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Association between travel distance and face-to-face consultations with general practitioners before an incident acute myocardial infarction: a nationwide register-based spatial epidemiological study

Thora Majlund Kjærulff ,[1] Kristine Bihrmann ,[1] Jens Søndergaard ,[2] Gunnar Gislason ,[1,3,4,5] Mogens Lytken Larsen,[6] Annette Kjær Ersbøll [1]

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For numbered affiliations see end of article.

Correspondence to
Dr Thora Majlund Kjærulff; thok@sdu.dk

ABSTRACT

Objectives This study examined the association between travel distance to the general practitioner's (GP) office and *no* face-to-face GP consultation within 1 year before an incident acute myocardial infarction (AMI).

Design A prospective cohort study using multilevel spatial logistic regression analysis of nationwide register data.

Setting Nationwide study including contacts to GPs in Denmark prior to an incident AMI in 2005–2017.

Participants 121 232 adults (≥30 years) with incident AMI were included in the study.

Primary and secondary outcomes measures The primary outcome was odds of not having a face-to-face GP consultation within 1 year before an incident AMI.

Results In total, 13 108 (10.8%) of the 121 232 individuals with incident AMI had no face-to-face consultation with the GP within 1 year before the AMI. Population density modified the association between travel distance and *no* face-to-face GP consultation. Increased odds of *no* face-to-face GP consultation was observed for medium (25th–75th percentile/1123–5449 m) and long (>75th percentile/5449 m) compared with short travel distance (<25th percentile/1123 m) among individuals living in small cities (OR (95% credible intervals) of 1.19 (1.10 to 1.29) and 1.19 (1.06 to 1.33), respectively) and rural areas (1.46 (1.26 to 1.68) and 1.48 (1.29 to 1.68), respectively). No association was observed for individuals living in large cities and the capital.

Conclusions Travel distance above approximately 1 km was significantly associated with *no* face-to-face GP consultation before an incident AMI among individuals living in small cities and rural areas. The structure of the healthcare system should consider the importance of geographical distance between citizens and the GP in remote areas.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The nationwide population registers ensured that the source population included all Danish residents and close to complete follow-up was available for the entire population minimising selection bias.
⇒ The list-based system, linking individuals and general practitioners (GPs) in Denmark, makes it possible to know which GP individuals are listed with at the date of acute myocardial infarction (AMI) even among individuals without contacts to the GP in a long period before the AMI.
⇒ The possibility to calculate the precise travel distance from the individual's home to the GP's office due to the combination of linkable data and exact geocoded addresses is unique.
⇒ The use of travel distance in the present study did not account for the actual travel time, which might have been relevant.
⇒ A more nuanced picture of the geographical proximity might have been possible to give if additional information on the method of transportation (eg, car, public transport, or bike) was available.

INTRODUCTION

In Denmark, 98% of all Danes are listed with a general practitioner (GP), enabling a strong relationship between GPs and their patients and ensuring continuity of care and effective disease prevention.[1] GP consultations provide an opportunity for risk assessment, modifications of health behaviour and initiation of primary preventive pharmacological treatment that contribute to prevent the development of acute myocardial infarction (AMI).[2 3] Also, GPs have a gatekeeper function as they refer patients to most office-based specialists as well as inpatient and outpatient hospital care. GPs are often responsible for coordinating the healthcare systems' efforts for patients with chronic diseases and with multimorbidity.[1]

Even though Denmark is a welfare state with universal access to healthcare, it is increasingly challenging to ensure adequate GP coverage in rural areas as many GPs are nearing retirement in these areas in combination with a shortage of newly qualified GPs.[1] A geographically unequal access to GPs is therefore likely.

Geographical inequalities in incident AMI and immediate case fatality following AMI have been observed in Denmark.[4–6] Geographical inequality in the proportion of fatal to non-fatal AMI was likewise found in Denmark, with a high proportion of fatal AMI observed in Northern Jutland. Lack of contact to the GP explained most of the geographical variation in the proportion fatal to non-fatal AMI.[7] Geographical proximity of GPs (eg, measured by travel distance) may be one crucial factor of accessibility related to whether citizens have face-to-face consultations with the GP with the opportunity to initiate disease prevention.[8] The extent to which travel distance may explain contact patterns to the GP before an AMI has to our knowledge not previously been studied.

This study aim was threefold. First, to investigate whether and to what extent geographical inequality in *no* face-to-face GP consultation before an incident AMI exists in Denmark. Second, to examine the association between travel distance and *no* face-to-face consultation with the GP within 1 year before AMI. Third, to investigate whether the potential association varied across levels of population density or across municipalities of Denmark.

