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Original Article

Association between socioeconomic and psychosocial factors with use of interventional and surgical treatments and outcomes in patients with myocardial infarction – Inpatient data of the largest European health care system

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ABSTRACT

Background: Myocardial infarction (MI) is an important driver of both morbidity and mortality on a global scale. Elucidating social inequalities may help to identify vulnerable groups as well as treatment imbalances and guide efforts to improve care for MI.
Methods: All hospitalized patient-cases with confirmed MI 2005-2020 in Germany were included in the study and stratified for socioeconomic or psychosocial factors (SPF) and the impact of SPF on treatment usage and adverse in-hospital events was analyzed.
Results: Overall, 4,409,597 hospitalizations of MI patients were included; of these, 17,297 (0.4 %) were coded with SPF. These patients were more often of female sex (49.4 % vs. 36.9 %, P<0.001), older (median 77.0 [IQR: 65.0–84.0] vs. 73.0 [62.0–81.0] years, P<0.001) and revealed an aggravated cardiovascular profile. Although SPF were independently associated with increased usage of cardiac catheterization (OR 1.174 [95 %CI 1.136-1.212]) and percutaneous coronary intervention (OR 1.167 [95 %CI 1.130-1.205]), they were accompanied by higher risk for a prolonged length of in-hospital stay >7 days (OR 1.236 [95 %CI 1.198-1.276]) and >10 days (OR 1.296 [95 %CI 1.254-1.339]). While SPF were associated with increased risk for deep venous thrombosis and/or thrombophlebitis (OR 1.634 [95 %CI 1.427-1.870]), pulmonary embolism (OR 1.337 [95 %CI 1.149-1.555]), and acute renal failure (OR 1.170 [95 %CI 1.105-1.240), these SPF were inversely associated with in-hospital case-fatality (OR 0.461 [95 %CI 0.433-0.490]).
Conclusions: This study demonstrates that SPF in hospitalized MI patients have significant impacts on treatments and outcomes. Fortunately, our data did not revealed an underuse of interventional treatments in MI patients with SPF.

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1. Introduction

Myocardial infarction (MI) remains a leading contributor for morbidity and mortality worldwide [1,2]. While the medical progress regarding diagnostic and therapeutic approaches has improved outcomes significantly in the last decades, disparities still exist in MI care and outcomes based on socioeconomic status and psychosocial factors [2-4]. These social determinants are known to influence cardiovascular health across the disease spectrum [5]. Patients of lower socioeconomic status have higher incidence of MI, worse risk factor control, lower treatment rates, and higher mortality compared to more advantaged groups [6-8]. Psychosocial stressors including social isolation, low income, and poor housing have also been linked to poor cardiovascular outcomes [6,8,9].

Most of the literature linking psychosocial factors with outcomes was generated from the United States (US). In the US, socioeconomic status impacts on the individual access of each patient to medical care [8,10,11]. The German nationwide inpatients sample might be an interesting opportunity for an inter-state and inter-health-care comparison. Due to the universal health coverage model in Germany, it is very important to investigate the impact of social disparities in MI care in Germany, which is the largest health care system in central Europe. Although mostly all German citizens are entitled to the same comprehensive medical care regardless of income or employment status, social and socioeconomic inequities may still manifest through differences in health-seeking behaviours, patient-provider interactions, and access to resources needed for optimal recovery [5]. Particularly, the impact of socioeconomic or psychosocial disparities on usage of interventional and surgical treatment modalities as well as resulting outcomes are of main interest and these study results could be compared to the already published studies and could be mirrored in the light of the literature. Accordingly, we sought to leverage nationwide hospitalization data to evaluate the prevalence of coded socioeconomic and psychosocial risk factors in MI patients in Germany over a 16-year period. We also examined associations between these social circumstances and treatments, length of stay, and in-hospital complications and mortality. Elucidating socioeconomic and psychosocial disparities can highlight at-risk groups and inform strategies to optimize emergency and especially MI care.

2. Methods

2.1. Data source

The statistical analysis of this conducted study was performed on our behalf by the Research Data Center (RDC), which is based at the Federal Bureau of Statistics (Wiesbaden, Germany). The analysis was performed by the RDC based on pre-specified SPSS syntax-codes (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. IBM Corp: Armonk, NY, USA), which we had previously generated and sent to the RDC. Aggregated/summarized study results were made available by the RDC (source: RDC of the Federal Statistical Office and the Statistical Offices of the federal states, DRG Statistics 2005-2020, own calculations) [12-14].

The objective of the study was to investigate temporal trends of hospitalized patients with MI (ICD-codes I21 or I22) during the observational period 2005-2020, stratifying these included MI-hospitalization-cases for coding of special socioeconomic or psychosocial circumstances (ICD-codes Z55-Z65) termed as socioeconomic or psychosocial factors (SPF) (**Table S1 of the supplementary material**). In addition, the impact of SPF on prolonged length of in-hospital stay, treatments and outcomes of MI patients was calculated.

2.2. Study oversight, support and ethical statement

We received no commercial support for the present study and there existed no foreign influence on the preparation of this publication. Since our study did not contain a direct access by us, as the investigators, to individual patient data but we had only access to aggregated/summarized results provided by the RDC (as aforementioned), an approval by ethics committee and also patients' informed consent were not required in accordance with German law [12].

2.3. Coding of diagnoses, procedures and definitions

Soon after the beginning of the new century in the year 2004, diagnosis- and procedure-related remuneration system was introduced for the hospitals in the German healthcare system. Coding of patient data on diagnoses, coexisting conditions, and on surgeries/procedures/interventions according to the German Diagnosis Related Groups (G-DRG) system and transferring these codes to the Institute for the Hospital Remuneration System is mandatory for German hospitals to receive remuneration regarding rendered and provided services [14,15]. In this context, patients' diagnoses are coded according to the International Statistical Classification of Diseases, and Related Health Problems (of the 10^{th} revision with German modification, ICD-10-GM), and diagnostic/interventional/surgical procedures are coded according to special OPS codes (Operationen- und Prozedurenschlüssel) [14,15]. With the present study analyzing the German nationwide inpatient sample, we identified all patients with MI (ICD-codes I21 or I22) hospitalized in German hospitals 2005-2020 (MI as main or secondary diagnosis).

