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ORIGINAL ARTICLE
Coronary artery disease

Time trends in incidence, treatment, and outcome in acute myocardial infarction in Norway 2013–19

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Aims Acute myocardial infarction (AMI) is a common cause of morbidity and mortality. The aim of the present study was to assess time trends in the incidence, treatment, and outcome of AMI in a nationwide registry–based cohort of patients.

Methods and results All patients with a first AMI registered in the Norwegian Myocardial Infarction Registry between 2013 and 2019 were included in this cohort study. The number of patients admitted to Norwegian hospitals with a first AMI decreased from 8933 in 2013 to 8383 in 2019. The proportion of patients with ST-elevation myocardial infarction (STEMI) was stable at 30% throughout the period, and the percentage of STEMI undergoing coronary angiography was stable at 87%. The proportion of patients with non-STEMI undergoing coronary angiography increased by 2.4% per year (95% confidence interval 1.6–3.3) from 58% in 2013 to 68% in 2019. More patients were discharged with secondary preventive medication at the end of study period. Age-adjusted 1-year mortality was reduced from 16.4% in 2013 to 15.1% in 2018. The changes over time were primarily seen in the oldest patient groups.

Conclusion In the period 2013–19 in Norway, we found a reduction in hospitalizations due to a first AMI. Both the percentage of patients undergoing coronary angiography as well as the percentage discharged with recommended secondary preventive therapy increased during the period, and the age-adjusted 1-year mortality after AMI decreased. A national AMI register provides important information about trends in incidence, treatment, and outcome, and may improve adherence to guideline recommendations.

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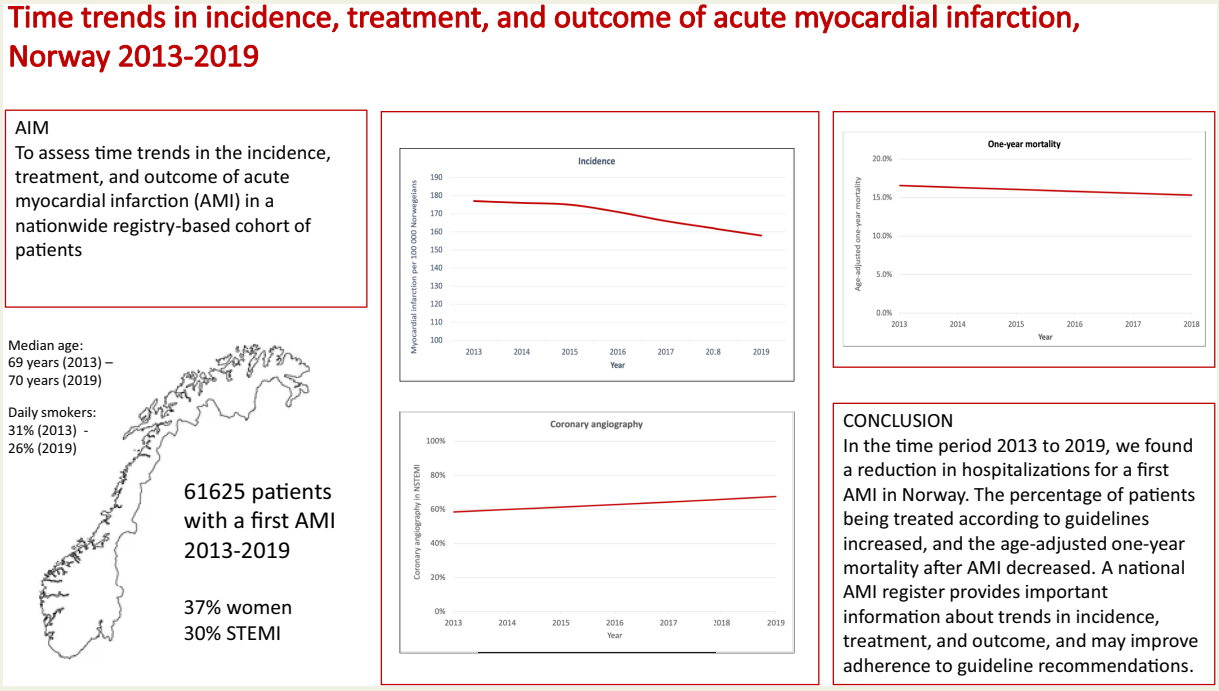
Graphical Abstract



