Cost-effectiveness and Budget Impact Analysis of Coronary CT Angiography in the Brazilian Unified Health System

Isabela Bispo Santos da Silva Costa,[1] Jorge A. Torreão,[2] Afonso Shiozaki,[3] Henrique Simão Trad,[4] Luana Emanuelly Sinhori Lopes,[5] Marcio S. Bittencourt,[6] Miguel Antônio Moretti,[7,8] Silvio Henrique Barberato,[9,10] Carlos E. Rochitte[11]

Instituto do Câncer do Estado de São Paulo – Universidade de São Paulo,[1] São Paulo, SP – Brazil
Hospital Cardio Pulmonar – IDOR - Instituto D'or de Pesquisa e Ensino,[2] Salvador, BA – Brazil
ND Núcleo Diagnóstico,[3] Maringá, PR – Brazil
Lotus Radiologia,[4] Ribeirão Preto, SP – Brazil
Universidade Estadual do Oeste do Paraná,[5] Cascavel, PR – Brazil
University of Pittsburgh,[6] Pittsburgh, Pennsylvania – USA
Hospital das Clinicas da Faculdade de Medicina da Universidade de São Paulo (HCFMUSP),[7] São Paulo, SP – Brazil
Faculdade de Medicina da Fundação do ABC,[8] Santo André, SP – Brazil
CardioEco Centro de Diagnóstico Cardiovascular,[9] Curitiba, PR – Brazil
Quanta Diagnóstico – Ecocardiografia,[10] Curitiba, PR – Brazil
Instituto do Coração do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo,[11] São Paulo, SP – Brazil

Abstract

Background: **Coronary artery disease (CAD) represents a major clinical and economic burden for the Brazilian Unified Health System (SUS). Although coronary computed tomography angiography (CCTA) has excellent diagnostic accuracy, cost-effectiveness analyses (CEA) based on national data are lacking.**

Objective: **To evaluate the cost-effectiveness and budget impact of incorporating CCTA as the initial diagnostic strategy for patients with suspected stable CAD from the SUS perspective.**

Methods: **A cost-effectiveness analysis (CEA) and a budget impact analysis (BIA) were conducted, comparing CCTA with invasive coronary angiography (ICA) and with a panel of functional tests in patients with suspected stable CAD. A one-year time horizon was adopted for the CEA and five years for the BIA. Effectiveness outcomes included the incidence of acute myocardial infarction (AMI), revascularization rates, and hospitalizations. Deterministic and probabilistic sensitivity analyses were performed.**

Results: **CCTA proved to be cost-effective, reducing costs related to AMI (R$610.18 vs. R$867.80), revascularization (R$1,378.14 vs. R$1,833.84), and hospitalization (R$602.86 vs. R$932.79), resulting in savings of R$329.93 per patient. Compared with functional tests, CCTA also reduced costs associated with AMI (R$610.18 vs. R$658.36), revascularization (R$1,378.14 vs. R$1,659.18), and hospitalization (R$602.86 vs. R$628.16). The BIA projected cumulative savings for SUS ranging from R$34.1 million to R$73 million over five years, depending on the comparator and diffusion scenario.**

Conclusions: **The results suggest that using CCTA as the initial diagnostic test for patients with low-to-moderate risk of CAD in SUS may represent an economically favorable strategy, with potential to generate substantial cost savings compared with the evaluated alternatives.**

Keywords: **X-Ray Computed Tomography; Coronary Artery Disease; Cost-Effectiveness Analysis; Myocardial Infarction; Unified Health System.**

Introduction

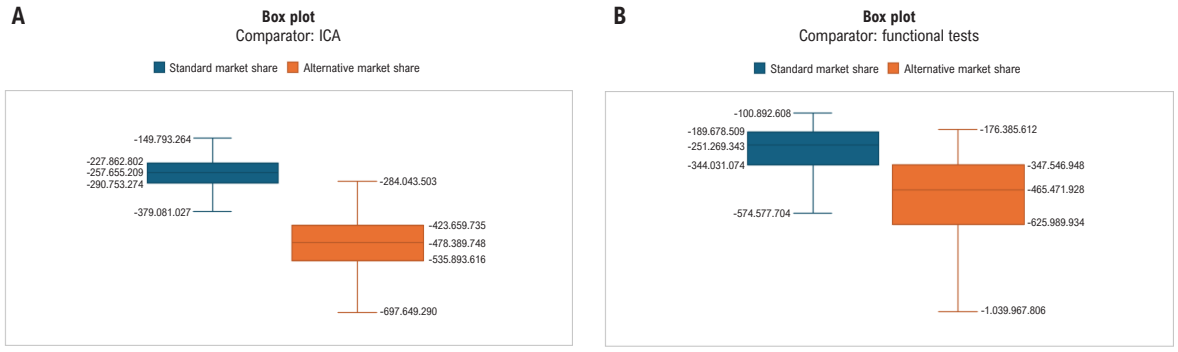
Coronary artery disease (CAD) remains one of the leading causes of morbidity and mortality in Brazil and imposes a substantial burden on the Brazilian unified health system (SUS).[1] In addition to direct costs related to consultations, diagnostic tests, medications, and hospitalizations, there are high-complexity expenditures and indirect costs associated with productivity loss and rehospitalizations.[2] In a universal system constrained by budget limitations, diagnostic strategies that optimize the care pathway – reducing events, avoiding unnecessary invasive procedures, and guiding effective therapies – are essential to improve clinical outcomes and ensure efficient resource allocation.[3]

Coronary computed tomography angiography (CCTA) has become established as a high-accuracy anatomical method for evaluating stable chest pain, with a high negative predictive value for ruling out obstructive CAD, the ability to detect non-obstructive disease, and to

Mailing Address: Isabela Bispo Santos da Silva Costa •
Instituto do Câncer do Estado de São Paulo - Universidade de São Paulo – Av. Dr. Arnaldo, 251. Postal Code 01246-000, São Paulo, SP- Brazil
E-mail: Isabela.bispo@hc.fm.usp.br
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Central Illustration: Cost-effectiveness and Budget Impact Analysis of Coronary CT Angiography in the Brazilian Unified Health System



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Results of the budget impact analysis. (A) Comparison of CCTA vs. ICA and (B) Comparison of CCTA vs. Functional tests, presenting standard (blue) and alternative (orange) market-share scenarios. CCTA: coronary computed tomography angiography; ICA: invasive coronary angiography.

characterize atherosclerotic plaque.[4] Incorporating CCTA as the initial diagnostic gateway can expedite the initiation of preventive therapies, reduce unnecessary diagnostic catheterizations, and rationalize the use of functional tests and revascularization procedures.

