

# Cardiac coronary tomography angiography (CCTA) use across geographical regions in the USA and the UK: a cross-sectional study

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## ABSTRACT

**Objective** Increased use of CT imaging has been identified as a key component of unsustainable rising healthcare costs in the USA and globally. Understanding evidence and its relation to imaging coverage policies can help identify patterns of variation to better inform high value care initiatives. This cross-sectional study evaluates regional differences in US utilisation of cardiac coronary tomography angiography (CCTA) and compares use in the USA and England.

**Design** We determined differences in CCTA order rates by US Medicare region and compared order rates in the US and England, compared CT scanner prevalence in the USA and UK, and reviewed the CCTA coverage policies for each region.

**Setting** The US and the UK.

**Participants** Medicare Coverage Database; Medicare 2018 Part B data; National Health Services 2018 data.

**Interventions** CCTA orders, CT scanner prevalence.

**Main outcome measures** CCTA orders per beneficiary, CT scanner prevalence, CCTA policy variation.

**Results** We found that CCTA coverage policies are more permissive in the UK compared with the USA. However, CT scanner prevalence per beneficiary is four times greater in the USA than the UK. There was significant variation in number of CCTA ordered per 100 000 beneficiaries between regions in England and the USA, ranging from 74 to 313 in the US and 57–317 in England.

**Conclusions** There is significant geographical variation in use of CCTA in both the USA and England, although overall use does not differ significantly between both countries. Similarities in order rates, despite a much higher CT scanner density in the USA, may be related to more permissive guidelines around use of CCTA in the UK. Variation in both countries may also reflect the lack of high-quality clinical outcomes data for use of CCTA, underscoring opportunities for more evidence and evidence-based policy to promote appropriate use of CCTA imaging.

## INTRODUCTION

Increasing use of cardiac imaging is a key driver of unsustainable rising healthcare costs.<sup>1 2</sup> Imaging use varies internationally, as with many technologies, its use is highest

### WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Increasing use of diagnostic imaging is a key component of unsustainable rising healthcare costs in the USA. There is variation in use of cardiac coronary tomography angiography (CCTA) in patients with suspected coronary artery disease. CCTA use may be driven by CT scanner prevalence (supply sensitive) and coverage policy, as outcomes data on its clinical benefit is lacking.

### WHAT THIS STUDY ADDS

⇒ This study quantifies the use of CCTA in the USA and England and compares coverage policies and density of CT scanners between the USA and the UK.

### HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The study findings underscore the importance of the need for outcomes data for CCTA and evidence-based coverage policy to promote appropriate use of CCTA.

in the USA, which performs 40% more MRIs than 10 other high-income countries—118 per 1000 population compared with 82 per 1000 population.<sup>2</sup> For all types of CT scans, the USA mean was 245 CTs per 1000 population compared with 151 per 1000 population in other high-income countries.<sup>2</sup> Appropriate use occurs when the chance of benefit outweighs chance of harm. Understanding imaging trends and what factors drive use of cardiac coronary tomography angiography (CCTA) can help inform the development of high value care initiatives that can promote appropriate imaging practices.

CCTA is a cardiac imaging test that captures a two-dimensional image of the heart, including the coronary arteries.<sup>3</sup> There is significant radiation from this test, estimated to be 12 mSv per examination (approximately 600 chest X-rays), with concomitant cancer risk.<sup>4 5</sup>

There is a lack of agreement in the scientific community on the clinical value of the CCTA for evaluation of patients with suspected coronary artery disease (CAD).<sup>6</sup> Many clinicians question whether imaging is helpful at all, particularly in patients who are at low risk of CAD,<sup>7,8</sup> while other clinicians argue that CCTA's association with reduced nonfatal myocardial infarctions supports its use.<sup>9</sup> CT scanning is an example of supply-sensitive care, meaning a greater supply of CT scanners is associated with more use of CT scans.<sup>10</sup>