Keywords Myocardial infarction • Time trends • Incidence • Outcome

Introduction

Cardiovascular disease is the most common cause of death in most European countries.[1] Acute myocardial infarction (AMI) is a common and serious presentation of cardiovascular disease and is associated with a high rate of mortality.[2,3]

The Norwegian Myocardial Infarction Registry (NORMI) was established as a national medical quality register in 2013 and is among the few national registries in Europe with ongoing data registration and high case coverage.[4,5] The register enables monitoring of incidence, treatment, and outcome after AMI. Through annual reports and scientific publications, the register has highlighted adherence to guideline recommendations for treatment of AMI.[6–11]

The European recommendations for the treatment of AMI have been updated several times during the study period, but the main recommendations for invasive assessment and secondary preventive treatment after AMI have remained unchanged.[12–15]

The aim of the present nationwide cohort study was to investigate time trends in hospital admissions, treatment, and outcome in patients with a first AMI in Norway in the period 2013–19.

Methods

The Norwegian Myocardial Infarction Registry

The NORMI, a part of the Norwegian Cardiovascular Disease Registry, is a national quality register. Registration into NORMI is mandatory without requiring patient's consent. For definition of AMI, the NORMI adhered to the Third and Fourth Universal Definition of Myocardial Infarction during the study period.[16,17] NORMI contains information on gender, age, cardiovascular risk factors, previous diseases and medication, symptoms and clinical findings, electrocardiogram (rhythm and ischaemic changes), in-hospital therapy and complications including death, as well as drugs prescribed at hospital discharge. The registration and quality of the information in the register have been described previously.[18,19] Causes of death were obtained from the Norwegian Cause of Death Register.

Study population

All patients admitted to hospitals in Norway with a first AMI between 1 January 2013 and 31 December 2019 and registered in the NORMI were included in this cohort study.

Outcomes and follow up

The outcomes of the study were the percentage of patients receiving coronary angiography during hospitalization, the prescription rate of secondary preventive therapy at hospital discharge, and 1-year mortality in patients with a first AMI. Follow-up data were available through NORMI until 31 December 2019.

Patient and public involvement

This study used existing data from Norwegian national health registries. Registration into these registries is mandatory (the Norwegian Cardiovascular Disease Registry Regulation and the Norwegian Health Register Act), and consent by the patient was not required.

Statistics

Continuous variables are presented as the mean ± standard deviation or median (25th percentile, 75th percentile). Categorical variables are presented as numbers and percentages. Age-adjusted mortality rates were calculated using direct standardization. Time trends were analysed (log-linear model) using the Joinpoint Regression Program (version 4.0; SEER software, National Cancer Institute, USA) and are presented as the expected annual per cent changes with a 95% confidence interval (CI). Other data were analysed using STATA version 17 (StataCorp LLC, College Station, TX, USA). A *P*-value of <0.05 was regarded as statistically significant.

Ethics

The Regional Committee for Medical and Health Research Ethics North approved the study (REK 2016/170).

Results

Hospital admissions

A total of 61 625 patients with a first AMI were registered in the NORMI in the period 2013–19. A total of 18 499 (30%) patients were classified as ST-elevation myocardial infarction (STEMI), and 40 709 (66%) patients as non-STEMI. The rest was unclassifiable. The number of registered patients per year with a first AMI was reduced from 8933 in 2013 to 8383 in 2019. The decline was minimal in the period 2013–15, but from 2016, we found a significant reduction of 4.4% (95% CI 4.1, 4.6) per year.

The number of admissions per year by gender and age group are presented in *Figure 1*. For both genders <90 years of age, there were statistically significant reduction during the period.