Clinical trials and pragmatic studies support this repositioning, demonstrating that an initial anatomical strategy with CCTA yields performance equivalent to functional approaches in clinical outcomes, with better risk discrimination and a lower proportion of invasive coronary angiographies (ICA) without significant obstruction.[4] Adding CCTA to standard care has improved diagnostic accuracy and has been associated with reduced myocardial infarction during longitudinal follow-up.[5] More recently, it has also been shown that, in patients with stable chest pain and low-to-intermediate risk, an initial CCTA strategy reduces procedure-related complications while maintaining clinical outcomes comparable to ICA.[6]

From an economic perspective, international cost-effectiveness analyses indicate an advantage for initial anatomical strategies in low-risk chest pain scenarios, showing that CCTA can be cost-effective when compared with functional testing.[7] In parallel, preliminary Brazilian evaluations suggest that, within the SUS context, CCTA has the potential to reduce incremental costs per avoided event and improve care efficiency.[8]

Despite this body of evidence, a relevant gap remains: the lack of robust and up-to-date national data that incorporate real SUS costs, typical care pathways, local health utilities, and sufficiently long time horizons to capture the sustained clinical and economic benefits of the anatomical strategy. Therefore, the present study aims to conduct a cost-effectiveness analysis of CCTA from the SUS perspective, contextualized within the Brazilian reality and compared with non-invasive and invasive diagnostic alternatives for patients with low-to-moderate risk of CAD.

Methods

To understand the clinical and economic impact of incorporating CCTA in patients with low-to-moderate risk of CAD, a cost-effectiveness model was developed. This analysis aims to evaluate the incremental cost-effectiveness ratio (ICER) of performing CCTA in patients with chest pain and low-to-moderate risk of CAD. Accordingly, a model was constructed based on studies identified in the literature, adapted to current Brazilian recommendations and context, and validated by experts.

The analysis was conducted from the SUS perspective, using a one-year time horizon for the cost-effectiveness analysis (CEA) and a five-year horizon for the budget impact analysis (BIA). To enhance transparency, the main components of the proposed study were summarized according to the Consolidated Health Economic Evaluation Report checklist,[9] presented in the Supplementary Material (Table S1).

The population considered for the cost-effectiveness analysis consisted of patients with low-to-moderate risk of CAD, presenting symptoms suggestive of myocardial ischemia but without evidence of recent acute cardiac events. The characteristics of this population (pre-test probability of CAD) reflect a profile similar to participants included in the PROMISE and DISCHARGE randomized clinical trials.

The comparators selected were: ICA and functional tests (myocardial perfusion scintigraphy under stress with at least three projections; stress echocardiography; exercise treadmill test). Comparing CCTA, ICA, and functional tests allows assessment not only of diagnostic and clinical effectiveness but also of the economic feasibility of these alternatives, providing a solid evidence-based foundation for health decision-making.

The effectiveness measures used in the analysis included:

• Proportion of patients experiencing acute myocardial infarction (AMI): Evaluation of the incidence of all AMI

cases among diagnosed patients, an important measure of the intervention's ability to prevent major adverse events.

• Hospitalization rates: An indicator reflecting the intervention's capacity to avoid unnecessary admissions, contributing to health system sustainability and improving patient quality of life.

• Need for revascularization: Assessment of revascularization procedures, such as percutaneous coronary intervention or coronary artery bypass grafting, ensuring that patients receive the most appropriate treatment.

The decision tree is illustrated in Figure 1.

Parameters, utility, and costs

The parameters used in the analysis were obtained from sources such as the DISCHARGE (2022)[6] and PROMISE (2015)[4] trials to ensure data accuracy and comparability. Each study contributed parameters related to its characteristic patient population, forming the health states evaluated. The parameters included:

• Time to acute myocardial infarction (AMI), hospitalizations, and revascularizations: data reflecting disease progression and management.

• Multiplication by a factor of 100: applied to facilitate calculations and comparisons.

• Cost data sources: values related to treatment of outcomes and diagnostic procedures were based on official tables such as BPS 2024[10] and SIGTAP 2024,[11] ensuring an analysis grounded in standardized and recognized cost references. Table 1 details these parameters for greater transparency and understanding of the data used.

Cost assessment was conducted from the SUS perspective, using official reimbursement values available in the SIGTAP/BPS database. The analysis adopted the Brazilian real (R$) as the currency and used 2025 as the base year. The estimated cost of CCTA was R$ 550.00, while the cost of functional tests totaled R$ 591.52.

The definition of this value considered the proportional use of diagnostic tests described in the PROMISE[4] study, applied as a proxy for the national scenario. Three functional methods with consolidated use in SUS were included:

• Myocardial perfusion scintigraphy under stress (minimum of 3 projections): Unit cost of R$ 408.52, resulting in R$ 817.04 per patient when applying the full protocol. This test represented 67.5% of the PROMISE[4] distribution, yielding a weighted average cost of R$ 551.40.

• Stress echocardiography: unit cost of R$ 165.00, corresponding to 22.4% of the distribution, with a weighted average cost of R$ 36.96 per patient.

• Exercise treadmill test: unit cost of R$ 30.00, representing 10.2% of the distribution, with a weighted average cost of R$ 3.06.

The sum of the weighted average values results in a final estimated cost of R$ 591.52 per patient, reflecting the current clinical practice profile for functional test utilization, considering proportions of 67.5% for scintigraphy, 22.4% for stress echocardiography, and 10.2% for treadmill testing.