The history of Medicare coverage of CCTA is illustrative of the interplay of science and politics.<sup>11</sup> In 2006, the Centers for Medicare and Medicaid (CMS) convened the Medicare Coverage Advisory Committee (now Medicare Evidence Development & Coverage Advisory Committee), an advisory panel of independent experts, to review the use of CCTA for diagnosing CAD.<sup>11</sup> When the expert committee found no evidence of benefit for use of CCTA, which would generally lead to a determination of non-coverage, CMS instead declined to issue any national coverage determination (NCD), likely for political reasons.<sup>12</sup> In the absence of an NCD, responsibility falls to local carriers (Medicare Administrative Contractor (MACs), online supplemental figure 1)<sup>13</sup> for defining local coverage determinations (LCDs). LCDs are done through a region-specific process mirroring that of an NCD, which involves informal meetings and external requests to develop an LCD, consultations, a proposed determination and public comment period, optional input of a Contractor Advisory Committee, and notice of a final determination.<sup>14</sup>

Specialist societies have published appropriate use guidelines for CCTA. In 2010, the *Journal of Cardiovascular Computed Tomography* published appropriate use criteria (AUC) for CCTA: 'ACCF/SCCT/ACR/AHA/ASE/ASNC/NASCI/SCAI/SCMR 2010 Appropriate Use Criteria for Cardiac Computed Tomography.'<sup>15</sup> The (AUC) guidelines state that if a patient has an intermediate pretest probability, regardless of their ability to exercise or interpret their electrocardiogram (ECG), CCTA is appropriate. In the case where a patient has a low pretest

probability, the appropriateness depends on if the ECG is interpretable and if the patient is able to exercise or not. In 2021, the *American Heart Association* published the 'AHA/ACC/ASE/CHEST/SAEM/SCCT/SCMR Guideline for the Evaluation and Diagnosis of Chest Pain' that recommends the use of CCTA for intermediate high risk patients with stable chest pain and no known CAD.<sup>16</sup>

The lack of a national coverage policy allows regional variation. For CCTA, the decision to not issue an NCD was rapidly followed by an increase in CCTA use among the Medicare population.<sup>11, 17</sup> When CMS declined to issue an NCD in 2006, CCTA use rose rapidly and continues to rise, as commercial payer coverage becomes more permissive.<sup>17, 18</sup>

The UK relies on the National Institute for Health and Care Excellence (NICE) to issue guidelines for the National Health Service (NHS). NICE has recommended CCTA as first-line diagnostic testing for stable CAD since 2016, and there is a class I (strongest) recommendation from the European Society of Cardiology in 2019.<sup>19, 20</sup>

We conducted a descriptive study evaluating regional differences in USA utilisation of CCTA for Medicare beneficiaries and comparing CCTA utilisation in the USA and England, the country in the UK with the largest population and highest rate of CCTA use.<sup>21</sup> As CCTA use is often related to availability of CT scanners, we also looked at density of CT scanners across regions.<sup>10</sup>

We undertook this study to better understand current trends in CCTA usage and its relation to evidence and coverage policies in the USA and UK. The primary country of interest in this analysis is the USA. England and the UK are used as comparators.

## METHODS

### Data sources

The Medicare Coverage Database was used to access LCDs for CCTA for each MAC.<sup>22</sup> Medicare Part B claims from 2018 from the Medicare Fee-for-Service Provider Utilisation & Payment Data Physician and Other Supplier Public Use File (Physician and Other Supplier PUF) was

**Table 1** Medicare Administrative Contractor (MAC) local coverage determination differences for CCTA

MAC	Level of pretest probability of CAD required	Stress test required before CCTA?
CGS	Low intermediate	No: 'CCTA may be used in lieu of an imaging stress test'
NGS	Low intermediate	No: 'CCTA may be used in lieu of an imaging stress test'
Palmetto	Intermediate only	Yes: 'uninterpretable or equivocal stress test results' required
First Coast	Low intermediate	Yes: 'equivocal stress test results' required
WPS	Low intermediate	No: all 'patients with anginal symptoms' are eligible
Novitas	No policy publicly available	No policy publicly available
Noridian	No policy publicly available	No policy publicly available

MAC region names: Palmetto GBA (Palmetto), Celerian Group Company Administrators (CGS), First Coast Service Options (First Coast), National Government Services Incorporated (NGS), Noridian Healthcare Solutions (Noridian), Novitas Solutions (Novitas) and WPS. CAD, coronary artery disease; CCTA, cardiac coronary tomography angiography; NGS, National Government Services Incorporated; WPS, Wisconsin Physicians Service Insurance Corporation.