2.4. Definitions

Obesity was defined as body mass index (BMI) $\geq$30 kg/m^2 according to the World Health Organization [16]. Recurrent MI was defined as recurrent MI in the first 4 weeks after a first MI. In addition, we defined three subgroups of SPF I) related to training/education and profession/career, II) related to environment, socioeconomic and social factors and III) related to childhood, education, family and psychosocial circumstances/factors (**Table S2 in the supplementary material**).

2.5. Study outcomes and adverse in-hospital events

The primary study outcomes were usage of reperfusion treatments as well as case-fatality with the death of all causes during in-hospital stay (in-hospital case fatality). In addition, we analyzed the prevalence of the in-hospital adverse events pneumonia (ICD-code J12-J18), cardio-pulmonary resuscitation (CPR, OPS code 8-77), shock (ICD codes R57), acute kidney failure (ICD code N17), pulmonary embolism (PE, ICD code I26), deep venous thrombosis and/or thrombophlebitis of the leg veins (DVT, ICD code I80), recurrent MI (ICD codes I22), ischemic or hemorrhagic stroke (ICD codes I61-I64), gastrointestinal bleeding (ICD code K92.0-K92.2), intracerebral bleeding (ICB, ICD code I61) and transfusion of erythrocytes (OPS codes 8-800).

2.6. Statistical analysis

To compare MI patients with and without additional coded SPF, we analyzed differences between these two patient groups. Differences in patient characteristics between the groups of hospitalized MI patients with and without SPF were calculated with the Wilcoxon-Whitney U test for continuous variables and Fisher's exact or chi^2 test for categorical variables, as appropriate.

Temporal and regional trends of total numbers of hospitalizations of MI patients with SPF over time and with increasing age, were estimated using linear regression analyses. The computed results are presented as beta (β)-estimates with corresponding 95 % confidence intervals (CI).

Univariate and multivariate logistic regression models were analyzed for the investigation regarding associations between SPF in MI patients on the one hand and prolonged in-hospital stay, interventional and surgical treatments as well as in-hospital adverse events on the other hand. In addition, we analysed the impact of the three defined subgroups of SPF on the aforementioned parameters. The multivariate regression models were adjusted for age, sex, cancer, heart failure, chronic obstructive pulmonary disease, essential arterial hypertension, acute and/or chronic renal failure, atrial fibrillation/flutter, hyperlipidemia, smoking, and diabetes mellitus. This epidemiological approach was chosen for adjustment to guarantee the widespread statistical independence of the impact of SPF on treatments, length of in-hospital stay and especially on the adverse in-hospital events in the light of the possible co-prevalence of these known factors influencing case-fatality negatively. The results of the logistic regressions are presented as Odds Ratios (OR) and 95 % CI.

All statistical analyses were carried out with the use of SPSS software (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. IBM Corp: Armonk, NY, USA) and only the P values <0.05 (two-sided) were considered to be statistically significant.

3. Results

Overall, 4,409,597 hospitalized MI patients (aged in median 73.0 [IQR 62.0-81.0] years, 37.0 % females) were treated in Germany in the years 2005-2020. Median length of in-hospital stay was 7.0 (4.0-12.0) days. Among these hospitalizations, 17,297 (0.4 %) were coded with SPF.

3.1. Temporal and regional trends

Hospitalizations of MI patients with SPF increased significantly from 140 (0.1 %) in the year 2005 to 2461 (1.0 %) in the year 2020 (β 3.93 [95 %CI 3.86 to 4.00], $P<0.001$, Fig. 1A); additionally, the proportion of hospitalizations of patients with MI in co-prevalence with SPF increased with age (β 0.31 [95 %CI 0.29 to 0.33], $P>0.001$, Fig. 1B).

While proportion of females as well as older patients aged ≥70 years were widely constant from 2005-2015, proportions decreased in later years (Fig. 2A). The rates of patients, who had a prolonged length of in-hospital stay declined over the observational period (Fig. 2C). Notably, the annual proportion of MI patients' hospitalizations with SPF treated with cardiac catheterization (β 1.34 [95 %CI 1.25 to 1.44], $P<0.001$) and percutaneous coronary intervention (PCI, β 1.14 [95 %CI 1.04 to 1.23], $P<0.001$) increased during the years 2005-2020, whereas the percentage of coronary artery bypass grafting (CABG) remained low (Fig. 2D). While proportion of patients with acute kidney injury increased (β 0.64 [95 %CI 0.47 to 0.80], $P<0.001$) over time, in-hospital case-fatality decreased significantly (β -0.79 [95 %CI -0.99 to -0.60], $P<0.001$) (Fig. 2B).

Highest total numbers of MI patients with SPF were detected in the 8th and 9th age-decade of life. The proportion of female MI patients with SPF increased substantially with age (Fig. 3A). Almost all adverse in-hospital events grew with age (Fig. 3B). Consistently, also the percentage of prolonged in-hospital stay was higher in older decades of life (Fig. 3C). While usage of CABG surgery was low in all decades, PCI was most often used in between the 5th and 7th age-decade (Fig. 3D). Our study revealed large differences regarding absolute numbers of MI hospitalizations afflicted by presence of SPF in the different federal states of Germany with highest total numbers in Baden-Wuerttemberg, Lower Saxony und North Rhine-Westphalia (Fig. 4A). While the rate of cardiac catheterizations was highest in Saarland and in Saxony-Anhalt (Fig. 4C), highest rates of ICU admission were detected in Bremen and Saarland (Fig. 4B).

As illustrated in Fig. 5, most MI patients with presence of SPF were treated in urban vs. suburban and vs. rural hospitals. While cardiac catheterizations (68.7 %) and PCI (52.9 %) were most commonly performed in rural hospitals, in-hospital case-fatality was similar in the hospitals of the different areas (Fig. 5).

