Cardiovascular Diabetology

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An observational study of therapeutic procedures and in-hospital outcomes among patients admitted for acute myocardial infarction in Spain, 2016–2022: the role of diabetes mellitus

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Abstract

Background We used the Spanish national hospital discharge data from 2016 to 2022 to analyze procedures and hospital outcomes among patients aged ≥ 18 years admitted for ST-elevation myocardial infarction (STEMI) and non–ST-elevation myocardial infarction (NSTEMI) according to diabetes mellitus (DM) status (non-diabetic, type 1-DM or type 2-DM).

Methods We built logistic regression models for STEMI/NSTEMI stratified by DM status to identify variables associated with in-hospital mortality (IHM). We analyzed the effect of DM on IHM.

Results Spanish hospitals reported 201,950 STEMIs (72.7% non-diabetic, 0.5% type 1-DM, and 26.8% type 2-DM; 26.3% female) and 167,285 NSTEMIs (61.6% non-diabetic, 0.6% type 1-DM, and 37.8% type 2-DM; 30.9% female). In STEMI, the frequency of percutaneous coronary intervention (PCI) increased among non-diabetic people (60.4% vs. 68.6%; $p < 0.001$) and people with type 2-DM (53.6% vs. 66.1%; $p < 0.001$). In NSTEMI, the frequency of PCI increased among non-diabetic people (43.7% vs. 45.7%; $p < 0.001$) and people with type 2-DM (39.1% vs. 42.8%; $p < 0.001$). In NSTEMI, the frequency of coronary artery by-pass grafting (CABG) increased among non-diabetic people (2.8% vs. 3.5%; $p < 0.001$) and people with type 2-DM (3.7% vs. 5.0%; $p < 0.001$). In the entire population, lower IHM was associated with undergoing PCI (odds ratio [OR] [95% confidence interval] = 0.34 [0.32–0.35] in STEMI; 0.24 [0.23–0.26] in NSTEMI) or CABG (0.33 [0.27–0.40] in STEMI; 0.45 [0.38–0.53] in NSTEMI). IHM decreased over time in STEMI (OR = 0.86 [0.80–0.93]). Type 2-DM was associated with higher IHM in STEMI (OR = 1.06 [1.01–1.11]).

Conclusions PCI and CABG were associated with lower IHM in people admitted for STEMI/NSTEMI. Type 2-DM was associated with IHM in STEMI.

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Keywords ST-elevation myocardial infarction, Non-ST-elevation myocardial infarction, Diabetes mellitus, Percutaneous coronary intervention, Coronary artery by-pass grafting, In-hospital mortality

Background

The incidence of acute myocardial infarction is still high in developed countries, although figures are slowly declining [1]. Diabetes mellitus is a key risk factor in coronary heart disease [2]. The anatomy of coronary vessels in people with diabetes differs from that of people without diabetes, in that the distribution of the lesions is more widespread [3], thus potentially hampering complete revascularization and negatively impacting outcomes [4].

Older studies reported an association between diabetes and in-hospital mortality (IHM) associated with acute myocardial infarction that has persisted over time [5]. We previously addressed this topic in the Spanish population. Using data from hospital discharges before 2014, we showed that IHM in people admitted to Spanish hospitals for myocardial infarction was 15% higher among those with type 2 diabetes than among those without diabetes [6]. In these studies, the authors used the International Classification of Disease, Ninth Revision (ICD-9) for coding and did not differentiate between ST-elevation myocardial infarction (STEMI) and non–ST-elevation myocardial infarction (NSTEMI). Additional studies from Spanish researchers who analyzed STEMI and NSTEMI separately using the same database have been published, although these replicate our findings, since they accessed data extracted from the same period [7].

Clinical management of patients with myocardial infarction has changed in recent years. New drugs and safer drug-eluting stents have reduced the risk of thrombosis, enabling the comparison of results after various approaches, such as percutaneous coronary intervention (PCI) and coronary artery by-pass grafting (CABG) [8]. However, some authors have reported heterogeneous outcomes driven by the presence of diabetes [9]. This perception could potentially modify treating clinicians' behavior when choosing between the diverse therapeutic options available to treat coronary heart disease in patients with diabetes.

We designed this study to obtain an overall and more recent picture of the clinical management of people admitted to Spanish hospitals for acute myocardial infarction and to analyze how diabetes mellitus can determine the choice of therapeutic procedures and hospital survival. Accordingly, we aimed to analyze the use of procedures and hospital outcomes during the period 2016–2022 among patients with type 1 diabetes, patients with type 2 diabetes, and patients without diabetes admitted with acute myocardial infarction (STEMI versus NSTEMI). We evaluated the diagnoses and procedures associated with IHM in this population and whether type 1 or type 2 diabetes was associated with IHM in people admitted for STEMI and NSTEMI.

Methods

Data source

We performed an epidemiological retrospective observational study using the Spanish National Hospital Discharge Database (SNHDD). The SNHDD is managed by the Spanish Ministry of Health, includes information from 99% of all public hospital discharges in Spain, and provides up to 20 diagnoses and 20 procedures for each hospital admission. Since 2016, the SNHDD has used the International Classification of Disease-Tenth Revision (ICD-10) for coding. More detailed information on the SNHDD is available online [10].

We analyzed data from all persons aged ≥ 18 years collected by the SNHDD over 7 consecutive years (January 1st, 2016, to December 31st, 2022). Our study population included patients discharged with a primary diagnosis of myocardial infarction (STEMI and NSTEMI). We used the specific ICD-10 codes shown in Supplementary Table 1. We stratified the study population according to the presence of type 1 diabetes, type 2 diabetes, and no diabetes. We excluded cases with missing information on age, sex, length of hospital stay (LOHS), and vital status at discharge.

Study variables

The primary outcomes of interest were IHM, that is, the percentage of patients who died during admission for each time-period evaluated, and LOHS. We sought information on the use of specific procedures during hospitalization, including PCI, CABG, thrombolytic therapy, and the need for a pacemaker, implantable cardioverter defibrillator, vasopressor drug, circulatory assist device, extracorporeal membrane oxygenation (ECMO), or mechanical ventilation (Supplementary Table 1). Patient variables included age and sex. We assessed comorbidity using the Charlson Comorbidity Index (CCI) and the methods for ICD-10–coded administrative databases described by Sundararajan et al. [11]. We also collected separate information on obesity, hypertension, lipid metabolism disorders, atrial fibrillation, cardiogenic shock, and previous myocardial infarction.