**Table 2** Medicare Administrative Contractor (MAC) region cardiac coronary tomography angiography (CCTA) orders and Medicare Beneficiaries in 2018

MAC region	Total CCTAs ordered	Medicare beneficiary population	Orders per 100 000 beneficiaries
Total	59 411	34 239 240	168.6
CGS	1 619	1 960 515	82.6
First Coast	7 897	2 607 736	302.8
NGS	13 242	4 224 003	313.5
Noridian	11 748	7 167 787	163.9
Novitas	13 537	9 263 036	146.1
Palmetto	8 329	5 935 939	140.3
WPS	3 039	4 080 224	74.5

MAC region names: Palmetto GBA (Palmetto), Celerian Group Company Administrators (CGS), First Coast Service Options (First Coast), NGS, Noridian Healthcare Solutions (Noridian), Novitas Solutions (Novitas) and WPS. The regions included under each MAC can be found at the following website: <https://www.cms.gov/files/document/ab-jurisdiction-map03282023pdf.pdf>. NGS, National Government Services Incorporated; WPS, Wisconsin Physicians Service Insurance Corporation.

used for CCTA usage numbers (CPT code: 75574).<sup>23</sup> The Physician and Other Supplier PUF dataset contains final action (i.e., all claim adjustments have been resolved) Part B non-institutional line items for the Medicare fee-for-service (FFS) population.<sup>24</sup> CCTA use in England was based on CCTA utilisation records from 2018 from the NHS Digital Imaging Dataset, a collection of data received from imaging departments throughout the UK.<sup>25</sup> CT scanner prevalence data for the UK and USA was sourced from the Organisation for Economic Co-operation and Development's (OECD) 2020 Health Equipment Report.<sup>26</sup>

### Statistical analysis

We grouped data by MAC regions and calculated beneficiary population covered by each MAC using CMS 2018 Medicare Beneficiary Population data.<sup>24</sup> Next, we determined differences between CCTA orders by MAC region using  $\chi^2$  tests (StataCorp. 2021. Stata Statistical Software: Release V.17., StataCorp). Then, we determined the magnitudes of differences in CCTA order rates between the seven MAC regions in the USA through estimated odds ratios using logistic regression. We used the MAC with the most conservative policies as the reference group for the other MACs in this study. Demographic data were not analysed as it is not available publicly. We then compared both CCTA use in the USA and England and CT scanner prevalence in the USA and the UK. The primary outcome is per-capita CCTA use, and the study factor is regional CCTA policy. Secondary outcomes include CT scanner use per capita.

## RESULTS

### CCTA policy in MAC regions and in the UK

There are seven MACs in the USA (table 1). MAC coverage policies are available online in the Medicare Coverage Database.<sup>22</sup> Two of the seven MACs (Noridian and Novitas) do not provide CCTA policy information

online. Some of the seven MAC regions (table 1) require stress testing, prior to coverage of CCTA, while other MAC regions do not. Out of the five policies identified, four MACs require a low-intermediate pretest probability of CAD (Wisconsin Physicians Service Insurance Corporation (WPS), First Coast, National Government Services Incorporated (NGS), Celerian Group Company Administrators (CGS)), while one MAC (Palmetto GBA) requires an intermediate pretest probability of CAD. Two MACs (Palmetto and First Coast) require a stress-test before CCTA. Palmetto was considered the most conservative of the seven and used as the comparator.

