Non-specific Chest Pain and 30-day Unplanned Readmissions in the United States: (From the Nationwide Readmission Database)

Running title: Chest pain and unplanned readmissions

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Abstract

Chest pain is a common reason for admission to hospital and little is known regarding 30-day unplanned readmissions after an admission with a primary discharge diagnosis of non-specific chest pain. We analyzed patients with a primary diagnosis of non-specific chest pain in the Nationwide Readmission Database who were admitted between 2010 and 2014. Rates, causes and predictors of 30-day unplanned readmissions were determined. A total of 1,842,270 patients had a diagnosis of non-specific chest pain. The 30-day unplanned readmission rate was 8.6%. From 2010 to 2014, there was an increase in 30-day unplanned readmissions from 8.1% to 9.5%. The majority of 30-day unplanned readmissions were for non-cardiac reasons (73.4%). The three most prevalent non-cardiac causes for readmissions were neuropsychiatric (10.9%), gastrointestinal (10.5%) and infections (9.9%) while the three most prevalent cardiac causes were coronary artery disease including angina (8.4%), arrhythmias (6.6%) and heart failure 5.5%. The strongest predictors of readmission were alcohol misuse (OR 1.74 95%CI 1.66-1.81), renal failure (OR 1.82 95%CI 1.76-1.87), cancer (OR 2.40 95%CI 2.27-2.53), discharge to a nursing home (OR 2.26 95%CI 2.18-2.34) and discharge against medical advice (OR 1.94 95%CI 1.86-2.02). The rate of 30-day unplanned readmission was 6.1% among those who received any test compared to 9.3% in those who did not receive any test. Rates of early unplanned readmissions occur following 1 in 12 admissions for non-specific chest pain with non-cardiac causes being the most common reason. Patients who receive a cardiovascular investigation appear to have fewer unplanned readmissions.

Key words: chest pain; non-cardiac chest pain

Introduction

The primary goal in the care of patients with non-specific chest pain is to accurately risk stratify and exclude patients with an acute coronary syndrome (ACS) or other serious cardiovascular conditions.[1] Once life threatening cardiovascular conditions have been excluded, it is reasonably safe to discharge patients, often with a diagnosis of non-specific chest pain.[2] Nevertheless, no investigation whether radiological or biochemical, is entirely accurate. There may be patients that are misdiagnosed or have serious cardiovascular pathology excluded in error, resulting in readmission to the hospital. Readmissions are an area of growing interest not well understood. To patients, readmissions represent a financial and emotional burden and place a resource burden on health care systems. As such, they serve as a surrogate for quality of care, which can incur financial penalties for hospitals. Currently, very little is known regarding 30-day unplanned readmissions after an admission with a primary discharge diagnosis of non-specific chest pain.

The objective of the current study is to evaluate the rates, trends, causes and predictors of 30-day unplanned readmission among patients admitted as in-patients to hospital with non-specific chest pain in an unselected national cohort.

Methods

The Nationwide Readmissions Database (NRD) contains national hospitalization and rehospitalization data for patients of all ages within the United States which is produced by the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality. The data is derived from 21 geographically-dispersed states and is designed to represent 49.1% of all US hospitalizations. The NRD contains a de-identified unique patient linkage number, which allows for the determination of readmissions by tracking of patients across hospitals within a calendar year. This dataset includes hospital inpatients and does not contain information from emergency departments.

We included men and women, aged 18 years or older, with a primary diagnosis of non-specific chest pain with discharge dates between 2010 and 2014 with 30-day follow up. Non-specific chest pain was defined by the International Statistical Classification of Disease and Related Health Problems (ICD) 9 codes 78650 (CHEST PAIN, UNSPECIFIED), 78651 (PRECORDIAL PAIN), 78652 (PLEURITIC PAIN) and 78659 (OTHER CHEST PAIN). Patients were excluded if they died during the index admission, were discharged during the month of December (thus lacking 30 days of follow up) or their first readmission was classified as elective within a calendar year.

To capture patient demographic, comorbidities, hospital characteristics and outcomes, the NRD codes and both ICD-9 and Elixhauser comorbidity codes were used. All comorbidities and procedures were derived from the index admission for non-specific chest pain. The NRD has information regarding age, sex, year, elective admission, weekend admission, primary expected payer, median household income, number of hospital beds, location, teaching status, discharge location, length of stay, and cost. Using the ICD-9 diagnostic codes, we defined several patient variables including smoking status (V1582 3051), dyslipidemia (2720–2724), coronary artery disease (41400–41407), previous myocardial infarction (MI) (412), previous percutaneous coronary intervention (PCI) (V4582), previous coronary artery bypass graft (CABG) (V4581), previous stroke or transient ischemic attack (V1254 438*), atrial fibrillation (42731) and dementia (290* 2941* 2942* 2948 3310–3312, 797) while the Elixhauser comorbidity codes were used to define alcohol misuse, chronic lung disease, diabetes mellitus, valvular heart disease, peptic ulcer disease, hypertension, renal failure, obesity, cancer, fluid and electrolyte disorder, pulmonary circulatory disorder, depression, peripheral vascular disease, hypothyroidism, liver disease and anemia. ICD 9 procedural codes were used to define coronary angiogram (8855 3722 3723 8853 8854 8856), echocardiogram (8872), stress test (8941 8942 8943 8944), CT chest (8741), magnetic resonance imaging scan (MRI) (8892), lung scan (9215), radioisotope scan (9205) and aortogram (8842). A single group of investigations for serious cardiovascular disease was defined as the composite of coronary angiogram, CT chest, lung scan, radioisotope scan, MRI and aortogram.

The primary outcome of this study was unplanned readmission within 30 days for any cause. We also determined the cost of the readmission, readmission length of stay and mortality rate during readmission.

Statistical analysis was performed on Stata 14.0 (College Station, TX). Estimated population sizes were determined by using the survey estimation command in Stata (SVY) with the NRD discharge weight (DISCWT). Estimated crude numbers of admissions for non-specific chest pain and 30-day unplanned readmission rates were plotted graphically over the study years. We used the PTREND function to evaluate the trends over time in admission for chest pain and 30-day readmissions. Descriptive statistics are presented according to the presence or absence of readmission. Multiple logistic regressions were used to examine the associations between the variables previously described and 30-day readmissions. A supplementary analysis of performed with stratification by receipt of investigations and previous coronary artery disease. We performed a sensitivity analysis evaluating different age

groups (<55 years, 55-64 years, 65-74 years and ≥75 years) separately. We performed further analysis examining the influence of cardiovascular investigation and coronary artery disease on 30-day unplanned readmissions, readmission mortality and readmission for cardiac causes.

Results

A total of 1,842,270 patients were included in the analysis (Figure 1) The 30-day unplanned readmission rate was 8.6% and the rate of death during the readmission episode was 2.3%. The extent of missing data in the cohort is shown in Supplementary Table 1. The comparison of patient characteristics of patients admitted in the month of January to November compared to December is shown in Supplementary Table 2.

Examining trends over time, there was a decline in non-specific chest pain admissions from 465,249 in 2010 to 276,719 in 2014 (Figure 2). Over the same duration there was an increase in the percentage of 30-day unplanned readmissions from 8.1% to 9.5% following an index admission of non-specific chest pain. Trend analysis revealed a significant trend over time for both admissions for chest pain (p<0.001) and 30-day unplanned readmission (p<0.001). More than 1 in 5 patients (21.0%) received one or more cardiovascular test.

