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Original Article

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Differences in diagnostication, and revascularisation of ischaemic heart disease in Western Denmark

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ABSTRACT

INTRODUCTION. In Denmark, the incidence of and mortality from ischaemic heart disease (IHD) has been declining. In this context, it is of interest to assess any regional differences in diagnostication and invasive treatment of IHD.

METHODS. We intended to describe the diagnostication and invasive treatment of IHD in Western Denmark at the regional/municipal level using the Western Denmark Heart Registry. Coronary angiography (CAG), percutaneous coronary intervention (PCI) and coronary arterial bypass grafting were registered from 2000 through 2019; cardiac multislice computed tomography (CMCT), from 2015 through 2019.

RESULTS. Concerning the use of revascularisation for acute coronary syndrome (ACS), we found comparable regional activity levels but significant differences between individual municipalities. Furthermore, the use of CAG for chronic coronary syndrome (CCS) was significantly higher and the use of CMCT significantly lower in the North Denmark Region than in the Central and South Denmark Regions.

CONCLUSION. We found differences in the rates of PCI for ACS at the municipal level but not between the Western Denmark regions. Furthermore, at the regional level, evaluation of chronic IHD differed regarding use of elective CAG and CMCT, and use of CMCT was not paralleled by a reduction in the number of CAG procedures. This may possibly prompt discussions on the strategy for invasive and non-invasive diagnosis of CCS and on targeted preventive measures.

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TRIAL REGISTRATION. not relevant.

In Denmark, the incidence of and the mortality from ischaemic heart disease (IHD) have been declining [1]. In this context, it is of interest to investigate any regional differences. The Western Denmark Heart Registry (WDHR) collects information on risk factors, diagnosis and revascularisation treatment of IHD in Jutland and on Funen, covering a population of 3.1 million inhabitants [2, 3]. The present work describes the use of invasive and non-invasive investigations and revascularisation treatment in the regions and municipalities of Western Denmark based on WDHR registration of cardiac multislice computed tomography (CMCT), coronary angiography (CAG), coronary revascularisation treatment with transluminal percutaneous coronary intervention

(PCI) or coronary arterial bypass grafting (CABG).

METHODS

We used the WDHR data on CAG, PCI, CABG and CMCT in individuals aged ≥ 40 years. The WDHR is a regional clinical quality database and also a data source for the Danish Heart Register, which nationally monitors the quality of interventional cardiology and thoracic surgical treatment [2, 3]. CAG, PCI and CABG have been registered since 1999. Registration of CMCT was initiated in 2008 and has been comprehensive since 2010. The reorganisation of the administration of Danish healthcare in 2007 from counties to regions and the associated reorganisation of municipalities changed the catchment areas of centres and hospitals, which may potentially have an impact on our investigation. Therefore, we have chosen the years from 2000 through 2019 to describe the use of CMCT and CAG, and the subsequent treatment of IHD by PCI or CABG in Western Denmark at the regional level, and the years from 2015 through 2019 at the municipal level. Data collected after 2019 are not included because of Covid-19-related changes of referral patterns in Denmark [4].

The current data sets include patients who underwent a CAG, PCI, CABG or CMCT procedure. The first procedure that the patient underwent during the five-year observation period from 2015 to 2019 was included; a total of 122,160 procedures. We describe the number of patients who had these procedures performed electively on the indication chronic coronary syndromes (CCS) and acutely/sub-acutely on the indication acute coronary syndromes (ACS). For ACS (ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), unstable angina pectoris, other acute cardiac conditions such as cardiogenic shock or cardiac arrest), only PCI procedures were included as PCI is the predominant treatment of these acute conditions. Revascularisation was defined as a PCI procedure and/or a CABG operation.

We calculated the results as rates (number per 100,000 inhabitants aged ≥ 40 years) to minimise differences in the age composition of the regions and municipalities.

Frequencies (proportions/rates) are compared by the chi-squared test; and the relationship between CMCT, CAG and revascularisation with PCI or CABG at the municipal level is assessed by the ANOVA test. The 25 and the 75 percentile rates or the tenth and 90 percentiles were used to compare differences between municipalities. Data were primarily reported as median with 95% confidence limits (CI). We chose a significance level of $\leq 1\%$.

The project is registered with the Danish Data Protection Agency (1-16-02-587-20). The provisions of the agency on the use and handling of data were met.

Trial registration: not relevant.