METHODS

Study population, data sources and study area

Denmark has an area of about 43 000 km^2 and has since 2007 been divided into five regions and 98 municipalities (online supplemental figure A1). The current municipality definition was used for the entire study period.

The study included adults (≥ 30 years) with incident AMI residing in Denmark between 2005 and 2017. Individuals living in the four island municipalities of Fanø, Læsø, Samsø and Ærø were excluded due to small population sizes. AMI cases were identified in the Danish National Patient Register[9] and the Danish Register of Causes of Death[10] with the International Classification of Disease 10th version (ICD-10) code I21 registered as the primary or secondary diagnosis or the underlying or contributing cause of death, respectively. ICD-8 code 410 and ICD-10 code I21 were used to exclude prevalent cases with previous AMI before the study period (1977–2004). High validity of the AMI diagnosis in the Danish National Patient Register and the Danish Register of Causes of Death has previously been reported.[11 12]

Information on sex, age and the residential location at date of AMI was obtained from the Danish Civil Registration System.[13] The Patient List Database, which was created and maintained by the Research Unit for General Practice in Aarhus, Denmark, was used to identify the link between individuals with AMI and the GP they were listed with at the date of AMI.[14] The last visit to the GP before an incident AMI and the addresses of GPs were identified in the Danish National Health Service Register.[15] The addresses of GPs and individuals were geocoded by publicly available information on coordinates of all buildings in Denmark from the National Address Register.[16] Information on sociodemographic characteristics was obtained from registers at Statistics Denmark.[17 18] Linkage of individuals and GPs across different nationwide registers was possible due to the unique personal identification number of all residents and the unique GP office identification number of all GP offices in Denmark.

Outcome

The study outcome was *no* face-to-face consultation with the GP within 1 year before an incident AMI (in the following referred to as *no* face-to-face GP consultation). Contacts to the GP included face-to-face visits to the GP's consulting room and GP home visits. For individuals who changed GP between the last face-to-face consultation with the GP and the date of AMI, the last face-to-face consultation to the previous GP before AMI was included in the analysis. Before 2014, GP consultations were registered per week without the exact date (Friday of that week was used when calculating time intervals). The exact date was available and used accordingly from 2014 onwards. Face-to-face consultations on the date of AMI or the date before (from 2014 onwards) or week of AMI (before 2014) were omitted as they were assumed to be directly linked to the AMI.

Determinants

The primary explanatory variable of interest was travel distance to the GP. Travel distance was estimated as the shortest road distance from the individual's residential location to the GP that the individual was listed with on the date of AMI. Information on GP addresses was registered for each quarter, but registration for some quarters were missing. Consequently, no exact date of moving was available. The date of moving for GPs was estimated to be the date before a new GP address was registered. If the interval between two different addresses exceeded 275 days, no address was registered for the GP during that time interval. However, the addresses of GPs in Denmark were very stable during the study period. The majority of the 3023 GPs that the individuals with AMI were listed with had not moved (n=2185, 72.3%), 766 (25.3%) had two addresses, and 72 (2.4%) had 3–5 addresses. When GPs changed location, they typically moved to an address close to the previous one (median Euclidean distance between addresses was 0.6 km). A street network file[19] was used in R software with the cppRouting package[20] to calculate the shortest road distance. The travel distance was missing for 633 individuals due to the following reasons: (1) no geocoded address for the GP at the date of the AMI (n=285); (2) residential addresses of individuals could not be connected to the street network (n=42); or (3) incalculable travel distance, for example, individuals living on islands and having a GP on the mainland (n=306). Travel distance was categorised into three groups by the 25th and 75th percentiles.

Other determinants of *no* face-to-face GP consultation considered were socioeconomic position and comorbidity. Socioeconomic position was measured at the individual level as annual equivalised disposable household income (lowest quintile, medium 60%, and highest quintile of the Danish population), highest obtained educational level (elementary: ≤9 years; short: 10–12 years; and medium/long: >12 years), and cohabitation status (living alone vs cohabiting). To account for income differences related to sex and retirement, annual equivalised disposable household income was grouped into quintiles separately for men and women aged below 65 years versus 65 years or above. Another Danish study used a similar measure of income.[21] Individuals with no information on the highest obtained education were included in the group with elementary educational level, as they matched this group regarding income level.

Individuals' comorbidity status was measured by the Charlson Comorbidity Score, including conditions listed in the original score.[22] The comorbidity status was divided into three levels: 0 (no comorbidity), 1 (mild comorbidity) and ≥2 (severe comorbidity) and based on data inpatient and outpatient hospital contacts from Danish National Patient Register[9] from a 10-year period preceding the year before the incident AMI (eg, if the incident AMI occurred in 2011 the comorbidity score was calculated for the period 2000–2010).