Three therapeutic strategies were considered for patients with chest pain or coronary syndrome: medical therapy (including AMI management), percutaneous coronary intervention (PCI), and coronary artery bypass grafting (CABG).

1. Medical treatment: The total estimated cost for the clinical management of patients with AMI was R$ 2,863.11, considering the use of medications (such as aspirin, clopidogrel, enoxaparin, beta-blockers, statins), laboratory and imaging tests (including electrocardiogram,

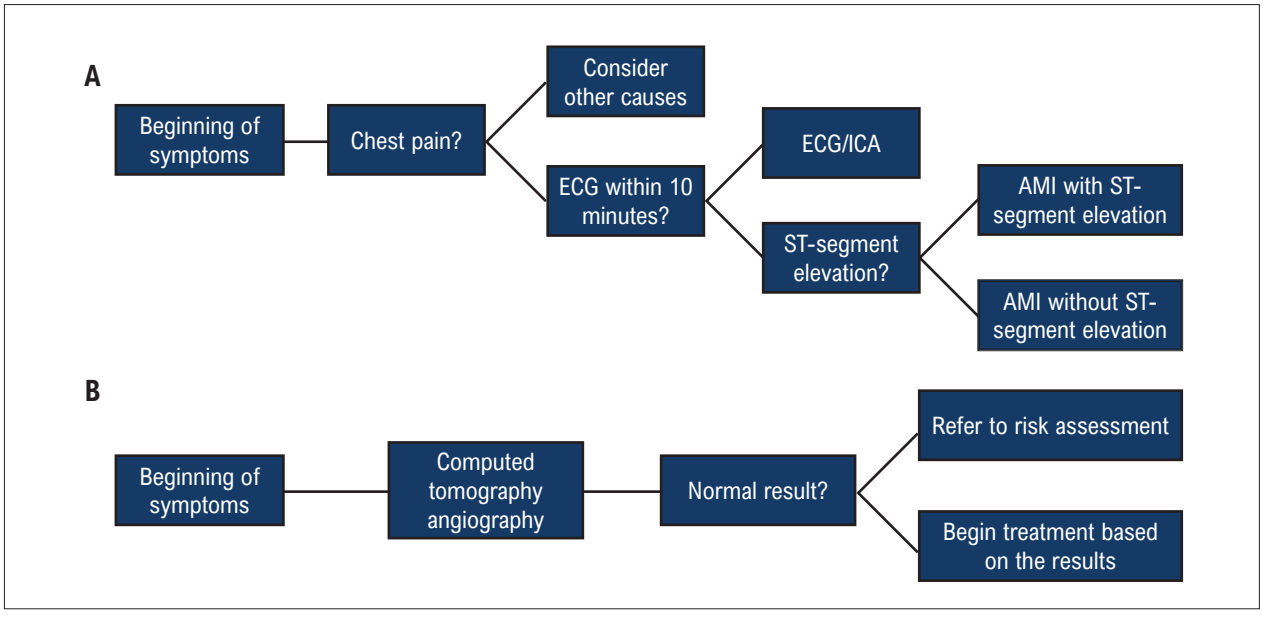


Figure 1 – *Decision tree model; ECG: electrocardiogram; AMI: acute myocardial infarction*

Table 1 – Parameters used in the cost-effectiveness analysis

Parameter	Value used	Reference
CCTA vs. ICA		
Probability of infarction – CCTA	2.10%	DISCHARGE, 2022[6]
Probability of infarction – ICA	3.00%	
Probability of revascularization – CCTA	14.20%	
Probability of revascularization – ICA	18.00%	
Probability of hospitalization – CCTA	0.20%	
Probability of hospitalization – ICA	0.60%	
CCTA vs functional tests		
Parameter	**Value used**	**Reference**
Probability of infarction – Functional tests	2.33%	PROMISE, 2015[4]
Probability of revascularization – Functional tests	18. x25%	
Probability of hospitalization – Functional tests	0,15%	

CCTA: coronary computed tomography angiography; ICA: invasive coronary angiography; ICER: incremental cost-effectiveness ratio.

echocardiogram, and serial serum biomarkers), as well as hospital admission (two ward days and three days in a coronary intensive care unit). All items were used in 100% of the evaluated patients. For modeling purposes, the AMI clinical outcome encompassed all cardiovascular events of this nature (including fatal and non-fatal AMI).

2. PCI: The total estimated cost of percutaneous coronary intervention with stent implantation was R$ 5,848.74, covering expenses related to admission to a type II Coronary Care Unit (CCU), complementary tests, medications, and specialized materials such as the balloon catheter and drug-eluting stent. The cost of ICA used for diagnostic confirmation and procedural planning was R$ 782.87.

3. CABG: The estimated cost was R$ 23,892.04, considering a longer hospital stay in the CCU, use of medications in adjusted doses, complementary tests, and the surgical procedure itself. This value represents the total hospitalization cost including all direct medical inputs.

All unit costs were extracted from the SIGTAP/BPS database, reflecting the reimbursement values paid by SUS. The quantity of each item used was determined based on standardized clinical protocols for each type of management. Table S2 details the final costs obtained through micro-costing, including tests, therapies, and costs related to clinical complications.

Deterministic and probabilistic multivariate sensitivity analysis

Deterministic and probabilistic sensitivity analyses were conducted to assess the robustness of the model's results in light of the inherent uncertainty of the parameters used. The deterministic sensitivity analysis was performed through univariate variations of the main parameters, adopting a ±20% range around the central values, in accordance with the official recommendation of the Ministry of Health's Economic Evaluation Guideline, used as the standard in the absence of variance data in the literature. This approach allowed identification of the parameters with the greatest influence on the model's outcomes.

The probabilistic sensitivity analysis was conducted using second-order Monte Carlo simulations with 1,000 iterations. Parameters were modeled using distributions appropriate to each variable type: Gamma distribution for costs and demand, and Beta distribution for probabilities. A 95% confidence interval was considered for all estimates.