3.2. Baseline characteristics

MI patients with additional potential health risks due to SPF were in median 4 years older (77.00 [IQR 65.00-84.00] vs. 73.00 [62.00-81.00], $P<0.001$) and more often females (49.4 % vs. 36.9 %, $P<0.001$), whereby especially the proportion of patients aged ≥70 years were

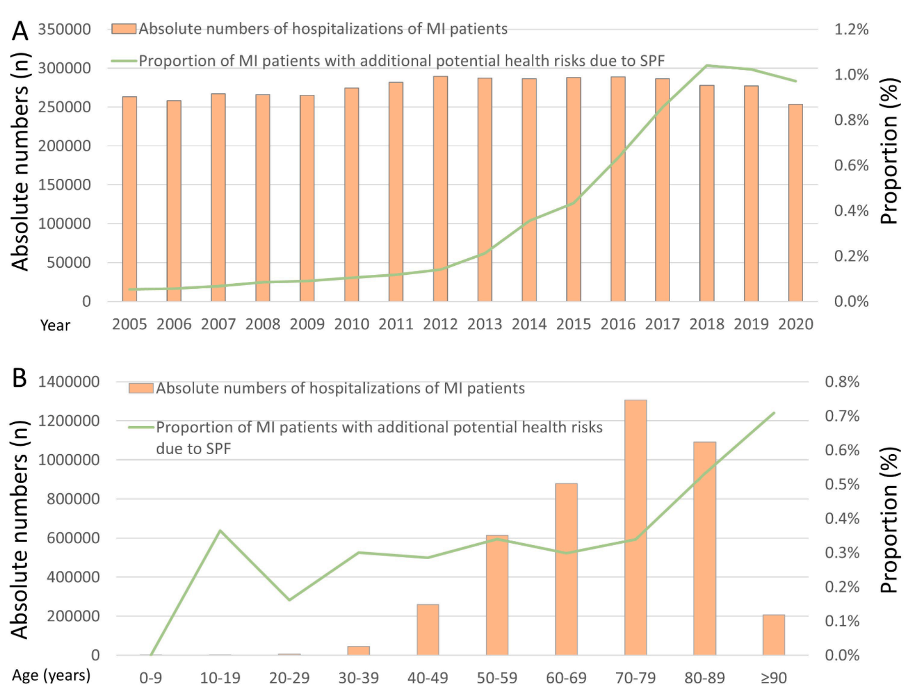

Fig. 1. Temporal trends regarding hospitalizations of patients with MI stratified for presence of socioeconomic or psychosocial factors (SPF).
Panel A – Total numbers regarding hospitalizations of MI patients and proportion of MI patients with socioeconomic or psychosocial factors (SPF) stratified for treatment year (2005-2020)
Panel B - Total numbers regarding hospitalizations of MI patients and proportion of MI patients with socioeconomic or psychosocial factors (SPF) stratified for age-decades.

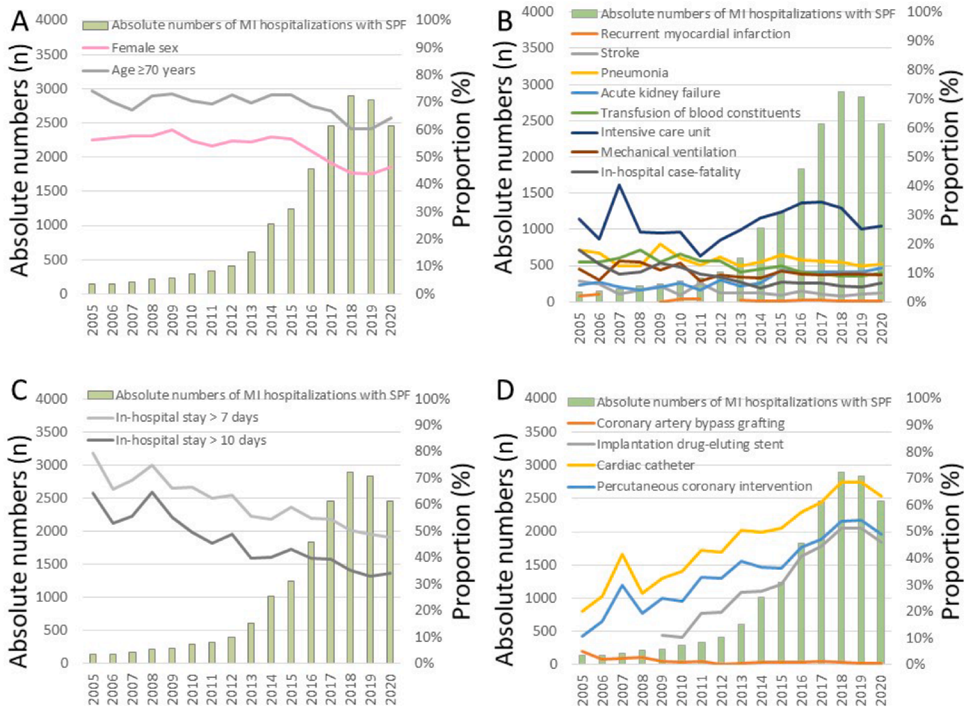

Fig. 2. Temporal trends of patient characteristics, adverse in-hospital events and interventional/surgical treatments in patients with MI and presence of socio-economic or psychosocial factors (SPF).
Panel A – Total numbers of patients with MI and presence of socioeconomic or psychosocial factors (SPF) and proportion of female sex and age ≥70 years in the different treatment years (2005-2020)
Panel B - Total numbers of patients with MI and presence of socioeconomic or psychosocial factors (SPF) and proportion of adverse in-hospital events in the different treatment years (2005-2020)
Panel C – Total numbers of patients with MI and presence of socioeconomic or psychosocial factors (SPF) and proportion of prolonged in-hospital stay in the different treatment years (2005-2020)
Panel D - Total numbers of patients with MI and presence of socioeconomic or psychosocial factors (SPF) and proportion of interventional and surgical treatments in the different treatment years (2005-2020).

distinctly higher in MI patients with SPF (65.9 % vs. 56.5 %, $P < 0.001$) (Table 1). MI patients with SPF had an aggravated cardiovascular profile with higher percentages of all investigated cardiovascular risk factors and cardiovascular comorbidities. While cancer was similarly prevalent in both groups, renal insufficiency and chronic obstructive pulmonary disease were also more often detected in MI patients with SPF (Table 1).