The population density was categorised into the capital, large cities (≥30 000 inhabitants), small cities (2000–29 999 inhabitants) and rural areas (<2000 inhabitants).

Furthermore, sex, age, year of AMI (2005–2009, 2010–2013, 2014–2017) and country of origin (Denmark and immigrants/descendants from Western countries vs immigrants/descendants from Non-Western countries) were also evaluated as determinants of not having face-to-face GP consultations. Potential collinearity between covariates included in the models was checked using Pearson correlation coefficient.

Statistical analysis

The effect of travel distance on *no* face-to-face GP consultation may vary by population density and/or geography due to geographical differences in car ownership, different availability of public transport between urban and rural areas, and different habits regarding transportation to healthcare or other services in the neighbourhood across the country. Consequently, three different analyses of the association between travel distance and odds of *no* face-to-face GP consultation were evaluated to elucidate the relationship between travel distance, face-to-face GP consultation, population density and residential location.

First, a multilevel spatial logistic regression analysis of the association between travel distance and no face-to-face GP consultation when accounting for the within and between municipality correlation was conducted (analysis 1). Second, the model from analysis 1 was expanded to include the interaction term between population density and travel distance to evaluate whether population density modified the effect of travel distance on *no* face-to-face GP consultation (analysis 2). This analysis assumed different associations between travel distance and *no* face-to-face GP consultation for individuals living in the capital, large cities, small cities and rural areas. Third, another extended version of the multilevel spatial regression analysis was conducted by including spatially varying coefficients of travel distance across municipalities of Denmark (analysis 3).[23] This analysis assumed that the association between travel distance and *no* face-to-face GP consultation varied across the country. All models were fully adjusted for socioeconomic position, age, sex, country of origin, comorbidity and population density (except for analysis 2 where population density was included as an effect modifier). The Deviance Information Criteria (DIC) value for the three analyses was compared, and the model with the lowest DIC value was assumed to provide the best fit to the observed data.[24] The model specifications of the multilevel spatial logistic regression analyses conducted using a Bayesian approach are described in online supplemental material.

Several supplementary analyses were performed on the model with the best fit to the observed data (ie, the analysis with the lowest DIC value). First, the analysis was performed with contacts to the GP including face-to-face, telephone and email consultations. Second, the analysis was performed within a subgroup of the study population with diabetes. Individuals with diabetes should be monitored regularly at the GP and they are therefore expected to have face-to-face consultations at least annually.[25] Diabetes was defined as at least one prescription redemption of drugs with Anatomical Therapeutic Chemical code A10 or an inpatient or outpatient hospital contact with ICD-8 code 249–250 or ICD-10 code E10–E14 before the date of AMI. Third, since no clear evidence support the categorisation of travel distance, three alternative categorisations were tested: (1) quintiles; (2) four categories defined by 25th, 75th and 90th percentiles; and (3) tertiles.

Data management was performed in SAS (V.9.4) software, and the spatial analyses were performed in R (V.4.2.1)[26] using the INLA package (www.r-inla.org).

Patient and public involvement statement

None.

RESULTS

The study population consisted of 124 007 adults aged 30 years or above with residential location in Denmark who experienced an incident AMI between 2005 and 2017. In total, 122 674 individuals with AMI (99%) were listed with a GP at the date of AMI. Few GPs could not be geocoded at the date of AMI, and individuals listed with these GPs were excluded (n=285). Individuals with no information on the travel distance (n=348), population

