • Partnerships with the equipment industry • High demand for the exam • Training/Internships abroad • New facilities for the future	• Dependence on study prescription (Cardiac CT Angio) • Changes in health policies • Economic crisis • Competition from other centres with identical procedures

In order to identify the internal and external factors, both favourable and unfavourable, that will enable us to achieve the desired objectives, we carried out a SWOT analysis, showing that internally there is a need to fill the shortage of radiologists to assess extra-cardiac pathologies that might appear as a "finding" when we carry out this examination. There will have to be effective management: in administrative organisation so that there is no poor patient follow-up/referral, in controlling expenditure on consumables and in the rotation of the multidisciplinary team so that there is no wear and tear and/or demotivation. In order to minimise threats to the project, criteria will be established for selecting patients who will benefit most from CT angiography and the added value of using CT angiography in the study of stable CAD as a first-line test will be made known to prescribing doctors and administrative/management bodies. Showing the importance of constant investment in human

resources and in updating equipment.

There must also be constant investment in optimising times, adjusting the number of procedures, updating the technical and scientific knowledge of the multidisciplinary team and in the quality of the services provided in order to maintain an advantage over any competition. The SWOT analysis highlighted the main strengths and weaknesses, as well as opportunities and threats, which are fundamental for identifying indicators and strategic initiatives.

5.3 Stakeholders

Stakeholders are a fundamental element in the success of any project. Stakeholders are all those who have a direct interest, or not, in the project's objectives. We can say that stakeholders play a critical role in the project's development, execution and success.

Taking into account the project's mission, vision and framework, there are various external and internal stakeholders, such as users, employees and funders.

Given the nature of the project, it is essential to assess all the stakeholders with whom ULSAC is close. Table 4 below identifies all the project's stakeholders.

Table 4 - External/Internal Stakeholders

External
• Users (citizens) • Primary health care professionals (doctors, TSDTs, nurses) • Government and Official Entities (CRIA Coordination, CA ULSAC, ACSS) • Suppliers (pharmaceutical industry and equipment/technology distributors, other suppliers) • Financiers (State/ACSS, subsystems, health insurance, European funds/programmes)
Internal
• Hospital managers - Responsible for approving and supervising the project. • Cardiology team - including cardiologists, cardiopneumologists, nurses and auxiliaries. • Radiologists - Radiology TSDT and Radiologist to interpret CT angio. • Finance Department - Analysing the economic costs and benefits of the project. • Ethics Committee - Will assess the ethical implications of using CT Angio as a first-line test.

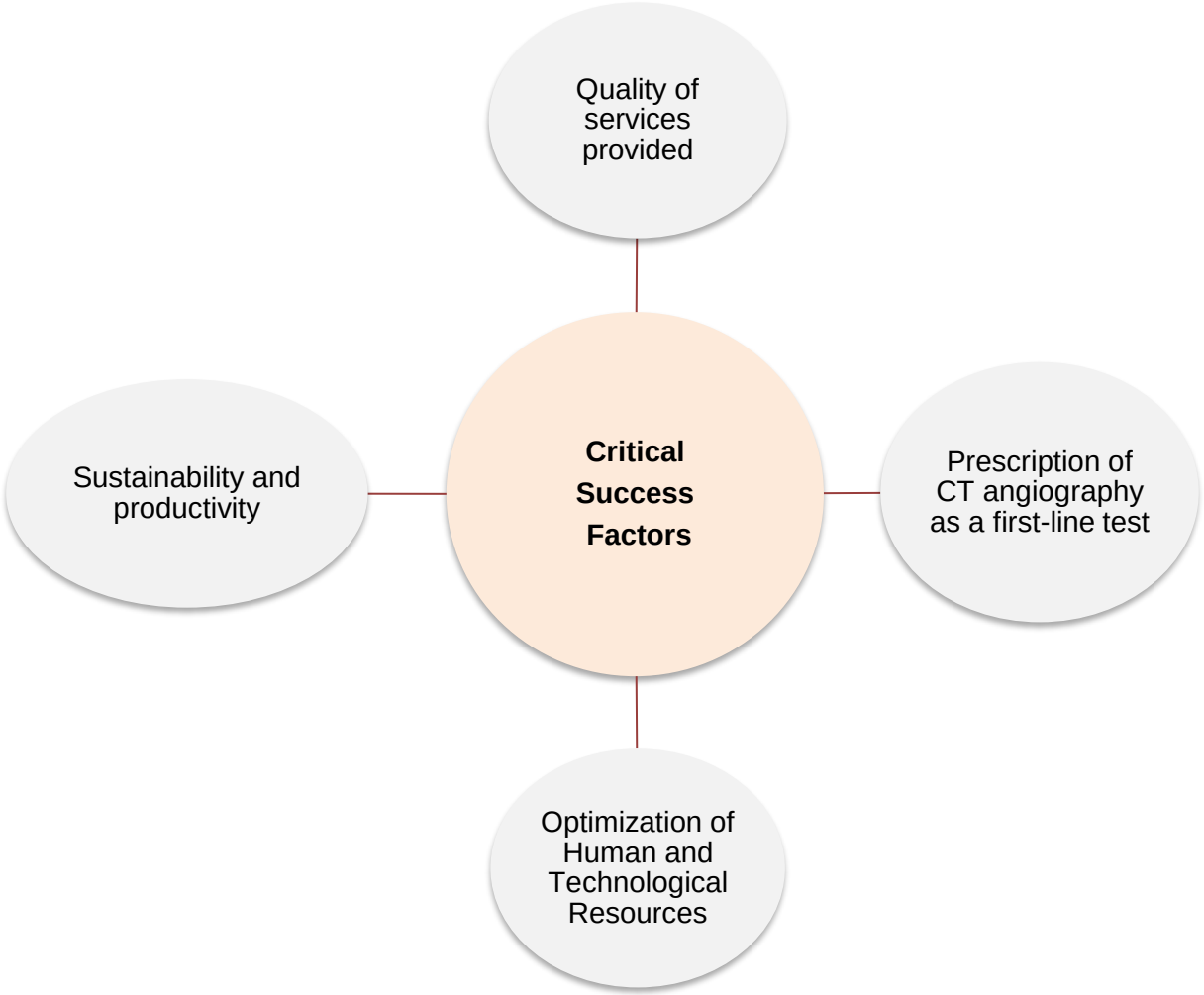
5.4 CRIA's critical success factors

Critical success factors are an essential component in achieving an organisation's objectives, they are a guide to implementing a strategy.

As this project is part of the ULSAC, it has an advantage over the competition. As it is a Local Health Unit, primary healthcare access to hospital examinations can be facilitated. However, in order to maintain the competitive edge, strong investment must be made in the continuous updating of scientific knowledge, in sustainable management, in the differentiation and quality of the service provided, in updating equipment, among other things.

Figure 7 demonstrates CRIA's critical success factors.

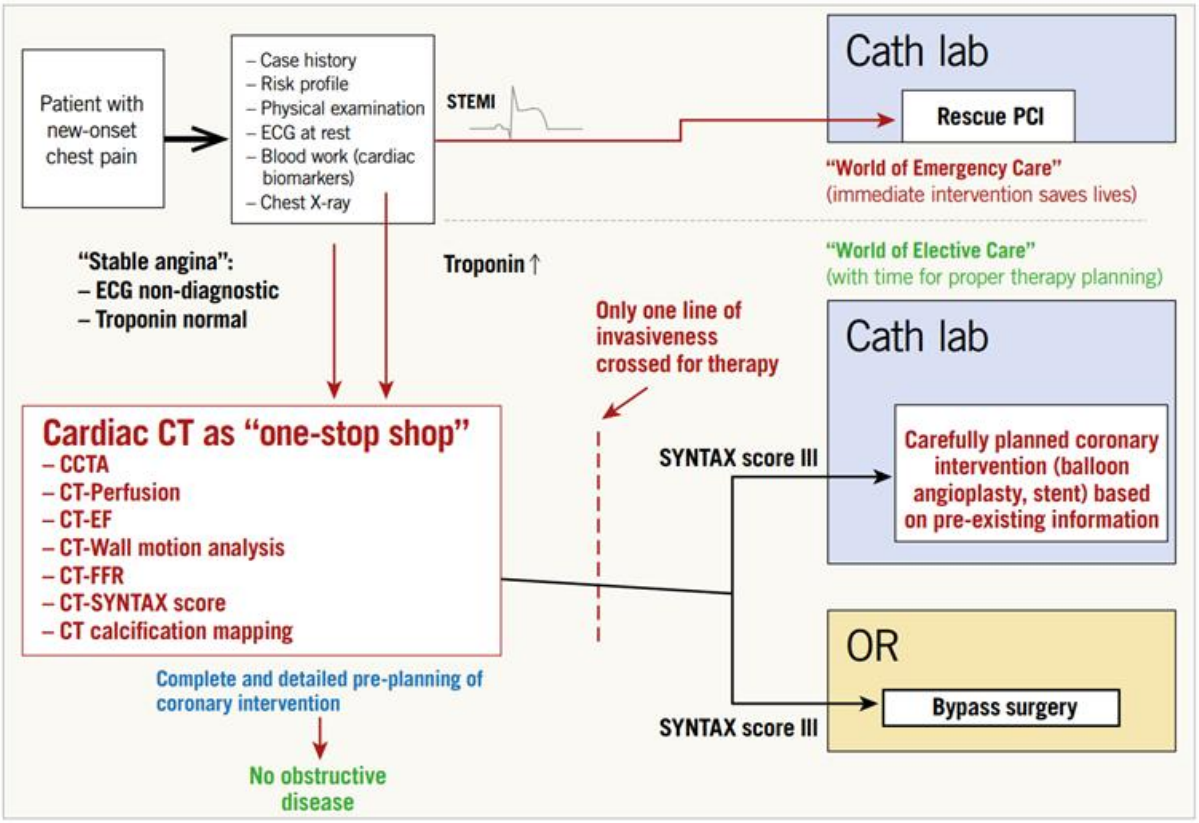
Figure 7 - Critical Success Factors



5.5 Proposed concept map

Figure 8 demonstrates the conceptual map proposed by CRIA for detecting CD.

