Association of admitting physician specialty and care quality and outcomes in non-ST-segment elevation myocardial infarction (NSTEMI): insights from a national registry

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Competing interests

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Data Availability

The authors do not have authorization to share the data, but it can be accessed through contacting the National Institute for Cardiovascular Outcomes Research (NICOR) upon approval.

Ethics:

Secondary use of anonymised MINAP dataset for research purposes is authorised under NHS research governance arrangements and further supported under section 251 of NHS act 2006 (NIGB: ECC1-06(d)/ 2011), which allows researchers to use patient information collected within the dataset for medical research without patient consent. Therefore, a formal ethical approval was not sought for this study.

Abstract

Background: Little is known about the association between admitting physician specialty and care quality and outcomes for non-ST-segment elevation myocardial infarction (NSTEMI).

Methods & Results: We identified 288,420 patients hospitalised with NSTEMI between 2010-2017 in the United Kingdom (UK) Myocardial Infarction National Audit Project (MINAP) database. The cohort was dichotomised according to care under a non-cardiologist (n = 146,722) and care under a cardiologist (n = 141,698) within the first 24 hours of admission to hospital. Patients admitted under a cardiologist were significantly younger (70-years vs 75 years, P<0.001), and less likely to be female (32% vs 39%, P<0.001). Independent factors associated with admission under a cardiologist included: prior history of percutaneous coronary intervention (PCI) (OR:1.04, 95% CI:1.01-1.07, P=0.04), hypercholesterolaemia (OR: 1.17, 95% CI: 1.15-1.20, P<0.001), hypertension (OR: 1.03, 95% CI: 1.01-1.04, P=0.01) and admission to an interventional centre (OR: 3.90, 95% CI: 3.79 – 4.00, P<0.001). Patients admitted under cardiology were more likely to receive optimal pharmacotherapy, undergo invasive coronary angiography (79% vs 60%, P<0.001), and receive revascularization in the form of percutaneous coronary intervention (PCI) (52% vs 36%, P<0.001). Following propensity score matching, odds of in-hospital all-cause mortality (OR:0.81, 95% CI: 0.79-0.85, P<0.001), reinfarction (OR:0.78, 95% CI: 0.66-0.91, P=0.001) and major adverse cardiovascular events (MACE) (OR: 0.81, 95% CI: 0.78-0.84, P <0.001) were lower in patients admitted under a cardiologist.

Conclusion: Patients with NSTEMI admitted under a cardiologist within 24 hours of hospital admission were more likely to receive guideline directed management and had better clinical outcomes.

Key words: NSTEMI, Cardiologist, Mortality

Introduction

There has been a significant growth in the United Kingdom (UK) cardiology work force over the past 20 years – from 12 cardiologists per million population in 2000 (second lowest in Europe)[1] to 26 per million (1,708 cardiologists in total) in 2019[2]. Despite this, there has been an even larger expansion in both the services and demands of the profession. Recognition, for instance, that specialist input leads to better outcomes for patients with heart failure (HF) or stroke have led to triaging of these patients under a dedicated service[3, 4].

Previous studies in the UK and the United States (US) have examined the effect of the specialty of the admitting physician on the management and outcomes of patients with acute myocardial infarction (AMI) – combining ST segment elevation myocardial infarction (STEMI) and non-ST-segment myocardial infarction (NSTEMI) admissions[1, 5]. Patients were more likely to be treated by a cardiologist if they had ST elevation, fewer comorbidities and were younger[6]. Furthermore, patients admitted under the care of cardiology were more likely to receive invasive procedures and had lower mortality[1, 5].

In the UK, patients who present with STEMI within 12 hours of onset of symptoms are immediately triaged for emergency invasive coronary angiography and ad hoc primary percutaneous coronary intervention (PCI) and thus almost universally admitted under the care of a cardiologist. For NSTEMI, however, there is more variability in the admission pathway. Patients often attend the emergency department (ED) and subsequently are referred to the on-call medical team or directly to the cardiology team[7]. Whilst the vast majority of these patients are eventually reviewed by a cardiologist during their index admission, there is significant variability as to which team and consultant is first and mainly responsible.

In this large national European study, we describe the clinical characteristics, management strategies and clinical outcomes of patients presenting with NSTEMI, according to the specialty of the admitting physician, looking in particular at descriptors of quality of care

using the European Society of Cardiology (ESC) Association for Acute Cardiovascular Care (ACVC) Quality Indicators (QI).

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Methods

Study design:

We used the Myocardial Ischaemia National Audit Project (MINAP), a prospective national registry of patients admitted to hospitals in the UK with an acute coronary syndrome. The MINAP dataset consists of 130 variables including baseline demographics and clinical characteristics, comorbid conditions, management strategies, pharmacotherapy, place of care, in-hospital clinical outcomes and diagnoses on discharge[8, 9]. Data are submitted by hospital clinical and clerical staff and approximately 90,000 pseudonymised records annually are uploaded to the National Institute for Cardiovascular Outcomes Research (NICOR).

Study population:

We included patients admitted with a diagnosis of NSTEMI in any of the 230 participating hospitals in England and Wales between 1st January 2010 to 31st March 2017. The discharge diagnosis of NSTEMI was determined by local clinicians according to presenting history, clinical examination, and the results of inpatient investigations in keeping with the consensus document of the Joint European Society of Cardiology and American College of Cardiology[10]. Patients were excluded if specialty of admitting physician, or vital status were missing. Furthermore, any individual patient's subsequent admissions were excluded from analysis (Figure 1). This constituted a final cohort of 288,420 patients with NSTEMI, who were then split into two groups depending on the specialty of the admitting physician; Group 1: not admitted under a cardiologist (admitted under general physicians or

other speciality physicians), group 2: admitted under a cardiologist. The admitting consultant was the clinician who had primary cared of the patient immediately (first 24 hours) after admission to hospital, and not the emergency department consultant. Individual patient's baseline risk was assessed using the Global Registry of Acute Coronary Events (GRACE) scoring systems. MINAP does not record GRACE explicitly, so a validated method was used to calculate patients' GRACE score[11].

Quality indicators:

The Association for Acute Cardiovascular Care (ACVC) of the European Society of Cardiology (ESC) quality indicators cover seven domains, including the evaluation of: (1) centre organisation, (2) reperfusion / invasive strategy, (3) in-hospital risk assessment, (4) antithrombotic treatment during hospitalisation, (5) secondary prevention discharge treatments, (6) patient satisfaction, and (7) composite QIs, and GRACE risk score-adjusted 30-day mortality[12, 13].

With respect to the ESC ACVC QIs we assessed: the use of invasive coronary angiography (ICA) within 72 hours of admission; the assessment of left ventricular (LV) function; the use of fondaparinux or low molecular weight heparin (LMWH); and the prescription of $P2Y_{12}$ inhibition, dual antiplatelet therapy (DAPT) and statins on discharge. For patients with moderate and severe LV systolic dysfunction (LVSD), the use of angiotensin converting enzyme inhibitor (ACEi) or angiotensin receptor blocker (ARB) and beta blocker on discharge was also evaluated. MINAP does not record the specific type or dose of statin prescribed so 'statin prescription' was used as a surrogate for high-intensity statin.