3.3. Length of in-hospital stay

In-hospital stay was longer in MI patients with SPF than without (8.00 [5.00-15.00] vs. 7.00 [4.00-12.00] days, P<0.001). Consecutively, a prolonged in-hospital stay >7 days (53.8 % vs. 45.2 %, $P < 0.001$) as well as >10 days (38.8 % vs. 30.1 %, P<0.001) was also more often detected in MI patients with SPF (Table 1).

SPF in MI patients were independently associated with prolonged length of in-hospital stay >7 days (OR 1.236 [95 %CI 1.198-1.276], P<0.001) and >10 days (OR 1.296 [95 %CI 1.254-1.339], P<0.001) (Table 2).

3.4. Interventional and surgical treatments

Interventional treatments such as cardiac catheterization (58.9 % vs. 57.9 %, P=0.007), PCI (45.3 % vs. 44.4 %, P=0.015) and implantation of drug-eluting stent (DES, 40.1 % vs. 28.5 %, P<0.001) were more often performed in MI patients with SPF in comparison to MI patients without SPF, whereas the surgical reperfusion strategy of CABG was less often performed in patients with SPF than in those without (0.8 % vs. 4.7 %, P<0.001) (Table 1).

SPF were associated with increased usage of cardiac catheterization (OR 1.174 [95 %CI 1.136-1.212], $P<0.001$), PCI (OR 1.167 [95 %CI 1.130-1.205], $P<0.001$) and DES implantation (OR 1.885 [95 %CI 1.825-1.946], $P<0.001$) independently of age, sex, cancer, heart failure, chronic obstructive pulmonary disease, essential arterial hypertension, acute and/or chronic renal failure, atrial fibrillation/flutter, hyperlipidemia, smoking, and diabetes mellitus (Table 2). In contrast, SPF in MI patients was accompanied by reduced use of CABG (OR 0.172 [95 %CI 0.146-0.203], $P<0.001$) (Table 2).

3.5. Adverse in-hospital events

The rate of in-hospital DVT (1.2 % vs. 0.7 %, $P<0.001$), PE (1.0 % vs. 0.7 %, $P<0.001$), acute kidney failure (9.6 % vs. 7.5 %, $P<0.001$) and pneumonia (13.9 % vs. 11.9 %, $P<0.001$) was higher in MI patients with SPF in comparison to those without (Table 1). In contrast, in-hospital death (6.5 % vs. 12.0 %, $P<0.001$) and CPR (3.6 % vs. 6.3 %, $P<0.001$) were less often detected in MI patients with SPF, which seems to be not surprising since these coded SPF are only in part already known at admission to the clinic, but might be more often identified during hospitalization. Thus, particularly in patients who deceased during the first 1-2 days of the hospitalization, existing SPF might not be recognized and therefore are not coded (Table 1). However, when focusing on the 3,612,617 hospitalized MI patients in Germany in the years 2005-2020 who were hospitalized >2 days and survived the first 2 days of hospitalization, presence of SPF was still accompanied by lower in-hospital case-fatality (5.6 % vs. 8.8 %, P<0.001) despite similar proportions of cardiac catheterizations (60.8 % vs. 60.3 %, $P=0.253$) and usage of PCI (47.5 % vs. 47.1 %, P=0.280) in MI patients with and without SPF (**Table S3 in the supplementary material**).

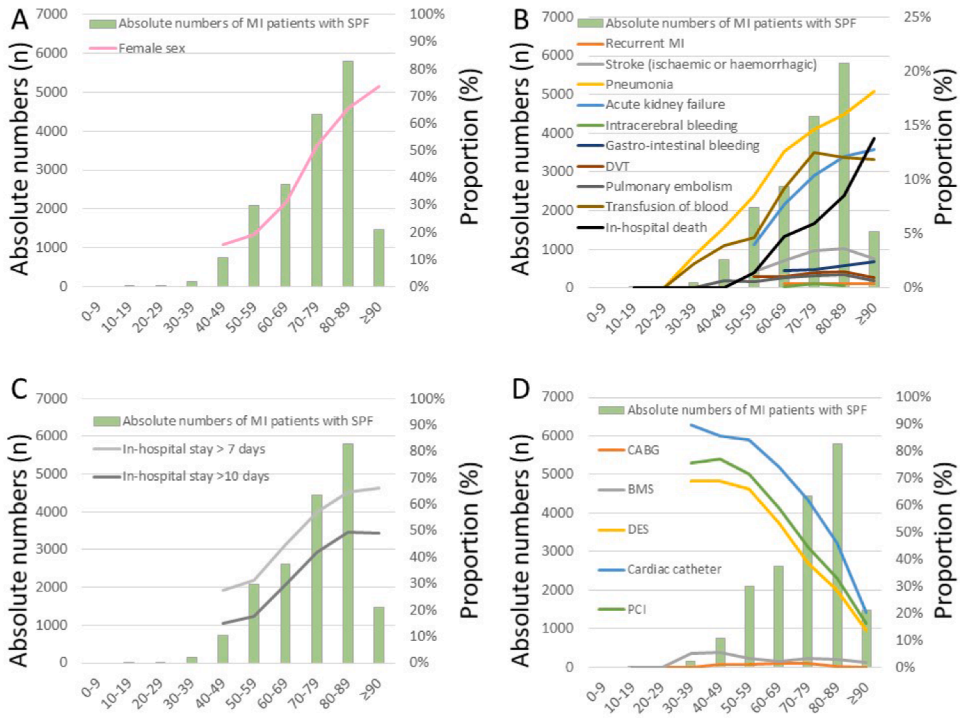

Fig. 3. Temporal trends of patient characteristics, adverse in-hospital events and interventional/surgical treatments in patients with MI and presence of socio-economic or psychosocial factors (SPF).