RESULTS

Figure A in the supplementary material shows the annual number of CAG, PCI, CABG and CMCT procedures since 2000 in Western Denmark. The number of CAG and PCI procedures increased around 2004, which temporally was associated with the introduction of primary PCI for STEMI. This was followed by a stable activity level with a slightly declining trend in numbers in recent years. Surgical revascularisation has decreased significantly in the course of the same period, whereas the use of CMCT has increased steadily since its inception in 2008.

Acute coronary syndromes

PCI procedures performed on the ACS indication were generally at the same level in the three regions with the numerically highest rate per 100,000 citizens aged ≥ 40 years being recorded in the North Denmark Region and

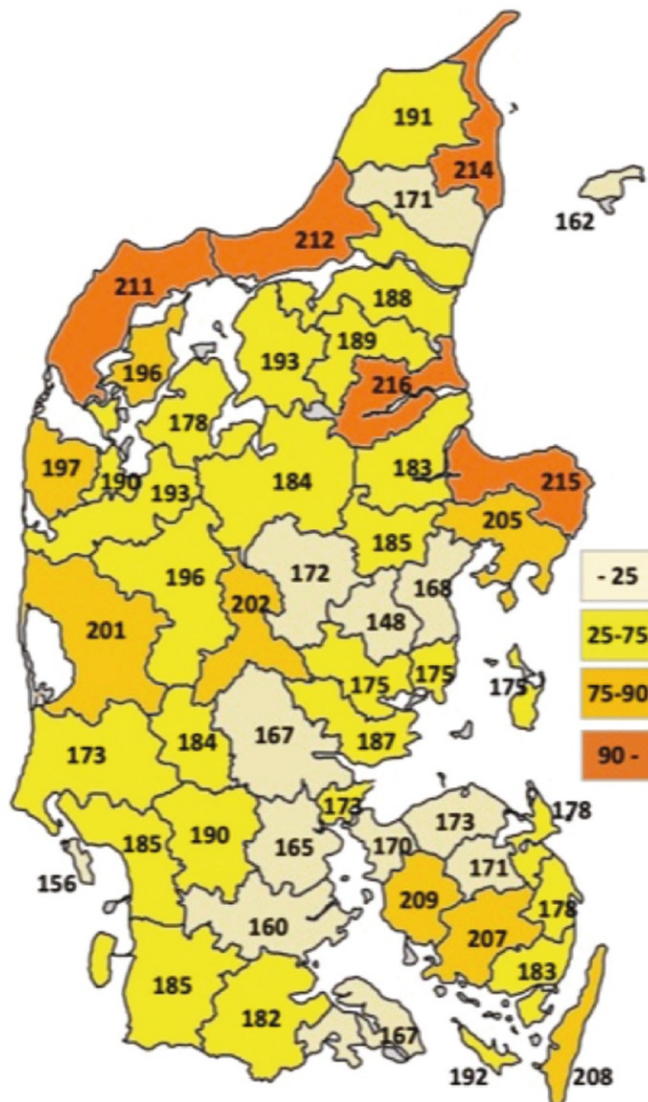
the lowest rate being registered in the South Denmark Region (Table 1). Differences ($p < 0.002$) at the municipal level were significant, with the highest rates being recorded in the municipalities of Frederikshavn, Thisted, Jammerbugt, Mariagerfjord and Norddjurs (Figure 1).

TABLE 1 Average number of patients per 100,000 inhabitants aged ≥ 40 years in the three regions of Western Denmark in 2015-2019 with first-time percutaneous coronary intervention (PCI) performed on the following indications: acute coronary syndrome (ACS), coronary angiography (CAG) and elective revascularisation for chronic coronary syndrome (CCS) and cardiac multislice computed tomography (CMCT).

	Region of Southern Denmark	Central Denmark Region	North Denmark Region	p value
<i>n/100,000 (95% confidence interval)</i>				
PCI ACS	183 (173-194)	185 (175-196)	201 (186-218)	0.115
Elective CAG	297 (285-311)	318 (305-332)	373 (352-394)	< 0.0001
Elective revascularization	150 (141-159)	189 (179-200)	183 (168-198)	< 0.0001
Cardiac CMCT	548 (531-566)	506 (489-523)	403 (381-425)	< 0.0001
Revascularization/CAG ^a , n/N	0.48	0.54	0.55	< 0.0001

a) The fraction refers to electively treated CCS patients.