Table 1 examines the patient and hospital characteristic for the analysis cohort with a principle diagnosis of non-specific chest pain. Patients who were readmitted were older and were more likely to be male. Readmitted patients were also more likely to be admitted on weekends and have existing coronary artery disease, previous MI, previous PCI and previous CABG. Other important comorbidities that were more prevalent among patients with readmissions were chronic lung disease, renal failure and anemia. Coronary angiography was less often performed during the index admission in patients that were readmitted. The length of stay and cost of the index admission were greater for patients who were readmitted.

The majority of 30-day unplanned readmissions were for non-cardiac reason and the most prevalent of these were neuropsychiatric, gastrointestinal, infections, respiratory and trauma (Figure 3). Among cardiac causes the most common diagnoses were angina, arrhythmia, heart failure, acute MI and pericarditis.

The strong predictors of 30-day unplanned readmissions were alcohol misuse, renal failure, cancer, discharge to nursing home and discharge against medical advice (Table 2).

The rate and causes of 30-day unplanned readmission are shown according to receipt of cardiovascular investigations (Supplementary Table 3). The 30-day unplanned readmission rate was 6.1% among those who received a cardiovascular investigation during their index admission compared to 9.3% in those who did not. The rate of death during the readmission was also lower among those who had a cardiovascular investigation at index admission (1.6%

vs 2.4%) and these patients had a lower mean length of stay for the readmission 5.1±6.1 days compared to 5.2±6.7 days. There was no difference in cost between those who were readmitted with a cardiovascular investigation during index admission compared to those who did not (no test $11,328±16,571 vs test $11,162±17,172, p=0.36). Among patients who were readmitted, the proportion of patients who were readmitted with a cardiac cause was lower in patients who received any cardiovascular investigation during their index admission compared to those who did not receive any test (23.2% vs 27.2%, p<0.001, Figure 4).

The rate and causes of 30-day unplanned readmission are shown according to previous coronary artery disease in Supplementary Table 4. The 30-day unplanned readmission rate was 12.0% among those who had previous coronary artery disease compared to 6.8% in those who did not have previous coronary artery disease. Only 13% of patients with a cardiac diagnosis for readmission had a cardiovascular test at index chest pain admission while majority 87% did not have a cardiovascular test.

The 30-day rate of readmission was 6.1% and 9.3% based on receiving a cardiovascular test and after adjustments for patient demographics and comorbidities there was a significant reduction in odds of readmission with receipt of any test (OR 0.73 95%CI 0.71-0.75). For readmission mortality, which was 1.6% for patients with a test compared to 2.4% for patients without a test, there was a non-significant difference once baseline covariate were adjusted for (OR 0.92 95%CI 0.75-1.13). Among patients with a cardiovascular test, the proportion of readmissions that were cardiac was 23.4% while for patients who did not receive a test it was 27.4% and after adjustments there was reduced odds of readmission for cardiac causes (OR 0.76 95%CI 0.71-0.81). Previous coronary artery disease was also associated with increased odds of readmission for cardiac causes (OR 1.33 95%CI 1.27-1.41). The results of the sensitivity analysis considering different age groups (<55 years, 55-64 years, 65-74 years and ≥75 years) are shown in Supplementary Table 5.

Discussion

Our analysis of hospital inpatients suggests that 1 in 12 patients with a diagnosis of non-specific chest pain return to hospital with an unplanned readmission within 30 days. Nearly three-quarters of unplanned readmissions following an index diagnosis of non-cardiac chest pain are non-cardiac in origin with major causes being neuropsychiatric, gastric, infectious and respiratory in origin. Major predictors of readmission in this group include alcohol misuse, renal failure, cancer, discharge to a nursing home and discharge against medical advice. It further appears that receipt of an investigation for cardiovascular disease are independently associated 27% reduced odds for unplanned readmission. These results

suggest that early unplanned readmissions are frequent among patients with non-specific chest pain and that greater use of in-hospital cardiac investigations may be associated with reduced subsequent 30-day unplanned readmissions, particularly for cardiac causes.

Our analysis suggests that admissions with a primary diagnosis of non-cardiac chest pain are common although rates are declining over time. In the litigious environment of current medical practice within the United States, there may be greater incentives for physicians to investigate to increase the likelihood of a definitive diagnosis for a patient's chest pain presentation as an inpatient. There may also be financial incentives to provide a firm diagnosis for billing purposes compared to an exclusionary diagnosis. We speculate that one of the possible reasons for the decline in number of non-specific chest pain may be the availability of better diagnostics in recent years such as the use of high-sensitivity troponin. Furthermore, it may also reflect the growth in availability of tests, improved sensitivity and specificity of tests and the timeliness of tests that can help identify coronary artery disease including invasive and CT coronary angiogram, MRI and nuclear imaging.

We observed a trend that readmissions among patients with a diagnosis of non-specific chest pain are increasing. In the United States, there is a growing primary care crisis as 65 million Americans are faced with difficulty obtaining prompt access to primary care.[3] Less access to primary care may result in patients returning to the hospital when problems arise and the high financial burden of healthcare expenses may result in low income adults to not seeking care till the last minute.[4] The Hospital Readmissions Reduction Program[5] has raised awareness of readmissions to health services and administrators that may result in better recording, monitoring and identification of readmissions. It is possible there is an increasingly elderly population who presents to hospital and these patients often have multiple co-existing illness that increase the risk of unplanned readmissions.[6]

We found that only 1 out of 5 patients received a test that were used to exclude life-threatening cardiovascular causes of chest pain. We assume that patients who did not receive any testing was due to atypical nature of the chest pain or history less concerning for potential cardiovascular disease. It is further conceivable that those who receive tests may be guided by abnormalities in other tests such as troponins, ECG and chest X-ray. However, we have shown that use of investigations appears to be associated with lower rate of unplanned readmissions. A review of non-specific chest pain among patients suspected for ACS suggests that one of the challenges is the lack of any comprehensive guideline specifying the optimal management.[7] Furthermore, there is an issue regarding the timing of investigations and for some patients it may be safe to have outpatient investigations.

Patients who are at risk of readmissions appear to have identifiable characteristics. Certain comorbid illnesses, including existing heart disease, alcohol misuse, renal failure and cancer, are also associated with 30-day readmission. Alcohol misuse may indirectly be associated with injuries sustained while intoxicated leading to readmissions. In end-stage renal disease, chest pain may result from pericarditis and pericardial effusions.[8] Chest pain may also be an underlying symptom of cancer as chest pain may be due to chest wall metastases, lung cancer, cancer of the oesophagus and pancreatic cancer.[9] Furthermore, malignancies are associated with activation of the coagulation cascade, platelet activation and aggregation which may cause chest pain from pulmonary thromboembolism.[10]

Interestingly, we found that psychiatric diagnoses were the most common cause for 30-day unplanned readmissions after an admission for chest pain. The availability of psychiatric services in hospitals is likely to be variable. Also, chest pain may be a manifestation of panic disorder and depression and as many as 1 in 3 patients presenting with acute pain has symptoms consistent with a psychiatric disorder.[11] One study demonstrated an association between psychiatric disorders and non-cardiac chest pain and patients with a previous psychiatric hospitalization have increased risk of death.[12] The authors suggest that these admissions may be an opportunity to engage and where appropriate intervene to modify cardiovascular risk in this difficult-to-reach and high-risk patient group.