Outcomes

Primary

Primary outcomes of interest included in-hospital all-cause mortality and major adverse cardiovascular events (MACE) (composite endpoint of in-patient all-cause mortality and reinfarction).

Secondary

Secondary outcomes of interest included cardiac mortality (death attributable to myocardial ischaemia or infarction, HF and cardiac arrest of unknown cause), non-cardiac mortality (any death not attributed to a cardiac cause), major bleeding (a composite of gastrointestinal, retroperitoneal and intracranial haemorrhage) and reinfarction.

Statistical Analysis:

Demographics, clinical characteristics and crude adverse outcomes of patients not admitted under a cardiologist vs those admitted under a cardiologist were compared using the Pearson chi-squared test for categorical variables. Continuous variables were compared using Student's t-test if normally distributed and using Wilcoxon Rank Sum test if not. Normality of distribution was assessed using Shapiro-Wilks test. Continuous variables are presented as medians and interquartile ranges (IQR) and categorical variables by proportions. Multiple imputations with chained equations (MICE) were used to impute values for variables with missing data. MICE is considered to be best practice when dealing with missing data, and can provide unbiased estimates even when levels of missing data are significant, and also some protection when the pattern of 'missingness' is not random[14]. For each binary outcome of interest, multivariable logistic regression analysis was applied on imputed datasets to estimate the risk of adverse outcomes between groups. Estimates were combined using Rubin's rules[15]. Logistics regression models were fitted using maximum likelihood estimation and were adjusted for age, sex, ethnicity, heart rate, blood pressure, serum creatinine concentration on

admission, family history of coronary artery disease (CAD), previous coronary artery bypass graft (CABG) surgery, ischaemic ECG changes, history of HF, LVSD, prior PCI, co-morbid conditions (history of diabetes mellitus, hypercholesterolaemia, angina, previous myocardial infarction, cerebrovascular accident, peripheral vascular disease, hypertension, smoking, asthma/COPD), pharmacotherapy (prescription of low molecular weight heparin, warfarin, un-fractionated heparin, GP IIb/IIIa inhibitor, intravenous nitrate, furosemide, aldosterone antagonist, fondaparinux, beta blockers, ACEi/ARB's, aspirin, $P2Y_{12}$ inhibitor, statins), cardiac arrest and procedures and investigations including coronary angiogram, PCI and CABG surgery during admission.

Sensitivity Analysis:

Propensity score matching (PSM) with the imputed data was used as a sensitivity analysis to estimate the average treatment effects (ATE). The two groups were matched on the same variables used in the multivariable statistical analyses. One to one nearest-neighbour matching with replacement was applied, followed by logistic regression analysis (the sole predictor being group membership) to obtain the ATE over the multiple imputed datasets. Finally, the coefficients were converted to odds ratios to allow for comparisons with the main analysis.

Subgroup Analysis:

In sub-group analysis, we subdivided the patients who were not admitted under a cardiologist into two further groups - those who were reviewed by a cardiologist later during their index admission and those who were not. We examined the levels of attainment of the ESC ACVC QIs between these two groups. Multivariable logistic regression was used on imputed datasets, controlled for the same covariates as in the main analysis, to compare the primary and secondary outcomes previously described between the following three groups:

1). Patients admitted under a cardiologist vs those not admitted under a cardiologist but later reviewed by a cardiologist.

2). Patients admitted under a cardiologist vs those not admitted under a cardiologist nor later reviewed by a cardiologist.

3). Patients not admitted under a cardiologist but later reviewed by one vs those not admitted by a cardiologist nor reviewed by one.

Prediction Model:

Multivariable logistic regression models were applied on the imputed data set to identify independent predictors of admission under a cardiologist. Variables that were examined included age, sex, ethnicity, family history of CAD, previous CABG surgery, history of HF, LVSD, prior PCI, co-morbid conditions (history of diabetes mellitus, hypercholesterolaemia, angina, previous myocardial infarction, cerebrovascular accident, peripheral vascular disease, hypertension, smoking, asthma/COPD), cardiac arrest, admission ward and hospital of admission (interventional vs non-interventional centre).

Temporal and Geographical Changes:

We evaluated all participating hospitals in our study to look at how the proportion of patients admitted under a cardiologist varied according to the hospital they were treated at. Risk standardised mortality rates adjusted for patients demographics (age, sex, ethnicity, serum creatinine concentration on admission, family history of CAD, previous CABG, ischaemic ECG changes, history of HF, LVSD, prior PCI, co-morbid conditions (history of diabetes mellitus, hypercholesterolaemia, angina, previous myocardial infarction, cerebrovascular accident, peripheral vascular disease, hypertension, smoking and asthma/COPD) were calculated for each centre in our study. Subsequently, we undertook logistic regression to see

if there was a correlation with the adjusted mortality rates and proportion of patients admitted under a cardiologist. Furthermore, temporal changes in the proportions of patients with NSTEMI admitted according to the specialty of the admitting physician were also evaluated as were the temporal changes in the clinical characteristics of patients admitted under a cardiologist.

All statistical analyses were performed with Stata 14.2 (College Station, Texas, USA) on the Athena university server with data anonymized. All statistical analyses were two-tailed, and an alpha of 5% was used throughout, without multiplicity adjustment.

Results

Baseline Characteristics:

Between January 2010 to March 2017, there were 369,435 patients admitted to hospital in England and Wales with a diagnosis of NSTEMI. Applying relevant exclusion criteria (Figure 1) produced a study cohort of 288,420 patients (22% excluded). Of these, 141,698 patients were admitted under a cardiologist (49%) within the first 24 hours.

Differences in clinical characteristics at admission between the two groups are presented in Table 1. Patients admitted under a cardiologist were significantly younger at presentation (median age 70y vs 75y, P<0.001) were more likely to have undergone previous PCI (15% vs 12%, P<0.001) and have a history of hypercholesterolaemia (40% vs 31%, P<0.001) or hypertension (56% vs 54%, P<0.001). Those not admitted under a cardiologist had higher rates of chronic renal failure (10% vs 7%, P<0.001), cerebrovascular disease (12% vs 9%, P<0.001), HF (9% vs 6%) and were more likely to present with cardiac arrest (3.4% vs 2.8%, P<0.001).

The proportion of patients with high GRACE risk (>140) scores were higher in the cohort that were not admitted under a cardiologist (81% vs 75%, P<0.001).

Pharmacotherapy, management strategies & unadjusted crude clinical outcomes for both cohorts are presented in Table 2. Patients admitted under a cardiologist were significantly more likely to receive statins (86% vs 79%, P<0.001), ACEi/ARB (84% vs 77%, P<0.001), and beta-blockers (85% vs 78%, P<0.001). The proportion of patients who underwent an ICA (79% vs 60%, P<0.001), PCI (52% vs 36%, P<0.001) or CABG surgery (8% vs 7%, P<0.001) was higher in the group admitted under a cardiologist.