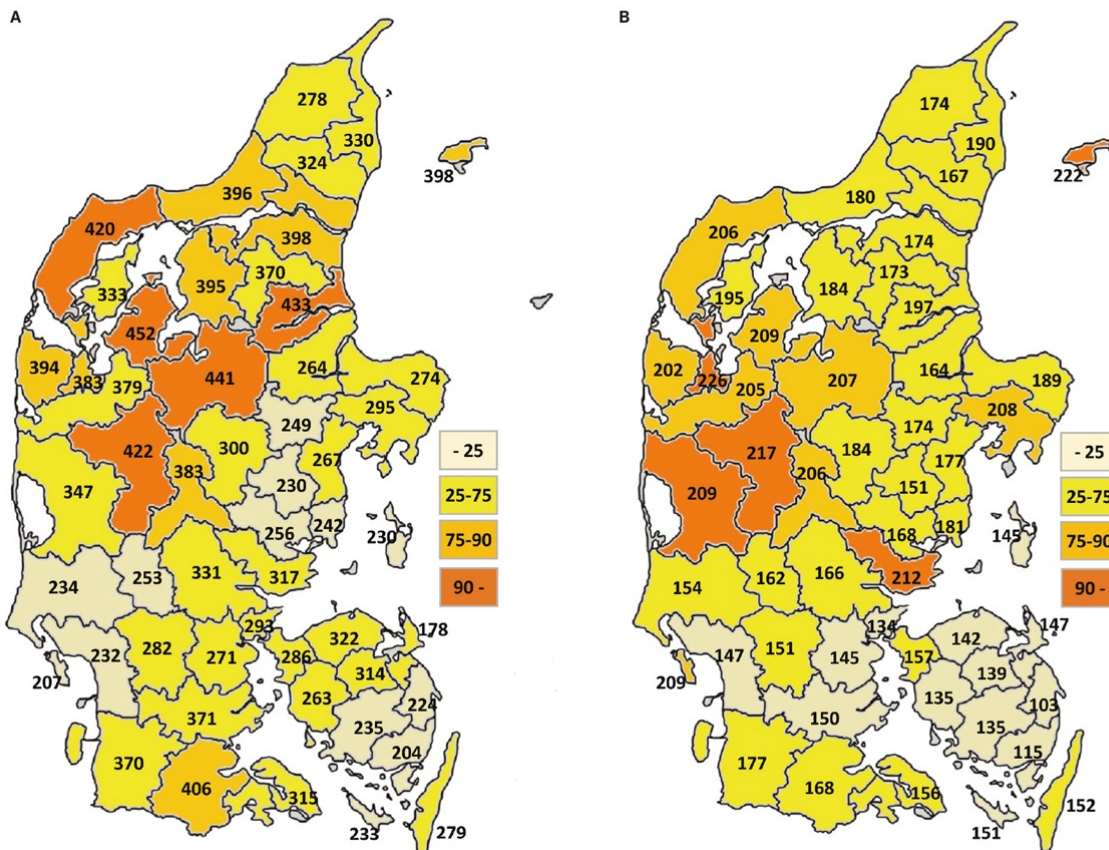
FIGURE 1 Patients with first-time percutaneous coronary intervention per 100,000 inhabitants aged ≥ 40 years on indication acute coronary syndrome in Western Danish municipalities. The colour codes refer to the 0-25, 25-50, 50-90 and 90-100 percentiles for Western Denmark. Significant differences were observed between individual municipalities ($p < 0.002$).



Chronic coronary syndromes

Proportionally, more elective CAGs were performed on the CCS indication in the North Denmark Region than in the Central and South Denmark Regions (Table 1). Significant differences were observed at the municipal level ($p < 0.0001$) with increased use of CAG in municipalities in the north-western part of Jutland, but relatively lower numbers on Funen and in Southern Jutland (Figure 2). A similar pattern was observed for revascularisations, with the lowest activity being recorded in the South Denmark Region (Table 1, Figure 2). The differences in revascularisation rates between individual municipalities were not statistically different ($p = 0.021$).