Statistical analysis

We performed the statistical analysis separately for STEMI and NSTEMI. Descriptive statistics for categorical variables are reported as percentages; continuous

variables are expressed as means with standard deviation or median with interquartile range, as required. We compared means using the *t* test or the Mann-Whitney test and proportions using the Fisher exact test. We constructed eight multivariable logistic regression models separately for STEMI and NSTEMI and stratified by diabetes status (type 1 diabetes, type 2 diabetes, no diabetes, entire population) to identify which variables were significantly associated with IHM. We provide adjusted odds ratios (ORs) and 95% confidence intervals (95%CIs). We used the Wald statistic to enter the variables one by one and determine which independent variables were to remain in the final model. We compared the new models created by the incorporation of additional variables using the likelihood ratio test. We ruled out linearity and first order (two by two) interactions between the variables that we included in the model. We conducted the statistical analysis with Stata version 14 (Stata, College Station, Texas, USA) and we set statistical significance at $p<0.05$ (two-sided).

Ethical aspects

The SNHDD database is anonymized and provided free of charge by the Spanish Ministry of Health after evaluation of an adequate research proposal [12]. Given the characteristics of this administrative database, the need for ethics committee approval or informed consent by participants is waived according to Spanish law.

Results

Clinical characteristics, procedures, and hospital outcomes for STEMI, 2016–2022

Spanish public hospitals reported 201,950 cases of STEMI during the period 2016–2022: 146,850 (72.7%) among people without diabetes, 1014 (0.5%) among people with type 1 diabetes, and 54,086 (26.8%) among people with type 2 diabetes (Table 1). Women accounted for 53,206 cases (26.3%). The age of the population without diabetes and with type 2 diabetes diminished significantly over time ($p<0.001$). The proportion of patients who received thrombolytic therapy decreased in all groups: 7.7% vs. 3.9% ($p<0.001$) among people without diabetes, 8.7% vs. 4.1% ($p=0.011$) among people with type 1 diabetes, and 5.7% vs. 3.4% ($p<0.001$) among people with type 2 diabetes. We recorded no differences for the rate of CABG. We observed higher rates of PCI among people without diabetes (60.4% vs. 68.6%; $p<0.001$) and among people with type 2 diabetes (53.6% vs. 66.1%; $p<0.001$), but not among people with type 1 diabetes (61.1% vs. 70.4%; $p=0.168$). The use of circulatory assist devices and ECMO increased among people without diabetes (both $p<0.001$). Over time, IHM declined among people without diabetes (7.5% in 2016 vs. 6.3% in 2022; $p<0.001$) and among people with type 2 diabetes (10.7% in 2016 vs. 9.2% in 2022; $p<0.001$).

Clinical characteristics, procedures, and hospital outcomes for NSTEMI, 2016–2022

Spanish hospitals reported 167,285 cases of NSTEMI during the period 2016–2022: 103,057 (61.6%) among people without diabetes, 980 (0.6%) among people with type 1 diabetes, and 63,248 (37.8%) among people with type 2 diabetes (Table 2). Women accounted for 51,647 cases (30.9%). Over time, the age of the population without diabetes diminished significantly ($p<0.001$). Rates of CABG increased among people without diabetes (2.8% vs. 3.5%; $p<0.001$) and among people with type 2 diabetes (3.7% vs. 5.0%; $p<0.001$). The percentage of patients undergoing PCI increased among people without diabetes (43.7% vs. 45.7%; $p<0.001$) and among people with type 2 diabetes (39.1% vs. 42.8%; $p<0.001$). The use of circulatory assist devices increased among people without diabetes ($p=0.008$), whereas the use of ECMO increased among people without diabetes ($p=0.006$) and among people with type 2 diabetes ($p=0.046$). We detected no variation in IHM during this period within any group.

Clinical characteristics, procedures, and hospital outcomes according to type of myocardial infarction and diabetes status

Among people admitted for STEMI, those without diabetes were more frequently men and had a lower CCI than people with diabetes (all $p<0.001$) (Table 3). People with type 1 diabetes were significantly younger (mean age = 53.6 ± 13.0) than people without diabetes (64.0 ± 14.0 years) and people with type 2 diabetes (69.8 ± 12.4 years; $p<0.001$). 5.0% of patients without diabetes had a code for cardiogenic shock, while the corresponding figures for those with T1DM and T2DM were 8.0% and 6.7%, respectively ($p<0.001$). In all years studied, most cases of cardiogenic shock were present upon hospital admission (>90%), and no significant changes in the prevalence of cardiogenic shock over time were observed.

Thrombolytic therapy and CABG were more frequently coded among patients with type 1 diabetes, whereas patients with type 2 diabetes less often underwent PCI (all $p<0.001$). LOHS was higher for people with type 1 diabetes and for people with type 2 diabetes ($p<0.001$). IHM was significantly higher among the population with type 2 diabetes (10.0%) than among the population without diabetes (6.7%) or with type 1 diabetes (6.4%) ($p<0.001$).

Among people admitted for NSTEMI, those with diabetes were more frequently men and had a lower CCI than those without diabetes (all $p<0.001$) (Table 3). People with type 1 diabetes were significantly younger (mean age 59.6 ± 12.9) than people without diabetes (68.5 ± 14.1

Table 1 Evolution along time (2016–2022) of clinical characteristics, procedures, and hospital outcomes during hospital admission for ST-elevation myocardial infarction (STEMI; ICD-10) in Spain according to diabetes mellitus (DM) status (no DM, type 1 DM, type 2 DM)