Temporal and Geographical Changes

The proportion of patients with NSTEMI admitted under a cardiologist increased from 41% in 2010 to 56% in 2017, P<0.001 (Figure 2). Supplementary Figure 1 demonstrates the significant variability in the proportion of patients admitted under a cardiologist within 24 hours of admission depending on which hospital they were treated at varying from 0 to 100 %. Supplementary Figure 2 demonstrates a statistically significant inverse correlation between the mortality rate (adjusted for demographics) and admission under a cardiologist (coefficient -0.024, CI: -0.034 to –0.013, P<0.001), with an R^2 of 0.08. Supplementary Table 1 shows how the clinical characteristics of patients admitted under a cardiologist has changed over time. There was an increase in patients who had cardiovascular risk factors such as diabetes (increase from 24% to 27%) and prior PCI (increase from 13% to 18%) from 2010 & 2011 to 2016 & 2017. There was large variability in the GRACE score as well. In 2010 and 2011, 75% of patients with NSTMEI who were admitted under a cardiologist had a high GRACE risk score, a percentage that increased to 83% in 2016 and 2017. There was no significant temporal change in the proportion of women admitted under a cardiologist.

Clinical outcomes

Clinical outcomes were significantly lower in patients admitted under a cardiologist for in-hospital all-cause mortality (2.9% vs 7.1%, P<0.001), cardiac mortality (2.4% vs 5.5%, P<0.001), reinfarction (0.7% vs 1%, P<0.001), major bleeding (1.4% vs 1.6%, P<0.001) and MACE (3.4% vs 7.8%, P<0.001). After adjustment for differences in baseline clinical and treatment characteristics on multivariate analysis, odds of all-cause mortality (OR: 0.76, 95% CI: 0.72-0.80, P<0.001), cardiac mortality (OR:0.87, 95% CI: 0.83-0.93, P<0.001), non-cardiac mortality (OR: 0.66, 95% CI: 0.60-0.72, P<0.001), reinfarction (OR: 0.78, 95% CI: 0.71-0.85, P<0.001), major bleeding (OR: 0.91, 95% CI: 0.85-0.97, P = 0.007) and MACE (OR: 0.75, 95% CI: 0.71-0.79, P<0.001) were all significantly lower in patients admitted under a cardiologist (Table 3).

Analysis with Propensity Score-Matching

In a PSM analysis, the adjusted risk during the index admission was significantly lower in patients admitted under a cardiologist for all-cause mortality (OR: 0.81, 95% CI: 0.79-0.85, P<0.001), cardiac mortality (OR: 0.86, 95% CI: 0.82-0.89, P<0.001), non-cardiac mortality (OR:0.70, 95% CI: 0.63-0.76, P<0.001), reinfarction (OR: 0.78, 95% CI: 0.66-0.91, P=0.001), major bleeding (OR: 0.90, 95% CI: 0.82-0.98, P=0.012) and MACE (OR: 0.81, 95% CI: 0.78-0.84, P<0.001) (Table 4). Supplement Figure 3 shows the level of matching between the two cohorts in this analysis.

Quality of care

With respect to the attainment for the ESC ACVC QIs, those admitted under a cardiologist were more likely to undergo ICA within 72 hours of admission (72% vs 52%, P<0.001). They were also more likely to have their LV function recorded in the medical notes (70% vs 59%,

P<0.001), receive optimal pharmacotherapy with DAPT (91% vs 89%, P<0.001) and statin (86% vs 79%, P<0.001) on discharge compared with those not admitted under a cardiologist. For those with moderate and severe LVSD, the use of ACEi/ARB (86% vs 83%, P<0.001) and beta blockers (87% vs 82%, P<0.001) was higher in those admitted under a cardiologist (Table 5).

Independent Predictors of admission under specialty

Independent negative predictors of admission under a cardiologist included: female patients (OR: 0.91, 95% CI: 0.88-0.93, P<0.001), patients with a prior diagnosis of HF (OR: 0.84, 95% CI: 0.80-0.87, P<0.001), cerebrovascular accident (OR: 0.88, 95% CI: 0.85 – 0.91, P<0.001), diagnosis of asthma or COPD (OR: 0.96, 95% CI: 0.93-0.98, P=0.002), and previous history of AMI (OR: 0.97, 95% CI: 0.94-0.99, P=0.01). Positive predictors of admission under a cardiologist included: prior history of PCI (OR: 1.04, 95% CI: 1.01-1.07, P=0.04), admission to coronary care unit (CCU) (OR: 17.0, 95% CI: 16.7-17.4, P<0.001), intensive care unit (ICU) (OR:1.99, 95% CI: 1.83-2.18, P<0.001) and to a cardiac interventional centre (OR:3.90, 95% CI: 3.79-4.00, P<0.001) (Table 6).

Subgroup analysis

In subgroup analysis, patients who were neither admitted under, nor reviewed by a cardiologist during their index admission represented a small group (4.7%). These patients were significantly less likely to have their LV function recorded in the notes (29% vs 62%, P<0.001), receive DAPT (72% vs 91%, P<0.001) or statin therapy (61% vs 81%, P<0.001) on discharge, and less likely to receive ACEi/ARB (69% vs 83%, P<0.001) or beta blockers (68% vs 83%, P<0.001) for their moderate and severe LVSD, compared with those who were not admitted

under, but were later reviewed by, a cardiologist during their index admission (Supplement table 2).

On multivariate analysis, patients admitted under a cardiologist had better outcomes with reduced all-cause mortality (OR: 0.87, 95% CI: 0.83-0.92, P<0.001), major bleeding (0.88, 95% CI: 0.83-0.94, P<0.001), reinfarction (OR: 0.79, 95% CI: 0.72 – 0.85, P<0.001) and MACE (OR: 0.85, 95% CI: 0.81-0.88, P<0.001) than those not admitted initially under a cardiologist, but reviewed later by one during index admission. Those admitted under a cardiologist had better outcomes of all-cause mortality (OR: 0.51, 95% CI: 0.48-0.55, P<0.001), reinfarction (OR: 0.81, CI: 0.67-0.96, P = 0.02) and MACE (OR: 0.48, 95% CI: 0.47 – 0.53, P<0.001) than those neither admitted under a cardiologist, nor later reviewed by one. Finally, of patients not admitted by a cardiologist, those reviewed later by one had significantly better outcomes of mortality (OR: 0.87, 95% CI: 0.82 – 0.92, P<0.001), major bleeding (OR: 0.88, 95% CI: 0.83 – 0.94, P<0.001), reinfarction (OR: 0.79, 95% CI: 0.72 – 0.86, P<0.001) and MACE (OR: 0.84, 95% CI: 0.80 – 0.89, P<0.001) compared with those that were never reviewed by a cardiologist (Supplement table 3).