Figure 8 - Proposed conceptual map to be realised at CRIA



5.6 General MCDT values

An analysis was made of all the MCDTs carried out at ULSAC for the diagnosis of stable CD, as well as their value in euros, according to the Ordinance published in the Diário da República, and a quantitative survey was made of the number of tests carried out throughout 2023, based on the records in ULSAC's information systems.

This analysis resulted in Table 5, which demonstrates the financial impact of these exams at the end of the year studied.

Table 5 - MCDT values

MCDT	Code	Ordinance value (€)	Exams 2023	Total Cost
Two-dimensional transthoracic echocardiography	M40560	38,80 €	129	**5 005,20 €**
Stress Echocardiogram	M40660	109,50 €	168	**18 396 €**
Test of effort	M40315	32,10 €	224	**7 190,40 €**
Stress myocardial perfusion scintigraphy	M58015	212,20 €	136	**28 859,20 €**
Myocardial perfusion scintigraphy at rest	M58020	144,75 €	136	**19 686 €**
Morphological cardiac MRI	M18111	127,90 €	125	**15 987,50 €**
Functional cardiac MRI	M18112	127,90 €	123	**15 731,70 €**
Cardiac MRI myocardial perfusion study	M18113	195,70 €	21	**4 109,70 €**
TC *Calcium score*	M16062	88,70 €	43	**3 814,10 €**
Cardiac CT (CT Angio)	M16064	196,60 €	43	**8 453,80 €**
Coronary CT	M16063	210,70 €	728	**153 389,60 €**
Catheterisation with selective coronary angiography	M40820	693,26 €	1003	**695 339,78 €**
		Total	2879	**975 962,98 €**

A survey was also carried out of the tests carried out at the ULSAC, and the number of MCDTs sent abroad, due to the inability to respond due to a lack of resources, which meant that the institution's TMRG could not be guaranteed. The years assessed were 2017 to 2019, the years before the Covid-19 pandemic, as the following years were atypical. See table 6.

Table 6 - General exam data from 2017 to 2019

			YEAR 2017			YEAR 2018			YEAR 2019		
MCDT	Code	Code DREAM	No. of MR Exams (inside)	No. of Exams MF (outside)	**Total**	No. of MR Exams (inside)	No. of MF Exams (outside)	**Total**	No. of Exams MR (inside)	No. of Exams MF (outside)	**Total**
Two-dimensional transthoracic echocardiography	M40560	C40560	23	90	113	22	68	90	39	90	129
Stress Echocardiogram	M40660	C40660	126	0	126	148	0	148	168	0	168
Test of effort	M40315	C40315	179	8	187	226	18	244	211	13	224
Stress myocardial perfusion scintigraphy	M58015	D58015	0	71	71	0	81	81	0	137	137
myocardial perfusion scintigraphy at rest	M58020	D58020	0	70	70	0	80	80	0	136	136
Morphological cardiac MRI	M18111	M18111	75	38	113	65	28	93	101	24	125
Functional cardiac MRI	M18112	M18112	74	38	112	65	28	93	99	24	123
Cardiac MRI myocardial perfusion study	M18113	M18113	0	36	36	0	27	27	0	21	21
TC *Calcium score*	M16062	M16062	0	0	0	0	23	23	0	43	43
Cardiac CT	M16064	M16064	0	12	12	0	16	16	0	23	23
Coronary CT	M16063	M16063	0	52	52	0	26	26	0	46	46
Catheterisation with selective coronary angiography	M40820	C40820	829	0	829	984	0	984	1003	0	1003

5.7 Analysing values in Euros for consumables with CT Angio

Table 7 demonstrates the amounts spent on consumables at each CT Angio.

Table 7 - Value of consumables spent per CT Angio

Consumables	Code	Description	unit	Average Price	Price pack	#	Price per patient
Abocat 18G	230023010	PERIPHERAL VEIN CATHETER 18G ANTI-SPIKE SYSTEM	UNIT	0,43 €		1	0,43 €
Bi-directional valve	230314001	BIDIRECTIONAL VALVE	UNIT	0,35 €		1	0,35 €
10ml syringe	230054002	UNRECOVERABLE LUER SYRINGE 10CC 2 PIECES	UNIT	0,04 €	0,35 x 2	2	0,07 €
Serum administration system	230063000	SERUM ADMINISTRATION SYSTEM	UNIT	0,26 €		1	0,26 €
25cm biconical valve prologator	230037000	10CM EXTENSION WITH INJECTION POINT	UNIT	2,84 €		1	2,84 €
Dilution needle	230006003	DILUTION NEEDLE 19G 1.1MMX25MM	UNIT	0,02 €		1	0,02 €
3-way tap extension	230034002	3-WAY TAP WITH EXTENSION	UNIT	0,39 €		1	0,39 €
Serum system debit controller	230063002	DEBIT CONTROLLER FOR SERUM SYSTEM	UNIT	0,51 €		1	0,51 €
Non-sterile gloves	220048001	NITRILE GLOVE WITHOUT POWDER SIZE M	UNIT	0,03 €		5	0,17 €
100cm extension	230010001	100CM EXTENDER	UNIT	0,26 €		1	0,26 €
Garrote	290670580	TOURNIQUET WITHOUT LATEX	UNIT	0,19 €		1	0,19 €
Electrodes (4)	240004000	LONG-LIFE ADULT MONITORING ELECTRODE	UNIT	0,06 €	0.62 pcs x 4	4	0,25 €
Hydrophilic gauze compress 10x10cm	210012014	HYD GAUZE PAD 10CMX10CM WITHOUT CONTRAST STERILE	UNIT	0,02 €		1	0,02 €
Non-woven adhesive	210005000	ADHESIVE BACKING ON FABRIC 10CMX10MT	BOBIN	1,38 €	1,46	0,1	0,14 €
TC injector syringe system	290496000				2.31/10 patients	1	0,23 €
Disinfectant	11012137				6.05 bottle	1	0,10 €
Nitromint	10046074	Nitroglycerin 0.5 mg sublingual tablet		0,16 €		1	0,16 €
Metoprolol 100mg	10049227	Metoprolol 100 mg Comp		0,05 €		1	0,05 €
Ivabradrine 7.5 mg	10043509	Ivabradine 7.5 mg Comp		0,24 €		1	0,24 €
TC injector extension system	29067004				33.21/10 patients	1	3,32 €
Contrast 350l 200ml	10032263	Low-osmolarity non-ionic radiological MC 27		23,30 €	23,3 / 2	0,5	11,65 €
Total							**21,66 €**

5.8 Analysing HR costs

Each AngioTC shift is attended by 1 member of each professional class. The amount spent per year was estimated for each. The figures are shown in tables 8 and 9.

Table 8 - HR spending per year / Full time

	Basic pay	Annual Basic Pay	sub Holidays + Christmas	social charges	Meal Allowance	Annual total
Cardiologist	2 779,29 €	33 351 €	5 559 €	9 241 €	1 373 €	49 524 €
TSDT Radiology	1 200,00 €	14 400 €	2 400 €	3 990 €	1 373 €	22 163 €
Nurse	1 200,00 €	14 400 €	2 400 €	3 990 €	1 373 €	22 163 €
Administrative assistant	757,01 €	9 084 €	1 514 €	2 517 €	1 373 €	14 488 €
Operational Assistant	705,00 €	8 460 €	1 410 €	2 344 €	1 373 €	13 587 €
						121 925 €

Table 9 - HR spending by exam

	Basic pay	No. of hours/week	Value / Hour	Value / Hour with social charges
Cardiologist	2 779,29 €	40	16,03 €	19,84252716€
Radiology Technician (TSDT)	1 200,00 €	35	7,91 €	9,791208791€
Nurse	1 200,00 €	35	7,91 €	9,791208791€
Administrative assistant	757,01 €	35	4,99 €	6,176702473€
Operational Assistant	705,00 €	35	4,65 €	5,752335165€
Cost/exam (1 per hour)				**51.49 €**

5.9 Analysing the costs of the proposed CT Angio

A comparison was made between the values in Euros paid by HESE (ULSAC) and the Installed Capacity Vs. Proposed Capacity, as shown in Table 10. The average value of each exam was calculated by adding the amount spent on consumables (21.66€) to the amount spent on HR (51.49€), giving a total of 63.15€/exam.