Our study has certain limitations. First, there is no possible linkage between years as the data is derived from five unique datasets. Second, we excluded patients who were discharged in the month of December in order to ensure adequate 30-day follow up. Another limitation was that the NRD dataset is not linked to the emergency care database so this study only captures patients who are admitted to a hospital rather than the entire population who present with chest pain. Finally, we do not have information on results of tests such as troponin levels, D-dimer levels, electrocardiograms and echocardiograms and we did not have information on planned follow up in the community and outpatient investigations.

In conclusion, 1 out of 12 patients hospitalized with non-specific chest pain are readmitted within 30 days of discharge and rates of readmission appear to be rising. Patients who are readmitted are more likely to misuse alcohol, have renal failure, cancer or be discharged to a nursing home or against medical advice. Majority of readmissions are due to non-cardiac causes and investigations during the index admission appear to be associated with fewer readmissions. While guidelines suggest that once ACS is excluded patients may be safely discharged, perhaps there should be greater assessment for other non-cardiac causes before making a diagnosis of non-specific chest pain in order to reduce early readmissions.

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Table 1: Characteristics of participants according to 30-day unplanned readmissions after admission for non-specific chest pain

Variable	No readmission (n=1,683,489)	Unplanned readmission (n=158,781)
Age (year)	59±15 (n=1,681,085)	62±15 (n=158,626)
Female	932,731 (55.4%)	79,521 (50.1%)
Weekend admission	421,470 (25.0%)	41,569 (26.2%)
Year		
2010	427,813 (25.4%)	37,436 (23.6%)
2011	376,804 (22.4%)	34,753 (21.9%)
2012	339,710 (20.2%)	31,874 (20.1%)
2013	288,765 (17.2%)	28,395 (17.9%)
2014	250,397 (14.9%)	26,322 (16.6%)
Primary expected payer		
Medicare	684,452 (40.8%)	89,975 (56.8%)
Medicaid	264,185 (15.8%)	32,852 (20.7%)
Private	473,870 (28.2%)	19,874 (12.5%)
Self-pay	156,486 (9.3%)	9,075 (5.7%)
No charge	18,438 (1.1%)	1,292 (0.8%)
Other	81,265 (4.8%)	5,450 (3.4%)
Quartile of median household income		
0-25th	548,075 (33.2%)	58,747 (37.7%)
26th-50th	406,486 (24.6%)	38,144 (24.5%)
51st-75th	375,886 (22.8%)	33,267 (21.3%)
76th-100th	321,452 (19.5%)	25,845 (16.6%)
Smoker	513,772 (30.5%)	51,543 (32.5%)
Alcohol misuse	68,963 (4.1%)	11,936 (7.5%)
Dyslipidemia	859,039 (51.0%)	74,909 (47.2%)
Hypertension	1,158,703 (68.8%)	117,352 (73.9%)
Diabetes mellitus	507,708 (30.2%)	64,322 (40.5%)
Obesity	290,687 (17.3%)	25,048 (15.8%)
Heart failure	4,970 (0.3%)	1,537 (1.0%)
Coronary artery disease	517,329 (30.7%)	70,527 (44.4%)
Previous myocardial infarction	171,669 (10.2%)	23,708 (14.9%)
Previous percutaneous coronary intervention	203,338 (12.1%)	26,671 (16.8%)
Previous coronary artery bypass graft	119,016 (7.1%)	18,966 (11.9%)
Valvular heart disease	3,249 (0.2%)	661 (0.4%)
Atrial fibrillation	126,240 (7.5%)	23,445 (14.8%)
Previous stroke or transient ischemic attack	115,274 (6.9%)	18,500 (11.7%)
Peripheral vascular disease	78,112 (4.6%)	13,792 (8.7%)
Pulmonary circulatory disorders	1,416 (0.08%)	436 (0.27%)
Peptic ulcer disease	457 (0.03%)	53 (0.03%)
Chronic lung disease	312,936 (18.6%)	45,644 (28.8%)
Renal failure	139,623 (8.3%)	34,845 (22.0%)
Liver disease	37,176 (2.2%)	6,568 (4.1%)
Hypothyroidism	188,228 (11.2%)	19,742 (12.4%)
Fluid and electrolyte disorder	193,114 (11.5%)	28,098 (17.7%)
Anemia	153,569 (9.1%)	31,365 (19.8%)
Cancer	26,703 (1.6%)	7,235 (4.6%)
Depression	186,267 (11.1%)	23,196 (14.6%)
Dementia	49,153 (2.9%)	8,895 (5.6%)
Charlson comorbidity index	1.0±1.3 (n=1,683,489)	1.8±1.7 (n=158,781)
Hospital bed size		

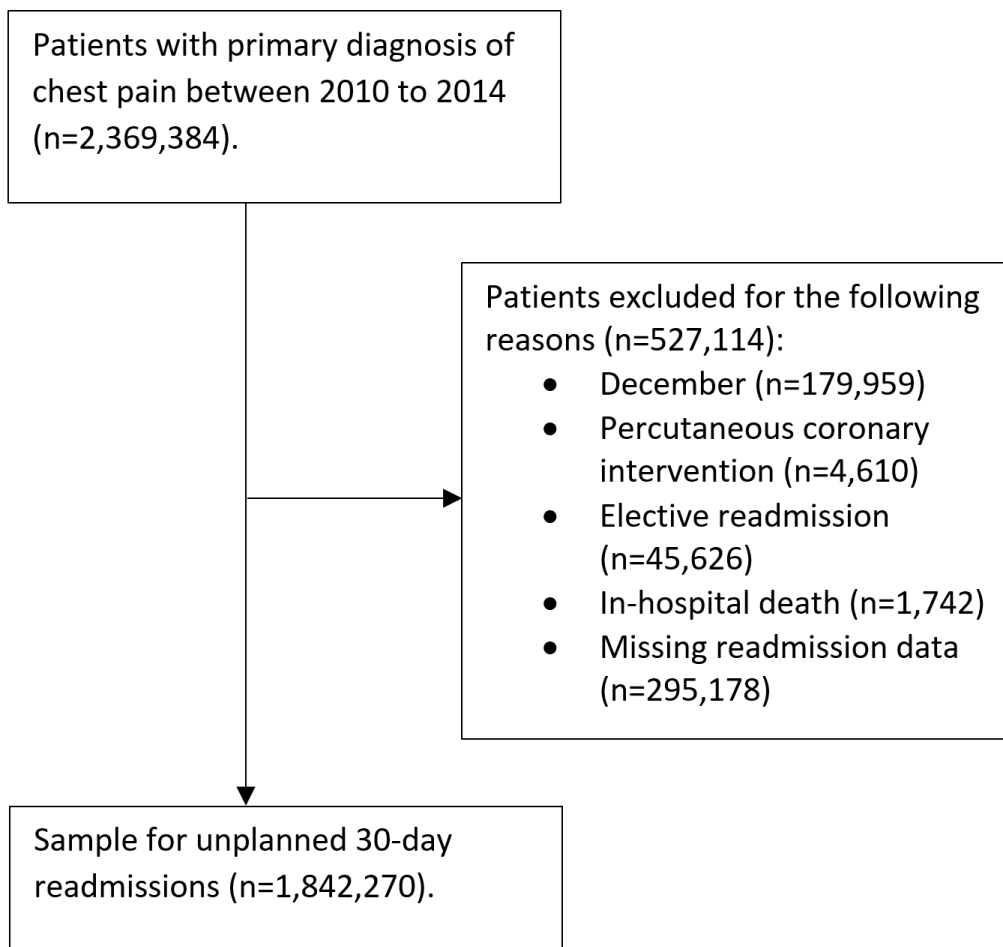|		
Small	155,053 (9.2%)	14,660 (9.2%)
Medium	412,715 (24.5%)	39,500 (24.9%)
Large	1,115,722 (66.3%)	104,621 (65.9%)
Urban hospital	129,948 (7.7%)	11,445 (7.2%)
Teaching hospital	749,142 (44.5%)	73,021 (46.0%)
Coronary angiogram	296,731 (17.6%)	18,438 (11.6%)
Echocardiogram	103,196 (6.1%)	7,731 (4.9%)
Stress test	106,121 (6.3%)	5,979 (3.8%)
Computed tomography thorax	25,751 (1.5%)	2,555 (1.6%)
Magnetic resonance imaging	361 (0.02%)	16 (0.01%)
Pulmonary scan	3,427 (0.2%)	463 (0.3%)
Radioisotope scan	4,619 (2.7%)	2,868 (1.8%)
Aortogram	19,667 (1.2%)	1,427 (0.9%)
Length of stay (days)	1.8±2.1 (n=1,683,452)	2.3±2.1 (n=158,781)
Cost (USD)	$5,301±4,245 (n=1,661,240)	$5,862±4,775 (n=156,505)
Discharge location		
Home/self-care	1,508,519 (89.7%)	117,687 (74.2%)
Transfer to other hospital	63,676 (3.8%)	15,804 (10.0%)
Care home	55,927 (3.3%)	15,395 (9.7%)
Discharge against medical advice	54,596 (3.2%)	9,801 (6.2%)