Clinical characteristics and risk factors

Clinical characteristics are presented in *Table 1*. A total of 22 581 patients (37%) with a first AMI were women. The proportion of women decreased from 37% in 2013 to 35% in 2019 (change per year: −0.9%, 95% CI −1.7, −0.2). The median age for men increased from 65 years (interquartile range 56–76 years) in 2013 to 67 years (interquartile range 57–76 years) in 2019. The median age in women was 76 years (interquartile range 66–85 years) throughout the study period. The proportion of smokers was reduced by 2.7% (95% CI 2.2, 3.2) per year, while the proportions of patients with diabetes and lipid-lowering therapy increased by 2.4% (95% CI 1.0, 3.8) and 2.0% (95% CI 0.4, 3.6) per year, respectively.

Coronary angiography and secondary preventive therapy

Invasive coronary angiography and percutaneous coronary intervention (PCI) were performed in 16 160 (87%) and 15 006 (81%) patients admitted with a first STEMI, and were performed in 25 561 (63%) and 17 101 (42%) patients admitted with a first non-STEMI, respectively. The proportion of patients with STEMI who underwent coronary angiography was stable during the period (change per year: 0.5%, 95% CI −0.4, 1.4), while the proportion of non-STEMI

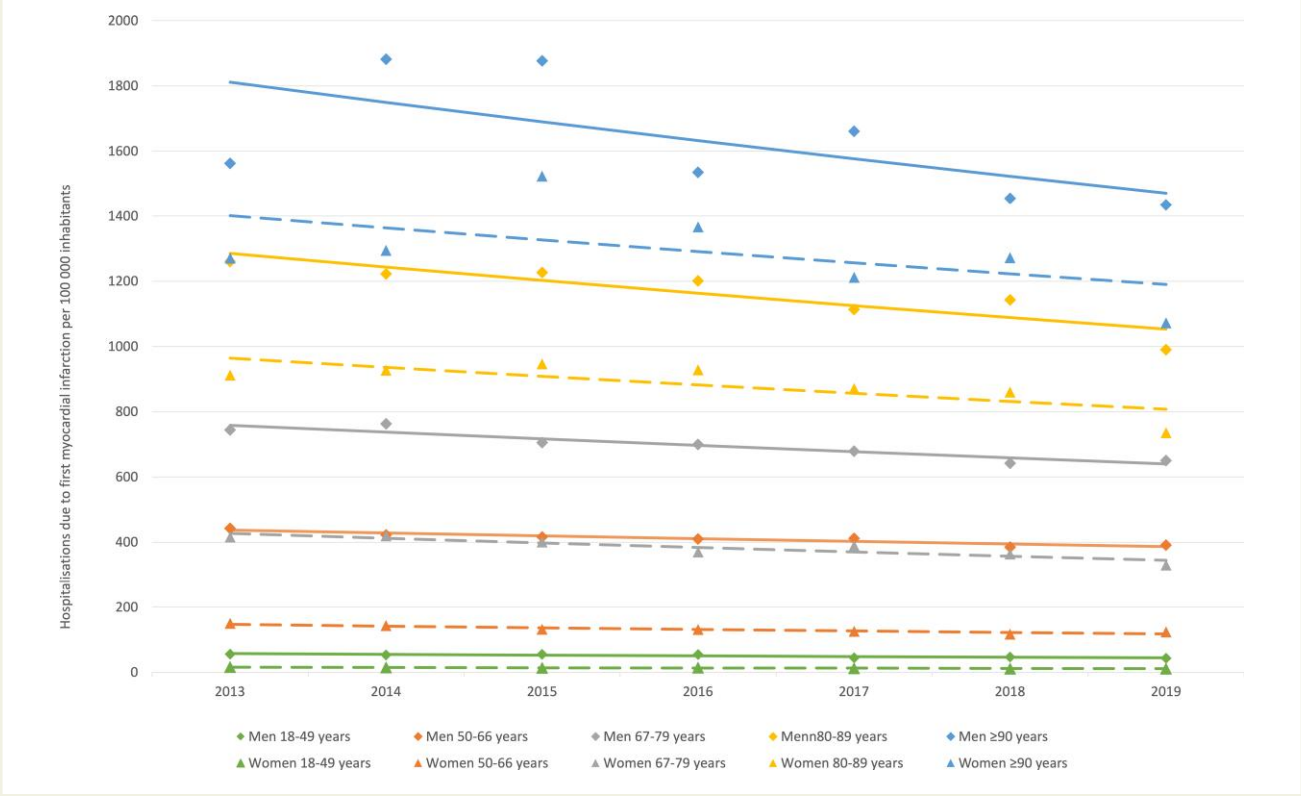


Figure 1 Patients admitted to hospitals with first acute myocardial infarction in Norway 2013–19 and registered in the Norwegian myocardial infarction register.