Budget impact analysis

The budget impact analysis was conducted alongside the cost-effectiveness evaluation, considering the incorporation of CCTA into the SUS for patients with suspected stable CAD. The estimate of the eligible population used the measured-demand method, based on DATASUS data for invasive diagnostic procedures (catheterization) and functional tests, applying an age cutoff (≥40 years). Future projections were adjusted according to population growth rates from the Brazilian Institute of Geography and Statistics (IBGE).

The choice of the aortic arch angiography procedure for population estimation is due to its status as the reference procedure coded and performed within SUS, serving as a direct comparator for the submitted technology. In accordance with Brazilian methodological guidelines for Budget Impact Analysis, we used the historical production of this official code (via TABNET/DATASUS) to accurately estimate the volume of eligible patients who would migrate to or benefit from the new technology, ensuring that the estimate reflects the real demand audited by

the public system. Details of the BIA are provided in the Supplementary Material.

Two technology-diffusion scenarios were modeled:

- **Base scenario:** annual growth of 5% in CCTA utilization;
- **Alternative scenario:** annual growth of 9.3%, based on international evidence;[12]

The time horizon of the analysis was five years, adopting the SUS perspective. Costs considered included diagnostic examinations, treatment of clinical events, and equipment acquisition. The analysis incorporated two infrastructure scenarios:

- **Base scenario:** no need for additional CT scanners;
- **Alternative scenario:** acquisition of additional scanners, based on average market prices.

In the base scenario, the eligible population is estimated to increase from approximately 7.9 thousand patients in 2025 to about 42.8 thousand in 2029 when compared with ICA, and from 16.1 thousand to 86.9 thousand when compared with functional tests.

In the alternative scenario, faster adoption of CCTA increases the eligible population in the early years, rising from about 14.7 thousand patients in 2025 to 31.8 thousand in 2029 when compared with ICA, and from 17.0 thousand to 36.7 thousand relative to functional tests. Installation costs were parameterized as R$ 0.00 in the budget impact model, considering that physical infrastructure and peripheral equipment are already available in high-complexity cardiovascular centers capable of performing coronary CT angiography.

Results

Comparison: CCTA versus ICA

Cost-effectiveness analysis. For the AMI outcome, CCTA showed a lower incidence of clinical events (2.10% vs. 2.97%) and a lower mean cost (R$ 610.18 vs. R$ 867.80), resulting in savings of R$ 257.62 [95% CI: –R$ 97.64 to R$ 225.86] per patient. Regarding myocardial revascularization, CCTA was also advantageous, reducing the rate of procedures (14.16% vs. 17.97%) and associated costs (R$ 1,378.14 vs. R$ 1,833.84), with savings of R$ 455.70 [95% CI: R$ 47.75 to R$ 516.56] per patient. For hospitalizations, a lower admission rate was observed with CCTA (0.22% vs. 0.63%), along with a lower mean cost (R$ 602.86 vs. R$ 932.79), representing savings of R$ 329.93 [95% CI: –R$ 51.69 to R$ 487.86] per patient (Table 2). These findings indicate that CCTA is dominant across all scenarios analyzed.

Sensitivity analysis. The probabilistic sensitivity analysis showed that most simulated scenarios clustered in the quadrant of lower cost and higher effectiveness, reinforcing the economic dominance of CCTA. The base case and median values confirmed this trend for all three outcomes (AMI, revascularization, and hospitalization), illustrated in Figures 2A, 2B, and 2C, respectively. The deterministic univariate analysis identified the relative risk of infarction, the cost of diagnostic tests, and AMI-related costs as the main drivers of incremental results, whereas variables such as discount rates and probabilities of revascularization or hospitalization had minimal impact. This demonstrates that direct costs and severe clinical events are the most influential factors in the robustness of the analysis (Figure 3A).

Table 2 – Cost-effectiveness analysis – compared with invasive coronary angiography (ICA)

Outcomes	CCTA	ICA	Incremental
Total cost	R$ 610.18	R$ 867.80	- R$ 257.62
Acute myocardial infarction (AMI)	2.10%	2.97%	0.86% avoided
ICER (R$)			Dominant ICER: -29.798 (IC95%: -85.720; 49.396)
Total cost	R$ 1.378.14	R$ 1.833.84	- R$ 455.70
Revascularization	14.16%	17.97%	3.81% avoided
ICER (R$)			Dominant RCEI: -11.961 (IC95%: -13.337; -1.990)
Total cost	R$ 602.86	R$ 932.79	- R$ 339.93
Hospitalization	0.22%	0.63%	0.41% avoided
ICER (R$)			Dominant ICER: -81.213 (9CI5%: -223.797; 119.863)

CCTA: coronary computed tomography angiography; ICA: invasive coronary angiography; 95% CI: 95% confidence interval; ICER: incremental cost-effectiveness ratio.