Table 10 - Using capacity vs. Increased capacity utilization

	Weekly times (7h per shift)	No. of exams Shift	No. of weekly exams	Week No.	No. of annual exams	Average cost per test	Total Cost
Using capacity	2	7	14	52	728	63,15	45 973 €
Increased capacity utilization	4	7	28	52	1456	63,15	91 946,40€

This figure of four shifts was arrived at by taking into account the HR available and capable of carrying out this exam. There are, however, professionals in training, but not yet autonomous. At the moment, the average annual capacity for CT angio is 728 exams, with this exam being carried out 1 shift a week, out of 10 possible shifts (5 mornings and 5 afternoons).

Once the project is implemented, it is proposed that 1,456 examinations will be carried out in one year, increasing the number of shifts to four a week.

The amount spent by ULSAC on sending tests to be carried out in Lisbon was calculated, namely stress myocardial perfusion scintigraphy (136 tests/year). The cost is borne whenever the patient is hospitalised or unable to afford outpatient treatment. We know that the cost that ULSAC incurs with each MCDT is increased by a not insignificant 0.58€/Km.

Each journey calculates approximately 250 kilometres from Évora to Lisbon to Évora. An average of 136 tests are currently sent out, so we arrive at a figure of 19 720€ per year spent on patient transport.

Implementing the project means changing the number of tests carried out to detect stable CD per year. It implies a 100 per cent decrease in some tests, a 50 per cent decrease in most MCDTs and a 100 per cent increase in CT angio.

The figures obtained are shown in the table 11.

Table 11 - Expected saving values

MCDT	Code	Ordinance value (€)	Current Test Capacity	Total Cost 2023	Test-taking capacity	Total Cost During the project	Saving
Two-dimensional transthoracic echocardiography	M40560	38,80 €	130	5 044,00 €	0	0 100%	-5 044,00 €
Stress Echocardiogram	M40660	109,50 €	170	18 615 €	85	9 307,50 € 50%	-9 308 €
Test of effort	M40315	32,10 €	220	7 062,00 €	110	3 531,00 € 50%	-3 531,00 €
Stress myocardial perfusion scintigraphy	M58015	212,20 €	136	28 859,20 €	68	14 429,60 € 50%	-14 429,60 €
Myocardial perfusion scintigraphy at rest	M58020	144,75 €	136	19 686 €	68	9 843,00 € 50%	-9 843,00 €
Morphological cardiac MRI	M18111	127,90 €	126	16 115,40 €	63	8 057,70 € 50%	-8 057,70 €
Functional cardiac MRI	M18112	127,90 €	120	15 348,00 €	60	7 674,00 € 50%	-7 674,00 €
Cardiac MRI myocardial perfusion study	M18113	195,70 €	30	5 871,00 €	15	2 935,50 € 50%	-2 935,50 €
TC *Calcium score*	M16062	88,70 €	80	7 096,00 €	0	0 € 100%	-7 096,00 €
CT angio	M16064	196,60 €	80	15 728,00 €	40	7 864,00 € 50%	-7 864,00 €
CT Coronary	M16063	210,70 €	725	152 757,50 €	1456	306 779 € 100%	154 021,5 €
Catheterisation with selective coronarography *	M40820	833,42 €	1 003	835 920,26 €	400	333 368,00 € 60%	-502 552,26 €
		Total	2 567	1 116 935,26 €	2 253	680 191,10 €	**- 417 217,56€**

Expected annual "saving

5.10 Analysing annual project spending

After collating all the amounts spent on HR, the amount spent on clinical material and medicines per year, we arrived at the figure of 91 946,40€, which is the annual amount expected to be spent on implementing this project, as shown in Table 12.

Table 12 - Expenditure per exam/year

	HR/exam expenses	Clinical Material Medicines	Value Total/exam	Annual budget requirement (1456 exams)
Exam cost	51,49 €	21,66 €	63,15 €	91 946,40 €

Chapter VI - Discussion

6. Discussion of Results

A review of the results yielded by this project indicates that it may serve as a reliable strategy for reducing costs and MCDTs in a targeted manner, while also redirecting resources. The figures demonstrate the economic viability and efficiency gains that would result from implementing the project, thereby reinforcing the case for optimising healthcare resources. It is imperative to underscore the significance of these findings.

The total expenditure on human resources, clinical materials and medicines per AngioTC examination was found to be 63,15€.

The complete elimination of two-dimensional transthoracic echocardiograms and calcium score CTs for the detection of stable CAD will result in an annual saving of 12 140€. A reduction of 60% in the number of catheterisations with selective coronary angiography, from 1003 to 400, will result in savings of 502 552,26€. This adjustment permits the reallocation of resources towards less invasive and less costly examinations, thereby facilitating an approach that prioritises economy and patient safety. A 50% reduction in the number of resting myocardial perfusion scintigraphies and a 50% reduction in the number of stress myocardial perfusion scintigraphies will result in savings of 9 843€ per year and 14 429,60€ per year, respectively. The project advocates for the elimination of these tests while ensuring the diagnosis of stable CAD remains uncompromised. An increase of 100% in the number of CT angiography examinations, from 725 per year to 1456, would result in estimated costs of 99 980,16€, thereby reinforcing the less invasive diagnosis.

The combination of the aforementioned reductions and the increase in CT angiography results in an estimated saving of 417 217,56€ per year in MCDTs for the detection of stable CAD. Furthermore, the aforementioned figure must be augmented by the 19 720€ saved on transporting patients to undertake MCDTs abroad. This results in an overall annual saving on MCDTs of 436 937,56€. However, in order to obtain an accurate estimation of the financial impact of the proposed changes, it is necessary to exclude the anticipated expenditure of 91 946,40€ per year, which would be incurred if four weekly CT angio shifts were to be conducted.

This results in a financial impact with a "saving" value of 344 991,16€ per year, which represents the final forecast. This annual saving demonstrates the project's potential to optimise financial efficiency without compromising the quality of the services provided, thereby achieving the central objective of the study.

6.1 Interpretation of Key Findings

The projected annual savings of 344 991,16€ demonstrate the financial viability of integrating CT angio into routine diagnostic workflows. This figure is driven by a substantial reduction in redundant or less effective diagnostic tests and an increase in the efficiency of diagnostic pathways. It is worthy of note that stress myocardial perfusion scintigraphy, which is currently one of the most expensive tests in the protocol, would see a 50% reduction, resulting in significant cost savings. Similarly, invasive procedures such as cardiac catheterisation, which should be reserved for conclusive diagnoses, could also be minimised.

Moreover, the implementation of CT angio is substantiated by findings from extensive clinical trials, such as the SCOT-HEART study, and recommendations from the European Society of Cardiology (ESC). These sources corroborate the efficacy of CT angiography as a diagnostic instrument, attesting to its superior accuracy and robust negative predictive value. This ensures the prompt and accurate identification of coronary artery disease, which is essential for prompt intervention and enhanced long-term patient outcomes.

6.2 Economic and Operational Analysis

The financial analysis demonstrates not only the direct cost savings but also broader systemic efficiencies. To illustrate, a reduction in the number of multislice computed tomography (MSCT) scans required: A 50% reduction in the number of traditional diagnostic tests conducted allows for the reallocation of resources, including staff time and equipment, which can be redirected toward addressing other critical healthcare needs.

A reduction in the costs associated with the transportation of patients. The centralisation of CT angio at ULSAC has the effect of reducing the necessity for patient transport to external facilities. This results in a saving of approximately 19 720€ per year in transportation costs.

The optimal distribution of resources: The objective of the project is to double the capacity for CT angio examinations, thereby ensuring that existing infrastructure and human resources are optimally utilised, reducing bottlenecks and wait times.

These operational improvements not only enhance cost efficiency but also improve the overall patient experience by reducing diagnostic delays and providing quicker, more reliable results.

6.3 Clinical implications and patient outcomes

The superiority of CT angio lies in its capacity to provide high-resolution imaging of coronary anatomy and plaque characteristics, which are pivotal for risk stratification and management. It is anticipated that the integration of this modality into routine practice will have a number of downstream effects on patient care.

It is anticipated that there will be a reduction in the number of invasive procedures. The high diagnostic accuracy of CT angio reduces the number of unnecessary referrals for cardiac catheterisation, an invasive and costly procedure.

Enhanced diagnostic speed and accuracy. The non-invasive nature and real-time imaging capability of CT angio facilitate more expedient and precise diagnoses, thereby reducing the risk of disease progression due to delays.

Another potential benefit is improved risk stratification. By identifying both calcified and non-calcified plaques, CT angio provides a more comprehensive assessment of the atherosclerotic burden, which in turn allows for the implementation of more tailored therapeutic interventions.