Table 1 Clinical characteristics in patients admitted to hospitals with first acute myocardial infarction in Norway 2013–19

	2013		2014		2015		2016		2017		2018		2019	
	n = 8933		*n* = 9012		*n* = 9020		*n* = 8926		*n* = 8773		*n* = 8578		*n* = 8383	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Men	5609	63	5656	63	5640	63	5652	63	5562	63	5454	64	5471	65
Median age (year, interquartile range)	69	(59–81)	69	(59–81)	70	(59–81)	70	(59–81)	70	(60–80)	70	(60–80)	70	(59–79)
Smoking	2777	31	2677	30	2642	29	2501	28	2393	27	2315	27	2204	26
Antihypertensive therapy	3984	45	3881	43	4005	44	3882	43	3863	44	3880	45	3779	45
Diabetes	1434	16	1403	16	1485	16	1491	17	1579	18	1535	18	1482	18
Lipid-lowering therapy	2287	26	2164	24	2203	24	2265	25	2343	27	2318	27	2319	28
Previous percutaneous coronary intervention	466	5	463	5	444	5	465	5	510	6	488	6	450	5
Previous coronary artery bypass grafting	397	4	391	4	370	4	394	4	393	4	349	4	308	4
Previous stroke (all types)	713	8	643	7	670	7	603	7	640	7	600	7	518	6