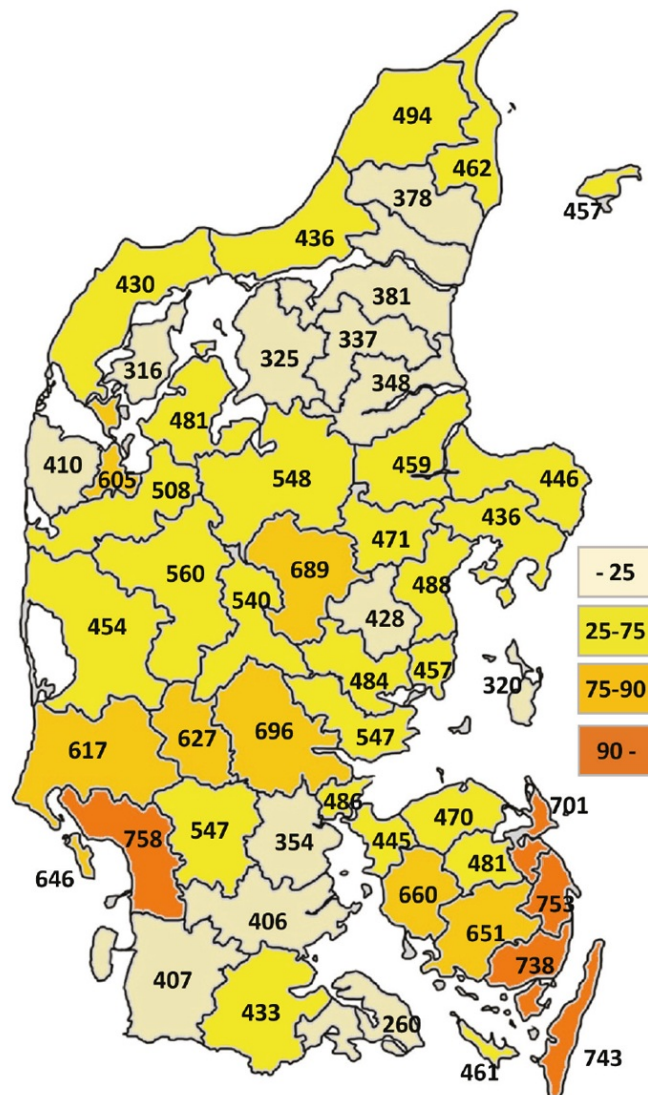
FIGURE 2 A. Patients with first-time elective coronary angiography per 100,000 inhabitants aged ≥ 40 years on indication chronic coronary syndrome in Western Danish municipalities. **B.** Patients with first-time elective revascularisation per 100,000 inhabitants aged ≥ 40 years on indication chronic coronary syndrome in Western Danish municipalities. On both maps, the colour codes refer to the 0-25, 25-50, 50-90 and 90-100 percentiles for Western Denmark. Significant differences ($p < 0.0001$) were observed in the use of coronary angiography but not in the use of revascularisations ($p = 0.021$) between individual municipalities.



As to CCS, a significant difference was observed in the ratio between CAG number and the number of revascularisations between the three regions with the lowest fraction in the South Denmark Region (Table 1).

CMCT utilisation rates in the South and Central Denmark Regions were 36% and 26% higher than in the North Denmark Region, respectively (Table 1). At the municipal level, significant ($p < 0.0001$) differences were observed with a high use of CMCT in Esbjerg, Svendborg and Nyborg municipalities (Figure 3). The same municipalities had relatively few elective CAG procedures.

FIGURE 3 Patients with first-time cardiac multislice computed tomography per 100,000 inhabitants aged ≥ 40 years on indication of chronic coronary syndrome in Western Danish municipalities. The colour codes refer to the 0-25, 25-50, 50-90 and 90-100 percentiles for Western Denmark. Significant differences were observed between individual municipalities ($p < 0.0001$).



The significant and continuous increase in the use of CMCT was only partly paralleled by a decrease in the number of CAG procedure in the South and Central Denmark Regions and not in the North Denmark Region (Figure A in supplementary material). Also, the different regional revascularisation/CAG fractions were not paralleled by the use of CMCT (Table 1).

DISCUSSION

In the current investigation based on the Western Danish Heart Registry, we found: 1) comparable regional use of revascularisation for ACS, but with increased rates per 100,000 citizens aged ≥ 40 years in individual

municipalities; 2) elective CAG for CCS were performed more frequently in the North Denmark Region; 3) CMCT was used more frequently in the Central and South Denmark Regions than in the North Denmark Region and this was not paralleled by a reduction in the number of CAG procedures.

Since year 2000, significant developments have been observed in the use of invasive diagnostic and treatment procedures for IHD in Denmark. In recent years, the sharp increase in the 2000 to 2007 period has been replaced by a stable or slightly declining trend for CAG and PCI, whereas the number of CABG operations has been reduced by 50%. Use of CMCT continues to increase. We expect this development to continue but to be affected by preventive measures and the changing age composition of the population [5].

Population data obtained from Statistics Denmark showed differences in the age distribution in regions and municipalities. As IHD primarily affects people over the age of 40 years, we exclusively included citizens aged ≥ 40 years and calculated the results as rates (number per 100,000 inhabitants aged ≥ 40 years) to minimise differences in age composition in regions and municipalities.