Chapter VII - Conclusion

7. Conclusion

In conclusion, the increasing prevalence of cardiovascular diseases, particularly stable CAD, represents a significant challenge for healthcare systems globally. This dissertation has examined the transformative role of coronary computed tomography angiography (CT angio) in addressing these challenges, demonstrating its efficacy as a first-line diagnostic tool. By conducting an exhaustive examination of its clinical and economic implications, this study demonstrates that CT Angio has the potential to enhance healthcare provision, inform future guidelines and improve patient outcomes within the National Health Service (NHS) and beyond.

The adoption of CT angio as a primary diagnostic modality represents a significant advance in the optimisation of healthcare delivery. The provision of precise, non-invasive imaging facilitates not only an early and accurate diagnosis, but also a reduction in the necessity for multiple diagnostic tests, invasive procedures and extensive consultations. This streamlined approach has the potential to improve patient pathways, decrease waiting times and enhance resource utilisation. For healthcare providers, the capacity to deliver diagnoses in a more expedient and dependable manner reinforces the overall quality of care and aligns with the mounting demand for efficacious and patient-centric services.

From an economic standpoint, the findings of this study underscore the cost-effectiveness of CT angio. The consolidation of diagnostic pathways enables the reduction of unnecessary expenditure on supplementary diagnostic techniques (MCDTs) and invasive procedures. This is particularly pertinent in contexts where resources are constrained, such as in Portugal, where healthcare systems are under pressure to maintain fiscal sustainability while responding to rising demands. The implementation of CT Angio within the SNS has the potential to alleviate these pressures by promoting a high-value care model that maximises clinical benefits while minimising costs.

Furthermore, the study offers crucial insights into the impact of CT Angio on the development of future clinical guidelines. In light of the growing emphasis on non-invasive diagnostic methods in international recommendations, such as those from the European Society of Cardiology (ESC) and the National Institute for Health and Care Excellence (NICE), this research supports the inclusion of CT Angio as a standard of care for stable CAD. The evidence presented herein supports the integration of this technology into updated national and international guidelines, ensuring consistency in practice and promoting equitable access to advanced diagnostic technologies.

From the perspective of healthcare provision, the broader implementation of CT angio has the potential to result in significant systemic improvements. By reducing the diagnostic burden on tertiary care centres, this technology enables a redistribution of healthcare resources, allowing specialists to focus on more complex cases. Moreover, the non-invasive nature of the procedure enhances patient compliance and satisfaction, particularly in cases where the pre-test probability of CAD is intermediate or low.

In the future, this research will facilitate further investigation into the long-term effects of CT angio on patient outcomes and healthcare systems. Further studies should evaluate the potential of this technology to reduce cardiovascular event rates, improve quality-adjusted life years (QALYs), and support population-wide risk stratification efforts. Furthermore, an additional avenue for investigation would be the integration of this technology with emerging techniques such as artificial intelligence for image analysis and predictive modelling, which could potentially enhance its diagnostic and prognostic capabilities.

In conclusion, the incorporation of CT angio into standard diagnostic procedures represents a significant shift in the approach to the management of stable coronary artery disease. By enhancing diagnostic precision, simplifying healthcare provision and reducing expenditure, this technology is aligned with the overarching objectives of contemporary healthcare systems. The findings of this dissertation provide a robust foundation for policy changes and guideline updates, and contribute to the ongoing pursuit of excellence in cardiovascular care. The adoption of CT angiography on a large scale has the potential to transform healthcare provision, improve patient outcomes and establish new standards for diagnostic precision and efficiency.

7.1 Limitations

The use of CT angiography is limited by the exposure to radiation, which can create resistance to frequent use in low-risk patients or young people due to the risks associated with cumulative exposure.

The test is not without limitations, particularly in the assessment of calcified lesions and in instances where calcifications are present along the coronary arteries. In such cases, the accuracy of detecting stable coronary disease may be compromised.

This study projects the potential savings if the number of AngioCT scans carried out at CRIA were to double. However, the number of tests prescribed will be contingent on a number of

factors, including the level of engagement of certain stakeholders, such as FGM doctors and other medical specialities who may not be fully conversant with the relevance of CT angiography.

It is imperative to continually identify and implement alternative solutions to overcome the challenges, ensuring an accurate and effective diagnosis.

7.2 Future lines of research

It is recommended that future research should focus on the concept of "saving" in healthcare, with a view to extending this type of study to other MCDTs in order to facilitate continuous improvement in the SNS and its sustainability. Further studies should be conducted and published with the aim of assessing the cost-effectiveness and cost-utility of health technologies and MCDTs. This should include an investigation of approaches to minimising direct and indirect costs, both tangible and intangible.

Further research is required to identify methods for enhancing the efficiency of the NHS. This should include the examination of indicators such as the Case Mix Index and other performance metrics, particularly in contexts where resources are scarce. The objective is to optimise the utilisation of technologies while simultaneously improving sustainability and access to quality healthcare.

Such studies can assist in the expansion and optimisation of health resource allocation, and further research is required to analyse evidence-based allocation models.

The development of new management tools for MCDTs is essential, particularly in contexts where the implementation of certain MCDTs is necessary to reduce waiting times for patients.

These types of studies provide fundamental data for decision-making and should focus on understanding how health policies can be optimised in order to maximise the positive economic impact on health systems. In order to achieve this, it is vital to conduct a thorough analysis of the current policies in place and to develop new proposals.

It thus appears imperative to augment the number of research centres specialising in economic studies within the domain of health. These lines of research have the potential to transform the way in which health technologies are assessed and implemented, thereby promoting the sustainability and efficiency of health systems.

Bibliography

ACSS. (n.d.). *Unidades locais de saúde*. https://www.acss.min-saude.pt

Altman, D. G., & Bland, J. M. (1994). Diagnostic tests. 1: Sensitivity and specificity. *BMJ, 308*(6943), 1552. https://doi.org/10.1136/bmj.308.6943.1552

Anastasius, M. B. B., Mugharbil, A., Zamorano, M. G., Murphy, D. T., & Leipsic, J. (2019). The value of imaging—the case for coronary computed tomography angiography. *Journal of Thoracic Imaging, 34*(1), 2-3. https://doi.org/10.1097/RTI.0000000000000381

Arbab-Zadeh, A. (2018). O desafio de relatar efetivamente os resultados da angiografia coronária por tomografia computadorizada. *JAMA Cardiology, 11*(1), 90–93. https://doi.org/10.1016/j.jcmg.2017.09.007

Arbab-Zadeh, A., Frazier, C. G., Philips, D. R., & Bauer, D. C. (2022). The role of coronary computed tomography angiography in the evaluation of coronary artery disease: A review. *JAMA Cardiology, 7*(8), 747–754. https://doi.org/10.1001/jamacardio.2022.1341

Barros, P. P. (2013). Custos da saúde: Alguns princípios. *Acta Médica Portuguesa, 26*(5), 496–498.

Benenati, S., Campo, G., Seitun, S., Caglioni, S., Leone, A. M., & Porto, I. (2024). Ischemia with non-obstructive coronary artery (INOCA): Non-invasive versus invasive techniques for diagnosis and the role of #FullPhysiology. *European Journal of Internal Medicine, 127*, 15–24. https://doi.org/10.1016/J.EJIM.2024.07.017

Bertoldi, E. G., Stella, S. F., Rohde, L. E. P., & Polanczyk, C. A. (2017). Cost-effectiveness of anatomical and functional test strategies for stable chest pain: Public health perspective from a middle-income country. *BMJ Open, 7*(4), e012652. https://doi.org/10.1136/bmjopen-2016-012652

Bettencourt, N., Mendes, L., Fontes, J. P., Matos, P., Ferreira, C., Botelho, A., Carvalho, S., Durazzo, A., Faustino, A., Ladeiras Lopes, R., Vasconcelos, M., Vieira, C., Correia, M., Ferreira, A. M., Ferreira, N., Pires-Morais, G., Almeida, A. G., Ferreira, M. J. V., & Teixeira, M. (2022). Documento de consenso sobre estratificação de risco cardiovascular e estudo da doença coronária em Portugal: A posição dos grupos de estudo de cardiologia nuclear, ressonância magnética e tomografia computorizada cardíaca, de ecocardiografia e de fisiopatologia do esforço e reabilitação cardíaca. *Revista Portuguesa de Cardiologia, 41*(3), 241–251. https://doi.org/10.1016/J.REPC.2020.10.009

Bleichrodt, H., & Quiggin, J. (1999). Life-cycle preferences over consumption and health: When is cost-effectiveness analysis equivalent to cost–benefit analysis? *Journal of Health Economics, 18*(6), 681–708. https://doi.org/10.1016/S0167-6296(99)00014-4