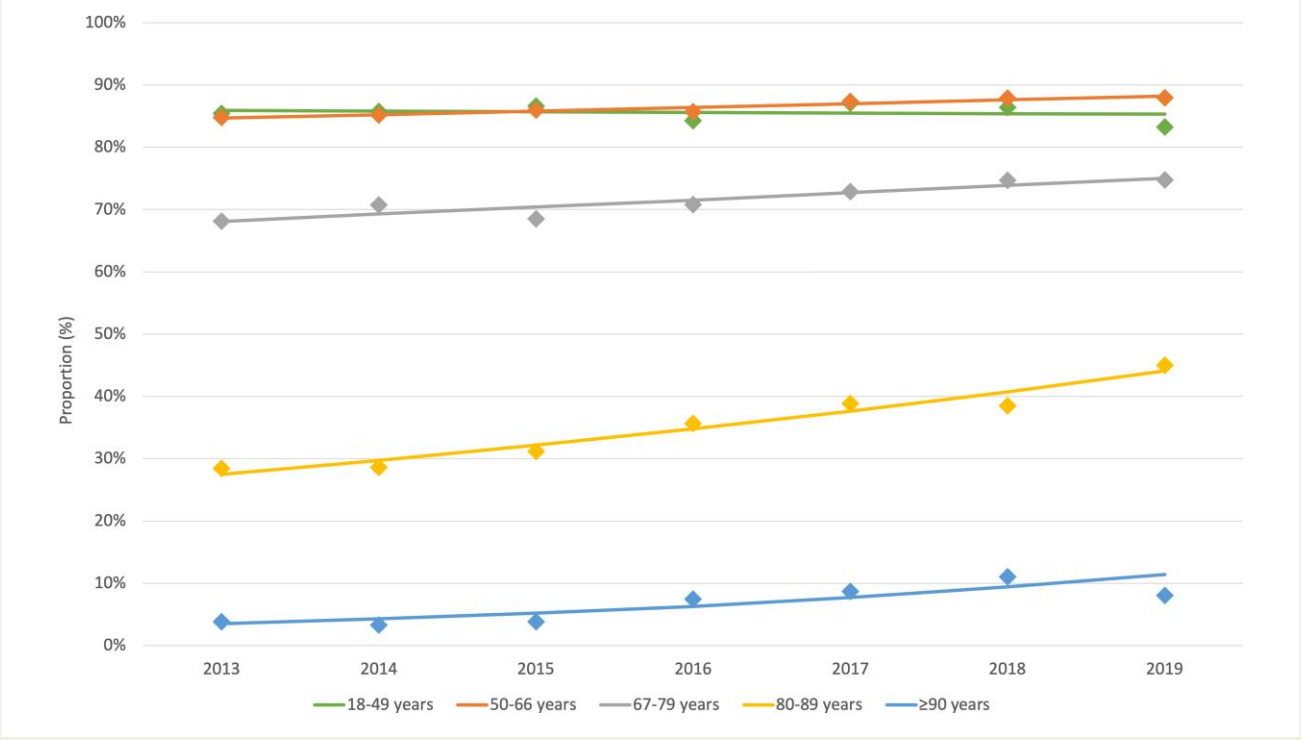


Figure 2 Proportion of patients admitted with acute non-ST-elevation myocardial infarction (first myocardial infarction) examined with coronary angiography in Norway 2013–19.

patients who underwent coronary angiography increased by 2.4% per year (95% CI 1.6, 3.3), from 58% in 2013 to 68% in 2019.

The proportion of women with non-STEMI who underwent coronary angiography increased by 3.2% per year (95% CI 1.6, 4.7) from 47% in 2013 to 56% in 2019, while the proportion of men with non-STEMI who underwent coronary angiography increased by 1.9% per year (95% CI 1.4, 2.4) from 68% in 2013 to 76% in 2019.

The proportion of patients with non-STEMI undergoing coronary angiography in relation to age is presented in *Figure 2* and *Table 2*.

The prescription of dual antiplatelet therapy (acetylsalicylic acid and P_2Y_{12} inhibitor) and statins in patients discharged alive increased from 76 to 77% for dual antiplatelet therapy (change per year: 0.4%, 95% CI 0.0, 0.7), and from 82 to 85% (change per year: 0.7%, 95% CI 0.4, 1.1) for statins during the study period.

Table 2 Coronary angiography and percutaneous coronary intervention in patients with acute non-ST-elevation myocardial infarction (first myocardial infarction) in Norway 2013–19

	2013					2014					2015					2016				
Age (years)	Patients	Coronary angiography		PCI		Patients	Coronary angiography		PCI		Patients	Coronary angiography		PCI		Patients	Coronary angiography		PCI	
	n	*n*	%	*n*	%	*n*	*n*	%	*n*	%	*n*	*n*	%	*n*	%	*n*	*n*	%	*n*	%
18–49	425	363	85	243	57	414	355	86	244	59	395	342	87	241	61	451	380	84	254	56
50–66	1771	1502	85	1021	58	1771	1508	85	1056	60	1687	1450	86	1025	61	1712	1467	86	1065	62
67–79	1750	1192	68	731	42	1898	1343	71	821	43	1843	1262	68	792	43	1940	1373	71	864	45
80–89	1472	419	28	268	18	1447	414	29	259	18	1428	445	31	289	20	1393	497	36	305	22
≥90	445	17	4	13	3	517	17	3	8	2	579	22	4	17	3	497	37	7	26	5

	2017					2018					2019				
Age (years)	Patients	Coronary angiography		PCI		Patients	Coronary angiography		PCI		Patients	Coronary angiography		PCI	
	n	*n*	%	*n*	%	*n*	*n*	%	*n*	%	*n*	*n*	%	*n*	%
18–49	348	303	87	196	56	368	318	86	214	58	352	293	83	200	57
50–66	1677	1465	87	1058	63	1586	1394	88	1026	65	1644	1446	88	979	60
67–79	2002	1459	73	926	46	1887	1410	75	918	49	1902	1422	75	932	49
80–89	1336	519	39	339	25	1281	493	38	335	26	1126	507	45	343	30
≥90	484	42	9	35	7	480	53	11	34	7	398	32	8	24	6