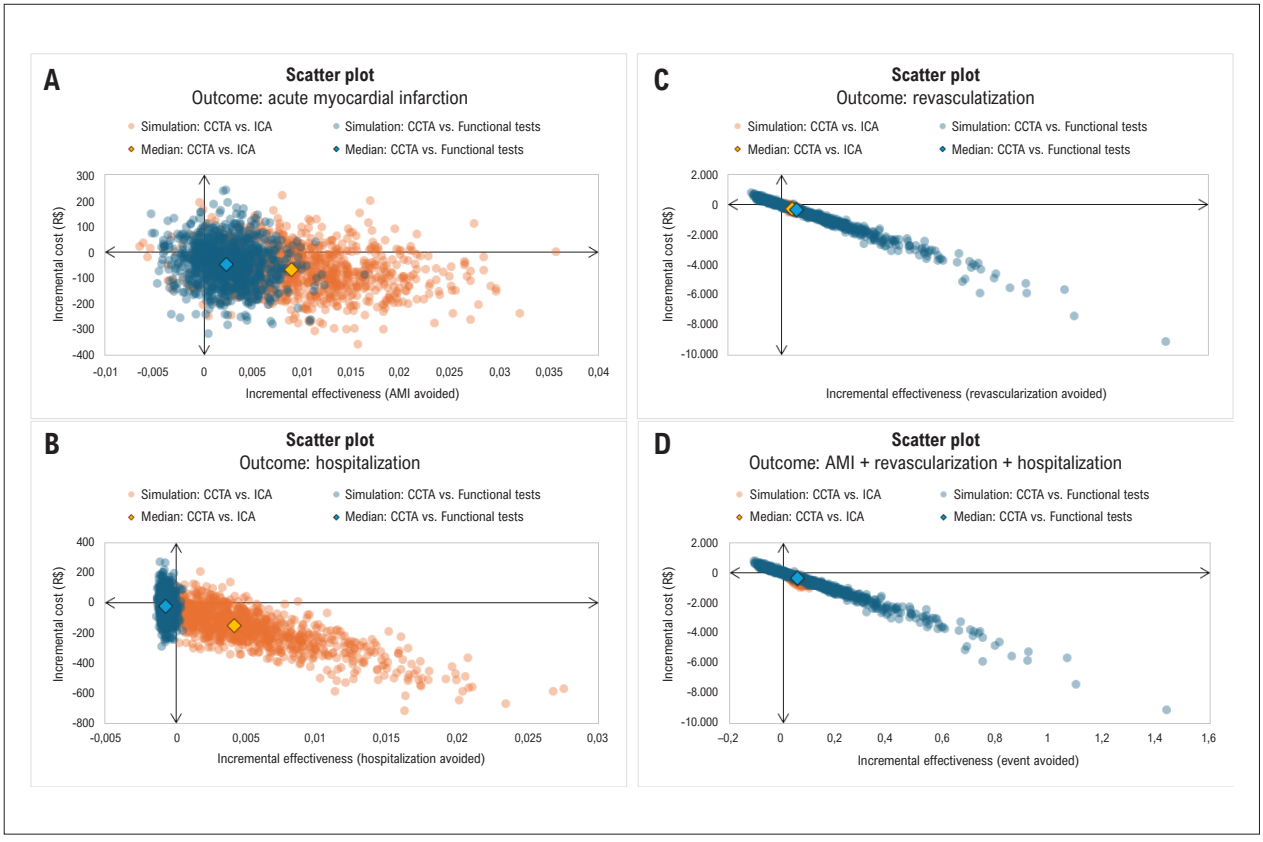


Figure 2 – *Deterministic one-way sensitivity analysis (DSA) comparing CCTA and ICA across different outcomes: (A) Acute myocardial infarction (AMI), (B) Revascularization, and (C) Hospitalization. CCTA: coronary computed tomography angiography; ICA: invasive coronary angiography; ICER: incremental cost-effectiveness ratio.*

For the revascularization outcome, in the deterministic analysis (Figure 3B), the factors with the greatest impact were the cost of diagnostic tests and the relative risk of revascularization, while variables such as discount rate, probability of infarction, hospitalization, and revascularization associated with CCTA had minimal effect. This indicates that the model is particularly sensitive to direct costs and revascularization outcomes. For the hospitalization outcome, in the deterministic analysis (Figure 3C), the most influential factors were the relative risk of hospitalization and the costs of diagnostic tests and admissions, whereas variables such as probabilities of clinical events, discount rate, and revascularization risk had minimal influence, highlighting the main sources of uncertainty in the model.

Budget impact analysis. In the base scenario of conservative diffusion (5% per year), presented in Table S6, the total accumulated cost over 5 years was approximately R$ 1.42 billion in the proposed scenario with CCTA, compared with R$ 1.45 billion in the current scenario using ICA. This difference resulted in overall savings of about R$ 34.1 million when considering the use of existing installed capacity, without the acquisition of new equipment. The incremental impact remained negative in all years, ranging from -R$ 2.1 million in 2026 to -R$ 11.6 million in 2030, with an incremental cost per patient totaling -R$ 223.33 over the analysis horizon. In the scenario with acquisition of new equipment, although the savings were reduced, the accumulated economic benefit remained significant, reaching approximately R$ 21.5 million, with an incremental cost per patient of -R$ 141.01.

In the alternative accelerated-diffusion scenario (9.3% per year), shown in the Central Figure (A), the results were even more pronounced. The total accumulated cost in the proposed scenario was approximately R$ 1.39 billion, compared with R$ 1.45 billion in the current scenario, corresponding to overall savings of about R$ 63.3 million when only existing installed capacity was considered. The incremental impact ranged from –R$ 4.0 million in 2026 to –R$ 21.5 million in 2030, and the incremental cost per patient reached –R$ 414.96 at the end of the period. In the alternative scenario with acquisition of new CT scanners, savings were also maintained, though of smaller magnitude, totaling approximately R$ 38.1 million over five years, with an incremental cost per patient of –R$ 250.32 (Table S7).

Comparison: CCTA versus functional tests

Cost-effectiveness analysis. When comparing CCTA with functional tests, the cost-effectiveness evaluation of clinical outcomes showed that the technology remained more effective and less costly in most scenarios, representing a