Boerhout, C. K. M., Feenstra, R. G. T., Somsen, G. A., Appelman, Y., Ong, P., Beijk, M. A. M., Hofstra, L., van de Hoef, T. P., & Piek, J. J. (2021). Coronary computed tomographic angiography as gatekeeper for new-onset stable angina. *Netherlands Heart Journal: Monthly Journal of the Netherlands Society of Cardiology and the Netherlands Heart Foundation, 29*(11), 551–556. https://doi.org/10.1007/s12471-021-01639-7

Bourbon, M., Alves, A. C., & Rato, Q. (2019). *Prevalência de fatores de risco cardiovascular na população portuguesa*. Instituto Nacional de Saúde Doutor Ricardo Jorge. https://www.insa.min-saude.pt/wp-content/uploads/2020/02/e_COR_relatorio.pdf

Burch, R. A., Siddiqui, T. A., Tou, L. C., Turner, K. B., & Umair, M. (2023). The cost-effectiveness of coronary CT angiography and the effective utilization of CT-fractional flow reserve in the diagnosis of coronary artery disease. *Journal of Cardiovascular Development and Disease, 10*(1), 25. https://doi.org/10.3390/jcdd10010025

Carmo, P. B. D., Magliano, C. A. D. S., Rey, H. C. V., Camargo, G. C., Trocado, L. F. L., & Gottlieb, I. (2022). Cost-effectiveness analysis of CCTA in SUS, as compared to other non-invasive imaging modalities in suspected obstructive CAD. *Arquivos Brasileiros de Cardiologia, 118*(3), 578–585. https://doi.org/10.36660/abc.20201050

Chang, H., Lin, F., Gebow, D., et al. (2019). Selective referral using CCTA versus direct referral for individuals referred to invasive coronary angiography for suspected CAD: A randomized, controlled, open-label trial. *JAMA Cardiology, 12*(7_Part_2), 1303–1312. https://doi.org/10.1016/j.jcmg.2018.09.018

Conselho das Finanças Públicas. (2023). *Relatório do Conselho das Finanças Públicas*. https://www.cfp.pt/uploads/publicacoes_ficheiros/cfp-rel-07-2023.pdf

Corballis, N., Tsampasian, V., Merinopoulis, I., Gunawardena, T., Bhalraam, U., Eccleshall, S., Dweck, M. R., & Vassiliou, V. (2023). CT angiography compared to invasive angiography for stable coronary disease as predictors of major adverse cardiovascular events: A systematic review and meta-analysis. *Heart & Lung, 57*, 207–213. https://doi.org/10.1016/J.HRTLNG.2022.09.018

Costa, J., Alarcão, J., Amaral-Silva, A., Araújo, F., Ascenção, R., Caldeira, D., Cardoso, M. F., Correia, M., Fiorentino, F., Gavina, C., Gil, V., Gouveia, M., Lourenço, F., Mello e Silva, A.,

Mendes Pedro, L., Morais, J., Vaz-Carneiro, A., Teixeira Veríssimo, M., & Borges, M. (2021). Os custos da aterosclerose em Portugal. *Revista Portuguesa de Cardiologia, 40*(6), 409–419. https://doi.org/10.1016/J.REPC.2020.08.007

Dell'Aversana, S., Ascione, R., Vitale, R. A., Cavaliere, F., Porcaro, P., Basile, L., Napolitano, G., Boccalatte, M., Sibilio, G., Esposito, G., Franzone, A., Di Costanzo, G., Muscogiuri, G., Sironi, S., Cuocolo, R., Cavaglià, E., Ponsiglione, A., & Imbriaco, M. (2023). CT coronary angiography: Technical approach and atherosclerotic plaque characterization. *Journal of Clinical Medicine, 12*(24), 7615. https://doi.org/10.3390/jcm12247615

Diário da República. (2017, julho 11). *1.ª série—N.º 132*. https://www.dre.pt

Doolub, G., Mamalakis, M., Alabed, S., Van der Geest, R. J., Swift, A. J., Rodrigues, J. C., … & Dastidar, A. (2023). Artificial intelligence as a diagnostic tool in non-invasive imaging in the assessment of coronary artery disease. *Medical Sciences, 11*(1), 20. https://doi.org/10.3390/medsci11010020

Eichler, H. G., Kong, S. X., Gerth, W. C., Mavros, P., & Jönsson, B. (2004). Use of cost-effectiveness analysis in health-care resource allocation decision-making: How are cost-effectiveness thresholds expected to emerge? *Value in Health, 7*(5), 518–528. https://doi.org/10.1111/J.1524-4733.2004.75003.X

ESC Scientific Document Group. (2020). 2019 ESC guidelines for the diagnosis and management of chronic coronary syndromes. *European Heart Journal, 41*(3), 407–477. https://doi.org/10.1016/j.rec.2020.05.011

Faria Alves, M., Ferreira, A. M., Cardoso, G., Lopes, R. S., Correia, M. D. G., & Gil, V. M. (2013). Probabilidade teórica de doença coronária pré- e pós-teste em duas estratégias diagnósticas – Contributo relativo da prova de esforço e da angio-TC cardíaca. *Revista Portuguesa de Cardiologia, 32*(3), 211–218.

Ferreira, A. M., Bettencourt, N., Matos, P., Oliveira, L., & Almeida, A. G. (2013). Familiaridade e perceções dos cardiologistas portugueses acerca da ressonância magnética cardíaca e angio-TC cardíaca - Dimensão da tarefa à nossa frente. *Revista Portuguesa de Cardiologia, 32*(7–8), 601–608. https://doi.org/10.1016/j.repc.2012.11.004

Ferreira, A. M., Marques, H., Gonçalves, P. A., & Cardim, N. (2014). Cost-effectiveness of different diagnostic strategies in suspected stable coronary artery disease in Portugal. *Arquivos Brasileiros de Cardiologia, 102*(4), 391–402. https://doi.org/10.5935/abc.20140042

Finck, T., Hardenberg, J., Will, A., et al. (2019). Acompanhamento de 10 anos após angiotomografia computadorizada coronária em pacientes com suspeita de doença arterial coronária. *J Am Coll Cardiol Img, 12*(7_Part_2), 1330–1338. https://doi.org/10.1016/j.jcmg.2018.07.020

Force, T., Gilles, M., Chairperson, M., et al. (2013). 2013 ESC guidelines on the management of stable coronary artery disease: The Task Force on the management of stable coronary artery disease. *European Heart Journal, 34*(39), 2949-3003. https://doi.org/10.1093/eurheartj/eht296

Gerber, T. C., Carr, J. J., Arai, A. E., Dixon, R. L., Ferrari, V. A., Gomes, A. S., et al. (2009). Ionizing radiation in cardiac imaging: A science advisory from the American Heart Association Committee on Cardiac Imaging of the Council on Clinical Cardiology and Committee on Cardiovascular Imaging and Intervention of the Council on Cardiovascular Radiology and Intervention. *Circulation, 119*(7), 1056–1065.

Gilard, M., Le Gal, G., Cornily, J. C., Vinsonneau, U., Joret, C., Pennec, P. Y., Mansourati, J., & Boschat, J. (2007). Midterm prognosis of patients with suspected coronary artery disease and normal multislice computed tomographic findings: A prospective management outcome study. *Archives of Internal Medicine, 167*(15), 1686–1689. https://doi.org/10.1001/archinte.167.15.1686

Ginsburg, M. E., Kravitz, R. L., & Sandberg, W. A. (2000). A survey of physician attitudes and practices concerning cost-effectiveness in patient care. *Western Journal of Medicine, 173*(6), 390–394. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1071190/

Goetz, C., Rotman, S. R., Hartoularos, G., & Bishop, T. F. (2015). The effect of charge display on cost of care and physician practice behaviors: A systematic review. *Journal of General Internal Medicine, 30*(6), 835–842. https://doi.org/10.1007/s11606-015-3226-5

Gorenoi, V., Schönermark, M. P., & Hagen, A. (2012). CT coronary angiography vs. invasive coronary angiography in CHD. *GMS Health Technology Assessment, 8*, Doc02. https://doi.org/10.3205/hta000100

Hadamitzky, M., Achenbach, S., Al-Mallah, M., Berman, D., Budoff, M., Cademartiri, F., et al. (2013). Optimized prognostic score for coronary computed tomographic angiography: Results from the CONFIRM registry (COronary CT Angiography EvaluatioN For Clinical Outcomes: An InteRnational Multicenter Registry). *J Am Coll Cardiol, 62*(5), 468–476.

Hamm, C. W., Albrecht, A., Bonzel, T., Kelm, M., Lange, H., Schachinger, V., et al. (2008).

Cateterismo cardíaco diagnóstico. *Clinical Research in Cardiology, 97*(8), 475–512. Errata em *Clinical Research in Cardiology, 97*(12), 925.

Hebbo, E., Khan, S., Manzo-Silberman, S., & Alasnag, M. (2024). The clinical approach to angina in women. *Interventional Cardiology Clinics*. https://doi.org/10.1016/J.ICCL.2024.08.001

Holman, D. J. (2000). The objective measurement of subjective quality in health care delivery. *International Journal for Quality in Health Care, 12*(3), 183–193.