Table 2: Predictors of 30-day unplanned readmissions after admission for non-specific chest pain

Variable	Odds ratios (95% CI)	p-value
Age (per year)	0.99 (0.99-0.99)	<0.001
Female	0.84 (0.82-0.85)	<0.001
Weekend admission	1.03 (1.01-1.05)	0.009
Year vs 2010		
2011	1.00 (0.97-1.04)	0.84
2012	0.98 (0.94-1.02)	0.29
2013	0.99 (0.95-1.03)	0.70
2014	0.99 (0.95-1.04)	0.76
Primary expected payer vs Medicare		
Medicaid	1.05 (1.02-1.09)	0.001
Private	0.47 (0.46-0.49)	<0.001
Self-pay	0.55 (0.52-0.57)	<0.001
No charge	0.63 (0.56-0.70)	<0.001
Other	0.62 (0.59-0.65)	<0.001
Quartile of median household income vs 0-25th		
26th-50th	0.94 (0.92-0.97)	<0.001
51st-75th	0.92 (0.89-0.95)	<0.001
76th-100th	0.89 (0.87-0.92)	<0.001
Smoking	0.99 (0.97-1.02)	0.49
Alcohol misuse	1.74 (1.66-1.81)	<0.001
Dyslipidemia	0.78 (0.76-0.80)	<0.001
Hypertension	1.01 (0.99-1.04)	0.25
Diabetes mellitus	1.28 (1.25-1.30)	<0.001
Obesity	0.92 (0.89-0.94)	<0.001
Heart failure	1.33 (1.17-1.53)	<0.001
Coronary artery disease	1.35 (1.32-1.39)	<0.001
Previous myocardial infarction	1.04 (1.01-1.07)	0.012
Previous coronary artery bypass graft	1.12 (1.08-1.16)	<0.001
Valvular heart disease	1.12 (0.92-1.37)	<0.001
Atrial fibrillation	1.54 (1.50-1.59)	<0.001
Previous stroke or transient ischemic attack	1.20 (1.15-1.24)	<0.001
Peripheral vascular disease	1.20 (1.16-1.25)	<0.001
Pulmonary circulatory disorders	1.38 (1.10-1.74)	0.006
Peptic ulcer disease	0.97 (0.60-1.55)	0.89
Chronic lung disease	1.41 (1.34-1.48)	<0.001
Renal failure	1.82 (1.76-1.87)	<0.001
Liver disease	1.41 (1.39-1.45)	<0.001
Hypothyroidism	1.05 (1.02-1.09)	0.001
Fluid and electrolyte disorder	1.30 (1.27-1.34)	<0.001
Anemia	1.50 (1.46-1.55)	<0.001
Cancer	2.40 (2.27-2.53)	<0.001
Depression	1.23 (1.20-1.27)	<0.001
Dementia	1.12 (1.06-1.17)	<0.001
Hospital bed size vs small		
Medium	1.00 (0.95-1.04)	0.88
Large	1.03 (0.99-1.07)	0.21
Urban hospital	0.86 (0.82-0.90)	<0.001
Teaching hospital	1.02 (0.99-1.04)	0.25
Coronary angiogram	0.71 (0.69-0.76)	<0.001
Echocardiogram	0.84 (0.80-0.87)	<0.001
Stress test	0.72 (0.68-0.76)	<0.001

Computed tomography thorax	1.17 (1.08-1.26)	<0.001
Magnetic resonance imaging	0.59 (0.28-1.25)	0.17
Pulmonary scan	1.06 (0.89-1.26)	0.49
Radioisotope scan	0.89 (0.83-0.96)	0.002
Aortogram	1.07 (0.96-1.18)	0.21
Discharge location vs home/self-care		
Transfer to other hospital	2.01 (1.93-2.09)	<0.001
Care home	2.26 (2.18-2.34)	<0.001
Discharge against medical advice	1.94 (1.86-2.02)	<0.001

Figure 1: Flow diagram of patient inclusions

Patients with primary diagnosis of chest pain between 2010 to 2014 (n=2,369,384).

Patients excluded for the following reasons (n=527,114):
- December (n=179,959)
- Percutaneous coronary intervention (n=4,610)
- Elective readmission (n=45,626)
- In-hospital death (n=1,742)
- Missing readmission data (n=295,178)

Sample for unplanned 30-day readmissions (n=1,842,270).