Table 3 Mortality after hospital admission for first acute myocardial infarction in Norway 2013–19

Age (years)	2013							2014							2015						
	Patients	30-day mortality		1-year mortality		1-year mortality — ischaemic heart disease		Patients	30-day mortality		1-year mortality		1-year mortality — ischaemic heart disease		Patients	30-day mortality		1-year mortality		1-year mortality — ischaemic heart disease	
	n	*n*	%	*n*	%	*n*	%	*n*	*n*	%	*n*	%	*n*	%	*n*	*n*	%	*n*	%	*n*	%
18–49	809	14	2	22	3	15	2	779	15	2	18	2	13	2	793	19	2	22	3	18	2
50–66	3098	89	3	146	5	75	2	2969	83	3	141	5	79	3	2905	85	3	137	5	80	3
67–79	2582	193	7	361	14	161	6	2789	195	7	373	13	160	6	2747	204	7	389	14	165	6
80–89	1890	328	17	638	34	296	16	1860	317	17	591	32	260	14	1871	319	17	602	32	267	14
≥90	553	151	27	275	50	128	23	615	167	27	343	56	162	26	704	206	29	371	53	177	25

Age (years)	2016							2017							2018						
	Patients	30-day mortality		1-year mortality		1-year mortality — ischaemic heart disease		Patients	30-day mortality		1-year mortality		1-year mortality — ischaemic heart disease		Patients	30-day mortality		1-year mortality		1-year mortality — ischaemic heart disease	
	n	*n*	%	*n*	%	*n*	%	*n*	*n*	%	*n*	%	*n*	%	*n*	*n*	%	*n*	%	*n*	%
18–49	798	12	2	24	3	11	1	660	10	2	13	2	6	1	677	9	1	17	3	13	2
50–66	2903	87	3	140	5	82	3	2921	83	3	134	5	70	2	2762	87	3	128	5	79	3
67–79	2775	180	6	357	13	150	5	2886	205	7	379	13	161	6	2811	161	6	340	12	133	5
80–89	1826	322	18	591	32	248	14	1708	297	17	528	31	207	12	1736	276	16	529	30	199	11
≥90	621	188	30	331	53	159	26	597	172	29	296	50	144	24	592	160	27	296	50	122	21