Variables		2016	2017	2018	2019	2020	2021	2022	*P* value
Population, N (%)	No DM	20,776 (73.0)	21,758 (73.0)	21,943 (72.5)	21,960 (72.3)	19,396 (72.9)	20,374 (72.7)	20,643 (72.6)	
	Type 1 DM	126 (0.4)	112 (0.4)	160 (0.5)	142 (0.5)	148 (0.6)	157 (0.6)	169 (0.6)	
	Type 2 DM	7548 (26.5)	7945 (26.7)	8149 (26.9)	8279 (27.3)	7056 (26.5)	7493 (26.7)	7616 (26.8)	< 0.001
Sex, female, N (%)	No DM	5220 (25.1)	5465 (25.1)	5487 (25.1)	5672 (25.8)	4637 (23.9)	5044 (24.8)	5041 (24.4)	< 0.001
	Type 1 DM	45 (35.7)	29 (25.9)	49 (30.6)	39 (27.5)	42 (28.4)	47 (29.9)	59 (34.9)	0.514
	Type 2 DM	2370 (31.4)	2523 (31.7)	2475 (30.4)	2502 (30.2)	2042 (28.9)	2174 (29.0)	2244 (29.5)	< 0.001
Age, mean (SD)	No DM	64.5 (14.4)	64.2 (14.4)	64.1 (14.1)	64.2 (14.1)	63.6 (13.7)	63.7 (13.7)	63.9 (13.6)	< 0.001
	Type 1 DM	54.0 (12.6)	54.5 (15.1)	51.6 (13.0)	52.8 (12.8)	53.3 (12.8)	54.3 (11.9)	55.1 (13.2)	0.227
	Type 2 DM	70.2 (12.6)	70.0 (12.5)	69.8 (12.5)	70.1 (12.3)	69.3 (12.4)	69.5 (12.3)	69.4 (12.2)	< 0.001
Charlson Comorbidity Index, mean (SD)	No DM	0.6 (1.1)	0.6 (1.1)	0.6 (1.1)	0.6 (1.1)	0.6 (1.1)	0.6 (1.1)	0.6 (1.2)	< 0.001
	Type 1 DM	1.3 (1.6)	1.2 (1.4)	1.1 (1.4)	1.4 (1.6)	1.3 (1.4)	1.3 (1.5)	1.2 (1.4)	0.133
	Type 2 DM	1.0 (1.4)	1.0 (1.4)	1.1 (1.4)	1.1 (1.5)	1.1 (1.5)	1.1 (1.5)	1.1 (1.5)	< 0.001
Thrombolytic therapy, N (%)	No DM	1602 (7.7)	1659 (7.6)	1229 (5.6)	1039 (4.7)	840 (4.3)	852 (4.2)	804 (3.9)	< 0.001
	Type 1 DM	11 (8.7)	15 (13.4)	9 (5.6)	11 (7.8)	3 (2.0)	12 (7.6)	7 (4.1)	0.011
	Type 2 DM	433 (5.7)	494 (6.2)	356 (4.4)	300 (3.6)	280 (4.0)	255 (3.4)	262 (3.4)	< 0.001
Coronary artery by-pass grafting (CABG), N (%)	No DM	196 (0.9)	170 (0.8)	194 (0.9)	186 (0.9)	166 (0.9)	200 (1.0)	165 (0.8)	0.264
	Type 1 DM	2 (1.6)	0 (0)	5 (3.1)	6 (4.2)	8 (5.4)	6 (3.8)	8 (4.7)	0.223
	Type 2 DM	106 (1.4)	90 (1.1)	106 (1.3)	106 (1.3)	104 (1.5)	103 (1.4)	107 (1.4)	0.622
Percutaneous coronary intervention (PCI), N (%)	No DM	12,537 (60.4)	13,544 (62.3)	14,079 (64.2)	14,138 (64.4)	13,595 (70.1)	14,193 (70.0)	14,153 (68.6)	< 0.001
	Type 1 DM	77 (61.1)	63 (56.3)	109 (68.1)	86 (60.6)	94 (63.5)	106 (67.5)	119 (70.4)	0.168
	Type 2 DM	4045 (53.6)	4475 (56.3)	4743 (58.2)	4989 (60.3)	4601 (65.2)	4996 (66.7)	5037 (66.1)	< 0.001
Pacemaker, N (%)	No DM	264 (1.3)	285 (1.3)	289 (1.3)	279 (1.3)	239 (1.2)	260 (1.3)	250 (1.2)	0.962
	Type 1 DM	5 (4.0)	2 (1.2)	3 (1.9)	5 (3.5)	1 (0.7)	4 (2.6)	4 (2.4)	0.622
	Type 2 DM	116 (1.5)	126 (1.6)	116 (1.4)	160 (1.9)	127 (1.8)	121 (1.6)	151 (2.0)	0.049
Implantable cardioverter defibrillator, N (%)	No DM	50 (0.2)	63 (0.3)	80 (0.4)	80 (0.4)	68 (0.4)	78 (0.4)	69 (0.3)	0.142
	Type 1 DM	0 (0)	0 (0)	1 (0.6)	0 (0)	2 (1.4)	2 (1.3)	1 (0.6)	0.549
	Type 2 DM	18 (0.2)	25 (0.3)	34 (0.4)	32 (0.4)	33 (0.5)	31 (0.4)	35 (0.5)	0.238
Circulatory assist devices, N (%)	No DM	322 (1.6)	368 (1.7)	369 (1.7)	392 (1.8)	399 (2.1)	412 (2.0)	458 (2.2)	< 0.001
	Type 1 DM	0 (0)	4 (3.6)	1 (0.6)	6 (4.2)	2 (1.4)	6 (3.8)	5 (3.0)	0.111
	Type 2 DM	151 (2.0)	138 (1.7)	156 (1.9)	151 (1.8)	158 (2.2)	167 (2.2)	163 (2.1)	0.162
Extracorporeal membrane oxygenation. (ECMO), N (%)	No DM	55 (0.3)	62 (0.3)	75 (0.3)	110 (0.5)	105 (0.5)	99 (0.5)	153 (0.7)	< 0.001
	Type 1 DM	0 (0)	0 (0)	1 (0.6)	1 (0.7)	1 (0.7)	1 (0.6)	1 (0.6)	0.955
	Type 2 DM	17 (0.2)	19 (0.2)	20 (0.3)	28 (0.3)	29 (0.4)	27 (0.4)	33 (0.4)	0.104
Mechanical ventilation, N (%)	No DM	984 (4.7)	1,104 (5.1)	1184 (5.4)	1218 (5.6)	1124 (5.8)	1124 (5.5)	1260 (6.1)	< 0.001
	Type 1 DM	14 (11.1)	11 (9.8)	12 (7.5)	13 (9.2)	18 (12.2)	18 (11.5)	12 (7.1)	0.661
	Type 2 DM	452 (6.0)	497 (6.3)	565 (6.9)	609 (7.4)	485 (6.9)	559 (7.5)	580 (7.6)	< 0.001
Vasopressor drugs, N (%)	No DM	218 (1.1)	276 (1.3)	370 (1.7)	417 (1.9)	416 (2.1)	624 (3.1)	576 (2.8)	< 0.001
	Type 1 DM	0 (0)	3 (2.7)	2 (1.3)	4 (2.8)	10 (6.8)	6 (3.8)	11 (6.5)	0.012
	Type 2 DM	101 (1.3)	101 (1.3)	129 (1.6)	160 (1.9)	187 (2.7)	278 (3.7)	245 (3.2)	< 0.001
Length of hospital stay (LOHS), median (IQR)	No DM	5 (7)	5 (7)	5 (7)	4 (7)	4 (6)	4 (7)	4 (6)	< 0.001
	Type 1 DM	5 (8)	5 (8)	5 (9)	5 (8)	5 (9)	5 (9)	5 (7)	0.350
	Type 2 DM	5 (9)	5 (8)	5 (8)	5 (8)	5 (8)	5 (8)	5 (8)	< 0.001
In-hospital mortality, N (%)	No DM	1563 (7.5)	1544 (7.1)	1454 (6.6)	1461 (6.7)	1286 (6.6)	1218 (6.0)	1294 (6.3)	< 0.001
	Type 1 DM	12 (9.5)	8 (7.1)	8 (5.0)	5 (3.5)	10 (6.8)	7 (4.5)	15 (8.9)	0.287
	Type 2 DM	804 (10.7)	823 (10.4)	894 (11.0)	842 (10.2)	674 (9.6)	657 (8.8)	698 (9.2)	< 0.001