Figure 2: Trends in admission for non-specific chest pain and rates of 30-day unplanned
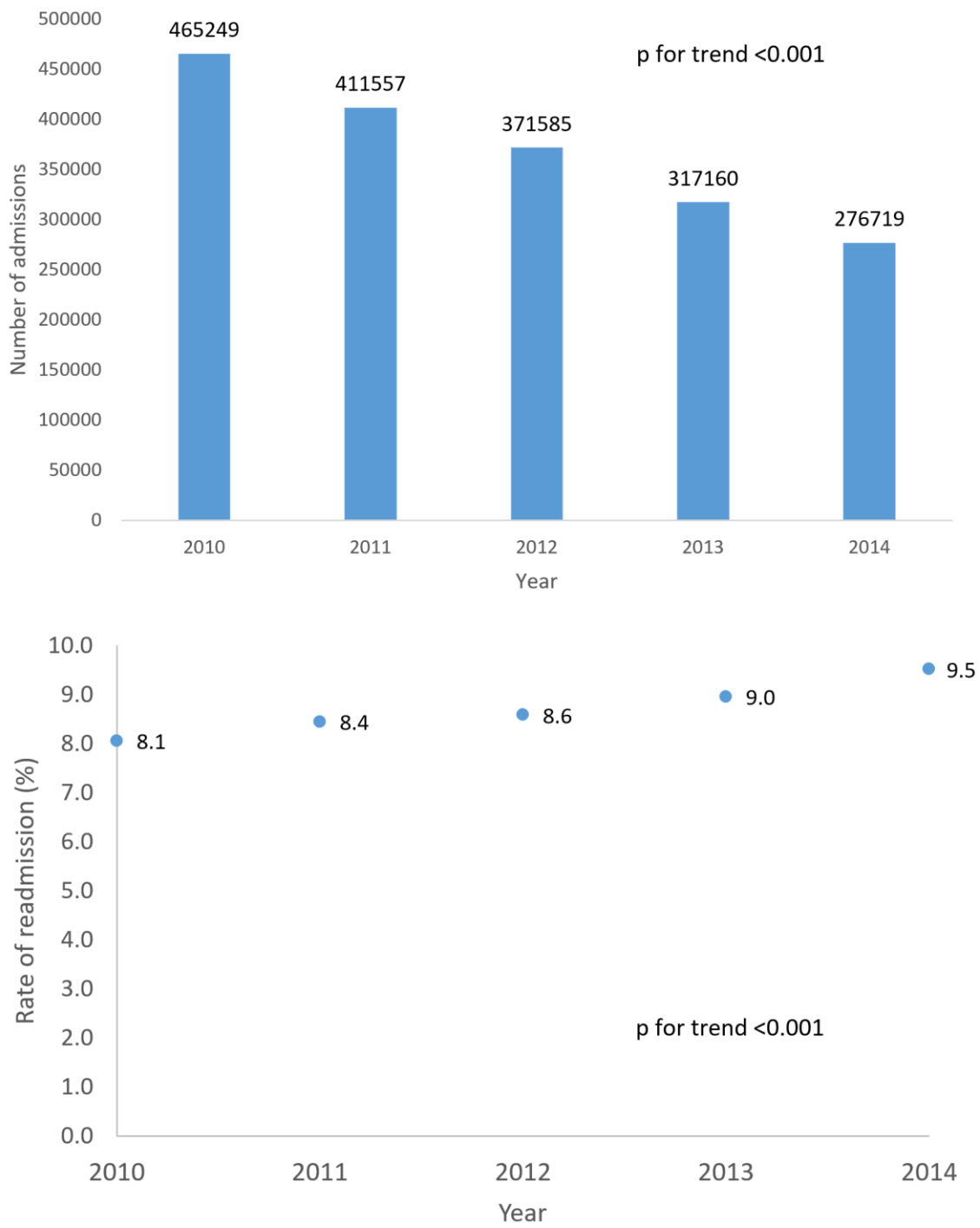
Figure 3: Causes of unplanned readmissions after admission for non-specific chest pain

Figure 4: Rate of cardiac and non-cardiac causes of unplanned readmissions after admission for non-specific chest pain according to receipt of investigation

Supplementary Table 1: Missing data (n=1,842,270)

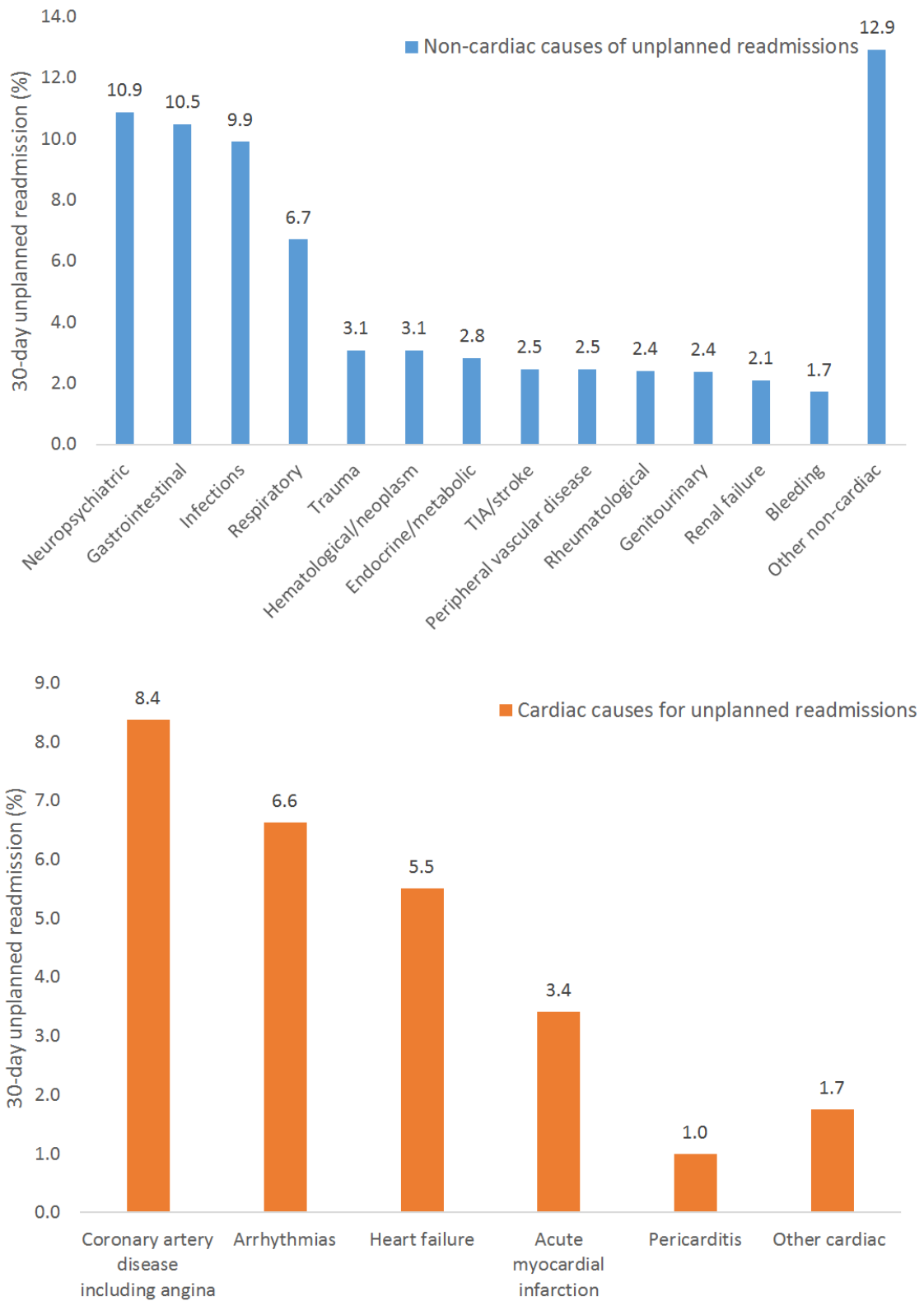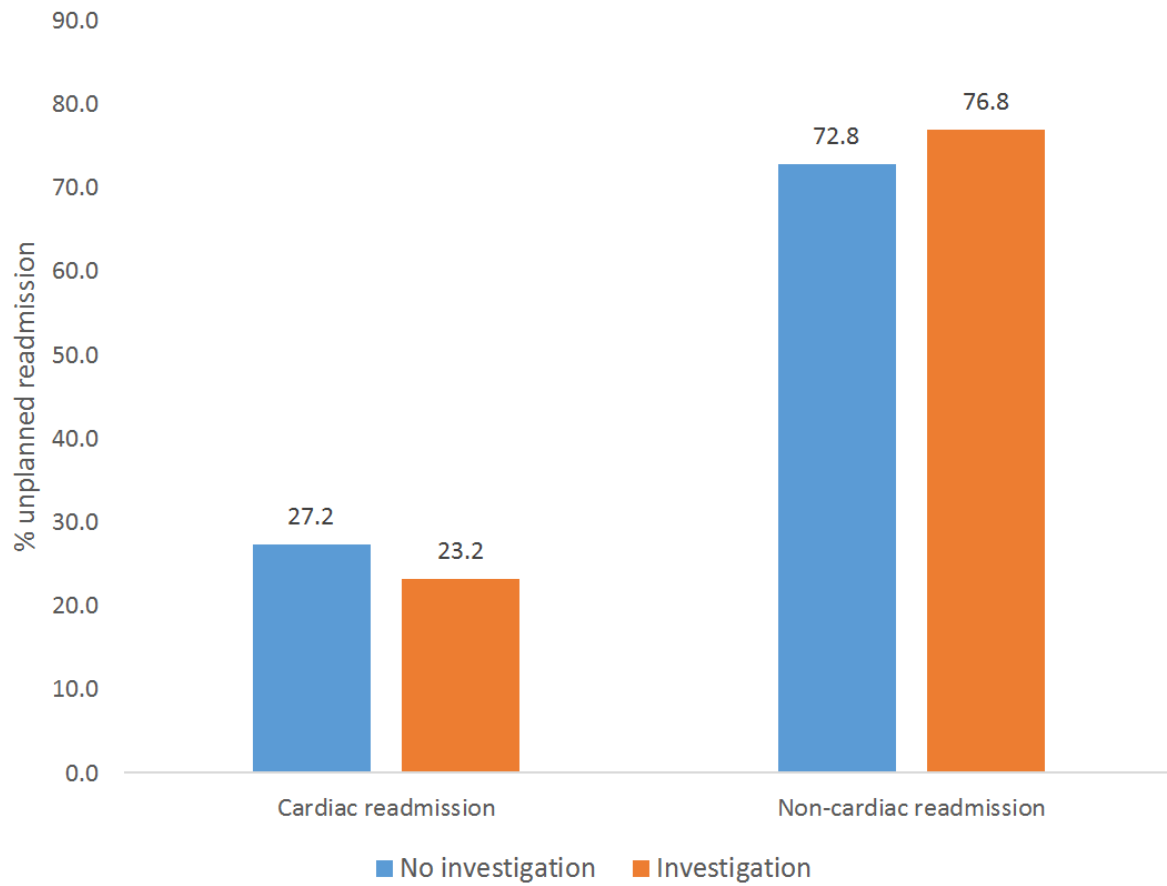| Variable	n	%
Age	2,559	0.14
Female	0	0
Weekend admission	11	0.001
Year	0	0
Primary expected payer	4,055	0.22
Quartile of median household income	34,368	1.87
Smoker	0	0
Alcohol misuse	0	0
Dyslipidemia	0	0
Hypertension	0	0
Diabetes mellitus	0	0
Obesity	0	0
Heart failure	0	0
Coronary artery disease	0	0
Previous myocardial infarction	0	0
Previous percutaneous coronary intervention	0	0
Previous coronary artery bypass graft	0	0
Valvular heart disease	0	0
Atrial fibrillation	0	0
Previous stroke or transient ischemic attack	0	0
Peripheral vascular disease	0	0
Pulmonary circulatory disorders	0	0
Peptic ulcer disease	0	0
Chronic lung disease	0	0
Renal failure	0	0
Liver disease	0	0
Hypothyroidism	0	0
Fluid and electrolyte disorder	0	0
Anemia	0	0
Cancer	0	0
Depression	0	0
Dementia	0	0
Charlson comorbidity index	0	0
Hospital bed size	0	0
Urban hospital	0	0
Teaching hospital	0	0
Coronary angiogram	0	0
Echocardiogram	0	0
Stress test	0	0
Computed tomography scan	0	0
Magnetic resonance imaging	0	00
Pulmonary scan	0	0
Radioisotope scan	0	0
Aortogram	0	0
Length of stay	37	0.002
Cost	24,525	1.3