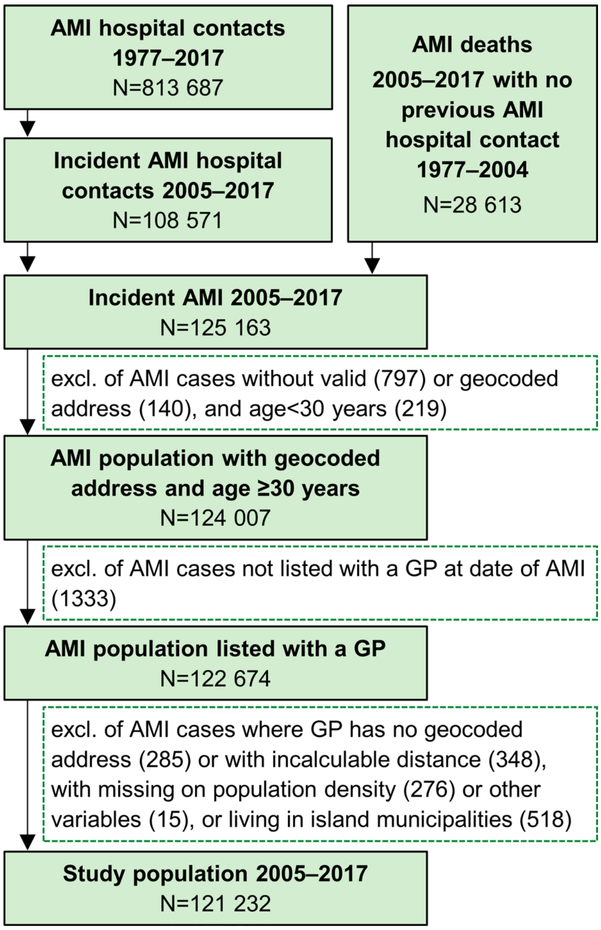

Figure 1 Flow chart of the study population. AMI, acute myocardial infarction; GP, general practitioner.

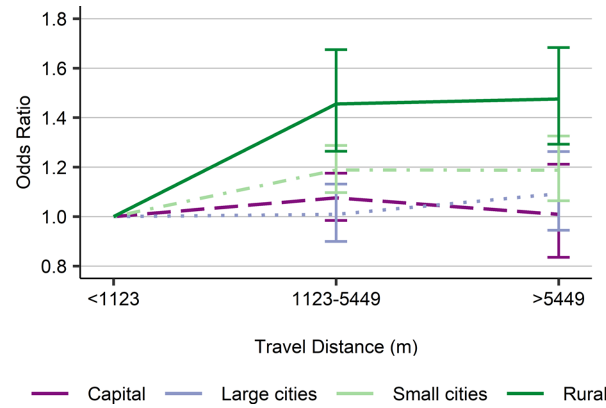

Figure 2 The association between travel distance and *no* face-to-face general practitioner (GP) consultation within 1 year before an incident acute myocardial infarction (AMI) modified by levels of population density (ie, living in the capital, large cities, small cities and rural areas) with short travel distance as the reference category for all levels of population density.

density (n=276), or at least one of the remaining variables (n=15) were excluded. Finally, 518 individuals living on small island municipalities were excluded leaving 121 232 individuals with incident AMI for the analysis (figure 1).

In total, 13 100 (10.8%) did not have a face-to-face consultation with the GP 1 year before the incident AMI. Median travel distance from the individual's home to the GP increased from 2053 m (IQR: 999–4789 m) in 2005 to 2677 m (1281–6282 m) in 2017. Markedly shorter travel distance was observed in the Capital Region of Denmark (1667 m) compared with the remaining regions (Zealand=2868 m, North=2622 m, Central=2708 m and South=2861 m). The DIC from analyses 1, 2 and 3 were 57 107.98, 57 100.00 and 57 106.30, respectively. The model including population density as an effect modifier (analysis 2) provided the best fit to the observed data, meaning that it is important to examine the effect of travel distance on *no* face-to-face GP consultation within levels of population density. Therefore, the reporting of results focuses on analysis 2. No strong correlation between covariates in the model were observed (all Pearson correlation coefficients<0.344).

Figure 2 shows how population density modified the effect of travel distance on *no* face-to-face GP consultation from analysis 2 when short distance was the reference category across all levels of population density. The association was most pronounced among individuals living in rural areas, who had 46%–48% increased odds of *no* face-to-face GP consultation if they had medium or long compared with short travel distance to the GP (1.46 (1.26 to 1.68) and 1.48 (1.29 to 1.68), respectively). The corresponding effects were 1.19 (1.10 to 1.29) and 1.19 (1.06 to 1.33) for medium and long compared with short travel distance, respectively, among individuals living in small cities. In contrast, no association was observed among individuals living in large cities or the capital.

Results from the fully adjusted analyses 1–3 are shown in table 1. Results on other determinants of *no* face-to-face GP consultation than travel distance were similar between the three analyses.

Determinants of relevance for *no* face-to-face GP consultation in analysis 2 other than the interaction between travel distance and population density were male sex (1.63 (1.56 to 1.70)), living alone (1.36 (1.31 to 1.42)), and high annual equivalised disposable household income (1.12 (1.05 to 1.20)). Decreased odds of *no* face-to-face GP consultation were seen in the two oldest compared with the youngest age group (0.58 (0.55 to 0.61) for individuals aged 65–74 years and 0.32 (0.31 to 0.34) for individuals aged 75 years or older). Immigrants and descendants from non-Western countries had also decreased odds of *no* face-to-face GP consultation (0.60 (0.54 to 0.66)). Odds of *no* face-to-face GP consultation was lower among individuals with one (0.43 (0.40 to 0.45) and two and more comorbidities (0.35 (0.33 to 0.37)) compared with individuals without comorbidities.