Panel A – Total numbers of patients with MI and presence of socioeconomic or psychosocial factors (SPF) and proportion of female sex in the different age-decades

Panel B - Total numbers of patients with MI and presence of socioeconomic or psychosocial factors (SPF) and proportion of adverse in-hospital events in the different age-decades

Panel C – Total numbers of patients with MI and presence of socioeconomic or psychosocial factors (SPF) and proportion of prolonged in-hospital stay in the different age-decades

Panel D - Total numbers of patients with MI and presence of socioeconomic or psychosocial factors (SPF) and proportion of interventional and surgical treatments in the different age-decades

Abbreviations: SPF = socioeconomic or psychosocial factors; MI = myocardial infarction; DVT = Deep venous thrombosis and/or thrombo-phlebitis; CABG = Coronary artery bypass grafting; BMS = Bare metal stent; DES = Drug eluting stent; PCI = Percutaneous coronary intervention.

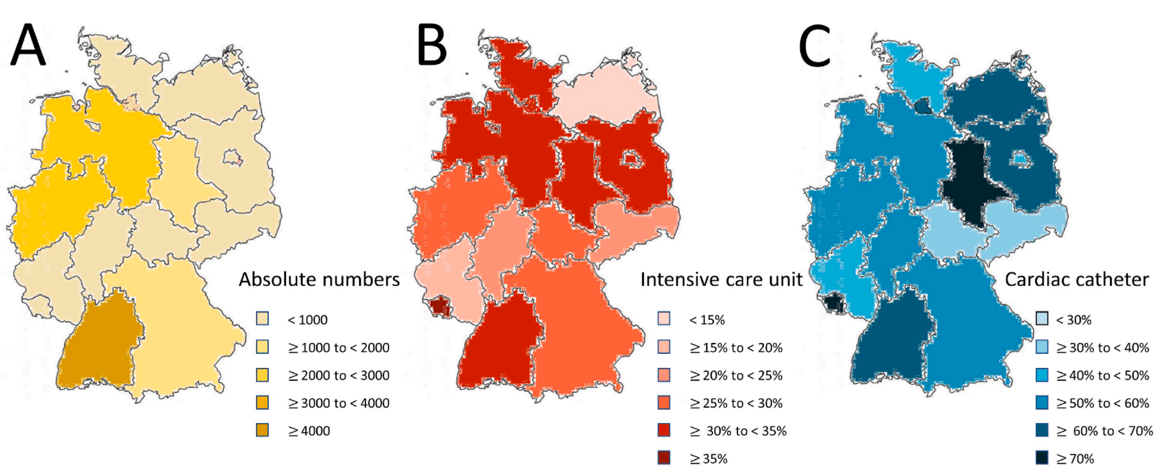

Fig. 4. Regional differences of MI hospitalizations with presence of socioeconomic or psychosocial factors (SPF) (A), admission on intensive care units (B) and use of cardiac catheter (C) in patients with MI.

Logistic regression analyses confirmed an independent association between SPF in MI patients with increased risk for DVT (OR 1.634 [95 % CI 1.427-1.870], $P<0.001$), PE (OR 1.337 [95 %CI 1.149-1.555], $P<0.001$), pneumonia (OR 1.060 [95 %CI 1.013-1.110], P=0.011) and acute renal failure (OR 1.170 [95 %CI 1.105-1.240], $P<0.001$) (Table 2). In contrast, SPF were independently associated with reduced in-hospital case-fatality (OR 0.461 [95 %CI 0.433-0.490], $P<0.001$) as well as CPR (OR 0.602 [95 %CI 0.555-0.652], $P<0.001$) (Table 2). In addition, SPF in MI patients affected occurrence of recurrent MI regarding decreased rates (OR 0.687 [95 %CI 0.542-0.870], $P=0.002$) (Table 2).

Subgroup-analysis of the three different investigated subgroups of SPF is shown in the **supplementary material**.

When focusing on the 3,612,617 hospitalized MI patients in

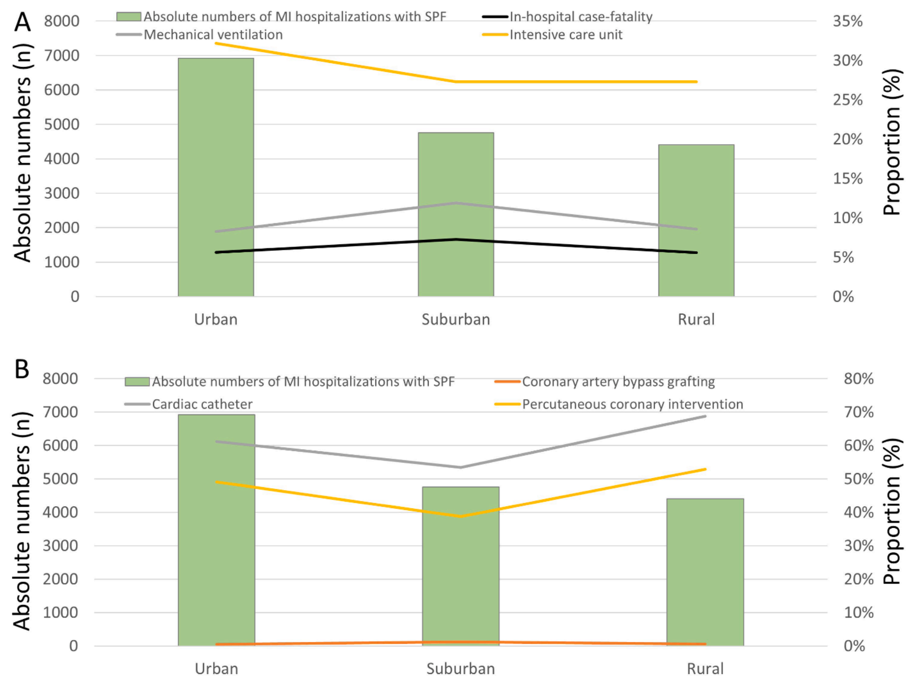

Fig. 5. Regional differences of MI hospitalizations with presence of socioeconomic or psychosocial factors (SPF) according to hospital area type (urban vs. suburban vs. rural (green bars), outcomes (A) and interventional/surgical treatments (B) in patients with MI.