The missing data for each variable is shown in supplement table 4. Our key study findings are summarised in the central illustration figure (Figure 3).

Discussion

Our analysis of a large national registry of care within a centrally funded health system shows a disparity of care for patients presenting with NSTEMI dependent on the specialty of their admitting physician. Patients who were admitted under a cardiologist tended to be younger, more likely male, and more likely to receive optimal pharmacotherapy treatments,

ICA and revascularization (PCI/CABG surgery) with greater overall quality of care compared with those not admitted under a cardiologist. In addition, once differences in baseline characteristics and presentation were adjusted for, there was reduced odds of in-hospital mortality (all-cause, cardiac and non-cardiac), major bleeding, reinfarction and MACE in patients admitted under a cardiologist. Finally, we report significant differences in practice across the 230 hospitals in England and Wales with wide variation reported in admitting physician. There was a significant, albeit weak correlation between standardized mortality rates of the individual centres and the proportion of patients admitted under a cardiologist.

Previous studies examining the impact of the admitting physician in AMI have several important limitations. Most studies are historical and have focussed on AMI collectively, which limits insight as patients with STEMI are currently almost universally admitted under a cardiologist in the UK and Europe. Several studies have been undertaken in the US, where disparities of care due to socioeconomic factors are determinants of admission specialty; those without health insurance would be less likely to be admitted under a cardiologist[16]. In addition, previous studies have drawn data from limited populations or geographic locations where hospitals were self-selected and not necessarily reflective of national patterns, resulting in selection bias. They have also focused primarily on mortality as their endpoint and did not look at differences in either processes of care, QIs or other important outcomes such as MACE or reinfarction.

Prior national and international studies have suggested an element of bias in determining which patients with AMI are admitted under, or treated by, a cardiologist. *Ayanian et al* studied 1837 patients in the US admitted with AMI. Patients were more likely to be treated by a cardiologist if they were younger, male or treated in hospitals offering PCI or bypass surgery. Those with prior congestive HF and hypertension were less likely to be treated by a cardiologist[17]. Similar findings were reported in the UK population in 2006 by *Birkhead et al*[1].

Their study involving 88,782 patients corroborated findings that younger and male patients were more likely to be admitted under a cardiologist. Patients with diabetes, hypertension, cerebrovascular disease, previous history of AMI and angina were significantly less likely to be admitted under a cardiologist[1]. Whilst historically such studies suggest that patients who were at lower risk and with fewer co-morbidities (both cardiac and non-cardiac) were treated by cardiologists, our study suggests wide variations in practice at the individual centre level. Our study shows a 15% increase in the proportion of NSTEMI patients admitted under a cardiologist from 2010 to 2017. Over time, the risk factor profile of patients has varied. During the time period of 2016 and 2017, for instance, 83% of NSTEMI patients admitted under a cardiologist had a high GRACE score; an increase from 75% in 2010 and 2011, with wide variation year on year. Whilst patients with cardiovascular risk factors such as diabetes or previous PCI have increased rates of admission under cardiologists overall, there is a temporal element to this with increased rates over time.

It is interesting to note that even in contemporary practice, significant sex-disparities persist, with women significantly less likely to be admitted under a cardiologist, which may explain why women are less likely to receive invasive treatment for NSTEMI, and when they do are less likely to be offered it in line with international recommendations[18, 19]. Paradoxically, patients with a prior history of AMI are less likely to be admitted by a cardiologist which may be explained by the fact that such patients are more likely to be elderly and comorbid. Interestingly, we report that patients admitted to a centre that has interventional cardiology facilities are more likely to be admitted under a cardiologist. The majority of interventional cardiology centres have dedicated cardiology support 24 hours per day in contrast to non-interventional centres. Thus, patients who are admitted outside the hours of normal cardiology services in non-interventional hospitals will more likely be admitted to either acute or general medical units. This may explain why our prior work has suggested that

higher risk patients are more likely to be invasively treated if admitted to a centre with on-site cardiac catherization facilities and have better outcomes[20].

Patients admitted under a cardiologist were more likely to attain the ESC ACVC QIs, where attainment of these specific QIs has been shown to have a significant association with decreased 30-day mortality[13]. Our analysis also showed increased rates of ICA and revascularisation in the form of PCI and CABG surgery in patients admitted under a cardiologist. *Jollis et al* found cardiologist were more likely than other physicians to treat patients with medications associated with improved survival, and have increased use of echocardiography, coronary angiography and revascularisation[5]. It is likely that cardiologists are familiar with up-to-date international guidelines for the management of NSTEMI patients, are more likely to manage high risk comorbid patients invasively, having more ready and direct access to diagnostic tests and procedures.

Clinical outcomes for NSTEMI patients including mortality (all-cause, cardiac and non-cardiac), major bleeding, reinfarction and MACE were significantly reduced in patients admitted under a cardiologist. Prior studies have shown in-patient mortality for AMI is worse in patients not treated by a cardiologist[1, 5]. Ours is the first study to show for NSTEMI patients, the outcomes of major bleeding and reinfarction are significantly lower in patients admitted under a cardiologist. This is likely multifactorial; cardiologists have a narrower clinical focus and are more likely to come across patients with NSTEMI than general physicians. As well as being more familiar with the diagnosis and guideline driven management. Early use of angiography with optimal guideline pharmacotherapy is likely to reduce reinfarction rates and increasing awareness of complications such as major bleeding are likely to result in personalised antiplatelet regimes according to bleeding risk as advocated in guidelines[21].

On subgroup analysis, it can be seen that patients who were not admitted, but who were later reviewed by a cardiologist (46%) during their index admission were significantly more

likely to receive guideline directed management and had better outcomes of all-cause mortality, major bleeding, reinfarction and MACE than the group not admitted under a cardiologist, nor reviewed by one. The number of patients in the subgroup of neither admitted nor reviewed by a cardiologist is small, so it is difficult to draw strong conclusions from this analysis. However, the lack of specialist care is one of the likely determinants in why patients in this group had significantly worse quality of care and outcomes.

It is important to recognise that a proportion of patients being admitted by non-cardiologists are a high risk group as denoted by their GRACE score. These patients may be more frail, multimorbid and not suitable for guideline directed pharmacotherapy or revascularization. Equally, resource allocation with limited numbers of cardiologist and their services is one of the key determinants in deciding the bed allocation and specialty of admitting physician. However, this alone is unlikely to account for the significantly better quality of care and outcomes of patients with NSTEMI admitted under a cardiologist. With a centrally funded healthcare system that is committed to equity of access to quality of care, significant disparities in care and outcomes should not exist. However, our analysis suggests significant differences in practice across individual units, highlighting the need for optimisation of local pathways ensuring that patients admitted with an NSTEMI, are admitted under the care of a cardiologist within the first 24 hours. Further education for non-cardiologists that deal with NSTEMI in the first 24 hours of care is likely to be beneficial and reduce such disparities."