Discharge location	0	0

Supplementary Table 2: Patient Characteristics for January to November compared to December

Variable	January to November (n=1,842270)	December only (n=115,927)
Age (year)	60±15 (n=1,839,710)	60±15 (n=115,756)
Female	1,012,251 (55.0%)	61,820 (53.3%)
Weekend admission	463,039 (25.1%)	29,397 (25.4%)
Year		
2010	465,249 (25.3%)	29,009 (25.0%)
2011	411,557 (22.4%)	27,422 (23.7%)
2012	371,585 (20.2%)	22,322 (19.3%)
2013	317,160 (17.2%)	18,751 (16.2%)
2014	276,719 (15.0%)	18,422 (15.9%)
Primary expected payer		
Medicare	774,427 (42.1%)	46,452 (40.2%)
Medicaid	298,037 (16.2%)	17,676 (15.3%)
Private	493,744 (26.9%)	33,411 (28.9%)
Self-pay	165,562 (9.0%)	11,384 (9.8%)
No charge	19,731 (1.1%)	1,265 (1.1%)
Other	86,715 (4.7%)	5,521 (4.8%)
Quartile of median household income		
0-25th	606,822 (33.6%)	36,710 (32.3%)
26th-50th	444,630 (24.6%)	27,281 (24.0%)
51st-75th	409,153 (22.6%)	26,413 (23.2%)
76th-100th	347,297 (19.2%)	35,030 (20.6%)
Smoker	565,315 (30.7%)	35,030 (30.2%)
Alcohol misuse	80,900 (4.4%)	4,630 (4.0%)
Dyslipidemia	933,948 (50.7%)	58,970 (50.9%)
Hypertension	1,276,055 (69.3%)	79,479 (68.6%)
Diabetes mellitus	572,030 (31.1%)	33,457 (28.9%)
Obesity	315,735 (17.1%)	19,199 (16.6%)
Heart failure	6,507 (0.4%)	279 (0.2%)
Coronary artery disease	587,856 (31.9%)	33,269 (28.7%)
Previous myocardial infarction	195,377 (10.6%)	10,612 (9.2%)
Previous percutaneous coronary intervention	230,009 (12.5%)	12,879 (11.1%)
Previous coronary artery bypass graft	137,982 (7.5%)	7,381 (6.4%)
Valvular heart disease	3,911 (0.2%)	178 (0.2%)
Atrial fibrillation	149,685 (8.1%)	8,301 (7.2%)
Previous stroke or transient ischemic attack	133,774 (7.3%)	7,027 (6.1%)
Peripheral vascular disease	91,904 (5.0%)	4,824 (4.2%)
Pulmonary circulatory disorders	1,852 (0.1%)	82 (0.1%)
Peptic ulcer disease	509 (0.03%)	25 (0.02%)
Chronic lung disease	358,580 (19.5%)	19,550 (16.9%)
Renal failure	174,468 (9.5%)	8,687 (7.5%)
Liver disease	43,744 (2.4%)	2,347 (2.0%)
Hypothyroidism	207,970 (11.3%)	12,434 (10.7%)
Fluid and electrolyte disorder	221,212 (12.0%)	13,046 (11.3%)
Anemia	184,934 (10.0%)	9,429 (8.1%)
Cancer	33,938 (1.8%)	1,954 (1.7%)
Depression	209,464 (11.4%)	11,610 (10.0%)
Dementia	58,048 (3.2%)	3,142 (2.7%)
Charlson comorbidity index	1.1±1.3 (n=1,842,270)	0.9±1.2 (n=115,927)
Hospital bed size		
Small	169,712 (9.2%)	10,696 (9.2%)