Table 2 Evolution along time (2016–2022) of clinical characteristics, procedures, and hospital outcomes during hospital admission for non-ST-elevation myocardial infarction (NSTEMI; ICD-10) in Spain according to diabetes mellitus (DM) status (no DM, type 1 DM, type 2 DM)

Variables		2016	2017	2018	2019	2020	2021	2022	*P* value
Population, N (%)	No DM	13,355 (62.3)	14,257 (62.0)	14,889 (61.2)	15,697 (60.8)	13,787 (61.6)	15,310 (61.7)	15,762 (61.9)	
	Type 1 DM	97 (0.5)	104 (0.5)	143 (0.6)	158 (0.6)	135 (0.6)	182 (0.7)	161 (0.6)	
	Type 2 DM	8001 (3.,3)	8626 (37.6)	9294 (38.2)	9978 (38.6)	8462 (37.8)	9338 (37.6)	9549 (37.5)	< 0.001
Sex, female, N (%)	No DM	3974 (29.8)	4281 (30.0)	4408 (29.6)	4727 (30.1)	4096 (29.7)	4609 (30.1)	4675 (29.7)	0.911
	Type 1 DM	25 (25.8)	29 (27.9)	54 (37.8)	62 (39.2)	45 (33.3)	71 (39.0)	54 (33.6)	0.159
	Type 2 DM	2733 (34.2)	2906 (33.7)	3054 (32.9)	3238 (32.5)	2681 (31.7)	2955 (31.6)	2970 (31.1)	< 0.001
Age, mean (SD)	No DM	68.75 (14.2)	68.8 (14.1)	68.6 (14.1)	68.5 (14.1)	68.2 (14.1)	68.4 (14.2)	68.2 (14.0)	< 0.001
	Type 1 DM	60.1 (13.6)	58.2 (13.0)	61.5 (13.3)	57.3 (13.2)	59.6 (11.7)	60.1 (13.1)	60.5 (12.1)	0.100
	Type 2 DM	73.0 (11.2)	73.0 (11.3)	73.0 (11.2)	73.1 (11.2)	72.9 (11.4)	73.0 (11.4)	73.0 (11.4)	0.828
Charlson's comorbidity index, mean (SD)	No DM	0.7 (1.2)	0.8 (1.3)	0.8 (1.3)	0.8 (1.3)	0.8 (1.3)	0.8 (1.4)	0.8 (1.3)	< 0.001
	Type 1 DM	1.9 (1.5)	1.7 (1.6)	1.9 (1.7)	2.3 (1.9)	2.0 (1.8)	1.8 (1.8)	1.8 (1.9)	0.057
	Type 2 DM	1.4 (1.6)	1.4 (1.5)	1.5 (1.7)	1.6 (1.7)	1.6 (1.8)	1.6 (1.7)	1.6 (1.7)	< 0.001
Coronary artery by-pass grafting (CABG), N (%)	No DM	377 (2.8)	384 (2.7)	415 (2.8)	485 (3.1)	450 (3.3)	524 (3.4)	554 (3.5)	< 0.001
	Type 1 DM	5 (5.2)	7 (6.7)	10 (7.0)	11 (7.0)	10 (7.4)	11 (6.0)	15 (9.3)	0.908
	Type 2 DM	293 (3.7)	332 (3.9)	393 (4.2)	402 (4.0)	334 (4.0)	428 (4.6)	479 (5.0)	< 0.001
Percutaneous coronary intervention (PCI), N (%)	No DM	5836 (43.7)	6300 (44.2)	6457 (43.4)	6924 (44.1)	6367 (46.2)	7027 (45.9)	7200 (45.7)	< 0.001
	Type 1 DM	40 (41.2)	40 (38.5)	63 (44.1)	71 (44.9)	56 (41.5)	93 (51.1)	80 (49.7)	0.301
	Type 2 DM	3124 (39.1)	3430 (39.8)	3671 (39.5)	4055 (40.6)	3694 (43.7)	4194 (44.9)	4082 (42.8)	< 0.001
Pacemaker, N (%)	No DM	48 (0.4)	59 (0.4)	61 (0.4)	78 (0.5)	61 (0.4)	81 (0.5)	68 (0.4)	0.377
	Type 1 DM	1 (1.0)	0 (0)	1 (0.7)	3 (1.9)	1 (0.7)	2 (1.1)	0 (0)	0.578
	Type 2 DM	39 (0.5)	51 (0.6)	61 (0.7)	62 (0.6)	51 (0.6)	59 (0.6)	68 (0.7)	0.679
Implantable cardioverter defibrillator, N (%)	No DM	18 (0.1)	14 (0.1)	35 (0.2)	22 (0.1)	33 (0.2)	23 (0.2)	35 (0.2)	0.013
	Type 1 DM	0 (0)	0 (0)	1 (0.7)	0 (0)	0 (0)	0 (0)	0 (0)	0.439
	Type 2 DM	10 (0.1)	14 (0.2)	17 (0.2)	19 (0.2)	18 (0.2)	20 (0.2)	15 (0.2)	0.813
Circulatory assist devices, N (%)	No DM	80 (0.6)	88 (0.6)	81 (0.6)	110 (0.7)	104 (0.8)	130 (0.9)	129 (0.8)	0.008
	Type 1 DM	1 (1.0)	4 (3.9)	1 (0.7)	2 (1.3)	1 (0.7)	9 (5.0)	3 (1.9)	0.059
	Type 2 DM	65 (0.8)	65 (0.8)	84 (0.9)	83 (0.8)	64 (0.8)	87 (0.9)	93 (1.0)	0.576
Extracorporeal membrane oxygenation (ECMO), N (%)	No DM	3 (0.0)	5 (0.0)	15 (0.1)	14 (0.1)	5 (0.0)	15 (0.1)	19 (0.1)	0.006
	Type 1 DM	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1.1)	1 (0.6)	0.398
	Type 2 DM	2 (0.0)	2 (0.0)	4 (0.0)	7 (0.1)	6 (0.1)	6 (0.1)	13 (0.1)	0.046
Mechanical ventilation, N (%)	No DM	292 (2.2)	345 (2.4)	378 (2.5)	443 (2.8)	378 (2.7)	411 (2.7)	446 (2.8)	0.005
	Type 1 DM	4 (4.1)	5 (4.8)	12 (8.4)	6 (3.8)	5 (3.7)	16 (8.8)	10 (6.2)	0.273
	Type 2 DM	309 (3.9)	337 (3.9)	457 (4.9)	490 (4.9)	383 (4.5)	474 (5.1)	483 (5.1)	< 0.001
Vasopressor drugs, N (%)	No DM	54 (0.4)	73 (0.5)	123 (0.8)	156 (1.0)	132 (1.0)	214 (1.4)	177 (1.1)	< 0.001
	Type 1 DM	0 (0)	0 (0)	2 (1.4)	2 (1.3)	4 (3.0)	7 (3.9)	2 (1.2)	0.123
	Type 2 DM	44 (0.6)	72 (0.8)	124 (1.3)	125 (1.3)	110 (1.3)	145 (1.6)	151 (1.6)	< 0.001
Length of hospital stay (LOHS), median (IQR)	No DM	5 (8)	5 (8)	5 (8)	5 (8)	5 (7)	5 (7)	5 (7)	< 0.001
	Type 1 DM	6 (11)	7 (11)	7 (11)	7 (14)	6 (9)	6 (9)	6 (11)	0.289
	Type 2 DM	6 (10)	6 (10)	6 (10)	6 (10)	5 (9)	6 (9)	6 (9)	< 0.001
In-hospital mortality, N (%)	No DM	556 (4.2)	583 (4.1)	660 (4.4)	610 (3.9)	551 (4.0)	646 (4.2)	598 (3.8)	0.095
	Type 1 DM	1 (1.0)	3 (2.9)	8 (6.0)	11 (7.0)	6 (4.4)	11 (6.0)	4 (2.5)	0.202
	Type 2 DM	457 (5.7)	505 (5.9)	568 (6.1)	543 (5.4)	495 (5.9)	516 (5.5)	559 (5.9)	0.497