International Organization for Standardization. (2015). *ISO 9001:2015 - Sistemas de gestão da qualidade - Requisitos*. Geneva, Switzerland: International Organization for Standardization.

Jaarsma, C., Leiner, T., Bekkers, S. C., Crijns, H. J., Wildberger, J. E., Nagel, E., et al. (2012). Diagnostic performance of noninvasive myocardial perfusion imaging using single-photon emission computed tomography, cardiac magnetic resonance, and positron emission tomography imaging for the detection of obstructive coronary artery disease: A meta-analysis. *J Am Coll Cardiol, 59*(19), 1719–1728.

Juarez-Orozco, L. E., Saraste, A., Capodanno, D., Prescott, E., Ballo, H., Bax, J. J., Wijns, W., & Knuuti, J. (2019). Impact of a decreasing pre-test probability on the performance of diagnostic tests for coronary artery disease. *European Heart Journal - Cardiovascular Imaging, 20*(11), 1198–1207. https://doi.org/10.1093/ehjci/jez054

Karády, J., Mayrhofer, T., Ivanov, A., Foldyna, B., Lu, M. T., Ferencik, M., Pursnani, A., Salerno, M., Udelson, J. E., Mark, D. B., Douglas, P. S., & Hoffmann, U. (2020). Cost-effectiveness analysis of anatomic vs functional index testing in patients with low-risk stable chest pain. *JAMA Network Open, 3*(12), e2028312. https://doi.org/10.1001/jamanetworkopen.2020.28312

Knuuti, J., Ballo, H., Juarez-Orozco, L. E., Saraste, A., Kolh, P., Rutjes, A. W. S., Jüni, P., Windecker, S., Bax, J. J., & Wijns, W. (2018). The performance of non-invasive tests to rule-in and rule-out significant coronary artery stenosis in patients with stable angina: A meta-analysis focused on post-test disease probability. *European Heart Journal, 39*(35), 3322–3330. https://doi.org/10.1093/eurheartj/ehy267

Knuuti, J., Wijns, W., Saraste, A., Capodanno, D., Barbato, E., Funck-Brentano, C., Prescott, E., Storey, R. F., Deaton, C., Cuisset, T., Agewall, S., Dickstein, K., Edvardsen, T., Escaned, J., Gersh, B. J., Svitil, P., Gilard, M., Hasdai, D., Hatala, R., Mahfoud, F., … ESC

Scientific Document Group. (2020). 2019 ESC guidelines for the diagnosis and management of chronic coronary syndromes. *European Heart Journal, 41*(3), 407–477. https://doi.org/10.1093/eurheartj/ehz425

Kodeboina, M., Piayda, K., Jenniskens, I., Vyas, P., Chen, S., Pesigan, R. J., Ferko, N., Patel, B. P., Dobrin, A., Habib, J., & Franke, J. (2023). Challenges and burdens in the coronary artery disease care pathway for patients undergoing percutaneous coronary intervention: A contemporary narrative review. *International Journal of Environmental Research and Public Health, 20*(9), 5633. https://doi.org/10.3390/ijerph20095633

Kumar, P., & Bhatia, M. (2022). Role of CT in the pre-and postoperative assessment of conotruncal anomalies. *Radiology: Cardiothoracic Imaging, 4*(3), e210089.

Lorenzoni, V., Bellelli, S., Caselli, C., et al. (2019). Cost-effectiveness analysis of stand-alone or combined non-invasive imaging tests for the diagnosis of stable coronary artery disease: Results from the EVINCI study. *European Journal of Health Economics, 20*(10), 1437–1449. https://doi.org/10.1007/s10198-019-01096-5

Machaalany, J., Yam, Y., Ruddy, T. D., Abraham, A., Chen, L., Beanlands, R. S., & Chow, B. J. W. (2009). Potential clinical and economic consequences of noncardiac incidental findings on cardiac computed tomography. *Journal of the American College of Cardiology, 54*(16), 1533–1541. https://doi.org/10.1016/j.jacc.2009.06.026

Manubolu, V. S., Ichikawa, K., & Budoff, M. J. (2024). Innovations in cardiac computed tomography: Imaging in coronary artery disease. *Progress in Cardiovascular Diseases, 84*, 51–59. https://doi.org/10.1016/j.pcad.2024.05.005

Minossi, J. G., & Silva, A. L. da. (2013). Medicina defensiva: Uma prática necessária? *Revista do Colégio Brasileiro de Cirurgiões, 40*(6), 494–501. https://doi.org/10.1590/s0100-69912013000600013

Mitropoulos, P., Vasileiou, K., & Mitropoulos, I. (2018). Understanding quality and satisfaction in public hospital services: A nationwide inpatient survey in Greece. *Journal of Retailing and Consumer Services, 40*, 270–275. https://doi.org/10.1016/j.jretconser.2017.03.004

Morgan, M. (1999). Patient satisfaction. In S. F. Isenberg & R. E. Gliklich (Eds.), *Profiting from quality: Outcomes strategies for medical practice* (p. 6). Jossey-Bass Publishers.

Moss, A. J., Williams, M. C., Newby, D. E., & Nicol, E. D. (2017). The updated NICE guidelines: Cardiac CT as the first-line test for coronary artery disease. *Current Cardiovascular Imaging*

Reports, 10(5), 15. https://doi.org/10.1007/s12410-017-9412-6

Neglia, D., Chiappino, D., & Magnoni, M. (2015). Lo studio SCOT-HEART. *Giornale Italiano di Cardiologia, 16*(11), 601–607. https://doi.org/10.1714/2066.22424

Neglia, D., Rovai, D., Caselli, C., Pietila, M., Teresinska, A., Aguade-Bruix, S., et al. (2015). Detection of significant coronary artery disease by noninvasive anatomical and functional imaging. *Circulation: Cardiovascular Imaging, 8*(3). https://doi.org/10.1161/CIRCIMAGING.114.002248

Nelson, A. J., Ardissino, M., & Psaltis, P. J. (2019). Current approach to the diagnosis of atherosclerotic coronary artery disease: More questions than answers. *Therapeutic Advances in Chronic Disease, 10*, 2040622319884819. https://doi.org/10.1177/2040622319884819

Newby, D., Williams, M., Hunter, A., Pawade, T., Shah, A., & Neglia, D. (2015). Lo studio SCOT-HEART. *Giornale Italiano di Cardiologia, 16*(11), 601–607. https://doi.org/10.1714/2066.22424

Nguyen, N. X., Tran, K., & Nguyen, T. A. (2021). Impact of service quality on in-patients' satisfaction, perceived value, and customer loyalty: A mixed-methods study from a developing country. *Patient Preference and Adherence, 15*, 2523–2538. https://doi.org/10.2147/PPA.S333586

Nicolau, J. C., Silva, S. A. M., Nogueira, P. R., & Lima, F. G. (2021). Avaliação da mortalidade hospitalar por infarto agudo do miocárdio em um período de 18 anos. *Arquivos Brasileiros de Cardiologia, 116*(4), 688–695. https://doi.org/10.5935/abc.20210039

Paech, D. C., & Weston, A. R. (2011). A systematic review of the clinical effectiveness of 64-slice or higher computed tomography angiography as an alternative to invasive coronary angiography in the investigation of suspected coronary artery disease. *BMC Cardiovascular Disorders, 11*, 32. https://doi.org/10.1186/1471-2261-11-32

Pessoa, M. J. (2005). *Qualidade dos cuidados de saúde: Dimensões e perspectivas*. Ministério da Saúde.

Pinto, E., Penha, D., Hochhegger, B., Monaghan, C., Marchiori, E., Taborda-Barata, L., & Irion, K. (2022). Achados incidentais de tórax na angiotomografia coronariana: Ensaio pictórico e proposta de manejo. *Jornal Brasileiro de Pneumologia, 48*(4), e20220015. https://doi.org/10.36416/1806-3756/e20220015

Pontone, G., Rossi, A., Guglielmo, M., Dweck, M. R., Gaemperli, O., Nieman, K., Pugliese, F., Maurovich-Horvat, P., Gimelli, A., Cosyns, B., Achenbach, S. (2022). Clinical applications of cardiac computed tomography: A consensus paper of the European Association of Cardiovascular Imaging—Part II. *European Heart Journal - Cardiovascular Imaging, 23*(4), e136–e161. https://doi.org/10.1093/ehjci/jeab292

Portugal.gov.pt. (2024). Nova organização dos cuidados de saúde: Conheça a grande reforma do SNS para 2024.

Ralapanawa, U., & Sivakanesan, R. (2021). Epidemiology and the magnitude of coronary artery disease and acute coronary syndrome: A narrative review. *Journal of Epidemiology and Global Health, 11*(2), 169–177. https://doi.org/10.2991/jegh.k.201217.001

Rao, S. V., Joly, J. M., Gao, S., & Thompson, C. A. (2021). Advances in coronary artery disease management: An update. *Journal of the American College of Cardiology, 78*(1), 112–130.