Medium	452,215 (24.6%)	28,829 (24.9%)
Large	1,220,343 (66.2%)	76,402 (65.9%)
Urban hospital	141,393 (7.7%)	8,009 (6.9%)
Teaching hospital	822,162 (44.6%)	51,685 (44.6%)
Coronary angiogram	315,169 (17.1%)	19,847 (17.1%)
Echocardiogram	110,927 (6.0%)	7,594 (6.6%)
Stress test	112,100 (6.1%)	7,151 (6.2%)
Computed tomography thorax	28,306 (1.5%)	1,845 (1.6%)
Magnetic resonance imaging	377 (0.02%)	30 (0.03%)
Pulmonary scan	3,890 (0.2%)	247 (0.2%)
Radioisotope scan	49,059 (2.7%)	3,114 (2.7%)
Aortogram	21,094 (1.1%)	1,215 (1.1%)
Length of stay (days)	1.8±2.1 (n=1,842,233)	1.7±2.7 (n=115,927)
Cost (USD)	$5,349±4,659 (n=1,817,745)	$5,348±4,347 (n=114,564)
Discharge location		
Home/self-care	1,626,206 (88.3%)	104,130 (89.9%)
Transfer to other hospital	79,479 (4.3%)	4,053 (3.5%)
Care home	71,322 (3.9%)	3,320 (2.9%)
Discharge against medical advice	64,397 (3.5%)	4,381 (3.8%)

Supplementary Table 3: Rate and causes of readmission by receipt of investigation

Rate	No investigation (n=1,455,566)	Investigation (n=386,703)
30-day unplanned readmission	135,112 (9.28%)	23,669 (6.12%)

Cause of readmission*	No investigation (n=98,240)	Investigation (n=18,167)
Neuropsychiatric	14,954 (11.08%)	2,299 (9.72%)
Gastrointestinal	13,824 (10.24%)	2,797 (11.83%)
Infections	13,358 (9.89%)	2,372 (10.03%)
Respiratory	8,925 (6.61%)	1,717 (7.26%)
Trauma	4,244 (3.14%)	658 (2.78%)
Hematological/neoplasm	4,176 (3.09%)	689 (2.92%)
Endocrine/metabolic	3,811 (2.82%)	676 (2.86%)
Peripheral vascular disease	3,082 (2.28%)	826 (3.50%)
Transient ischemic attack/stroke	3,171 (2.35%)	731 (3.09%)
Rheumatologically	3,160 (2.34%)	653 (2.76%)
Genitourinary	3,295 (2.44%)	461 (1.95%)
Renal failure	2,872 (2.13%)	438 (1.85%)
Bleeding	2,322 (1.72%)	404 (1.71%)
Other non-cardiac	17,046 (12.63%)	3,445 (14.57%)

Cause of readmission*	No investigation (n=36,774)	Investigation (n=5,479)
Coronary artery disease including angina	12,030 (8.91%)	1,258 (5.32%)
Acute myocardial infarction	4,916 (3.64%)	484 (2.05%)
Heart failure	7,662 (5.68%)	1,066 (4.51%)
Arrhythmias	8,792 (6.51%)	1,715 (7.25%)
Pericarditis	1,242 (0.92%)	329 (1.39%)
Other cardiac	2,132 (1.58%)	628 (2.66%)

Investigation defined as composite of coronary angiogram, computed tomography thorax, pulmonary scan, radioisotope scan, magnetic resonance imaging and aortogram.
*121 patients were not included in the analysis because of missing data for cause of readmission.

Supplementary Table 4: Rates and causes of readmission by previous coronary artery disease

Rate	No previous coronary artery disease (n=1,207,363)	Previous coronary artery disease (n=634,907)
30-day unplanned readmission	82,402 (6.82%)	76,379 (12.03%)

Cause of readmission*	No previous coronary artery disease (n=64,691)	Previous coronary artery disease (n=51,715)
Neuropsychiatric	11,233 (13.64%)	6,021 (7.89%)
Gastrointestinal	9,454(11.48%)	7,167 (9.39%)
Infections	8,660 (10.52%)	7,071 (9.26%)
Respiratory	5,539 (6.73%)	5,103 (6.69%)
Trauma	2,653 (3.22%)	2,249 (2.95%)
Hematological/neoplasm	2,991 (3.63%)	1,874 (2.46%)
Endocrine/metabolic	2,441 (2.96%)	2,046 (2.68%)
Peripheral vascular disease	1,925 (2.34%)	1,986 (2.60%)
Transient ischemic attack/stroke	1,915 (2.33%)	1,984 (2.60%)
Rheumatologically	2,155 (2.62%)	1,658 (2.17%)
Genitourinary	1,968 (2.39%)	1,788 (2.34%)
Renal failure	1,564 (1.90%)	1,747 (2.29%)
Bleeding	1,288 (1.56%)	1,438 (1.88%)
Other non-cardiac	10,906 (13.25%)	9,584 (12.56%)

Cause of readmission*	No previous coronary artery disease (n=17,644)	Previous coronary artery disease (n=24,610)
Coronary artery disease including angina	4,089 (4.97%)	9,199 (12.05%)
Acute myocardial infarction	2,021 (2.45%)	3,379 (4.43%)
Heart failure	3,313 (4.02%)	5,416 (7.10%)
Arrhythmias	5,466 (6.64%)	5,041 (6.60%)
Pericarditis	1,094 (1.33%)	477 (0.63%)
Other cardiac	1,662 (2.02%)	1,098 (1.44%)

Coronary artery disease defined by composite of previous coronary artery disease, previous myocardial infarction, previous percutaneous coronary intervention and previous coronary artery bypass graft.

*121 patients were not included in the analysis because of missing data for cause of readmission.

Supplementary Table 5: Sensitivity analysis of readmissions and predictors of readmission by age group