The geographical distribution of the residual OR of *no* face-to-face GP consultation from the fully adjusted model is shown in figure 3. Living in the municipalities on Lolland and Falster and the municipalities of Copenhagen, Aalborg and Roskilde was associated with increased residual odds of *no* face-to-face GP consultation

Table 1 Results from analyses 1–3 investigating the association between travel distance and no face-to-face consultation with the general practitioner (GP) within 1 year before an incident acute myocardial infarction (AMI)

Variable	Level		Study population N	No face-to-face GP consultation N (%)	Analysis 1 OR (95% CrI)	Analysis 2 OR (95% CrI)	Analysis 3 OR (95% CrI)
Travel distance (analysis 1)							
Travel distance	Short		30 308	2695 (8.9)	1 (ref)		
	Medium		60 616	6734 (11.1)	1.15 (1.09 to 1.20)		
	Long		30 308	3679 (12.1)	1.19 (1.12 to 1.27)		
Interaction between travel distance and population density (analysis 2)							
Travel distance across levels of population density	Capital	Short	8412	966 (11.5)		1 (ref)	
		Medium	12 736	1650 (13.0)		1.08 (0.98 to 1.18)	
		Long	1129	163 (14.4)		1.01 (0.84 to 1.21)	
	Large cities	Short	4370	419 (9.6)		1 (ref)	
		Medium	18 282	1915 (10.5)		1.01 (0.90 to 1.13)	
		Long	3719	473 (12.7)		1.09 (0.95 to 1.26)	
	Small cities	Short	13 595	1033 (7.6)		1 (ref)	
		Medium	20 636	2073 (10.0)		1.19 (1.10 to 1.29)	
		Long	5491	579 (10.5)		1.19 (1.06 to 1.33)	
	Rural areas	Short	3931	277 (7.0)		1 (ref)	
		Medium	8962	1096 (12.2)		1.46 (1.26 to 1.68)	
		Long	19 969	2464 (12.3)		1.48 (1.29 to 1.68)	
Travel distance varies across municipalities (analysis 3)							
Travel distance	Short		30 308	2695 (8.9)			1 (ref)
	Medium		60 616	6734 (11.1)			1.14–1.15 (1.08–1.09 to 1.21–1.22)
	Long		30 308	3679 (12.1)			1.19–1.20 (1.11–1.12 to 1.27–1.29)
Remaining covariates in the analyses							
Calendar year	2005–2009		51 092	5440 (10.7)	1 (ref)	1 (ref)	1 (ref)
	2010–2013		36 738	3672 (10.0)	0.92 (0.88 to 0.96)	0.92 (0.88 to 0.96)	0.92 (0.88 to 0.96)
	2014–2017		33 402	3996 (12.0)	1.08 (1.03 to 1.13)	1.08 (1.03 to 1.13)	1.08 (1.03 to 1.13)
Sex	Males		74 460	9837 (13.2)	1.63 (1.56 to 1.70)	1.63 (1.56 to 1.70)	1.63 (1.56 to 1.70)
	Females		46 772	3271 (7.0)	1 (ref)	1 (ref)	1 (ref)