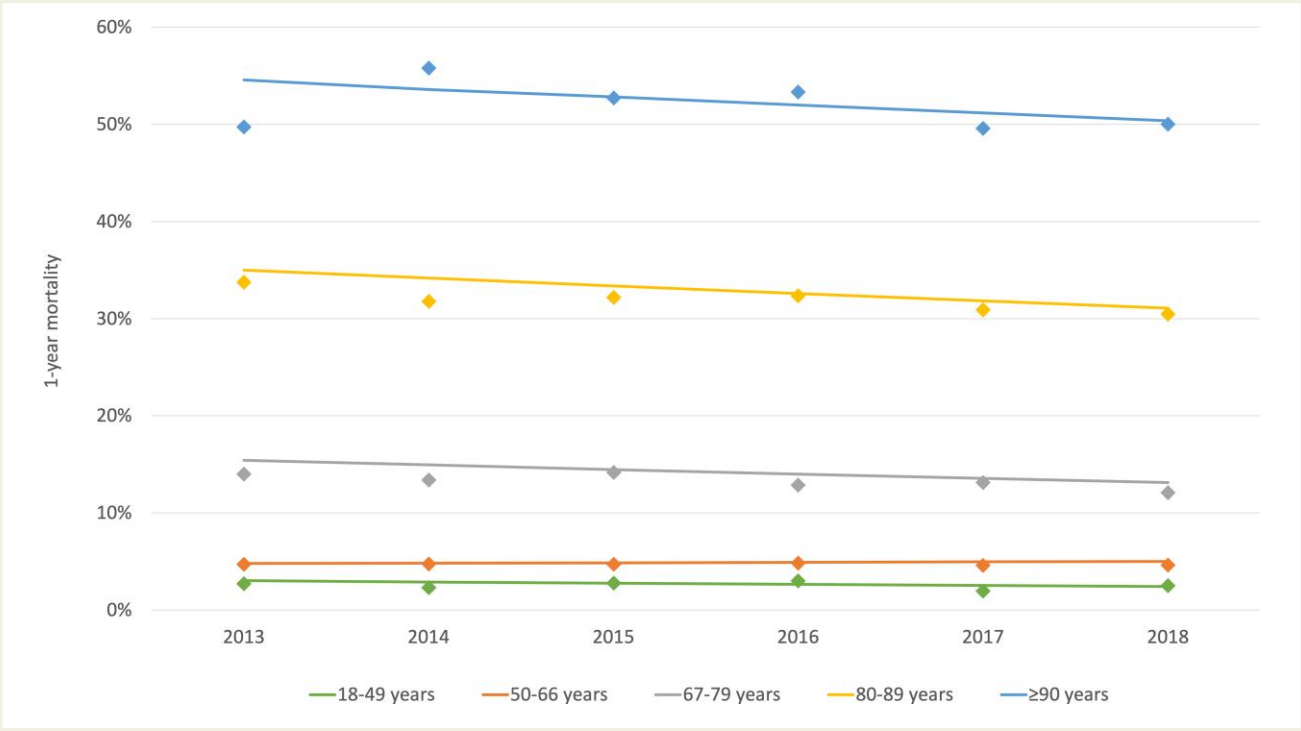


Figure 3 One-year mortality after admission for first acute myocardial infarction in Norway 2013–19.

Outcome

All-cause mortality after a first AMI in different age groups is presented in *Table 3* and *Figure 3*. We found no changes in age-adjusted 30-day mortality during the period, but age-adjusted 1-year mortality was reduced by 1.6% (95% CI 0.4, 2.7) per year from 16.4% in 2013 to 15.1% in 2018. The reduction in mortality was found in patients with non-STEMI: age-adjusted 1-year mortality after non-STEMI was reduced from 17.8% in 2013 to 15.2% in 2018, while it was unchanged at 14% after STEMI. Information regarding 1-year mortality after STEMI and non-STEMI in different age groups is presented in Supplementary material online, *Table S1*. With respect to gender differences, the reduction was seen only in men; age-adjusted 1-year mortality for men was reduced by 2.6% (95% CI 0.4, 4.8) per year, but we found no corresponding change for women.

Ischaemic heart disease (ICD-10 code I20-I25) was reported as the cause of death in 47% of patients who died within 1 year in 2013. The proportion was reduced to 43% in 2018.

Discussion

This nationwide study of patients with a first AMI admitted to hospitals in Norway from 2013 to 2019 revealed a reduction in hospitalizations due to a first AMI and a gradual increase in the proportion of patients who were examined with coronary angiography and prescribed guideline-recommended secondary preventive therapy. The age-adjusted 1-year mortality decreased during the period. The changes over time were primarily seen in the oldest groups.

A reduced number of hospital admissions and a reduced incidence of AMI in Norway in the period 1991–2014 has been described previously.[20] Our study from a national medical quality register shows a further reduction in the number of admissions for incident AMIs until 2019. The relatively high proportion of STEMI vs. non-STEMI patients can be explained by inclusion of patients with first-time AMI only.

In another Norwegian study, the Tromsø study, the declining incidence of acute coronary syndrome was largely attributed to changes in coronary risk factors such as lower cholesterol and blood pressure levels, fewer smokers and more physical activity in the population.[21] The present study includes only patients admitted to hospitals with an AMI and cannot be used to assess changes in risk factors in the general population. However, in our study, the proportion of patients with a first AMI who smoked was higher than in the general population [2013: 15%; 2019: 9% (age 16–74 years)], suggesting that smoking is still an important modifiable risk factor for AMI, especially in younger patients.[11,22]

The guidelines from the European Society of Cardiology recommended early coronary angiography in most patients with non-STEMI.[12–15] Although the proportion of patients with non-STEMI who underwent coronary angiography increased from 58 to 68% during the period, the proportion is still lower in Norway than in other countries in Europe with national AMI registries.[4] Although the proportion undergoing coronary angiography increased most in the older age groups, it was still significantly lower in these groups compared with younger age groups. Increasing comorbidity with increasing age may have had an impact on the choice of treatment strategy. The gender difference in the proportion of women and men who were

examined with coronary angiography is also noteworthy and persisted during the study period.[6] Possible differences in symptoms and clinical findings in suspected AMI in younger and older patients and in women and men cannot explain the differences, since only patients with the diagnosis of AMI were registered in the NORMI and consequently were included in this study. We have not investigated geographical differences in treatment strategy, but distance to hospitals offering coronary angiography has probably also been of importance.