Germany in the years 2005-2020, who were hospitalized >2 days and survived the first 2 days of hospitalization, these results remained widely unchanged (**Table S4 in the supplementary material**).

4. Discussion

In this analysis of more than 4 million MI hospitalizations in Germany from 2005-2020, only 0.4 % were coded with socioeconomic or psychosocial factors (SPF). Hospitalizations of MI patients with SPF increased significantly, but on a low level up to 1.0 % in the year 2020. This increase might be driven by higher awareness of SPF, sociodemographic changes in the German population with growing poverty and its consequences on health, but also changes in coding behaviour due to stronger need to justify prolonged length of in-hospital stay in MI patients [17,18]. Our study detected regional differences regarding frequency of SPF in MI patients as well as usage of interventional treatment. These regional differences regarding frequency of SPF might be triggered by socioeconomic status in the different federal states [19, 20]. While studies of the US, China and other countries revealed no differences regarding the usage of interventional treatments between rural and urban hospitals in MI patients regardless of SPF [21-23], our study identified that usage of cardiac catheterizations and PCI in MI patients with SPF were most commonly performed in rural German hospitals. While data of the US reported that lower-income patients hospitalized for MI were less often admitted to urban hospitals or hospitals that provide CABG and PCI [24,25], our regional trend data suggest that MI patients with SPF were also in rural hospitals timely and adequately treated with PCI, although patients with SPF tended to be older, of female sex, and had a more aggravated cardiovascular profile with higher percentages of all investigated cardiovascular risk factors and cardiovascular comorbidities. It is well known from previously published studies that socioeconomic status is inversely correlated with cardiovascular disease outcomes and the prevalence of cardiovascular risk factors [26-28]. Consecutively, length of in-hospital stay was longer and patients with SPF suffered more often of complications like pneumonia and kidney failure, most likely driven by their increased vulnerability for these complications during hospitalization. Besides these mentioned adverse in-hospital events, which complicate the hospitalization course and prolong the length of in-hospital stay, it has to be suggested that in MI patients with SPF more often factors of home care have to be clarified and ensured before patients' discharge from the hospital in comparison to those MI patients without SPF. However and in contrast to what we expected, MI patients with SPF had statistically a lower in-hospital case-fatality and in addition, a lower rate of recurrent MI. The logistic regression analysis confirmed an association between SPF and statistically a reduced in-hospital mortality independently of age, sex and comorbidities. We suggest that this finding regarding lower in-hospital case-fatality is primarily, but at least in part, induced by an under-coding/under-diagnosing of SPF in those MI patients, who deceased during the most life-threatening early acute phase of the first 2 days of hospitalization. During this most vulnerable period in MI patients, coding of SPF does not trigger higher remuneration for the provided healthcare services in the hospitals (as SPF is often coded as a primary cause of prolonged in-hospital stay). However, in order to overcome this problem, we performed a sensitivity analysis in more than 3.5 million MI patients, who were hospitalized >2 days and therefore, survived the first 2 days of hospitalization. In contrast to our suggestion, we detected also in this sub-group once again a statistically lower in-hospital case-fatality rate in MI patients with than without SPF. Thus, this result of the subgroup was largely in line with the results obtained for the overall cohort. Therefore, an under-coding seems only in-part the explanation of this finding. Remarkably, previously published studies demonstrated that sociodemographic determinants such as living alone and low-income are important risk factors for pre-hospital deaths in ischemic heart disease/MI and these patients die more often a pre-hospital death [7,29]. In line with the aforementioned results, it could be assumed that higher proportion of pre-hospital deaths in patients with severe MI in co-prevalence with SPF, might be another reason for differences regarding the in-hospital case-fatality rate of MI patients with and without SPF. In this context, SPF might be considered as an obstacle for reaching the hospital alive and therefore, SPF might lead to a selection BIAS since severe MI cases with SPF reach the hospitals less often alive than those patients with severe MI, but without SPF. A further explanation might be the involvement of social services in the hospital. The physicians and the social services might identify the SPF and determinants in the treated MI patients to plan the rehabilitation

Table 1
Patients' characteristics, medical history, presentation and adverse in-hospital events of the 4,409,597 hospitalizations of MI patients in Germany in the years 2005-2020 stratified for presence of socioeconomic or psychosocial factors (SPF).