Continued

Table 1 Continued

Variable	Level	Study population	No face-to-face GP consultation	Analysis 1	Analysis 2	Analysis 3
		N	N (%)	OR (95% CrI)	OR (95% CrI)	OR (95% CrI)
Age	30–64 years	43 528	7790 (17.9)	1 (ref)	1 (ref)	1 (ref)
	65–74 years	29 728	2888 (9.7)	0.58 (0.56 to 0.61)	0.58 (0.55 to 0.61)	0.58 (0.56 to 0.61)
	≥75 years	47 976	2430 (5.1)	0.32 (0.31 to 0.34)	0.32 (0.31 to 0.34)	0.32 (0.31 to 0.34)
Cohabitation status	Living alone	53 651	5455 (10.2)	1.36 (1.31 to 1.42)	1.36 (1.31 to 1.42)	1.36 (1.31 to 1.42)
	Married/cohabiting	67 581	7653 (11.3)	1 (ref)	1 (ref)	1 (ref)
Country of origin	Native Danes and IDs from Western countries	116 651	12 647 (10.8)	1 (ref)	1 (ref)	1 (ref)
	IDs from other countries	4581	461 (10.1)	0.60 (0.54 to 0.66)	0.60 (0.54 to 0.66)	0.60 (0.54 to 0.66)
Annual disposable household income	Low	30 294	3070 (10.1)	1 (ref)	1 (ref)	1 (ref)
	Medium	73 810	7607 (10.3)	0.97 (0.93 to 1.02)	0.97 (0.93 to 1.02)	0.97 (0.93 to 1.02)
	High	17 128	2431 (14.2)	1.12 (1.05 to 1.20)	1.12 (1.05 to 1.20)	1.12 (1.05 to 1.20)
Educational level	Elementary	61 877	5650 (9.1)	1 (ref)	1 (ref)	1 (ref)
	Short	45 768	5667 (12.4)	0.95 (0.91 to 0.99)	0.94 (0.91 to 0.99)	0.95 (0.91 to 0.99)
	Medium/long	13 587	1791 (13.2)	0.98 (0.92 to 1.04)	0.98 (0.92 to 1.04)	0.98 (0.92 to 1.04)
Comorbidity	0 diseases	70 485	10 567 (15.0)	1 (ref)	1 (ref)	1 (ref)
	1 disease	21 745	1240 (5.7)	0.43 (0.40 to 0.45)	0.43 (0.40 to 0.45)	0.43 (0.40 to 0.45)
	2 or more diseases	29 002	1301 (4.5)	0.35 (0.33 to 0.37)	0.35 (0.33 to 0.37)	0.35 (0.33 to 0.37)
Population density	Capital	22 277	2779 (12.5)	1 (ref)	NA	1 (ref)
	Large cities	26 371	2807 (10.6)	0.86 (0.79 to 0.95)	NA	0.86 (0.79 to 0.94)
	Small cities	39 722	3685 (9.3)	0.79 (0.72 to 0.86)	NA	0.78 (0.72 to 0.86)
	Rural areas	32 862	3837 (11.7)	0.87 (0.80 to 0.95)	NA	0.87 (0.79 to 0.95)

GP, general practitioner; ID, immigrant and descendant; n, number; Travel distance, short=<1123 m, medium=1123–5449 m and long=>5449 m.

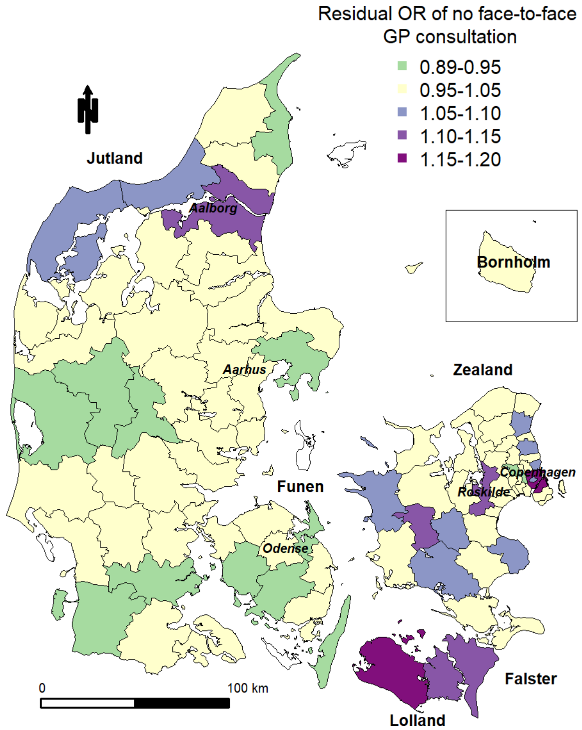

Figure 3 Map of the geographical distribution of the residual odds ratio (OR) of *no* face-to-face general practitioner (GP) consultation within the year before an incident acute myocardial infarction (AMI) after accounting for travel distance, sociodemographic characteristics and comorbidity (analysis 2).

compared with the national mean after accounting for the interaction between travel distance and population density, sociodemographic characteristics and comorbidity. The credible intervals for all other municipalities included 1 (online supplemental figure A2 in supplementary showing the geographical distribution of residual OR for *no* face-to-face GP consultation according to statistical significance), meaning that the residual odds of no face-to-face GP consultation was not statistically significantly different from the national mean for these municipalities.

In the simple model (analysis 1), medium and long travel distance to the GP was associated with increased odds of *no* face-to-face GP consultation. The OR (95% CrI) of the fully adjusted association was 1.15 (1.09 to 1.20) for medium versus short travel distance and 1.19 (1.12 to 1.27) for long compared with short travel distance. The association between travel distance and *no* face-to-face GP consultation did not vary significantly across the country (analysis 3). The OR of medium compared with short travel distance ranged from 1.14 to 1.15 (95% CrI: lower limit ranged from 1.08 to 1.09; upper limit from 1.21 to 1.22), and the OR for long compared with short travel distance ranged from 1.19 to 1.20 (95% CrI: lower limit ranged from 1.11 to 1.12; upper limit from 1.27 to 1.29) across municipalities of Denmark.