Sakellarides, C. (2019). Saúde na Europa e em Portugal: Considerações a propósito do Relatório "Health at a Glance: Europa 2018". *Acta Médica Portuguesa, 32*(1), 7–10. https://doi.org/10.20344/amp.11786

Sakellarides, C. (2020). National health service: Responding to current challenges through necessary transformations. *Acta Médica Portuguesa, 33*(2), 133–142.

SCOT-HEART Investigators. (2015). CT coronary angiography in patients with suspected angina due to coronary heart disease (SCOT-HEART): An open-label, parallel-group, multicentre trial. *The Lancet, 385*(9985), 2383-2391.

Sehgal, R. T., & Gorman, P. (2011). Internal medicine physicians' knowledge of health care charges. *Journal of Graduate Medical Education, 3*(2), 182-187. https://doi.org/10.4300/JGME-D-10-00186.1

Serruys, P. W., Hara, H., et al. (2021). Coronary computed tomographic angiography for complete assessment of coronary artery disease: JACC state-of-the-art review. *Journal of the American College of Cardiology*. https://doi.org/10.1016/j.jacc.2021.06.019

Silva, A., Santos, B., & Pereira, C. (2015). Os desafios dos cuidados hospitalares para o Sistema Nacional de Saúde. *Revista Portuguesa de Gestão & Saúde, 14*(1), 35-48.

Silvestri, M. T., Xu, X., Long, T., Bongiovanni, T., Bernstein, S. L., Chaudhry, S. I., Silvestri, J.

I., Stolar, M., Greene, E. J., Dziura, J. D., Gross, C. P., & Krumholz, H. M. (2018). Impact of cost display on ordering patterns for hospital laboratory and imaging services. *Journal of General Internal Medicine, 33*(8), 1268–1275. https://doi.org/10.1007/s11606-018-4495-6

Simões, J., Lourenço, A., Dias, A., Escoval, A., Ferreira, A. S., & Paquete, A. T. (2010). *30 Anos do Serviço Nacional de Saúde: Um percurso comentado*. Coimbra: Almedina.

Smith, J. (2020). Tendências atuais no debate sobre prestação de cuidados de saúde. *Revista de Saúde Pública, 10*(2), 45-62.

Sousa, A. (2009). Saúde dos portugueses: Progressos e desafios. *Revista Portuguesa de Saúde Pública, 27*(1), 65-68.

Sun, Z. (2016). Coronary CT angiography in coronary artery disease: Opportunities and challenges. *Australasian Medical Journal, 9*(5), 111-123. https://doi.org/10.4066/AMJ.2016.2618

Sun, Z., Al Moudi, M., & Cao, Y. (2014). CT angiography in the diagnosis of cardiovascular disease: A transformation in cardiovascular CT practice. *Quantitative Imaging in Medicine and Surgery, 4*(5), 376–396. https://doi.org/10.3978/j.issn.2223-4292.2014.10.02

Sun, Z., Choo, G. H., & Ng, K. H. (2012). Coronary CT angiography: Current status and continuing challenges. *The British Journal of Radiology, 85*(1013), 495–510. https://doi.org/10.1259/bjr/15296170

Taylor, A. J., Cerqueira, M., Hodgson, J. M., et al. (2010). ACCF/SCCT/ACR/AHA/ASE/ASNC/NASCI/SCAI/SCMR 2010 appropriate use criteria for cardiac computed tomography. A report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the Society of Cardiovascular Computed Tomography, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the American Society of Nuclear Cardiology, the North American Society for Cardiovascular Imaging, the Society for Cardiovascular Angiography and Interventions, and the Society for Cardiovascular Magnetic Resonance. *Journal of the American College of Cardiology, 56*(22), 1864-1894. https://doi.org/10.1016/j.jacc.2010.07.005

Thribhuvan Reddy, D., Grewal, I., García Pinzon, L. F., Latchireddy, B., Goraya, S., Ali Alansari, B., & Gadwal, A. (2024). The role of artificial intelligence in healthcare: Enhancing coronary computed tomography angiography for coronary artery disease

management. *Cureus, 16*(6), e61523. https://doi.org/10.7759/cureus.61523

Tilburt, J. C., Wynia, M. K., Sheeler, R. D., Thorsteinsdottir, B., James, K. M., Egginton, J. S., Liebow, M., Hurst, S., Danis, M., & Goold, S. D. (2013). Views of US physicians about controlling health care costs. *JAMA, 310*(4), 380-388. https://doi.org/10.1001/jama.2013.8278

Van den Boogert, T. P. W., Claessen, B. E. P. M., Boekholdt, S. M., et al. (2021). O impacto e os desafios da implementação da CTCA de acordo com as diretrizes da ESC de 2019 sobre síndromes coronárias crônicas: Uma pesquisa e projeção dos serviços de CTCA na Holanda. *Insights Imaging, 12*, 186. https://doi.org/10.1186/s13244-021-01122-2

Van der Bijl, N., Joemai, R. M., Geleijns, J., Bax, J. J., Schuijf, J. D., de Roos, A., & Kroft, L. J. (2010). Assessment of Agatston coronary artery calcium score using contrast-enhanced CT coronary angiography. *AJR. American Journal of Roentgenology, 195*(6), 1299–1305. https://doi.org/10.2214/AJR.09.3734

Van Rosendael, A. R., Crabtree, T., Bax, J. J., Nakanishi, R., Mushtaq, S., Pontone, G., Andreini, D., Buechel, R. R., Gräni, C., & Feuchtner, G. (2019). Standardized reporting to improve coronary artery disease management: Coronary computed tomography angiography. *Journal of the American College of Cardiology*.

Vasilopoulos, A., & Kouliaki, E. K. (2022). Evaluation of the factors related to the satisfaction of the users from the provided primary health care services in structures of the Attica Basin. *Hellenic Journal of Nursing Science, 22–27*. https://doi.org/10.24283/hjns.202213

Wasfy, M. M., Brady, T. J., Abbara, S., Nasir, K., Hoffmann, U., Cury, R. C., Di Carli, M. F., & Blankstein, R. (2012). Comparison of cardiac computed tomography examination appropriateness under the 2010 revised versus the 2006 original appropriate use criteria. *Journal of Cardiovascular Computed Tomography, 6*(2), 99–107. https://doi.org/10.1016/j.jcct.2011.12.005

Weberling, L. D., Lossnitzer, D., Frey, N., & André, F. (2022). Coronary computed tomography vs. cardiac magnetic resonance imaging in the evaluation of coronary artery disease. *Diagnostics, 13*(1), 125.

Weir-McCall, J., Williams, M., Shah, A., et al. (2023). National trends in coronary artery disease imaging: Associations with health care outcomes and costs. *Journal of the American College of Cardiology: Cardiovascular Imaging, 16*(5), 659–671. https://doi.org/10.1016/j.jcmg.2022.10.022

White, R. D., Erdal, B. S., Demirer, M., Gupta, V., Bigelow, M. T., Dikici, E., Candemir, S., Galizia, M. S., Carpenter, J. L., O'Donnell, T. P., Halabi, A. H., & Prevedello, L. M. (2020). Artificial intelligence to assist in exclusion of coronary atherosclerosis during CCTA evaluation of chest pain in the emergency department: Preparing an application for real-world use. *Journal of the American College of Cardiology, 76*(25), 2982–3021. https://doi.org/10.1093/ehjqcco/qcaa060

Williams, M. C., Hunter, A., Shah, A. S. V., Assi, V., Lewis, S., Smith, J., Berry, C., Boon, N. A., Clark, E., Flather, M., Forbes, J., McLean, S., Roditi, G., Van Beek, E. J. R., Timmis, A. D., & Newby, D. E. (2016). Use of coronary computed tomographic angiography to guide management of patients with coronary disease. *Journal of the American College of Cardiology, 67*(15), 1759–1768. https://doi.org/10.1016/j.jacc.2016.02.026

World Health Organization (WHO). (2023). *Cardiovascular diseases (CVDs)*. https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)

World Heart Federation. (2023). *World heart report 2023*. https://world-heart-federation.org/wp-content/uploads/World-Heart-Report-2023.pdf

Zeb, I., Abbas, N., Nasir, K., & Budoff, M. J. (2014). Coronary computed tomography as a cost-effective test strategy for coronary artery disease assessment: A systematic review. *Atherosclerosis, 234*(2), 426–435. https://doi.org/10.1016/j.atherosclerosis.2014.02.011

ANNEXES

Anexo 1- Autorização do Coordenador do CRIA à realização do projeto

CRIA

Autorizado
é de grande
importância para
o serviço

6/2/2024

Exmo. Coordenador do

Centro de Responsabilidade Integrada Cérebro-Cardiovascular

(CRIA)

Assunto: Pedido da Técnica Superior de Diagnóstico e Terapêutica de Cardiopneumologia Cláudia Russo, para realização de um Projeto de Tese de Mestrado.