Strengths and limitations

There are a number of strengths to this study. Our analysis represents the largest study to date that looks at differences in NSTEMI patients by the specialty of the admitting physician. The MINAP database encapsulates an almost complete record of NSTEMI patients admitted

in the UK and represents one of the largest national real-world databases of this cohort of patients in the world, including those that are high risk and have multiple comorbid illness, such that they are either not included or under-represented in clinical trials.

Despite these strengths, there are a number of important limitations common to observational studies of this type. The MINAP data collection shares the weakness of other national registries, including self-reporting of adverse events where there is no external validation of these. Although the MINAP dataset included important clinical and demographic variables of interest, there are limitations to data collected. For instance, the database does not capture frailty score or index, severity of coronary artery disease or an exhaustive list of comorbid conditions. Nor does the database capture the type or does of statin used. This is important as there is emerging evidence that this has a key role on in-hospital mortality outcomes[22]. Our data does not show the precise degree of involvement of cardiologists' input in patients not admitted under a cardiologist, nor does it show transference of care to those not admitted under a cardiologist. In addition, the MINAP database only records in-hospital clinical outcomes and it is possible that long term follow-up data may reveal further differences in the crude clinical outcomes of patients admitted under a cardiologist compared to those who were not.

Conclusion

Our study demonstrates that between 2010-2017, less than 50% of patients diagnosed with NSTEMI were admitted under a cardiologist. There is wide variation of practice amongst the centres in England and Wales, and a significant correlation exists which shows the mortality rate for individual centres decreases as the proportion of patients admitted under a cardiologist increases. Those admitted under a cardiologist were more likely to attain the ESC ACVC QIs and had better outcomes of mortality, major bleeding, reinfarction and MACE. Urgent work is

required to look at the downstream effects of patients not admitted under a cardiologist and further quantify why such disparities of care persist.

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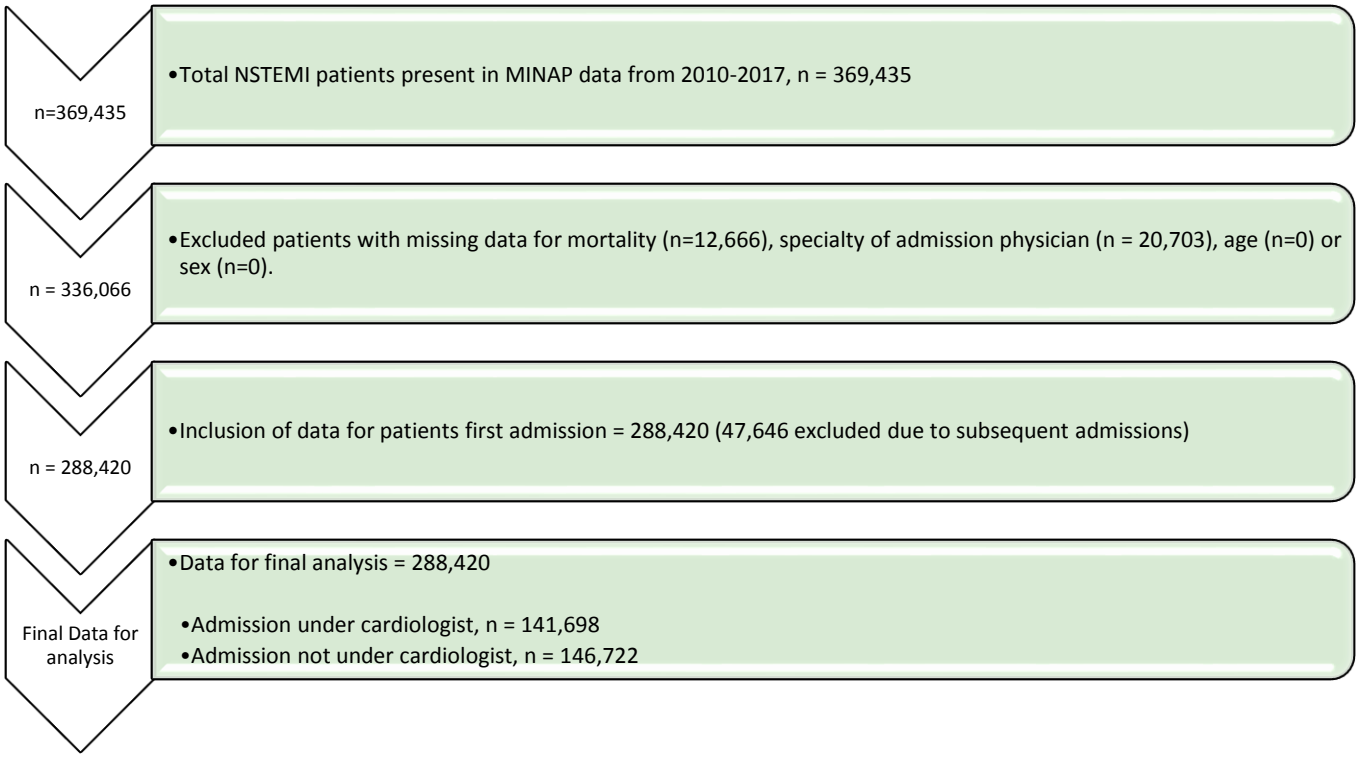
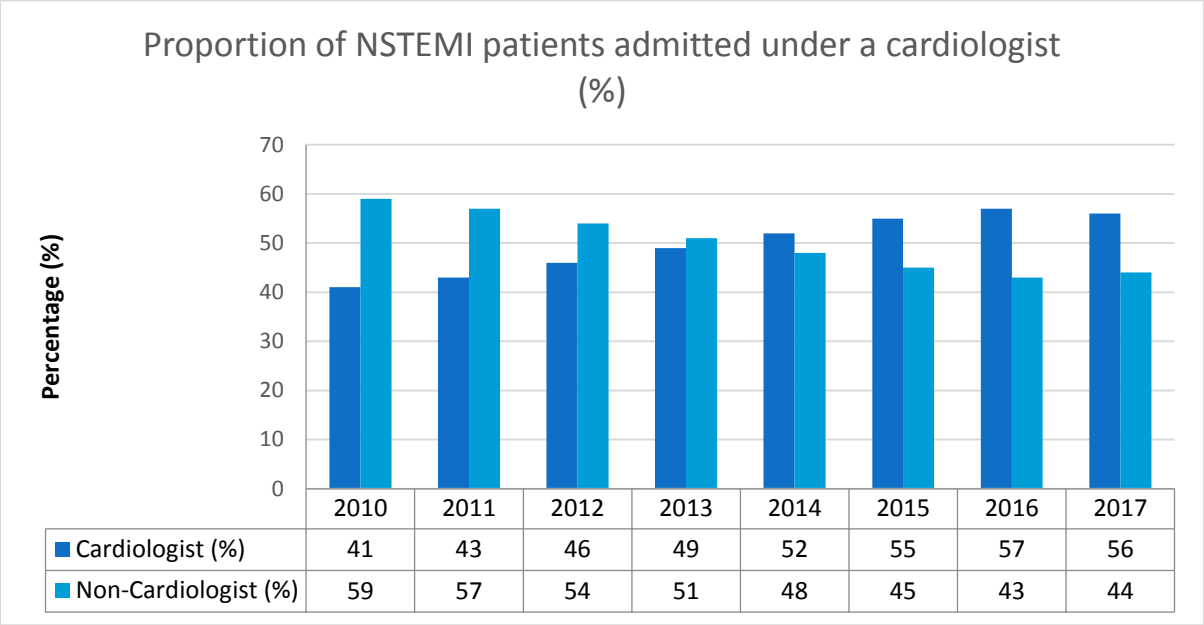
Figure 1: STROBE diagram to show to show all participant inclusion and exclusion