In England, there is one universal coverage policy that recommends CCTA as first-line diagnostic testing for stable CAD.<sup>19 20</sup>

### CCTA usage between MAC regions

NGS and First Coast had the highest CCTA orders per 100 000 beneficiaries (313.5 and 302.8, respectively) (table 2). WPS was the MAC region with the lowest CCTA orders at 74.5 orders per 100 000 beneficiaries (table 2). Physicians caring for Medicare beneficiaries within four MAC regions (NGS, First Coast, Noridian, Novitas) had statistically significantly higher odds of ordering a CCTA (table 3), as compared with Palmetto (ORs with 95% CI: 2.23 (2.18–2.30); 2.16 (2.10–2.23); 1.17 (1.14–1.2); 1.04 (1.01–1.07), respectively). Physicians within the NGS and First Coast MAC regions are more than two times more likely to order a CCTA, as compared with physicians in the Palmetto MAC region (ORs with 95% confidence limits: 2.23 (2.18–2.30); 2.16 (2.1–2.23), respectively). Two regions (CGS, WPS) had lower odds of ordering a CCTA compared with Palmetto with WPS being the lowest at an OR of 0.53 (0.50–0.55)).

### Variation in CCTA usage within and between the USA and England

The overall order rates in the USA and England in 2018 were 168.6 and 152.4 per 100 000 beneficiaries,

**Table 3** Cardiac coronary tomography angiography ordering rates across Medicare Administrative Contractor (MAC) regions

MAC region	OR (95% confidence limits)	P value
Palmetto GBA (comparator group)	1.0 (reference)	N/A
NGS	2.23 (2.18–2.30)	<0.001
First Coast	2.16 (2.10–2.23)	<0.001
Noridian	1.17 (1.14–1.20)	<0.001
Novitas	1.04 (1.01–1.07)	<0.001
CGS	0.59 (0.56–0.62)	<0.001
WPS	0.53 (0.50–0.55)	<0.001

Comparator group: Palmetto GBA. MAC region names: Palmetto GBA (Palmetto), Celerian Group Company Administrators (CGS), First Coast Service Options (First Coast), NGS, Noridian Healthcare Solutions (Noridian), Novitas Solutions (Novitas) and WPS.

N/A, not available; NGS, National Government Services Incorporated; WPS, Wisconsin Physicians Service Insurance Corporation.

respectively. CCTA orders are higher in the USA compared with England (table 4), but they were not statistically significant. There was large variation in the range of CCTA orders across England's 42 NHS regions, with the lowest ordering region having 57 per 100 000 beneficiaries and the highest having 317 per 100 000 beneficiaries. CCTA orders across US MAC regions per 100 000 beneficiaries ranged between 75 and 314.

### CT scanner prevalence analysis

CT scanner prevalence in 2020 was greater than fourfold higher in the USA than in the UK, with 4.2 CT scanners per 100 000 people in the USA compared with 0.9 CT scanners per 100 000 people in the UK (table 4).

## DISCUSSION

We found significant differences in CCTA coverage policies across the USA and when compared with the UK's NICE guidelines. There are also significant differences in CCTA orders per beneficiary at the regional carrier level. Conservative coverage policy in the USA and the UK did not always correspond to a lower rate of CCTA

**Table 4** The USA and England cardiac coronary tomography angiography (CCTA) orders and US and UK CT scanner prevalence

Country	Regional CCTA orders per 100 000 beneficiaries (US data: 2018; England data: 2018)	CT scanner prevalence per 100 000 (US and UK data: 2020)
USA (medicare)	75–314	4.2
England/UK (National Health Service)	57–317	0.9

use, suggesting there are additional reasons to explain test ordering behaviour, including demographic factors and medical culture. For example, one of the MACs (First Coast) with the highest rates of CCTA orders per medical beneficiary covers Florida only, a state commonly found to be a high volume user of medical care.<sup>27</sup>

There was much regional variation of CCTA use in the USA and England. The USA slightly exceeds England in CCTA orders, although by a non-significant amount. Higher volumes of medical procedures are typical in the US healthcare, especially for supply-sensitive care such as CCTA; however, England has a more liberal coverage policy for CCTA than many regions in the USA. This may be related to the similarity of order rates in both countries even though availability of CT scanners is much lower in the UK than the USA. Among the 42 NHS regions, one region had >300 orders per 100 000 beneficiaries. Among the seven USA MACs, two regions had >300 orders per 100 000 beneficiaries. The smaller availability of CT scanners in the UK along with similar order rates to the USA indicates that each CT machine is being used more often in England than the USA. According to the OECD 2020 Health Equipment report, the USA has almost 40% of CT scanners in ambulatory care provider clinics while the UK has the majority of its CT scanners within hospitals. The centralisation of CT scanners in hospitals in the UK could be a driver in increased use per machine.