Secondary preventive drugs such as antiplatelet therapy and statins are important in preventing new cardiovascular events and are recommended as secondary prevention after AMI.[12–15] The proportions of patients prescribed these drugs after AMI in Norway were comparable with other countries in Europe.[4,5] However, several studies have demonstrated a remaining gap between the guidelines and the achievement of recommended targets for cardiovascular risk factors and medication use after myocardial infarction.[8,23–29] Early combination of statin, ezetimibe, and in some cases also inhibitors of proprotein convertase subtilisin/kexin type 9 is recommended in patients with high risk of new events.[30]

Mortality after AMI has shown a declining trend in Norway for many years.[31] The present study shows a further reduction in all-cause mortality after AMI for the period 2013–19. The NORMI does not have follow-up data for secondary preventive therapy, but more favourable risk profiles, improved acute treatment with an increasing proportion of patients examined with coronary angiography and treated with PCI, and increased prescription of secondary preventive drugs may have contributed to the improved survival. Changes in the general mortality in the population as well as changes in the use of medical diagnostic codes and procedure codes may also have affected the results, which must therefore be interpreted with caution.

The main strengths of this study are the large and unselected population comprising nearly all patients hospitalized with a first AMI in Norway from 2013 to 2019, and a nearly complete follow up. However, there are some important limitations associated with the study design and the NORMI. This study was an observational study, making it impossible to demonstrate causal associations between treatment and outcomes. Only AMIs that led to hospitalization were registered in the NORMI. A few hospitals did not deliver complete data for the whole period, but the coverage compared with the Norwegian Patient Register was >90%.[18] We only obtained deidentified data from the NORMI and the Norwegian Cardiovascular Disease Registry and could not verify the information through medical records at the individual patient level. Nevertheless, the degree of completeness and correctness of most variables in the NORMI have been shown to be high.[32] The findings of the study must be interpreted with caution and generalization of the results should be avoided.

Conclusion

In conclusion, in the time period 2013–19 in Norway, we found a reduction in the number of patients admitted with a first AMI. Furthermore, more patients with a first AMI underwent coronary angiography, more patients were prescribed secondary preventive therapy at discharge, and the age-adjusted 1-year mortality after AMI was reduced in this period. The national myocardial infarction registry provides important information about AMI and may have contributed to better adherence to guideline recommendations.

Lead author biography

Jarle Jortveit is a senior researcher and cardiologist at Sørlandet Hospital Arendal, Norway. He is also co-founder and chief medical officer in ECG247 Smart Heart Sensor.

Authors' contributions

J.J. and S.H. were responsible for the conception of the study, and the analysis and interpretation of data. J.J. drafted the manuscript. A.H.P. contributed to the analysis and interpretation of the data and critically revised the manuscript. J.L. and S.H. critically revised the manuscript. All gave final approval and agreed to be accountable for all aspects of work ensuring its integrity and accuracy.

Data availability

The data underlying this article were provided by the Norwegian Institute of Public Health under license/by permission. Data will be shared on request to the corresponding author with permission of the Norwegian Institute of Public Health.

Supplementary material

Supplementary material is available at *European Heart Journal Open* online.

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Conflict of interest: J.J. has received speaking fees from Amgen, AstraZeneca, BMS, Boehringer Ingelheim, Novartis, Pfizer, and Sanofi. He is a chief medical officer in ECG247 Smart Heart Sensor. S.H. has received speaking fees from Boehringer Ingelheim, BMS, Pfizer, and Sanofi. All other authors no conflict of interest.

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