years) and people with type 2 diabetes (73.0 ± 11.3 years; $p < 0.001$). For NSTEMI patients without diabetes, cardiogenic shock was recorded in 1.3% of patients without diabetes, 4.1% of patients with T1DM, and 2.1% of those with T2DM ($p < 0.001$). As with STEMI cases, over 90% of NSTEMI patients experienced cardiogenic shock at the time of emergency room presentation, and no temporal trends in prevalence were observed. CABG was more frequently coded among patients with type 1 diabetes, whereas patients with type 2 diabetes less often

Table 3 Clinical characteristics, procedures, and hospital outcomes according to myocardial infarction type (ST-elevation [STEMI] vs. non-ST-elevation myocardial infarction [NSTEMI]; ICD-10) among people with type 1 diabetes mellitus (DM), type 2 DM or no-DM in Spain (2016–2022)

Variables	STEMI				NSTEMI			
	No-DM	Type 1 DM	Type 2 DM	*P* value	No-DM	Type 1 DM	Type 2 DM	*P* value
STEMI involving left main coronary artery, N (%)	916 (0.6)	9 (0.9)	364 (0.7)	0.285	NA	NA	NA	NA
STEMI involving left anterior descending coronary artery, N (%)	23,643 (16.1)	191 (18.9)	7606 (14.1)	< 0.001	NA	NA	NA	NA
STEMI involving other coronary artery of anterior wall, N (%)	32,394 (22.1)	249 (24.6)	12,487 (23.1)	< 0.001	NA	NA	NA	NA
STEMI involving right coronary artery, N (%)	23,637 (16.1)	132 (13.0)	7637 (14.1)	< 0.001	NA	NA	NA	NA
STEMI involving other coronary artery of inferior wall, N (%)	39,228 (26.7)	236 (23.3)	14,124 (26.1)	0.002	NA	NA	NA	NA
STEMI involving left circumflex coronary artery, N (%)	4497 (3.1)	27 (2.7)	1344 (2.5)	< 0.001	NA	NA	NA	NA
STEMI involving other sites, N (%)	8021 (5.5)	46 (4.5)	2761 (5.1)	0.004	NA	NA	NA	NA
STEMI of unspecified site, N (%)	14,514 (9.9)	124 (12.2)	7763 (14.4)	< 0.001	NA	NA	NA	NA
All STEMI combined, N (%)	146,850 (100)	1014 (100)	54,086 (100)	NA	NA	NA	NA	NA
NSTEMI	NA	NA	NA	NA	103,057 (100)	980 (100)	63,248 (100)	NA
Sex, female, N (%)	36,566 (24.9)	310 (30.6)	16,330 (30.2)	< 0.001	30,770 (29.9)	340 (34.7)	20,537 (32.5)	< 0.001
Age, mean (SD)	64.0 (14.0)	53.6 (13.0)	69.8 (12.4)	< 0.001	68.5 (14.1)	59.6 (12.9)	73.0 (11.3)	< 0.001
CCI, mean (SD)	0.6 (1.1)	1.3 (1.5)	1.1 (1.5)	< 0.001	0.8 (1.3)	1.9 (1.8)	1.5 (1.7)	< 0.001
CCI = 0, N (%)	98,144 (66.8)	415 (40.9)	26,510 (49.0)		61,602 (59.8)	260 (26.5)	24,126 (38.2)	
CCI = 1, N (%)	29,158 (19.9)	271 (26.7)	12,777 (23.6)		20,366 (19.8)	226 (23.1)	13,814 (21.8)	
CCI = 2, N (%)	10,748 (7.3)	120 (11.8)	6,135 (11.3)		10,479 (10.2)	145 (14.8)	8761 (13.9)	
CCI ≥ 3, N (%)	8800 (6.0)	208 (20.5)	8664 (16.0)	< 0.001	10,610 (10.3)	349 (35.6)	16,547 (26.2)	< 0.001
Obesity, N (%)	18,726 (12.8)	134 (13.2)	10,858 (20.1)	< 0.001	13,935 (13.5)	146 (14.9)	13,250 (21.0)	< 0.001
Hypertension, N (%)	57,592 (39.2)	353 (34.8)	29,491 (54.5)	< 0.001	47,053 (45.7)	435 (44.4)	34,157 (54.0)	< 0.001
Lipid metabolism disorders, N (%)	61,585 (41.9)	471 (46.5)	32,228 (59.6)	< 0.001	48,950 (47.5)	544 (55.5)	40,802 (64.5)	< 0.001
Atrial fibrillation, N (%)	15,658 (10.7)	68 (6.7)	7525 (13.9)	< 0.001	14,781 (14.3)	87 (8.9)	11,031 (17.4)	< 0.001
Cardiogenic shock, N (%)	7286 (5.0)	81 (8.0)	3634 (6.7)	< 0.001	1345 (1.3)	40 (4.1)	1306 (2.1)	< 0.001
Previous myocardial infarction, N (%)	8237 (5.6)	83 (8.2)	52,96 (9.8)	< 0.001	11,548 (11.2)	177 (18.1)	11,206 (17.7)	< 0.001