Exmo. Sr. Professor Doutor Lino Patrício, eu Cláudia Sofia Mendes Magro Russo com o número mecanográfico 3099, TSDT de Cardiopneumologia na ULSAC, a desempenhar funções de TSDT de Cardiopneumologia no CRIA, mestranda no Curso de Mestrado de Gestão de Unidades de Saúde, venho por este meio solicitar autorização para a realização de um projeto de Tese no CRIA com o título:

"Diagnóstico de Doença Coronária Estável por AngioTC
como exame de primeira linha – Estudo Económico"

Agradece desde já a disponibilidade dispensada, estando ao dispor para fornecer qualquer esclarecimento adicional.

Sem outro assunto de momento, os melhores cumprimentos

Cláudia Magro Russo

(TSDT Cláudia Magro Russo)

23/01/2024

Anexo 2 – Autorização do Conselho de Administração da ULSAC à realização do projeto

26/12/2024
Enviar a Comissão Ética
Luísa Rebocho
Diretora Clínica

HESE-Comissão Ética Saúde
N.º Entrada: 011/24
Data Entrada: 27/12/24
Assinatura:

Exmos. Membros do Conselho de Administração

do Hospital do Espírito Santo de Évora

Assunto: Pedido da Técnica Superior de Diagnóstico e Terapêutica da área de Cardiopneumologia para realização de um Projeto de Tese de Mestrado.

Cláudia Sofia Mendes Magro Russo com o número mecanográfico 3099, TSDT de Cardiopneumologia no HESE, a desempenhar funções no CRIA, mestranda no Curso de Mestrado de Gestão de Unidades de Saúde, na Escola Superior de Gestão do Instituto Politécnico de Santarém, com o número de aluna 230000115, vem por este meio solicitar autorização para a realização de um projeto de Tese nesta instituição, no serviço CRIA, com o título:

"Diagnóstico de Doença Coronária Estável por AngioTC
como exame de primeira linha – Estudo Económico"

Diagnóstico da problemática:

Tendo em conta a área geográfica (todo o Alentejo, exceto litoral alentejano), a que a recém-criada Unidade Local de Saúde do Alentejo Central (ULSAC), tem que dar resposta em termos de diagnóstico e tratamento da Doença Coronária (DC), as listas de espera para Coronáriografia tendem a aumentar.

A coronáriografia ou cateterismo cardíaco é o exame de fim de linha, invasivo, para deteção de DC, devendo ser apenas realizado quando existe evidencia clara de DC, porem este exame é muitas vezes requisitado pelos médicos para esclarecimento da presença ou não de DC.

Este projeto permitirá diminuir o número de Coronáriografias e outros Meios Complementares de Diagnóstico e Terapêutica (MCDT), libertando vagas para os doentes que têm efetivamente necessidade de os realizar.

1/ 2

Objetivo do Projeto:

Justificar a mais valia da implementação de um protocolo de diagnóstico e exclusão de doença coronária estável por AngioTC como teste de primeira linha.

Avaliar o "Saving" produzido por uma estratégia de diagnóstico dirigida por AngioTc em doentes com suspeita de DC de risco baixo e intermédio, ao invés da realização de muitos outros MCDT para deteção de DC estável.
O projeto será desenvolvido pelo CRIA, por essa razão serão apresentados os seus fatores críticos de sucesso.

Metodologia:

Este será um projeto com uma componente retrospetivo por espelhar o custo e o número de exames funcionais realizados na agora ULSAC, antigo HESE, para diagnóstico de doença coronária estável no de 2023.

Prospetivo por ter como objetivo avaliar o "Saving" com a implementação de um protocolo de diagnóstico e/ou exclusão de DC de risco baixo e intermédio, por AngioTC como teste de primeira linha.

Serão calculados todos dos gastos do projeto.

Será realizado um plano de ação e serão projetadas as espectativas do projeto.

Agradeço desde já a disponibilidade dispensada, estando ao dispor para fornecer qualquer esclarecimento adicional.

Sem outro assunto de momento, os melhores cumprimentos.

Cláudia Magro Russo

(TSDT Cláudia Magro Russo)

19/02/2024

2/ 2

Anexo 3 – Parecer da Comissão de ética da ULSAC

REPÚBLICA PORTUGUESA SAÚDE | SNS SERVIÇO NACIONAL DE SAÚDE | UNIDADE LOCAL DE SAÚDE ALENTEJO CENTRAL

18/9/2024
Ao CA
Luísa Rebocho
Diretora Clínica

COMISSÃO DE ÉTICA
Hospital do Espírito Santo de Évora, EPE (HESE, EPE)

Parecer da CES nº 011/24
Nº entrada no HESE: 460 de 23/02/2024

Título do Projeto: Diagnóstico de Doença Coronária Estável por AngioTC como exame de primeira linha – Estudo Económico

Investigadores: Cláudia Sofia Mendes Magro Russo

Local: CRIA/HESE

Enquadramento: Curso de Mestrado de Gestão de Unidades de Saúde – Escola Superior de Gestão do Instituto Politécnico de Santarém

Tipo de Estudo: Retrospetivo, prospetivo

Com base nos documentos apresentados

- Estão definidos os critérios de inclusão __Sim___
- São apresentados os Instrumentos de recolha de dados ___Sim__
- Está garantida a confidencialidade dos dados recolhidos __Sim___
- Está garantida a participação livre, voluntária e informada, dos participantes __N/A__

Parecer da Comissão de Ética do HESE, EPE:

Favorável __X__

Condicional ___

NOTAS:

Data: 09/04/2024

APROVADO
ATA N.º 17 em 24/04/2024
O Conselho de Administração
Vítor Faria
Presidente
Maria Cáo Cerrão
Vogal
António
Vogal
Luísa Rebocho
Dir. Clínica CS Hospitalares
José Chora
Enfermeiro Diretor
Dr. Clínico CS Primários

Dr. Manuel Amoedo
Presidente da Comissão de Ética

Anexo 4 – Declaração de autoria e de originalidade

DECLARAÇÃO DE AUTORIA E DE ORIGINALIDADE

Eu, Cláudia Sofia Mendes Magro Russo estudante nº 230000115 declaro que sou a única autora da dissertação, intitulada "Diagnóstico de Doença Coronária Estável por Angio Tomografia Computadorizada como exame de primeira linha: Análise de custos num Centro de Responsabilidade Integrada" apresentada para obtenção do grau de Mestre em Gestão de Unidades de Saúde pela Escola Superior de Gestão e tecnologias de Santarém.

Declaro ainda que identifiquei de uma forma clara e citei corretamente trabalhos de outros autores que tenham sido utilizados neste trabalho; no caso de ter utilizado frases retiradas de trabalhos de outros autores, referenciei-as devidamente ou, se as redigi com palavras diferentes, indiquei o trabalho original de onde foram adaptadas. Assim, declaro que não há qualquer plágio (apropriação indevida da obra intelectual de outra pessoa, assumindo, implícita ou explicitamente, a autoria da mesma, ainda que por omissão) no documento entregue e que reconheço que tal prática poderia resultar em sanções disciplinares e legais.

Por fim, declaro que este trabalho, em parte ou no todo, não foi previamente submetido para a mesma finalidade.

Tenho consciência que o plágio ou a cópia pode determinar a anulação do grau atribuído, bem como, originar responsabilidade criminal, civil e disciplinar. Constitui igualmente uma grave violação da ética académica.

Évora, dezembro de 2024

O (A) Estudante

(Assinatura legível)

Anexo 5 – Parecer do Orientador

Parecer do Orientador

Lino Manuel Ribeiro Patrício, Licenciado em Medicina (mestrado integrado), Doutorado em Ciências da Saúde, pela Universidade de Coimbra, Faculdade de Medicina, Professor Associado Convidado (Escola de Saúde e Desenvolvimento Humano) da Universidade de Évora, considera que o Trabalho Final de Mestrado apresentado por **Cláudia Sofia Mendes Magro Russo**, visando obter o grau de Mestre em Gestão de Unidades de Saúde, subordinada ao tema "**Diagnóstico de Doença Coronária Estável por Angio Tomografia Computadorizada como exame de primeira linha: análise de custos num Centro de Responsabilidade Integrada.**", está em condições de ser entregue e defendido publicamente.

Lino Manuel Ribeiro Patrício

Évora, 28 de dezembro de 2024

Anexo 6 – Parecer da Orientadora

POLITÉCNICO DE SANTARÉM

Parecer da Orientadora

Sandra Margarida Bernardes de Oliveira, Doutora em Economia da Saúde, Professora Adjunta do Departamento de Ciências Sociais e Organizacionais da Escola Superior de Gestão e Tecnologia do Instituto Politécnico de Santarém, considera que o Trabalho Final de Mestrado apresentado por **Cláudia Sofia Mendes Magro Russo**, visando obter o grau de Mestre em Gestão de Unidades de Saúde, subordinada ao tema "**Diagnóstico de Doença Coronária Estável por** Angio Tomografia Computadorizada **como exame de primeira linha: análise de custos num Centro de Responsabilidade Integrada.**", está em condições de ser entregue e defendido publicamente.

Sandra Bernardes de Oliveira

Sandra Margarida Bernardes de Oliveira

Santarém, 28 de dezembro 2024