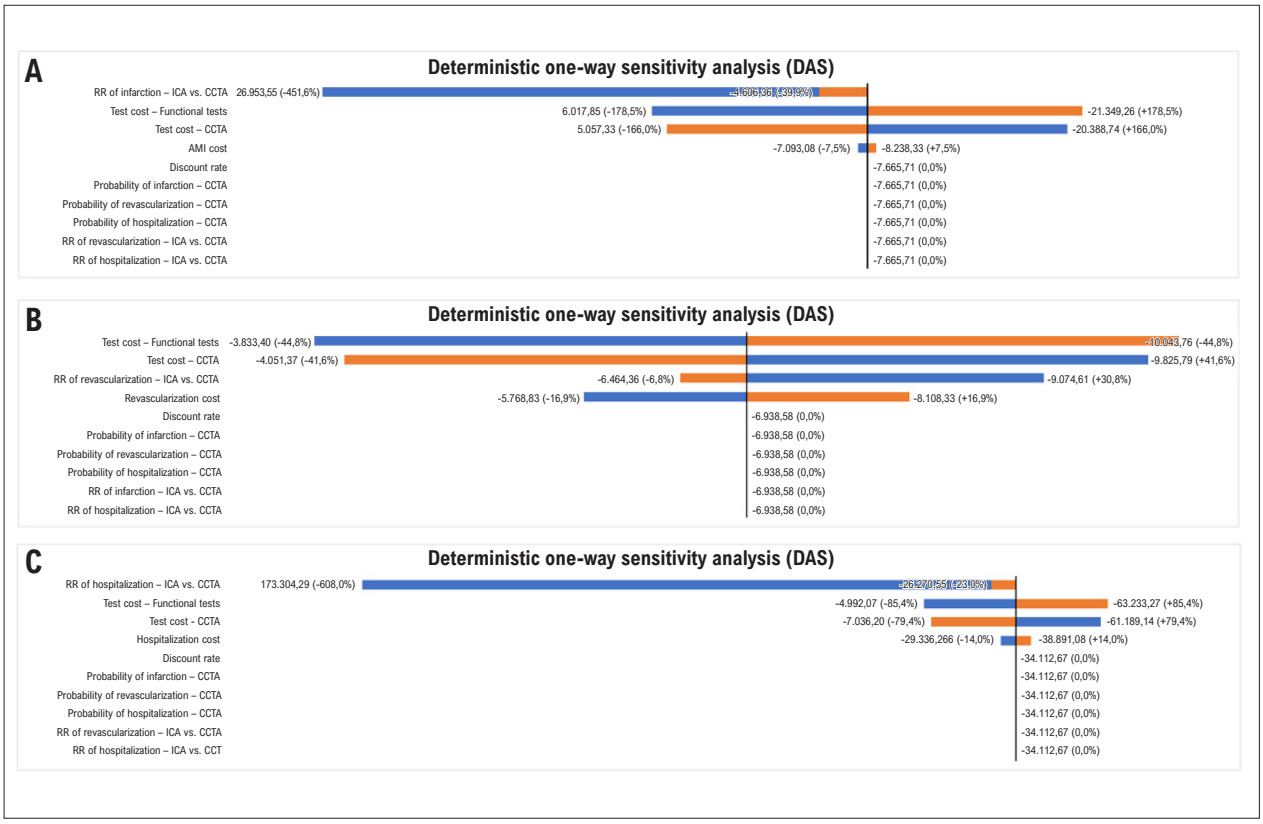


Figure 3 – *Deterministic one-way sensitivity analysis (DSA) comparing CCTA and ICA across different outcomes: (A) Acute myocardial infarction (AMI), (B) Revascularization, and (C) Hospitalization. CCTA: coronary computed tomography angiography; ICA: invasive coronary angiography; ICER: incremental cost-effectiveness ratio.*

dominant strategy in two of the three analyses conducted. For the AMI outcome, CCTA demonstrated a lower incidence of clinical events (2.10% vs. 2.33%), associated with average savings of R$ 48.18 [95% CI: –R$ 111.24 to R$ 199.04] per patient (R$ 610.18 vs. R$ 658.36). This result confirms its economic dominance by combining fewer adverse events with lower direct costs.

Regarding revascularization, CCTA also proved superior, with a reduction of 4.10 percentage points in procedure rates (14.16% vs. 18.25%) and savings of R$ 281.04 [95% CI: –R$ 484.90 to R$ 3,351.87] per patient (R$ 1,378.14 vs. R$ 1,659.18). For the hospitalization outcome, although CCTA showed a lower mean cost (R$ 602.86 vs. R$ 628.16; savings of R$ 25.31 [95% CI: –R$ 135.76 to R$ 178.04] per patient), the event rate was slightly higher (0.22% vs. 0.15%). This scenario characterizes the strategy as lower-cost but also lower-effectiveness. Full cost and effectiveness data are detailed in Table 3.

Sensitivity analysis. For the outcomes AMI and revascularization, the PSA shows that the distribution of simulations lies within the incremental cost-effectiveness plane. Most points are located near the horizontal axis and tend to cluster in the lower-right quadrant, suggesting that, in most scenarios, the evaluated strategy is more effective and less costly than the comparator. Despite the dispersion of results, the median (in red) is positioned in a region that reinforces this dominance pattern, while the base-case point (in blue) indicates consistency in the direction of the findings (Figures 2A, 2B, and 2C). Thus, the PSA strengthens the robustness of the intervention, even in the presence of parameter uncertainty within the model. For the hospitalization outcome, the probabilistic analysis (Figure 2B) showed wide dispersion of simulations, with a predominance of scenarios indicating lower costs and modest gains in effectiveness, suggesting a tendency toward cost savings with maintenance or slight improvement in clinical outcomes.

The univariate deterministic sensitivity analysis (DSA) showed that the variables with the greatest impact on the incremental result were the costs of diagnostic tests (functional tests and CCTA) and the relative risk of infarction between functional tests and CCTA. These factors exhibited wide variation ranges, demonstrating that they are the main drivers of result instability. In contrast, variables such as AMI-related costs, discount rate, and probabilities of clinical events associated with CCTA showed minimal or no variation, indicating low influence on the final outcome. Thus, the DSA indicates that the uncertainty of the analysis is concentrated primarily in test costs and relative infarction risks, while the remaining parameters play a secondary role (Figure 4A).

Table 3 – Cost-effectiveness analysis – compared with functional tests

Outcomes	CCTA	Functional tests	Incremental
Total cost	R$ 610.18	R$ 658.36	- R$ 48.18
Acute myocardial infarction (AMI)	2.10%	2.33%	0,23% avoided
ICER (R$)			Dominant RCEI: -20.707 (IC95%: -368.821; 192.620)
Total cost	R$ 1.378.14	R$ 1.659.18	- R$ 281.04
Revascularization	14.16%	18.25%	4,10% avoided
ICER (R$)			Dominant RCEI: -6.863 (95%CI: -14.691; 2.084)
Total cost	R$ 602.86	R$ 628.16	-R$ 25.31
Hospitalization	0.22%	0.15%	+ 0.07%
ICER (R$)			Lower cost with lower effectiveness RCEI: 37.285 (95%CI: -360.157; 712.402)

CCTA: coronary computed tomography angiography; ICA: invasive coronary angiography; 95% CI: 95% confidence interval; ICER: incremental cost-effectiveness ratio.