Thrombolytic therapy, N (%)	8025 (5.5)	68 (6.7)	2380 (4.4)	< 0.001	NA	NA	NA	NA
Vasopressor drugs, N (%)	2897 (2.0)	36 (3.6)	1201 (2.2)	< 0.001	929 (0.9)	17 (1.7)	771 (1.2)	< 0.001
Mechanical ventilation, N (%)	7998 (5.5)	98 (9.7)	3747 (6.9)	< 0.001	2693 (2.6)	58 (5.9)	2933 (4.6)	< 0.001
CABG, N (%)	1277 (0.9)	35 (3.5)	722 (1.3)	< 0.001	3189 (3.1)	69 (7.0)	2661 (4.2)	< 0.001
PCI, N (%)	96,239 (65.5)	654 (64.5)	32,886 (60.8)	< 0.001	46,111 (44.7)	443 (45.2)	26,250 (41.5)	< 0.001
Pacemaker, N (%)	1866 (1.3)	24 (2.4)	917 (1.7)	< 0.001	456 (0.4)	8 (0.8)	391 (0.6)	< 0.001
Implantable cardioverter defibrillator, N (%)	488 (0.3)	6 (0.59)	208 (0.38)	0.088	180 (0.17)	1 (0.1)	113 (0.18)	0.843
Circulatory assist devices, N (%)	2,720 (1,85)	24 (2.4)	1084 (2.0)	0.047	722 (0.7)	21 (2.1)	541 (0.9)	< 0.001
ECMO, N (%)	659 (0.5)	5 (0.5)	173 (0.3)	< 0.001	76 (0.1)	3 (0.3)	40 (0.1)	0.016
LOHS, median (IQR)	4 (4)	5 (5)	5 (5)	< 0.001	5 (5)	6 (7)	6 (6)	< 0.001
In-hospital mortality, N (%)	9820 (6.7)	65 (6.4)	5392 (10.0)	< 0.001	4204 (4.1)	44 (4.5)	3643 (5.8)	< 0.001

STEMI ST-elevation myocardial infarction, *NSTEMI* non- ST-elevation myocardial infarction, *DM* Diabetes mellitus, *SD* Standard deviation, *CCI* Charlson's comorbidity index, *CABG* Coronary artery by-pass grafting, *PCI* Percutaneous coronary intervention, *ECMO* Extracorporeal membrane oxygenation, *LOHS* Length of hospital stay, *IQR* Interquartile rangeby-pass grafting, *PCI* Percutaneous coronary intervention

underwent PCI (all $p<0.001$). LOHS was higher for people with type 1 diabetes and people with type 2 diabetes ($p<0.001$). IHM was significantly higher in people with type 2 diabetes (5.8%) than among people without diabetes (4.1%) or with type 1 diabetes (4.5%) ($p<0.001$).

Variables associated with IHM during admission for STEMI

The multivariable logistic regression models showed that the variables associated with higher IHM in persons admitted for STEMI were female sex, advanced age, a higher number of comorbidities, cardiogenic shock, and need for mechanical ventilation or ECMO

(Supplementary Table 2). Analysis of the whole study population revealed that lower IHM was associated with undergoing CABG (OR: 0.33 [0.27–0.40]) and PCI (OR: 0.34 [0.32–0.35]). In the STEMI population, IHM was 14% lower in 2022 than in 2016 (OR: 0.86 [0.80–0.93]). Type 2 diabetes was associated with a higher IHM in people admitted for STEMI (OR: 1.06 [1.01–1.11]).

Variables associated with IHM during admission for NSTEMI

The multivariable logistic regression models showed that the variables associated with higher IHM in people admitted for NSTEMI were female sex, advanced age, a higher number of comorbidities, cardiogenic shock, and need for mechanical ventilation or circulatory assist devices (Supplementary Table 3). Analysis of the whole study population revealed that lower IHM was associated with CABG (OR: 0.45 [0.38–0.53]) and PCI (OR: 0.24 [0.23–0.26]). In the entire population with NSTEMI, IHM remained stable when 2022 was compared with 2016 (OR: 0.97 [0.88–1.06]). Neither type 1 diabetes (OR: 1.09 [0.76–1.57]) nor type 2 diabetes (OR: 1.00 [0.95–1.05]) was associated with higher IHM in people admitted for NSTEMI.