Supplementary analysis

Results from the supplementary analysis including the alternative outcome of *no* contact with the GP within 1 year before an incident AMI showed that the association between travel distance and *no* contact with the GP attenuated (online supplemental table A1) for individuals living in small cities and rural areas.

In total, 20 173 (16.6%) of the study population had diabetes, of which 894 (4.4%) had not had a face-to-face GP consultation within 1 year before the AMI. Results from this analysis were associated with great uncertainty and no firm conclusion could therefore be drawn from these estimates (online supplemental table A1).

The supplementary analysis considering the alternative categorisations of travel distance showed increased odds of *no* face-to-face consultation with increasing travel distance in all three alternative models (online supplemental table A2). No relevant difference was observed between the individuals in the 75th–90th and ≥90th percentile meaning that it is reasonable to aggregate these groups.

DISCUSSION

Results from this nationwide register-based study showed minor geographical inequality in *no* face-to-face GP consultation 1 year before an incident AMI across municipalities in Denmark after accounting for population density, sociodemographic characteristics and comorbidity. The effect of travel distance was modified by population density. Among individuals living in small cities, those with a travel distance above approximately 1 km had 19% higher odds of *no* face-to-face GP consultation. The corresponding effect for individuals living in rural areas was 46%–48% higher odds of *no* face-to-face GP consultation if the travel distance to the GP exceeded approximately 1 km. No effect of travel distance on *no* face-to-face GP consultation was observed among individuals living in large cities and the capital. Several explanations of this finding might exist; however, it is probable that a more comprehensive infrastructure of public transport in urban areas compensate for medium and long travel distance to the GP. The effect of travel distance on *no* face-to-face GP consultation did not vary across municipalities of Denmark.

The association between travel distance and all types of GP consultations (face-to-face, telephone, and email consultations) attenuated and a significant and relevant difference in GP consultations across travel distances was only observed for individuals in rural areas. This finding indicated that telephone and email consultations partly compensate for face-to-face consultations for individuals with medium and long travel distance to the GP.

Comparison with other studies

The literature on contacts to GPs before an acute disease, including AMI, is limited. A study from Norway examined contact patterns during the last year and month before an incident AMI and found that the majority had contact to the GP. In line with results from the present study, men and younger individuals were more likely not to have had contact to the GP before an incident AMI.[27] Nevertheless, the effect of travel distance on contact patterns before an AMI was not evaluated.

A review by Kelly *et al* (2016) of studies on the association between travel distance/time to healthcare facilities on a range of different health outcomes found that the majority of studies supported that travelling further was associated with worth health outcome.[28] Out of the 108 identified studies, only 9 evaluated the travel distance/time to the GP. Four of these studies examined cancer-related outcomes.[29–32] The remaining investigated asthma,[33] hepatitis C,[34] diabetes-related foot disease,[35] inpatient episodes[36] and non-specific healthcare visits.[37] None of these studies were conducted within individuals with cardiovascular diseases. A more recent study on travel distance and cardiovascular disease found no association between travel distance to primary care physicians and ischaemic heart disease mortality.[38] However, the measure of travel distance was difficult to compare to the one used in the present study, as Saijo *et al* (2018) used distance from the centroid of citizens' census block to the nearest primary care physician and aggregated the measure to the municipality level for an ecological spatial analysis.

Strength and limitations

This study is solely based on register data, which have several advantages. The unique personal identification number and the unique GP office identification number enable the linkage of data across several registers. Moreover, the list-based system, linking individuals and GPs in Denmark, makes it possible to know which GP individuals are listed with at the date of AMI even among individuals that did not have contacts with the GP in a long period before the AMI. The possibility to calculate the precise travel distance from the individual's home to the GP's office due to the combination of linkable data and exact geocoded addresses is unique. Contrary, many similar studies have estimated the Euclidian distance from the individual's home or centroid of the areas where the patient lives to the nearest GP.[28] However, data from the present study showed that only 21% of the study population were listed with the nearest GP when measured by the Euclidian distance. Less precise measures of travel distance may limit the ability to study the association between travel distance and health outcomes. The use of travel distance in the present study did not account for the actual travel time, which might have been relevant. Moreover, a more nuanced picture of the geographical proximity might have been possible to give if additional information on the method of transportation (eg, car, public transport, or bike) was available.