Differences at the regional or municipal level may potentially be explained by both differences in the incidence of IHD and different diagnosis and treatment strategies. Therefore, we focused on the groups of electively treated CCS, which mainly consist of the diagnosis of stable angina pectoris, and on ACS, which primarily includes acute STEMI, NSTEMI and unstable angina pectoris. We considered ACS treatment to be uniform in Denmark and in accordance with international treatment guidelines [6, 7]. Patients with ACS were presumed to receive the same treatment regardless of residence. Therefore, geographical differences in the use of PCI for ACS treatment expectedly reflected the frequency of IHD in the area.

This investigation contributed with new knowledge of the frequency of IHD at the municipal level. We observed a particularly high frequency of IHD in Djursland, the northern part of the Kattegat coast and in the western and northern parts of North Jutland. The highest frequency was seen in Norddjurs Municipality (215 PCI procedures per 100,000 inhabitants) and the lowest frequency was recorded in Skanderborg Municipality (148 PCI procedures per 100,000 inhabitants). This difference at the municipal level may potentially give rise to considerations of targeted preventive measures.

Concerning CCS, the number of treatments and examinations performed on the indication of CCS may be an expression of regional treatment differences and of varying IHD frequency. Geographically, a pattern was seen for elective CAG and revascularisation of CCS similar to that for PCI treatment of ACS. Relatively speaking, most elective CAGs were performed in the North Denmark Region. One contributing factor may be the numerically increased incidence of IHD in North Jutland (Table 1), but a local preference for CAG in the diagnosis of CCS cannot be ruled out. Thus, CMCT was used significantly more frequently in the Central Denmark (+26%) and in the South Denmark Regions (+36%) than in the North Denmark Region. This difference may probably be explained by different strategies for investigating CCS in the three regions.

It seems reasonable to expect that a high use of CMCT would lead to fewer CAG procedures and thus relatively more revascularisations [8]. This did not seem to be the case as no clear correlation was observed between elective CAG and CMCT per 100,000 inhabitants at either the municipal or the regional level. The purpose of CMCT is to avoid CAG in patients with normal coronary arteries as CAG is an invasive procedure that is associated with a small risk of serious complications. With fewer normal CAG procedures and thus more CAG procedures with subsequent revascularisation, it seems reasonable to expect a high revascularisation to CAG fraction with widespread use of CMCT. A significant difference was seen in the revascularisation/CAG fraction in the three regions with higher and similar ratios in the North and the Central Denmark Regions even if the lowest use of CMCT was recorded in the North Denmark Region. Additionally, there were municipalities with a particularly high use of CMCT; Esbjerg (758 CMCT procedures/100,000 inhabitants) and the three East Funen

municipalities, Svendborg, Nyborg and Kerteminde (with 738, 753 and 701 CMCT procedures/100,000 inhabitants, respectively). The same municipalities performed relatively few elective CAG procedures but at the same time few elective revascularisations. For comparison, the three municipalities with the lowest use of CMCT were the municipalities of Soenderborg, Samsøe and Morsoe, with 260, 316 and 320 CMCT procedures/100,000 inhabitants, respectively. The marked differences in CMCT use at both the regional and the municipal level may probably be explained by differences in IHD assessment strategies and may potentially trigger a discussion of the optimal algorithm for assessment of CCS patients. Regional differences have previously been described regarding disease incidence and treatment in Denmark [9-11].

This publication was a retrospective assessment of a prospectively collected data material in the Western Danish Heart Registry. Accordingly, we were able to demonstrate only associations, which are not necessarily causal. It was a specific problem that our results depended on the pattern and tradition for referral of possible IHD patients, which may possibly differ between regions. Also, we included acute cardiac conditions such as cardiogenic shock and cardiac arrest in patients with PCI for ACS. Some of these relatively few patients might not suffer from ACS.

CONCLUSION

Significant geographical differences were observed in the rates of PCI for ACS and thus most likely in the frequency of IHD between Western Danish municipalities. The relatively increased use of CAG in the North Denmark Region could only partly be due to an increased IHD incidence. CMCT in the IHD assessment was performed more often in the Central and South Denmark Regions than in the North Denmark Region with significant differences being observed at the municipal level; and the use of CMCT did not seem to be paralleled by a reduction of CAG procedures. Our study may possibly prompt discussions on strategy for the diagnostics of CCS and for targeted preventive measures for IHD in specific municipalities.

https://ugeskriftet.dk/files/a01220007_-_supplementary.pdf

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Conflicts of interest none. Disclosure forms provided by the authors are available with the article at ugeskriftet.dk/dmj

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