Discussion

We found that the proportion of patients who received thrombolytic therapy decreased after admission for STEMI. The reasons underlying this finding are that evidence supports urgent PCI over thrombolytic therapy [13] and that skilled interventional cardiologists provide timely care in many hospitals in developed countries. Furthermore, circumstances such as diagnostic uncertainties, late presentation in the emergency department, a rise in the number of high-clinical-risk patients, and the increasing number of people with a high probability of bleeding could shift the balance in favor of primary PCI. A recent paper from D'Ascenzo F, et al., showed an overall low risk of both ischemic and bleeding complications within the first year after PCI for acute coronary syndrome [14]. However, these authors detected a trend to increasing bleeding risk beyond the fourth month after a PCI. Optimizing the balance between ischemic and bleeding risk still represents a challenge when treating patients undergoing PCI for an acute coronary syndrome.

In the context of STEMI, it did not come as a surprise to observe higher rates of PCI over time. This procedure is preferred owing to its less invasive nature and quicker recovery times than CABG and is considered the gold standard for STEMI where available [15]. In hospitals where primary PCI is not readily available without patient transfer, rates of thrombolytic therapy have been reported to be significant, since it is accepted that when PCI cannot be offered within a reasonable timeframe, thrombolytic treatment plus transfer to another facility for PCI is a reasonable option [16]. Indeed, older studies often reported similar mortality rates for both strategies [17]. We could not evaluate the rates of the diverse procedures stratified by the size of the hospitals because the data provided by the Ministry of Health were not sufficient to perform this analysis. Despite the incremental use of PCI in STEMI, rates of CABG did not decrease. Instead, CABG rates stabilized over time in STEMI, possibly reflecting the use of PCI as the default procedure for initial reperfusion to treat the culprit coronary lesion on presentation at the hospital, after which, if required, the patient undergoes CABG for multivessel disease [18]. This approach may change in the near future, when PCI becomes the main option for multivessel disease [19, 20].

In this study, we report an annual incidence of approximately 35,000 PCIs among patients admitted with STEMI or NSTEMI, translating to a rate of less than 1000 per 1,000,000 population. The PCI rate was approximately 67% for STEMI cases. This figure aligns with data reported for Spain in 2007 but is significantly lower than more recent rates documented in our country, which report PCI utilization in STEMI patients at around 80% [21, 22]. We hypothesize that the discrepancy between our findings and the higher PCI rates reported in the recent study may be attributed to the study populations of the studies. The other Spanish investigation analyzed data from a registry that involved contributions from 83 hospitals participating in data collection following the implementation of the acute myocardial infarction code by the Association of Interventional Cardiology of the Spanish Society of Cardiology [21, 22]. In contrast, our study encompasses all Spanish hospitals within the National Health System, regardless of hospital size, healthcare network characteristics, or the presence of an infarction code, which may account for the observed lower PCI rate. In NSTEMI, rates of PCI also increased over time. Updated clinical guidelines recommend PCI as a primary intervention for NSTEMI as well [23]. In contrast with our data for STEMI, rates of CABG in NSTEMI increased during the study period. Rates of CABG in NSTEMI may be affected by individual patient factors, regional variations, and specific healthcare system practices. The factors that potentially predispose physicians to perceive CABG as a better option than PCI to treat multivessel coronary disease include anatomic considerations, comorbidities such as diabetes mellitus and chronic kidney disease, and female sex [24]. Given the unstable nature of NSTEMI and the potential for threatened myocardium, many clinicians give even higher priority to successful revascularization than in STEMI [25], especially after the higher incidence rates of stroke reported with CABG have been reduced—if not eliminated—among patients with NSTEMI [26].

We noticed that in both STEMI and NSTEMI patients with type 2 diabetes less often underwent PCI. This disparity may be attributed to factors such as the higher prevalence of comorbidities in diabetic patients, which could complicate the decision-making process for PCI [27]. Additionally, there may be concerns about the potential risks and outcomes of PCI in diabetic individuals, leading to a more conservative approach to treatment. Furthermore, differences in access to healthcare, provider bias, and patient preferences could also determine the underutilization of PCI in this population. Addressing these disparities requires a comprehensive understanding of the unique challenges faced by diabetic patients with acute coronary syndromes and the development of tailored strategies to optimize their cardiovascular care and outcomes. For instance, the Syntax Score is a tool that helps to select the best strategy for specific patients with multivessel coronary disease [28, 29].

Patients with type 1 diabetes admitted for a myocardial infarction were younger than people without diabetes or people with type 2 diabetes. This may be the reason CABG was more frequently coded among patients with type 1 diabetes in both STEMI and NSTEMI. CABG removes large segments of the artery that would have added to the total risk of necrosis resulting from occlusion. With PCI alone, the probability of occlusion is not reduced in the non-stented regions of the vessel [30]. This reasoning may prompt multidisciplinary teams to favor CABG among people with type 1 diabetes and multivessel disease [31]. We admit that evidence on the short-term survival of type 1 diabetes patients after revascularization for myocardial infarction is scarce. Long-term survival after CABG in patients with type 1 diabetes has been reported to be worse than in the rest of the population [32]. Factors such as duration of exposure to hyperglycemia, abnormal vascular findings, and long-term inflammation may contribute to adverse outcomes among this population.

In the multivariate analysis, undergoing CABG or PCI was associated with a lower IHM in both STEMI and NSTEMI. The trend was not statistically significant for CABG in STEMI or for PCI or CABG in NSTEMI owing to the small number of cases among people with type 1 diabetes. The association between lower IHM and a more invasive approach has incentivized researchers in recent years to design studies to achieve physiology-guided complete revascularization among older patients admitted for a myocardial infarction [33].

IHM was 14% lower in 2022 than in 2016 among people admitted for STEMI. In contrast, we detected no changes in IHM over time in NSTEMI, as outlined elsewhere [34]. Nguyen et al. found that progressively lower times to coronary angiography accounted for the decreasing one-year mortality rates in STEMI [34]. This contrasts with findings for NSTEMI, where times to coronary angiography remained unchanged. The strategy of an early invasive coronary evaluation in high-risk NSTEMI cases, such as those identified by the GRACE risk score [35], may generate better clinical outcomes than a delayed invasive strategy [23, 36]. Regrettably, we had no access to this information in our database. Other research groups have identified low left ventricular ejection fraction and absence of PCI as factors associated with early mortality after hospital discharge among people admitted for NSTEMI [37]. The absence of change in IHM over time in NSTEMI—in contrast with STEMI—suggests that there may be several factors at play in the outcomes of these two types of myocardial infarctions.