Parameters	Hospitalizations of MI patients with additional potential health risks due to socioeconomic or psychosocial factors (SPF) (n= 17,297; 0.4 %)	Hospitalizations of MI patients without additional potential health risks due to socioeconomic or psychosocial factors (SPF) (n= 4,392,300; 99.6 %)	P-value
Age (years)	77.00 (65.00-84.00)	73.00 (62.00-81.00)	**<0.001**
Age ≥70 years	11,391 (65.9 %)	2,481,722 (56.5 %)	**<0.001**
Female sex	8536 (49.4 %)	1,620,948 (36.9 %)	**<0.001**
In-hospital stay (days)	8.00 (5.00-15.00)	7.00 (4.00-12.00)	**<0.001**
In-hospital stay > 7 days	9304 (53.8 %)	1,984,027 (45.2 %)	**<0.001**
In-hospital stay >10 days	6719 (38.8 %)	1,322,860 (30.1 %)	**<0.001**
Cardiovascular risk factors			
Obesity	1678 (9.7 %)	390,908 (8.9 %)	**<0.001**
Essential arterial hypertension	10,282 (59.4 %)	2,432,334 (55.4 %)	**<0.001**
Diabetes mellitus	5534 (32.0 %)	1,340,806 (30.5 %)	**<0.001**
Hyperlipidaemia	8362 (48.3 %)	1,767,264 (40.2 %)	**<0.001**
Comorbidities			
Heart failure	8006 (46.3 %)	1,668,121 (38.0 %)	**<0.001**
Peripheral artery disease	1390 (8.0 %)	290,356 (6.6 %)	**<0.001**
Atrial fibrillation/flutter	4521 (26.1 %)	989,406 (22.5 %)	**<0.001**
Chronic obstructive pulmonary disease	1674 (9.7 %)	390,815 (8.9 %)	**<0.001**
Chronic renal insufficiency (glomerular filtration rate <60 ml/ min/1,73 m^2)	3614 (20.9 %)	708,241 (16.1 %)	**<0.001**
Cancer	644 (3.7 %)	160,541 (3.7 %)	0.634
Treatment			
Cardiac catheter	10,186 (58.9 %)	2,541,893 (57.9 %)	**0.007**
Percutaneous coronary intervention (PCI)	7836 (45.3 %)	1,949,322 (44.4 %)	**0.015**
Implantation drug-eluting stent	6943 (40.1 %)	1,253,920 (28.5 %)	**<0.001**
Coronary artery bypass grafting	145 (0.8 %)	205,717 (4.7 %)	**<0.001**
Intensive care unit	5052 (29.2 %)	1,354,499 (30.8 %)	**<0.001**
Mechanical ventilation	1660 (9.6 %)	545412 (12.4 %)	**<0.001**
Adverse events during hospitalization			
In-hospital death	1130 (6.5 %)	527,317 (12.0 %)	**<0.001**
Cardio-pulmonary resuscitation	625 (3.6 %)	275,145 (6.3 %)	**<0.001**
Shock	781 (4.5 %)	318,570 (7.3 %)	**<0.001**
Deep venous thrombosis and/or thrombophlebitis	216 (1.2 %)	31,417 (0.7 %)	**<0.001**
Pulmonary embolism	172 (1.0 %)	30953 (0.7 %)	**<0.001**
Acute kidney failure	1658 (9.6 %)	331,529 (7.5 %)	**<0.001**

Table 1 (*continued*)

Adverse events during hospitalization			
Pneumonia	2396 (13.9 %)	524,349 (11.9 %)	**<0.001**
Recurrent myocardial infarction	69 (0.4 %)	24,931 (0.6 %)	**0.003**
Stroke (ischaemic or haemorrhagic)	509 (2.9 %)	125,252 (2.9 %)	0.473
Intracerebral bleeding	41 (0.2 %)	12,681 (0.3 %)	0.206
Gastro-intestinal bleeding	287 (1.7 %)	65,053 (1.5 %)	0.053
Transfusion of blood constituents	1799 (10.4 %)	545,268 (12.4 %)	**<0.001**

and home care after hospitalization. In this context, the identification of SPF during the in-hospital stay in MI patients after the most vulnerable phase of hospitalizations planning the early discharge from the acute-care-hospital might be the most important factor for a statistically reduced in-hospital case-fatality rate. We hypothesize that these mentioned factors might play key roles regarding statistically recognized reduced in-hospital case-fatality rate of MI patients with SPF compared to those without SPF despite higher complication rates in MI patients with SPF. In addition, our study demonstrates an important difference in the inter-state and inter-health-care comparison between North America and Germany regarding the use of interventional and surgical revascularization. In the US, where access to care is significantly impacted by socioeconomic status, an increase regarding neighbourhood income from the lowest to the highest quintile was associated with a 23 % increase in rates of use of coronary angiography and a 45 % decrease in waiting times for coronary angiography [8]. In contrast, in our study rates of cardiac catheter and PCI were fortunately not decreased by SPF. The logistic regression models showed even a higher frequency of cardiac catheter and PCI in MI patients with SPF in comparison to those MI patients without SPF independently of age, sex and comorbidities, which might be driven by the universal health coverage model in Germany. Nevertheless, these beneficial treatments might contribute to the better outcome regarding lower case-fatality in MI patients with SPF. However, SPF was associated with a decrease regarding usage of CABG, which is in accordance with previously published studies [30,31]. Since also Yusuf et al. stated that although high-income was in part related to higher burden of cardio-vascular risk factors, better control of these risk factors and more frequent use of proven pharmacologic therapies and revascularization mitigate these disadvantages [10].

The findings of the present study of SPF influencing prognosis after MI are in line with previous study results. Several studies revealed an association between socioeconomic status and the incidence and mortality rates of MI. The studies found that individuals with lower socioeconomic status were at a higher risk of experiencing an incident MI event [7,32]. Notably, even after controlling for personal income, education, and occupation, living in a disadvantaged neighbourhood was associated with an increased incidence of coronary heart disease [11]. In contrast to our study, the authors showed that MI patients with lower socioeconomic status had higher mortality rates across different time-frames after MI (28 days and 1 year) compared to those with higher socioeconomic status. Remarkably, in accordance with our hypothesis also the prehospital mortality was higher in MI patients with low socioeconomic status [7]. In line, a subsequent study from the same authors revealed that a low socioeconomic position (i.e. low income) was associated with a significantly higher risk of prehospital coronary death [33]. Even among patients who were hospitalized alive for MI, those with low income faced a significantly higher risk of death during the subsequent 12 months compared to those with high income [7]. Interestingly, a more recent study investigated how early-life socioeconomic factors and later-life socioeconomic status relate to MI incidence and

Table 2
Impact of socioeconomic or psychosocial factors (SPF) on in-hospital death and adverse events during in-hospital stay in patients with myocardial infarction (univariate and multivariate logistic regression model).