Variable	Age <55 years (n=728,094)	Age 55-64 years (n=444,112)	Age 65-74 years (n=321,847)	Age ≥75 years (n=345,658)
Rate of 30-day readmissions (%)	53,226 (7.3%)	36,386 (8.2%)	29,119 (9.1%)	39,895 (11.5%)
Non-cardiac causes for readmissions (%)	40,925 (76.9%)	26,521 (72.9%)	20,619 (70.8%)	28,078 (70.4%)
Predictors of readmission within age groups	Age <55 years	Age 55-64 years	Age 65-74 years	Age ≥75 years
Female	0.81 (0.78-0.83)	0.76 (0.73-0.79)	0.87 (0.83-0.92)	0.91 (0.87-0.95)
Weekend admission	1.06 (1.02-1.11)	1.04 (0.99-1.10)	1.01 (0.96-1.07)	0.98 (0.94-1.03)
Year vs 2010				
2011	1.02 (0.97-1.09)	1.01 (0.94-1.08)	0.97 (0.90-1.02)	0.99 (0.93-1.06)
2012	1.05 (0.99-1.11)	0.96 (0.90-1.03)	0.96 (0.89-1.04)	0.91 (0.86-0.99)
2013	1.08 (1.02-1.15)	0.96 (0.89-1.02)	0.95 (0.88-1.02)	0.94 (0.88-1.00)
2014	1.07 (1.00-1.14)	0.96 (0.90-1.04)	0.98 (0.91-1.08)	0.92 (0.86-0.99)
Primary expected payer vs Medicare				
Medicaid	0.89 (0.85-0.93)	1.07 (1.01-1.13)	1.21 (1.08-1.35)	0.94 (0.83-1.07)
Private	0.36 (0.34-0.38)	0.47 (0.44-0.50)	0.82 (0.75-0.89)	0.96 (0.86-1.07)
Self-pay	0.48 (0.45-0.51)	0.56 (0.51-0.61)	0.90 (0.69-1.17)	0.81 (0.61-1.09)
No charge	0.57 (0.50-0.65)	0.57 (0.45-0.71)	1.13 (0.48-2.66)	0.25 (0.06-1.12)
Other	0.54 (0.50-0.58)	0.57 (0.52-0.62)	0.72 (0.60-0.86)	0.88 (0.72-1.06)
Quartile of median household income vs 0-25th				
26th-50th	0.94 (0.89-0.98)	0.94 (0.89-1.00)	0.99 (0.92-1.05)	0.96 (0.91-1.00)
51st-75th	0.95 (0.90-0.99)	0.94 (0.89-1.00)	0.89 (0.83-0.95)	0.93 (0.88-0.98)
76th-100th	0.94 (0.89-1.00)	0.89 (0.83-0.95)	0.86 (0.80-0.92)	0.93 (0.88-0.98)
Smoking	1.00 (0.96-1.04)	0.98 (0.94-1.02)	1.04 (0.98-1.09)	0.96 (0.91-1.01)
Alcohol misuse	1.83 (1.73-1.94)	1.75 (1.62-1.89)	1.43 (1.26-1.63)	1.01 (0.82-1.24)
Dyslipidemia	0.77 (0.74-0.80)	0.76 (0.73-0.80)	0.77 (0.73-0.81)	0.82 (0.79-0.85)
Hypertension	1.03 (1.00-1.07)	0.97 (0.93-1.02)	0.92 (0.87-0.97)	0.93 (0.88-0.98)
Diabetes	1.35 (1.03-1.40)	1.18 (1.13-1.24)	1.28 (1.22-1.34)	1.21 (1.16-1.26)
Obesity	0.92 (0.88-0.96)	0.92 (0.87-0.98)	0.90 (0.84-0.97)	1.00 (0.92-1.08)
Heart failure	1.35 (1.03-1.78)	1.71 (1.32-2.21)	1.34 (1.00-1.80)	1.16 (0.93-1.44)
Coronary artery disease	1.43 (1.36-1.51)	1.33 (1.26-1.41)	1.37 (1.29-1.45)	1.19 (1.13-1.24)

Previous myocardial infarction	0.99 (0.93-1.05)	1.07 (1.00-1.14)	0.97 (0.91-1.04)	1.05 (1.00-1.12)
Previous percutaneous coronary intervention	1.18 (1.11-1.30)	1.15 (1.08-1.23)	1.02 (0.95-1.09)	1.03 (0.97-1.09)
Previous coronary artery bypass	1.20 (1.11-1.30)	1.23 (1.14-1.32)	1.10 (1.03-1.18)	1.08 (1.02-1.14)
Valvular heart disease	1.82 (1.26-2.46)	0.87 (0.50-1.50)	1.49 (0.97-2.28)	0.91 (0.68-1.21)
Atrial fibrillation	1.60 (1.47-1.74)	1.70 (1.58-1.83)	1.57 (1.48-1.68)	1.45 (1.39-1.51)
Previous stroke or transient ischemic attack	1.33 (1.24-1.43)	1.17 (1.09-1.26)	1.23 (1.14-1.31)	1.07 (1.01-1.13)
Peripheral vascular disease	1.33 (1.21-1.45)	1.22 (1.12-1.33)	1.20 (1.11-1.30)	1.16 (1.09-1.23)
Pulmonary circulatory disorders	1.81 (1.22-2.69)	2.11 (1.26-3.53)	0.77 (0.44-1.36)	1.18 (0.76-1.84)
Peptic ulcer disease	1.43 (0.55-3.70)	1.04 (0.40-2.72)	0.62 (0.24-1.57)	0.69 (0.29-1.68)
Chronic lung disease	1.36 (1.30-1.42)	1.47 (1.40-1.54)	1.54 (1.46-1.62)	1.32 (1.26-1.39)
Renal failure	2.29 (2.16-2.44)	2.00 (1.88-2.13)	1.78 (1.67-1.91)	1.45 (1.38-1.52)
Liver disease	1.42 (1.31-1.54)	1.37 (1.26-1.50)	1.19 (1.04-1.37)	1.45 (1.20-1.74)
Hypothyroidism	1.13 (1.06-1.21)	1.03 (0.96-1.11)	1.01 (0.95-1.08)	1.03 (0.98-1.09)
Fluid and electrolyte disorder	1.25 (1.20-1.32)	1.28 (1.21-1.36)	1.30 (1.22-1.39)	1.32 (1.25-1.39)
Anemia	1.54 (1.46-1.63)	1.61 (1.51-1.71)	1.52 (1.43-1.61)	1.37 (1.30-1.44)
Cancer	3.42 (3.01-3.88)	2.85 (2.55-3.18)	2.38 (2.14-2.65)	1.76 (1.60-1.94)
Depression	1.42 (1.36-1.49)	1.15 (1.08-1.22)	1.17 (1.09-1.26)	1.04 (0.98-1.11)
Dementia	1.05 (0.68-1.61)	1.03 (0.83-1.28)	1.20 (1.07-1.35)	1.09 (1.03-1.16)
Hospital bed size vs small				
Medium	1.08 (1.00-1.16)	1.03 (0.95-1.12)	0.93 (0.85-1.03)	0.93 (0.86-1.01)
Large	1.12 (1.01-1.16)	1.07 (0.98-1.16)	0.93 (0.85-1.01)	0.98 (0.91-1.05)
Urban hospital	0.80 (0.76-0.88)	0.85 (0.79-0.92)	0.85 (0.78-0.93)	0.91 (0.85-0.99)
Teaching hospital	1.04 (0.99-1.08)	1.01 (0.96-1.06)	0.98 (0.93-1.04)	1.00 (0.95-1.04)
Coronary angiogram	0.74 (0.71-0.79)	0.69 (0.64-0.74)	0.66 (0.61-0.71)	0.75 (0.69-0.81)
Echocardiogram	0.85 (0.82-0.95)	0.84 (0.77-0.91)	0.80 (0.71-0.89)	0.85 (0.78-0.93)
Stress test	0.69 (0.65-0.78)	0.70 (0.63-0.79)	0.72 (0.64-0.82)	0.80 (0.72-0.90)
Computed tomography thorax	1.22 (1.01-1.28)	1.23 (1.06-1.44)	1.09 (0.89-1.33)	1.09 (0.91-1.29)
Magnetic resonance imaging	0.97 (0.39-2.43)	0.48 (0.08-2.98)	-	0.33 (0.04-2.69)
Pulmonary scan	1.18 (0.87-1.60)	1.06 (0.75-1.51)	0.89 (0.57-1.39)	1.02 (0.72-1.43)
Radioisotope scan	0.87 (0.76-1.00)	0.90 (0.77-1.05)	0.96 (0.81-1.14)	0.83 (0.72-0.95)
Aortogram	1.03 (0.86-1.24)	1.11 (0.90-1.35)	0.99 (0.77-1.27)	1.17 (0.93-1.47)
Discharge location vs home/self-care				
Transfer to other hospital	1.95 (1.78-2.14)	1.83 (1.68-2.00)	2.12 (1.95-2.31)	2.00 (1.88-2.13)

Care home	2.49 (2.25-2.75)	2.30 (2.09-2.53)	2.52 (2.33-2.73)	2.01 (1.91-2.12)
Discharge against medical advice	2.05 (1.94-2.17)	1.86 (1.71-2.02)	1.69 (1.50-1.91)	1.61 (1.40-1.85)