Type 2 diabetes was associated with a higher IHM in people admitted for STEMI, but not in those admitted for NSTEMI. Older reports had already stated that IHM was associated with diabetes in acute coronary syndromes [38, 39], although even recent studies do not specifically address the possible differences in associations between type 2 diabetes and IHM in STEMI vs. NSTEMI [40]. We do not have an unequivocal explanation for this finding. Simply accounting for type 2 diabetes as a variable without establishing risk categories according to degree of metabolic control (hemoglobin A1c or the triglyceride-glucose index) can mask significant associations for subcategories of the variable [41]. In addition, residual confounding may underlie the association between type 2 diabetes and IHM only in the STEMI model, whilst potential confounders were fully accounted for in the NSTEMI model. Notwithstanding, biological or therapeutical differences could be playing a role in the influence exerted by type 2 diabetes among people with these two forms of myocardial infarction: for example, the percentage of people with NSTEMI and acute total coronary occlusion [42] or the higher percentage of patients with type 2 diabetes who underwent CABG in NSTEMI than in STEMI [43].

Our study is subject to a series of limitations. First, the data are supported by the information that physicians recorded in the discharge report, which also depends on manual coding by administrative staff. However, Spanish researchers have proven the validity of this dataset for research purposes among patients admitted with coronary syndrome [44]. The anonymity of the database precludes detecting whether the same patient was admitted to hospital more than once during each year. Second, the SNHDD is an administrative database that was not designed for clinical research, as it only records up to 20 diagnoses and 20 procedures coded using the ICD-10 system. Consequently, it lacks detailed information on specific treatment techniques such as stent types, radial or femoral access, reperfusion success, pharmacotherapy (including specific antiplatelet or anticoagulant therapies

and treatments for diabetes), and periprocedural complications. The absence of data on anticoagulant treatment in patients with atrial fibrillation undergoing PCI is significant and should be addressed in future studies with more detailed clinical information [45]. Third, the database does not collect data on the physician performing the PCI, making it impossible to evaluate the impact of operator experience. Forth, were also unable to analyze the number of patients who underwent rescue PCI following failed thrombolysis, as the ICD-10 coding system does not include a specific code for rescue PCI. Fifth, regrettably, the SNHDD does not provide information on the exact time of hospital admission or the timing of treatment interventions, which prevents the calculation of treatment delays. Sixth, in this study, the impact of the COVID-19 pandemic on the organization of procedures, treatment delays, and mortality was not assessed. Although COVID-19 may have influenced delayed patient presentation to the emergency department with acute coronary syndrome, this effect was likely confined to the initial months of the pandemic in early 2020. ST-elevation myocardial infarction (STEMI) in hospitalized patients with COVID-19 is rare but has been associated with poor in-hospital outcomes [46]. However, COVID-19 was not linked to increase in-hospital mortality (IHM) among patients with diabetes admitted for heart conditions, as demonstrated in previous reports from Spain [47]. Furthermore, Tokarek et al., utilizing a large database, supports our decision not to include COVID-19 as a covariate as they reported that a COVID-19 diagnosis did not affect mortality or the prevalence of other periprocedural complications, regardless of the timing of the intervention [48]. Finally, residual confounding cannot be discharged and some associations, particularly concerning type 1 diabetes, may not have reached statistical significance due to the relatively low number of events observed.

Despite these limitations, hospital discharge databases have been utilized in Spain and other countries to study time trends and the epidemiology of myocardial infarction and its treatment [5–7, 27, 49–55].

Conclusions

During 2016–2022, the frequency of PCI increased among people admitted for STEMI and for NSTEMI to Spanish hospitals, whereas that of CABG remained stable in STEMI and increased in NSTEMI. Patients with type 2 diabetes less often underwent PCI in both STEMI and NSTEMI. Undergoing CABG or PCI was associated with lower IHM in both STEMI and NSTEMI. IHM was 14% lower in 2022 than in 2016 only in STEMI, although we detected no changes in IHM in NSTEMI. Lastly, type 2 diabetes was associated with a higher IHM in people with STEMI, but not in NSTEMI. These data contribute valuable information about the procedures and short-term outcomes of myocardial infarction in recent years. We need additional studies to better understand the heterogeneity of coronary syndromes among people with diabetes and to improve the clinical management of affected patients.

Abbreviations

CABG	coronary artery by-pass grafting
CCI	Charlson Comorbidity Index
ECMO	extracorporeal membrane oxygenation
ICD-9	International Classification of Disease, Ninth Revision
ICD-10	International Classification of Disease-Tenth Revision
IHM	in-hospital mortality
LOHS	length of hospital stay
NSTEMI	non–ST-elevation myocardial infarction
PCI	percutaneous coronary intervention
SNHDD	Spanish National Hospital Discharge Database
STEMI	ST-elevation myocardial infarction

Supplementary Information

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Supplementary Material 1

Author contributions

JMdMY, RJG and ALdA contributed to the study design and interpretation of the results. VHB, JdMD, NCC and JJZL contributed to the collection, analysis, or interpretation of data. JMdMY, AJS, ALdA, and RJG prepared the manuscript. NCC VHB, JdMD, AJS and JJZL critically revised the manuscript. All authors gave final approval and agreed to be accountable for all aspects of the work, ensuring integrity and accuracy. All authors read and approved the final manuscript.

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Availability of data and materials

According to the contract signed with the Spanish Ministry of Health, which provided access to the databases from the SNHDD, we cannot share the databases with any other investigator, and we have to destroy the databases once the investigation has concluded. Consequently, we cannot upload the databases to any public repository. However, any investigator can apply for access to the databases by filling out the questionnaire available at http://www.msssi.gob.es/estadEstudios/estadisticas/estadisticas/estMinisterio/SolicitudCMBDdocs/Formulario_Peticion_Datos_CMBD.pdf. All other relevant data are included in the paper.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests
The authors declare no competing interests.

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