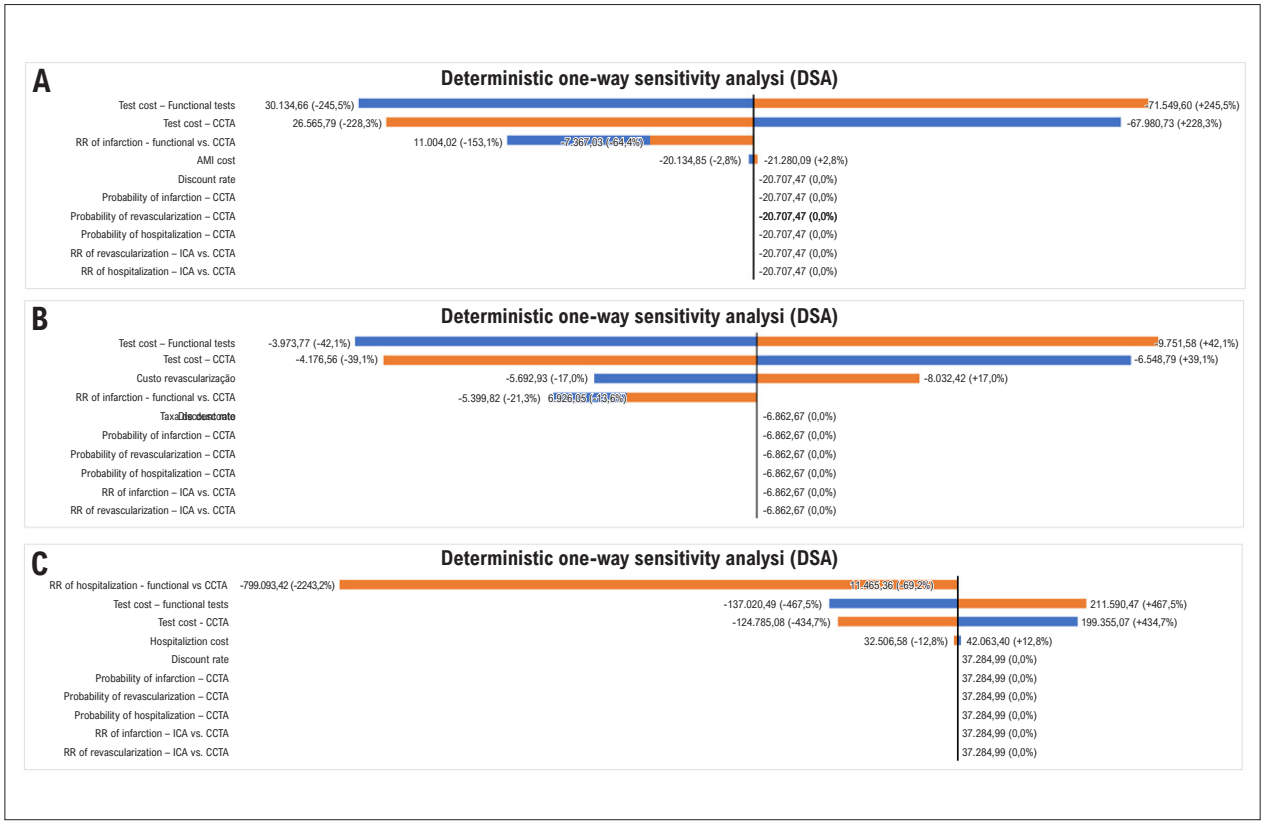


Figure 4 – *Deterministic one-way sensitivity analysis (DSA) comparing CCTA and Functional tests across different outcomes: (A) Acute Myocardial Infarction (AMI), (B) Revascularization, and (C) Hospitalization.*

In the deterministic analysis (Figure 4B), the greatest impact on the incremental result was observed for diagnostic test costs and revascularization costs, whereas clinical variables, discount rates, and relative risks had minimal influence, indicating that direct costs are the main determinants of model uncertainty. In the deterministic analysis (Figure 4C), the variables with the greatest impact were the relative risk of hospitalization and diagnostic test costs, while variables such as hospitalization costs, discount rate, and probabilities of clinical events had minimal influence, highlighting the main determinants of uncertainty in the model.

Budget impact analysis. In the base scenario of conservative diffusion (5% per year), presented in Table S8 and Central Illustration (B), the total accumulated cost between 2026 and 2030 was R$ 1.64 billion in the proposed scenario, compared with R$ 1.68 billion in the current scenario. This represents overall savings of approximately R$ 39.3 million when considering the use of existing infrastructure, without the acquisition of new CT scanners. The annual incremental impact was negative in all years, ranging from –R$ 2.49 million in 2026 to -R$ 13.4 million in 2030. The incremental cost per patient followed the same trend, reaching -R$ 223.33 by the end of the period. In the alternative scenario that includes the need for equipment acquisition, although the savings were smaller, cumulative savings of approximately R$ 23.6 million were still observed, with an incremental cost per patient of -R$ 134.13.

In the alternative accelerated-diffusion scenario (9.3% per year), presented in Figure 4B, the savings were even more substantial. The total accumulated cost decreased to R$ 1.61 billion in the proposed scenario, compared with R$ 1.68 billion in the current scenario, corresponding to overall savings of approximately R$ 73 million when considering existing installed capacity. The incremental impact ranged from -R$ 4.63 million in 2026 to -R$ 24.9 million in 2030, with an accumulated incremental cost per patient of -R$ 414.96. In the scenario with acquisition of additional equipment, savings were smaller but still meaningful, totaling R$ 44.7 million over the period, with an incremental cost per patient of -R$ 254.40 (Table S9). In summary, both in the conservative and accelerated diffusion scenarios – and regardless of the need for new CT scanners – CCTA proved advantageous compared with functional tests, consistently reducing SUS healthcare expenditures.