NSTEMI; non-ST-segment elevation myocardial infarction, MINAP; myocardial Infarction national audit project

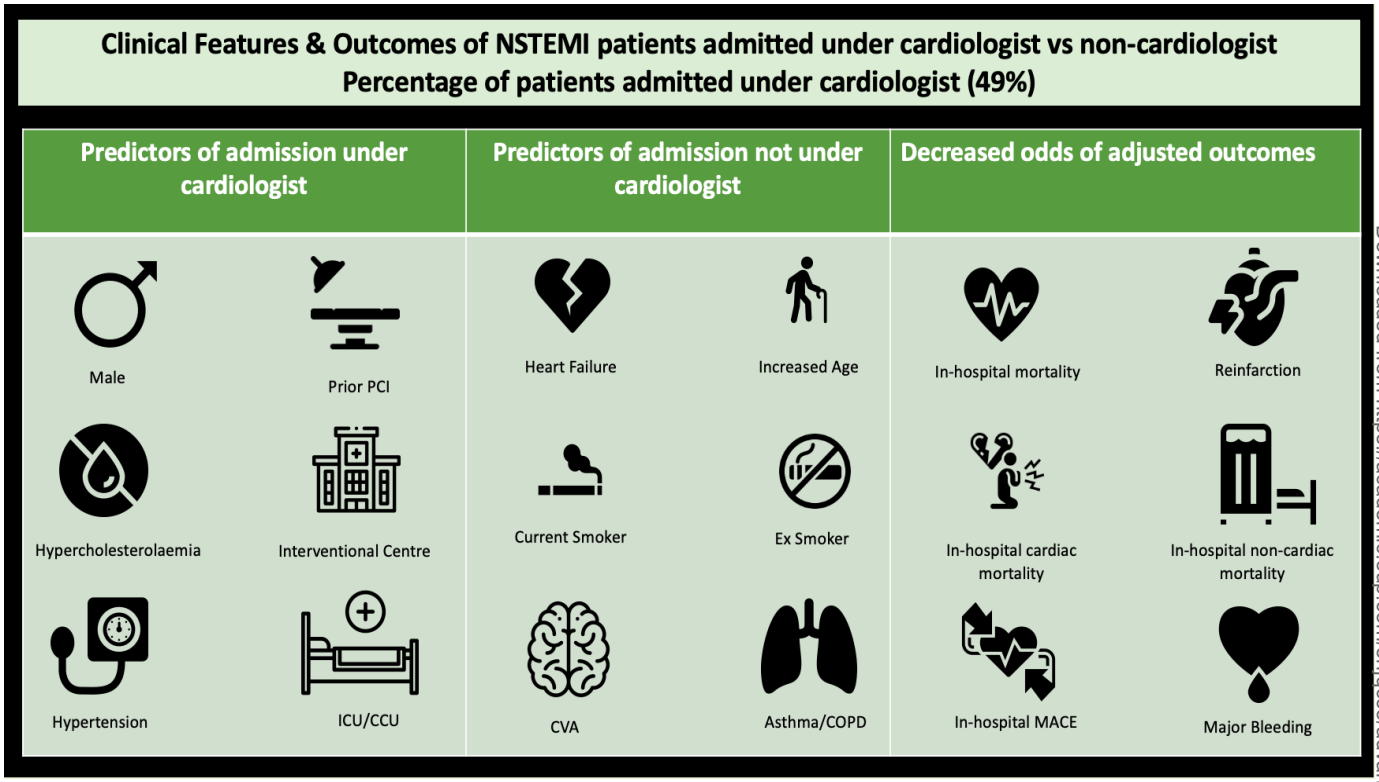
Figure 2: The proportion of NSTEMI patients between 2010-2017 admitted by specialty of physician



	2010	2011	2012	2013	2014	2015	2016	2017
Cardiologist (%)	41	43	46	49	52	55	57	56
Non-Cardiologist (%)	59	57	54	51	48	45	43	44

NSTEMI; non-ST-segment elevation myocardial infarction

Figure 3: Central illustration figure



CABG surgery: coronary artery bypass grafting surgery; PCI: percutaneous coronary intervention, NSTEMI: non -ST-segment elevation myocardial infarction, COPD; chronic obstructive pulmonary disease, ICU; intensive care unit, CCU; coronary care unit, CVA; cerebrovascular accident, MACE: major adverse cardiovascular events

Table 1: Clinical characteristics

Variables	Non-cardiologist (n = 146,722)	Cardiologist (n = 141,698)	P-value
Age (years), median [IQR]	75 (64 -84)	70 (59 – 79)	<0.001
Women (%)	57,921/146,722 (39%)	45,597/141,698 (32%)	<0.001
Caucasians (%)	127,208/137,059 (93%)	115,854/127,051 (91%)	<0.001
BMI median [IQR]	27 (24-31)	27 (24-31)	<0.001
Basal crepitations (%)	18,071/88,422 (20%)	12,441/97,191 (13%)	<0.001
Pulmonary oedema (%)	5,470/88,422 (6.5%)	5,258/97,191 (5.4%)	<0.001
Cardiogenic shock (%)	472/88,422 (0.5%)	592/97,191 (0.6%)	0.032
High risk GRACE score >140 (%)	69,078/85,107 (81%)	69,829/93,327 (75%)	<0.001
Intermediate risk GRACE score 109-140 (%)	12,883/85,107 (15%)	18,686/93,327 (20%)	<0.001
Low risk GRACE score <109 (%)	3,146/85,107 (4%)	5,812/93,727 (5%)	<0.001
ECG ST changes (%)	110,514/143,048 (77%)	107,838/138,631 (78%)	0.001
Previous smoker (%)	52,366/137,976 (38%)	49,320/136,173 (36%)	<0.001
Current smoker (%)	27,893/137,976 (20%)	32,916/136,173 (24%)	<0.001
Chronic renal failure (%)	13,841/139,381 (10%)	10,059/135,436 (7%)	<0.001
Prior percutaneous coronary intervention (%)	16,265/139,448 (12%)	20,281/135,716 (15%)	<0.001
Diabetes (%)	37,409/144,663 (26%)	35,322/139,807 (25%)	<0.001
CCF (%)	12,738/139,391 (9%)	8,560/135,435 (6%)	<0.001
Hypercholesterolemia (%)	43,555/138,529 (31%)	53,083/134,364 (40%)	<0.001
Previous MI (%)	39,731/140,847 (28%)	36,810/136,050 (27%)	<0.001
Angina (%)	42,518/139,305 (31%)	40,194/135,435 (30%)	<0.001
Cerebrovascular disease (%)	16,285/139,704 (12%)	11,606/135,597 (9%)	<0.001
Peripheral vascular disease (%)	7,175/138,986 (5%)	7,314/135,034 (5%)	0.003
Hypertension (%)	76,394/140,570 (54%)	75,845/136,423 (56%)	<0.001
Asthma / COPD (%)	26,586/139,856 (19%)	21,978/135,714 (16%)	<0.001