	Univariate regression model		Multivariate regression model*	
	OR (95 % CI)	P-value	OR (95 % CI)	P-value
Adverse events during in-hospital stay				
In-hospital death	0.512 (0.482-0.544)	**<0.001**	0.461 (0.433-0.490)	**<0.001**
In-hospital stay > 7 days	1.413 (1.371-1.456)	**<0.001**	1.236 (1.198-1.276)	**<0.001**
In-hospital stay >10 days	1.474 (1.429-1.520)	**<0.001**	1.296 (1.254-1.339)	**<0.001**
Recurrent myocardial infarction	0.702 (0.554-0.889)	**0.003**	0.687 (0.542-0.870)	**0.002**
Pneumonia	1.186 (1.136-1.239)	**<0.001**	1.060 (1.013-1.110)	**0.011**
Deep venous thrombosis and/or thrombophlebitis	1.755 (1.534-2.008)	**<0.001**	1.634 (1.427-1.870)	**<0.001**
Pulmonary embolism	1.415 (1.217-1.645)	**<0.001**	1.337 (1.149-1.555)	**<0.001**
Acute renal failure	1.299 (1.234-1.366)	**<0.001**	1.170 (1.105-1.240)	**<0.001**
Cardio-pulmonary resuscitation	0.561 (0.518-0.608)	**<0.001**	0.602 (0.555-0.652)	**<0.001**
Stroke (ischemic or hemorrhagic)	1.033 (0.946-1.128)	0.473	0.959 (0.877-1.048)	0.352
Intracerebral bleeding	0.821 (0.604-1.115)	0.207	0.861 (0.633-1.170)	0.338
Gastro-intestinal bleeding	1.122 (0.998-1.262)	0.053	1.030 (0.916-1.159)	0.620
Transfusion of blood constituents	0.819 (0.780-0.860)	**<0.001**	0.732 (0.697-0.770)	**<0.001**
Interventional/surgical treatments				
Cardiac catheter	1.043 (1.012-1.075)	**0.007**	1.174 (1.136-1.212)	**<0.001**
Percutaneous coronary intervention (PCI)	1.038 (1.007-1.070)	**0.015**	1.167 (1.130-1.205)	**<0.001**
Implantation drug-eluting stent	1.678 (1.628-1.730)	**<0.001**	1.885 (1.825-1.946)	**<0.001**
Coronary artery bypass grafting	0.172 (0.146-0.203)	**<0.001**	0.172 (0.146-0.203)	**<0.001**
Mechanical ventilation	0.749 (0.712-0.788)	**<0.001**	0.719 (0.682-0.757)	**<0.001**
Intensive care unit	0.925 (0.895-0.956)	**<0.001**	0.923 (0.893-0.955)	**<0.001**

* Adjustment: Adjusted for age, sex, cancer, heart failure, chronic obstructive pulmonary disease, essential arterial hypertension, acute and/or chronic renal failure, atrial fibrillation/flutter, hyperlipidemia, smoking, and diabetes mellitus.

survival in Finland [34]. The authors reported that childhood conditions, such as lower parental education, occupational background, and household crowding, were associated with increased MI risk and also short-term survival after MI was better for those with favourable childhood circumstances [34]. These findings underscore the critical role of early-life socioeconomic conditions in shaping cardiovascular health outcomes, suggesting that preventive measures and tailored strategies with healthy lifestyle for reducing MI risk may need to begin in childhood and extend throughout one's life course. Likewise, the importance of psychosocial factors in cardiovascular disease is increasingly acknowledged as recently highlighted by a position paper of the German Cardiac Society [35]. Furthermore, the importance of psychological support of MI patients was underlined in the ESC guidelines for the management of acute coronary syndromes 2023 [2] and the 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice [36]. In this context it is well known, that patients with heart disease are affected by a two-fold increased risk for anxiety, mood disorders and depression, whereas anxiety and psychological stress are associated with poor outcome [2,37]. In support of this, Stewart et al. analyzed the influence of persistent psychological distress, encompassing symptoms of depression and anxiety, on the long-term mortality of individuals diagnosed with stable coronary artery disease [38]. Patients who consistently reported experiencing at least moderate psychological distress, noted on three or more assessments (accounting for 3.7 % of the subjects), faced a considerably higher risk of both cardiovascular-related mortality and all-cause mortality in comparison to individuals who reported no psychological distress. In general, there is mounting evidence that psychosocial stressors like lack of social support, loneliness, experiencing stress in early childhood such as violence, neglect, sexual and emotional abuse as well as social discrimination, chronic stress at the workplace, shift work, pronounced acute stress situations, and mental health conditions and comorbidities can increase risk of cardiovascular disease and mortality after cardiovascular manifestation as well as delayed medical care [35].

Overall, this study detected socioeconomic and psychosocial circumstances in only a small proportion of MI patients (0.4 %), but these circumstances had significant impacts on treatments and outcomes. This is the main reason that additional research on how to identify, to classify and mitigate effects of socioeconomic and psychosocial determinants on health in different populations and their impact in different health care systems is warranted to optimize care.

4.1. *Limitations*

The present study has some important limitations: Due to the nature of an ICD- and OPS-code-based study-analysis for hospitalized patients, under-reporting and under-coding are possible biasing factors. In addition, data on concomitant medication or laboratory markers are not available and no pre-hospital as well as no follow-up evaluation is available since data are only limited to the time-frame of the in-hospital course.

5. Conclusions

In conclusion, our study sheds light on the landscape of MI care in Germany, emphasizing the importance of socioeconomic and psychosocial inpatient outcomes. Fortunately, our data negate an underuse of interventional treatments in patients with SPF. However, it underscores the need for tailored approaches to address the challenges faced by MI patients with SPF, including extended hospital stays and a higher burden of comorbidities. These findings provide valuable insights for healthcare providers and policymakers aiming to optimize care for this vulnerable patient population. Further research is warranted to explore specific interventions and strategies to mitigate the impact of socioeconomic and psychosocial determinants of health in MI care.

Conflicts of interest

OH, SA-K, PL, VHS, FK-A, DG, KP, PW, KL, AD, TM and KK report no

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CRedit authorship contribution statement

O.H., L.H. and K.K. contributed to the conception and design of the work; O.H., L.H., S.A.-K. and K.K contributed to the acquisition and interpretation of data; O.H., L.H., V.H.S. and K.K. drafted the manuscript; O.H., L.H. and K.K. contributed to the analysis and interpretation of data; all authors critically revised the manuscript. All authors gave final approval and agreed to be accountable for all aspects of work ensuring integrity and accuracy.

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Data availability

All codes used in this study are publicly available online. The data is available at the Federal Statistical Office of Germany (Statistisches Bundesamt, DEStatis) (source: RDC of the Federal Statistical Office and the Statistical Offices of the federal states, DRG Statistics 2005-2020, and own calculations).

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ejim.2024.05.032.

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