Discussion

This pioneering study, conducted within the Brazilian context, evaluated the cost-effectiveness and budget impact of CCTA compared with both ICA and functional tests from the SUS perspective. The results suggest that CCTA may represent a potentially advantageous strategy, associated with lower costs and greater efficiency in virtually all scenarios analyzed, reinforcing its role as the preferred initial method for evaluating patients with low-to-moderate risk of CAD. Coronary computed tomography angiography is a tool capable of providing a non-invasive anatomical diagnosis of CAD.

In the comparative analysis between CCTA and ICA, CCTA demonstrated lower mean costs across all outcomes: savings of R$ 257.62 per patient for acute myocardial infarction, R$ 455.70 per patient for myocardial revascularization, and R$ 329.93 per patient for hospitalizations. These values confirm the economic superiority of CCTA over the invasive strategy. In comparison with functional tests, CCTA also showed savings in nearly all scenarios. Average reductions of R$ 48.18 per patient were observed for infarction, R$ 281.04 per patient for revascularization, and R$ 25.31 per patient for hospitalizations. Although the latter scenario showed lower cost associated with a small difference in effectiveness, the overall economic impact favors CCTA as a dominant technology.

The budget impact analysis further strengthened the relevance of these findings, projecting cumulative savings of R$ 63.3 million compared with ICA and R$ 73.0 million compared with functional tests, even when considering only the current installed capacity in the country. In a universal health system such as SUS, with limited resources and increasing demand, these values highlight the importance of incorporating more cost-effective diagnostic strategies.

The results presented align with major international recommendations. NICE, in the United Kingdom, recommends CCTA as the first-line test for evaluating patients with stable chest pain and intermediate probability of obstructive CAD, reserving functional tests for inconclusive cases.[13] Similarly, European guidelines also recognize CCTA as the preferred initial method.[14] In the United States, although there is still broader use of the exercise treadmill test – particularly in patients capable of achieving high exercise workloads – this approach has limitations, as it does not detect non-obstructive CAD.[15]

Large clinical trials such as PROMISE, SCOT-HEART, and DISCHARGE have highlighted the diagnostic accuracy and prognostic impact of CCTA, demonstrating improved detection of CAD, reduction in cardiovascular events, and optimization of healthcare resource use.[4-6] In particular, the SCOT-HEART 2018 study showed that the use of CCTA, combined with standard care, resulted in a significantly lower rate of the primary endpoint (death from coronary heart disease or nonfatal myocardial infarction) compared with standard care alone [2.3% vs. 3.9%; Hazard Ratio (HR) 0.59; 95% CI 0.41–0.84; p=0.004]. In addition to offering more precise diagnosis, CCTA contributes to appropriate risk stratification and therapeutic guidance, resulting in improved clinical outcomes.[16]

Beyond its diagnostic accuracy, CCTA offers the advantage of reducing unnecessary invasive procedures. Previous studies have shown that adopting a CCTA-based strategy led to a reduction of more than 70% in unnecessary ICA referrals, with consequent reduction in risks associated with invasive interventions and more rational use of healthcare resources, without compromising clinical outcomes.[17,18]

Although the studies analyzed in this report focused predominantly on patients with intermediate pre-test probability of obstructive CAD, the results should be interpreted primarily within this specific context.[4-6] However, given the high demand for CAD-related diagnostic testing, these findings gain broader relevance for healthcare providers, offering evidence to support the definition of the relative role of different diagnostic modalities within clinical pathways for atherosclerosis.

Our study presents several limitations that should be considered when interpreting the results. First, it was designed for the Brazilian public healthcare context; therefore, the data used were extracted from official sources, and all unit values were obtained from the SIGTAP/BPS database, reflecting the reimbursement amounts paid by SUS. The analysis relied on official reimbursement values, which are often lower than the actual costs of service provision but represent the standardized amounts regulated by SUS. In the absence of national data, information from previously cited randomized clinical trials was used. The five-year time horizon adopted for this study may underestimate long-term benefits, particularly regarding the cumulative prevention of AMI and revascularization procedures. Another limitation is the restricted assessment of the adequate availability of CT scanners across the country, as their distribution is uneven, as is the availability of specialized professionals for image acquisition and interpretation. Finally, the estimated proportion of functional test utilization, based on data from the PROMISE[4] study, does not fully reflect clinical practice in Brazil, particularly regarding the use of functional tests. However, PROMISE remains the main clinical trial with appropriate methodology comparing the diagnostic technologies addressed in this report.

Despite these limitations, the present study helps fill an important evidence gap in the national context by demonstrating that incorporating CCTA into SUS has the potential to reduce unnecessary invasive procedures, optimize costs, and expand equity in access to CAD diagnosis. This initiative represents an important step toward aligning Brazil with international best practices, promoting greater efficiency in cardiovascular care and generating benefits for patients, healthcare managers, and the health system as a whole.

Conclusions

Coronary computed tomography angiography proved to be a dominant and cost-effective strategy compared with invasive coronary angiography and functional tests in patients with low to moderate risk of CAD from the perspective of the Brazilian Unified Health System. Its implementation over a five-year period would result in significant savings for the healthcare system.

Author Contributions

Conception and design of the research: Costa IBSS, Torreão JA, Shiozaki A, Trad HS; Acquisition of data: Costa IBSS, Torreão JA, Trad HS; Analysis and interpretation of the data: Costa IBSS, Torreão JA, Shiozaki A, Trad HS, Lopes LES, Bittencourt MS; Statistical analysis: Trad HS, Lopes LES, Bittencourt MS; Writing of the manuscript: Costa IBSS, Torreão JA, Shiozaki A; Critical revision of the manuscript for intellectual content: Costa IBSS, Torreão JA, Bittencourt MS, Moretti MA, Barberato SH, Rochitte CE.

Potential Conflict of Interest

Luana Emanuelly Sinhori Lopes received sponsorship from Siemens for statistical analyses.

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Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

This article does not contain any studies with human participants or animals performed by any of the authors.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Availability of Research Data

The underlying content of the research text is contained within the manuscript.

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*Supplemental Materials

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