Family history of CAD (%)	27,832/113,944 (24%)	37,249/117,955 (32%)	<0.001
Heart rate, bpm, median (IQR)	80 (68-94)	76 (65-90)	<0.001
Systolic blood pressure, median (IQR)	140 (121-158)	140 (122-158)	0.011
Moderate LVSD (%)	18,212/113,852 (16%)	22,098/110,155 (20%)	<0.001
Severe LVSD (%)	8,016/113,852 (7%)	8,781/110,155 (8%)	<0.001
Cardiac arrest (%)	4,942/145,051 (3.4%)	3,930/137,731 (2.8%)	<0.001
Previous CABG surgery (%)	11,997/139,722 (8.6%)	12,344/135,841 (9.1%)	<0.001

CABG surgery; coronary artery bypass grafting surgery, PCI; percutaneous coronary intervention, MI; myocardial infarction, BMI; body mass index, GRACE: global registry of acute coronary events, ECG; electrocardiograph, CCF; congestive cardiac failure, COPD; chronic obstructive pulmonary disease, CAD; coronary artery disease, IQR; interquartile range, LVSD; left ventricular systolic dysfunction, EF; ejection fraction

Table 2: Management strategy & crude clinical outcome

Variables	Non-cardiologist (n = 146,722)	Cardiologist (n = 141,698)	P-value
Low molecular weight heparin (%)	69,383/129,534 (54%)	61,382/122,972 (50%)	<0.001
Fondaparinux (%)	63,826/129,805 (49%)	56,027/123,564 (45%)	<0.001
Warfarin (%)	8,828/129,359 (7%)	7,437/121,758 (6%)	<0.001
Unfractionated heparin (%)	10,270/128,971 (8%)	24,966/121,391 (21%)	<0.001
Glycoprotein IIb/IIIa inhibitor (%)	2,764/130,257 (2%)	5,360/124,330 (4%)	<0.001
IV Nitrate (%)	14,248/129,411 (11%)	18,134/121,675 (15%)	<0.001
Furosemide (%)	40,760/129,623 (31%)	30,932/122,148 (25%)	<0.001
Calcium channel blockers (%)	24,856/129,354 (19%)	23,751/122,004 (19%)	0.110
IV beta blockers (%)	1,213/129,443 (0.9%)	1,430/122,954 (1.2%)	<0.001
MRA (%)	8,530/128,636 (6.6%)	8,838/20,819 (7.3%)	<0.001
Thiazide diuretics (%)	6,228/129,133 (5%)	5,817/121,522 (5%)	0.672
Aspirin (%)	139,748/146,289 (96%)	137,808/141,272 (98%)	<0.001
$P2Y_{12}$ inhibitor (%)	133,353/146,149 (91%)	130,197/141,117 (92%)	<0.001
Statins (%)	115,904/146,355 (79%)	121,235/140,543 (86%)	<0.001
ACE inhibitors/ARB (%)	113,765/146,356 (77%)	118,669/140,676 (84%)	<0.001
Beta-Blockers (%)	113,561/145,645 (78%)	119,393/140,067 (85%)	<0.001
Radionuclide Study (%)	3,262/130,769 (2.5%)	3,069/120,458 (2.6%)	0.394
Exercise test (%)	3,097/132,386 (2%)	6,518/123,244 (5%)	<0.001
Coronary angiogram (%)	185,569/142,047 (60%)	106,844/134,410 (79%)	<0.001
Percutaneous coronary intervention (%)	37,534/103.424 (36%)	61,890/119,233 (52%)	<0.001
CABG surgery (%)	7,198/103,424 (7%)	9,741/119,233 (8%)	<0.001
Revascularization (CABG surgery/PCI) (%)	44,732/103,424 (43%)	71,631/119,233 (60%)	<0.001

Death (%)	10,408/146,722 (7.1%)	4,041/141,698 (2.9%)	<0.001
Cardiac mortality (%)	8,039/146,722 (5.5%)	3,342/141,698 (2.4%)	<0.001
Reinfarction (%)	1,408/140,077 (1.0%)	998/134,297 (0.7%)	<0.001
Major bleeding (%)	2,346/144,983 (1.6%)	1,866/138,724 (1.4%)	<0.001
MACE* (%)	11,444/146,722 (7.8%)	4,877/141,698 (3.4%)	<0.001

CABG surgery; coronary artery bypass grafting surgery, IV; intravenous, MRA; mineralocorticoid receptor antagonist, ACE; angiotensin converting enzyme inhibitor, ARB; angiotensin receptor blockers, MACE; major adverse cardiovascular events

∗ MACE is defined as composite endpoint of in-patient mortality and reinfarction

Table 3: Risk of in-hospital Adverse Outcomes following multivariate adjustments

Clinical outcomes	Adjusted Odds* ratio as compared to reference (non-cardiologist)	P-value	95% CI
All-cause mortality (n of observations = 288,420)	OR: 0.76	<0.001	0.72-0.80
Cardiac mortality (n of observations = 288,420)	OR: 0.87	<0.001	0.83 – 0.93
Non-cardiac mortality (n of observations = 288,420)	OR: 0.66	<0.001	0.60 – 0.72
Reinfarction (n of observations = 288,420)	OR: 0.78	<0.001	0.71 – 0.85
Major bleeding (n of observations = 288,420)	OR: 0.91	0.007	0.85 – 0.97
MACE# (n of observations = 288,420)	OR: 0.75	<0.001	0.71 - 0.79

* Adjusted for age, sex, ethnicity, heart rate, blood pressure, serum creatinine level, family history of coronary heart diseases, previous coronary artery bypass graft surgery, ischaemic ECG changes, history of heart failure, left ventricle systolic dysfunction, prior percutaneous coronary intervention (PCI), history of diabetes mellitus, hypercholesterolaemia, history of angina, history of myocardial infarction, history of cerebrovascular accident, history of peripheral vascular disease, hypertension, smoking, asthma/COPD, prescription of low molecular weight heparin, warfarin, un-fraction heparin, GP 2b/3a inhibitor, IV nitrate, furosemide, aldosterone antagonist, fondaparinux, beta blockers, angiotensin converting enzyme inhibitor/angiotensin receptor blockers, aspirin, P2Y12 inhibitor, statins, cardiac arrest, coronary angiogram, PCI and CABG surgery on imputed data.