The nationwide population registers ensured that the source population included all Danish residents and close to complete follow-up was available for the entire population minimising selection bias and increasing the generalisability to other study populations. However, results might only be generalised to populations with similar healthcare systems.

The completeness of the Danish nationwide registers is in general high, as information is used for administrative purposes. Thus, hospitals and GPs have economic incentives to register patient contacts, as they are reimbursed based on these registered data.[9 15] One downside of register data is that they are collected for administrative use, and not all clinically relevant information is available. As an example, information on diagnosis and preventive initiatives established by the GP would have been useful to include in the present study.

Conclusion and implications

This study shows minor geographical inequality in *no* face-to-face GP consultation within 1 year before AMI in Denmark. A travel distance of approximately above 1 km increased odds of *no* face-to-face GP consultations for individuals living in rural areas and small cities, but no association was observed for individuals living in large cities and the capital.

Some variation in geographical proximity to healthcare services across the country is inevitable and must be acceptable. GP offices cannot be geographically equally placed as the population density has to be considered. However, Oliver and Mossialos (2004)[8] argue that the allocation of healthcare resources by regions must be done according to the population size, the sociodemographic profile of the population, and the population's healthcare needs rather than remain on a historically unequal distribution of resources towards wealthy regions. In addition, local healthcare providers must ensure that resources are distributed within the regional population to promote equal access to equal needs. Efforts should be made to ensure that sufficient staff and facilities are available in disadvantaged areas.[8] Future research should monitor accessibility to GPs over time and space with a focus on travel distance and other relevant measures as travel time, transportation type (eg, car ownership or public transport), number of citizens per GP, and GP coverage in the areas.

At the policy level in Denmark, both shifting Danish governments and the General Practitioners' Association have proposed initiatives to ensure enough GPs in rural areas[39–41]; however, a political agreement has not yet been achieved. The present study found that travel distance to the GP matters, especially among residents in rural areas. Travel distance is, moreover, found to increase over the study period. Efforts should be made to reduce travel distance and time by, for example, ensuring GP facilities in rural areas and adequate public transport infrastructure throughout the country. In Denmark, the revenue for GPs is depending on the number of citizens listed with each GP. Thus, GPs must cover a geographically larger area in less-populated parts of the country to obtain a reasonable income level. Policies could change the economic incentives to attract more GPs to rural areas.

This study found that adding telephone and email consultations to face-to-face consultation attenuated the association between travel distance and no GP contacts before an AMI and partly compensate for face-to-face GP consultations. However, whether the quality of email and telephone consultations is the same as the quality of face-to-face consultations is unclear. Video consultations might be another alternative to in-person face-to-face consultations. The global pandemic of COVID-19 has increased the use of video consultations.[42] Although the evidence from research on video consultations is limited, it points towards video consultations being safe, effective and related to high satisfaction among providers and patients.[42] Experiences within a group of individuals with type 2 diabetes in Denmark have also shown promising results and find video consultations to be a safe alternative to standard outpatient care.[43] Video consultations could potentially be used as an alternative to in-person face-to-face consultations among individuals with long travel distance to the GP in remote areas.

Author affiliations
[1]National Institute of Public Health, University of Southern Denmark, Copenhagen, Denmark
[2]Research Unit for General Practice, Department of Public Health, University of Southern Denmark, Odense, Denmark
[3]Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark
[4]The Danish Heart Foundation, Copenhagen, Denmark
[5]Department of Cardiology, The Cardiovascular Research Centre, Copenhagen University Hospital Herlev and Gentofte, Gentofte, Denmark
[6]Department of Clinical Medicine, Aalborg University, Aalborg, Denmark

Contributors TMK performed the data management and data analysis and drafted the manuscript and is the guarantor of the study. All authors contributed to the study conception and design. AKE and KB supervised the statistical analyses. All authors contributed to the interpretation and discussion of the results. A critical revision and final approval of the manuscript was done by all authors.

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Ethics approval The present study was based on register data with no direct contact to study subjects. According to Danish law, register-based statistical analysis can be conducted without informed content from the study subjects, and it is not required to obtain approval from an ethical committee. The Danish Data Protection Agency approved the study (approval number: 2015-57-008, no.16/4085).

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ORCID iDs
Thora Majlund Kjærulff http://orcid.org/0000-0002-3314-6570
Kristine Bihrmann http://orcid.org/0000-0002-4127-9111
Jens Søndergaard http://orcid.org/0000-0002-1629-1864
Gunnar Gislason http://orcid.org/0000-0002-0548-402X
Annette Kjær Ersbøll http://orcid.org/0000-0002-9407-3387

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