Our finding highlights the importance of having evidence-based outcomes data for diagnostic tests to help inform use and coverage so that testing and treatment can lead to improved health outcomes. Outcomes evidence is essential to best direct use of healthcare resources.

Limitations include lack of granularity in the dataset. It would be helpful to understand if there are a small number of individual physicians driving a majority of CCTA orders in certain regions or if there are widespread differences in CCTA ordering habits across all physicians in different regions. However, the CMS dataset lacks detailed clinical information. Additionally, variation in CCTA ordering may be due to underlying sociodemographic differences in Medicare beneficiaries in different regions. This could not be considered in our analysis due to lack of availability and thus, we cannot comment on appropriateness of use of CCTA. A long-standing limitation of CMS data is that it includes FFS claims only, as Medicare Advantage (plans offered by private companies and approved by Medicare) data are not publicly available. Finally, this is a population-level analysis and, therefore, existing associations need to be interpreted with caution.

The rapid increase in use of CCTA following CMS declining to issue a national coverage decision for CCTA in the USA in 2006, and the continued variability in CCTA utilisation across Medicare regions highlights the problems of non-evidence-based policy. A 2017 systematic review and meta-analysis found that CCTA, when compared with functional stress testing, has no significant impact on death or cardiac hospitalisation and leads to an increase in downstream invasive procedures.<sup>28</sup> In

addition, a large-scale observational study did not show benefit for patients undergoing initial testing strategy with stress or anatomical imaging compared with those undergoing an initial exercise stress test.<sup>29</sup>

The SCOT-HEART trial is often cited as justification to make CCTAs first line for stable angina.<sup>9</sup> The SCOT-HEART 2018 paper concluded that CCTA use shows a significant reduction in their primary clinical endpoint, which was defined as: nonfatal myocardial infarction or death from coronary heart disease. Of note, disease-specific mortality was not statistically significant which suggests that nonfatal myocardial infarctions alone drove the significant difference in the primary outcome. Additionally, the SCOT-HEART trial randomised patients into either receiving standard care plus CCTA or standard care alone; 85% of patients received functional stress testing in both arms.<sup>28</sup> The SCOT-HEART trial compares functional stress testing plus CCTA compared with functional stress testing alone.

Despite the lack of robust evidence and consensus on outcomes benefit and the radiation risk, CCTA use continues to grow.<sup>28</sup> Imaging tests, such as CCTA, are often not held to similar clinical outcomes criteria of benefit as therapeutics. Additionally, often imaging tests such as CCTA lead to additional testing and downstream tests of unknown clinical value.<sup>30</sup> More awareness and discussion of benefits, and selecting and prioritising outcome measures (e.g., non-fatal myocardial infarctions, cardiac deaths, cardiac hospitalisations, procedure-related complications, exposure to radiation) can help inform and direct national CCTA policy that is grounded in evidence. Systematic collection of CCTA outcomes data in a national database could help build a robust dataset used to drive future policy creation.

## CONCLUSION

We found much variation in use of CCTA across the USA and England, and a fourfold higher prevalence of CT scanners in the USA. High variation in coverage policies across the USA and in utilisation of CCTA across the USA and England illustrates opportunities for better informed evidence-based policy. In addition, comparing USA to England CCTA utilisation while considering differences in permissiveness of coverage policies highlights the potential impacts of scanner availability within supply-sensitive care, such as CCTA use. Future studies should further evaluate areas with higher ordering rates and look at clinical outcomes to begin to understand the drivers of CCTA use and help to reduce low-value care.

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**Contributors** BB led the acquisition, analysis and interpretation of data for the study. RJ supported the analysis and interpretation of the data for the study as well led the final formatting of the manuscript. JN assisted in the analysis of the data. SD and RR provided substantial contributions to the conception and design of the work and RR submitted the study. RR is the guarantor.

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