CABG surgery; coronary artery bypass grafting surgery
MACE; major adverse cardiovascular events
MACE is defined as composite endpoint of in-patient mortality and reinfarction

Table 4: Propensity Score-Matched Analysis with Average Treatment Effects on imputed data

Outcome	Group	Coefficient* (95% CI)	Odds Ratio* (95% CI)	P Value
In-hospital all-cause mortality (n=288,420)	Group 1: non-cardiologist	Reference		<0.001
	Group 2: cardiologist	-0.0122748 (-0.0143335 to -0.0102161 to	0.81 (0.79-0.85)	
In-hospital cardiac mortality (n=288,420)	Group 1: non-cardiologist	Reference		<0.001
	Group 2: cardiologist	-0.0074849 (-0.0093405 to -0.0056294)	0.86 (0.82-0.89)	
In-hospital non-cardiac mortality (n=288,420)	Group 1: non-cardiologist	Reference		<0.001
	Group 2: cardiologist	-0.0047899 (-0.0058406 to -0.0037392)	0.70 (0.63-0.76)	
In-hospital reinfarction (n=288,420)	Group 1: non-cardiologist	Reference		0.001
	Group 2: cardiologist	-0.002142 (-0.0033762 to -0.0009078)	0.78 (0.66-0.91)	
In-hospital major bleeding (n=288,420)	Group 1: non-cardiologist	Reference		0.012
	Group 2: cardiologist	-0.0016258 (-0.0028904 to -0.0003611)	0.90 (0.82-0.98)	
In-hospital MACE n=288,420)	Group 1: non-cardiologist	Reference		<0.001
	Group 2: cardiologist	-0.0137383 (-0.015805 to -0.0116715)	0.81 (0.78-0.84)	

* Adjusted for age, sex, ethnicity, heart rate, blood pressure, serum creatinine level, family history of coronary heart diseases, previous coronary artery bypass graft surgery, ischaemic ECG changes, history of heart failure, left ventricle systolic dysfunction, prior percutaneous coronary intervention (PCI), history of diabetes mellitus, hypercholesterolaemia, history of angina, history of myocardial infarction, history of cerebrovascular accident, history of peripheral vascular disease, hypertension, smoking, asthma/COPD, prescription of low molecular weight heparin, warfarin, un-fraction heparin, GP 2b/3a inhibitor, IV nitrate, furosemide, aldosterone antagonist, fondaparinux, beta blockers, angiotensin converting enzyme inhibitor/angiotensin receptor blockers, aspirin, P2Y12 inhibitor, statins, cardiac arrest, coronary angiogram, PCI and CABG surgery on imputed data.

CABG surgery; coronary artery bypass grafting surgery
MACE; major adverse cardiovascular events
MACE is defined as composite endpoint of in-patient mortality and reinfarction

Table 5: ESC ACVC Quality indicators

	Non-cardiologist (n = 146,722)	**Cardiologist (n = 141,698)**	**P-Value**
Coronary angiography received within 72 hours (%)	23,953/46,164 (52%)	57,393/79,880 (72%)	<0.001
LV function recorded in notes (%)	67,085/113,852 (59%)	77,019/110,155 (70%)	<0.001
Adequate $P2Y_{12}$ Inhibition on discharge (%)	133,353/146,149 (91%)	130,197/141,117 (92%)	<0.001
Fondaparinux or LMWH received (%)	115,509/130,777 (88%)	104,034/125,796 (83%)	<0.001
DAPT received on discharge (%)	129,256/145,949 (89%)	127,702/140,966 (91%)	<0.001
High intensity statin on discharge* (%)	115,904/146,355 (79%)	121,235/140,543 (86%)	<0.001
ACE inhibitor or ARB on discharge for those with moderate and severe LVSD (%)	21,626/26,190 (83%)	26,411/30,649 (86%)	<0.001
B-blocker on discharge for those with moderate and severe LVSD (%)	21,367/26,096 (82%)	26,658/30,539 (87%)	<0.001

ESC; European society of cardiology, Association for Acute Cardiovascular Care (ACVC), GRACE; global registry of acute coronary events, CRUSADE; can rapid risk stratification of unstable angina patients suppress adverse outcomes with early implementation of the ACC/AHA guidelines, LV; left ventricle, LMWH; low molecular weight heparin, DAPT; dual antiplatelet therapy, ACEi/ARB; angiotensin converting enzyme inhibitor/angiotensin receptor blockers, LVSD; left ventricular systolic dysfunction N/A; not available

*MINAP does not record the specific type of statins, so 'statin prescription' was used as a surrogate for high intensity statin.

Table 6: Independent predictors of admission under cardiologist

	Odds Ratio	**95% CI (lower)**	**95% CI (upper)**	**P-Value**
Age	***0.99***	***0.98***	***0.99***	***<0.001***
Sex (female)	***0.91***	***0.88***	***0.93***	***<0.001***
Family History of CHD	***1.04***	***1.01***	***1.07***	***0.01***
Previous CABG surgery	1.01	0.97	1.05	0.68
Moderate LVSD	1.00	0.97	1.03	0.88
Severe LVSD	1.03	0.98	1.08	0.21
Heart Failure	***0.84***	***0.80***	***0.87***	***<0.001***
BAME	***0.94***	***0.90***	***0.97***	***0.001***
Previous PCI	***1.04***	***1.00***	***1.07***	***0.04***
Diabetes	***0.98***	***0.96***	***1.00***	***0.07***
Hypercholesterolaemia	***1.17***	***1.15***	***1.20***	***<0.001***
History of angina	***1.06***	***1.04***	***1.09***	***<0.001***
History of AMI	***0.97***	***0.94***	***0.99***	***0.01***
History of CVA	***0.88***	***0.85***	***0.91***	***<0.001***
History of PVD	***1.05***	***0.99***	***1.09***	***0.05***
Hypertension	***1.03***	***1.01***	***1.05***	***0.01***
Ex-smoker	***0.90***	***0.88***	***0.92***	***<0.001***
Current smoker	***0.92***	***0.89***	***0.95***	***<0.001***
Asthma/COPD	***0.96***	***0.93***	***0.98***	***0.01***
Cardiac Arrest	1.03	0.97	1.09	0.37
CCU	***17.0***	***16.7***	***17.4***	***<0.001***
ICU	***1.99***	***1.83***	***2.18***	***<0.001***
Interventional Centre	***3.90***	***3.79***	***4.00***	***<0.001***

CHD; coronary heart disease, CABG surgery; coronary artery bypass graft surgery, LVSD; left ventricular systolic dysfunction, BAME; Black, Asian and minority ethnic, PCI; percutaneous coronary intervention, AMI; acute myocardial infarction, PVD; peripheral vascular disease, CVA; cerebrovascular accident, COPD; chronic obstructive pulmonary disease, CCU; coronary care unit, ICU; intensive care unit.