Relation Between Age and Unplanned Readmissions After Percutaneous Coronary Intervention (Findings From The Nationwide Readmission Database)

Running title: Age and unplanned readmission in PCI

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Abstract

It is unclear how age affects rates and causes of unplanned early readmissions following percutaneous coronary intervention (PCI). We analyzed patients in the Nationwide Readmission Database in the United States between 2010 and 2014 and examine the impact of age on readmissions after PCI. The primary outcomes were age specific 30-day rates and causes of unplanned readmissions. A total of 2,294,345 procedures were analyzed with a 9.6% unplanned readmission rate within 30 days. Unplanned readmissions were 8.1%, 8.1%, 9.5% and 12.6% for age groups <55, 55-64.9, 65-74.9 and ≥75 years, respectively. With increasing age there was an increase in the rate of non-cardiac causes for readmissions (for ages <55, 55-64.9 and ≥75 years, rates were 54.1%, 54.8%, 56.6% and 57.1% respectively p<0.001). Older age was associated with an increased prevalence of infections (13.9% ≥75 years vs 7.7% <55 years), gastrointestinal disease (11.5% ≥75 years vs 9.5% <55 years) and bleeding (7.4% ≥75 years vs 2.9% <55 years) as causes for non-cardiac readmissions and a reduced prevalence of non-specific chest pain (9.9% ≥75 years vs 31.4% <55 years). For cardiac causes, older age was associated with increased prevalence for readmissions due to heart failure (34.6% ≥75 years vs 11.9% <55 years) but a reduced prevalence of coronary artery disease including angina (25.7% ≥75 years vs 51.3% <55 years). In conclusion, older patients have the highest rates of unplanned 30-day readmissions following PCI, with different causes for readmission compared to younger patients. Interventions designed to reduce readmissions after PCI should be age-specific.

Introduction

Percutaneous coronary intervention (PCI) is one of the most common interventional procedures undertaken in hospitals[1] with over 600,000 procedures performed annually in the United States alone.[2] PCI has evolved to be safe, with declining rates of complications, despite the increasing average age of populations undergoing PCI.[3] Compared to younger patients, elderly patients have more multi-vessel disease,[4] calcific disease[5] and a greater prevalence of comorbidities and frailty known to adversely impact PCI outcomes.[6,7] Unplanned early readmissions are common amongst older patients for all-cause hospital admissions but data are more limited in the PCI setting.[8] For example, whilst age has been reported to be associated with increased readmission following PCI[9] this is not consistent across the literature.[10-11] Older patients also have a greater burden of comorbidities and we have previously reported that more than half of all causes for readmission are due to non-cardiac reasons.[12,13] To date, there has been no previous study that specifically evaluates the impact of age on early unplanned readmissions in patients who undergo PCI, or whether the causes of unplanned readmissions differ by age. We have therefore used data from the National Readmission Database to evaluate temporal trends, clinical predictors, causes and outcomes for 30-day unplanned readmissions in different age groups in over 2 1/2 million patients who underwent PCI in the United States.

Methods

The Agency for Healthcare Research and Quality (AHRQ) has developed the Nationwide Readmission Database (NRD), which is part of the Healthcare Cost and Utilization Project (HCUP). This database is a publicly available database of all-payer hospital inpatient stays, which is derived from State Inpatient Databases which contains a unique patient number which can be used to track patients across different hospitals within a State and adhering to privacy guidelines in the USA. The data are derived from 21 states that are geographically dispersed and accounts for approximately 49% of the total US resident population and approximately 49% of hospitalization. National estimates can be estimated from discharge weights.

Men and women age 18 years or greater who underwent PCI between 2010 and 2014 were included in the analysis. PCI was defined by the International Classification of Disease - 9th Clinical Modification (ICD-9) procedural code 00.66, 36.06 and 36.07.[12,13] The first PCI was defined by the first PCI procedure within a calendar year. Age groups were defined by <55 years, 55-64.9 years, 65-74.9 years and ≥75 years. Patients who were discharged in the

month of December were excluded because they would not have 30-day follow up for readmissions, as individuals cannot be tracked across years. We excluded patients who had an elective readmission (i.e. pre-planned) which was defined by the ELECTIVE variable in the NRD dataset which indicates whether the admission to hospital was elective.

The data collection is described in detail in the Supplementary Data. Causes of 30-day readmission were determined from the first diagnostic Clinical Classification Software codes (Supplementary Table 1). Statistical analysis was performed on Stata 14.0 (College Station, Texas, USA). A flow diagram was used to illustrate participants included in the analysis and those that were excluded because they were discharged in the month of December (patients discharged in month of December may not have had 30-days of follow up in the annual records of the NRD), died during index admission and those with elective readmission. The proportion of PCI cases performed in each age group and the rates of unplanned readmission and in-hospital mortality for each age group were reported graphically. Descriptive statistics were used to compare patients who were readmitted and non-readmitted within each age categories. Statistical differences between groups for continuous variables were tested using the t-test and for categorical variables the Chi^2 test. The survey estimation command was used for all analyses as recommended by AHRQ in order to take into account the complex survey design of the NRD database. Multiple logistic regressions were used to determine the independent effect of age in the pre-defined age groups on unplanned readmission. The regression models included adjustment for all demographic, comorbidities, hospital-related, procedural and outcomes variables.

Results

Between 2010 and 2014 there were 2,576,141 admissions for PCI and 9.6% were an unplanned readmission within 30 days (Figure 1). The proportion of total PCI procedures undertaken in the elderly (≥75 years) was nearly 24% during the years that this study took place. Unplanned readmissions remained fairly constant among the oldest (≥75 years) age group at 12.6% (Figure 2). Rates of unplanned readmissions among patients in the 2 younger age categories declined over time.

The characteristics of readmitted patients stratified by age are shown in Table 1 and Supplementary Table 2. Across all age groups, women and patients undergoing non-elective procedures were more likely to be readmitted and in general, comorbidities were more common in the readmission group. Similarly, in-hospital adverse outcomes at the index procedure were also more common among patients that were readmitted. The cost of index

PCI was higher in the group that was readmitted compared to those who were not readmitted. Unplanned readmissions less frequently had a diagnosis of acute myocardial infarction (AMI) in the 2 younger age groups whilst in the older cohorts, the rates of AMI were greater in the readmitted group. For discharge location, patients with an unplanned readmission had lower rates of discharge to home compared to non-readmitted patients across all age groups.

Table 2 shows mortality rates during readmission, the length of stay and cost associated with the readmission for each of the age categories. Older age was associated with greater mortality, length of stay and cost during the readmission episode.

The independent predictors of readmission within each age group are shown in Table 3 and Supplementary Table 3. Female sex, diabetes, atrial fibrillation, previous stroke/TIA, chronic lung disease, renal failure, liver failure and depression were all independently associated with greater odds of readmission across all age groups. Smoking was associated with reduced odds for readmission in the youngest age groups. Hypertension and previous CABG were associated with greater odds of readmission for the younger age groups but not in the oldest age group. Use of drug eluting stent and receipt of emergency CABG was associated with a reduction in odds for readmission for all age groups. Discharge location influenced readmissions as transfer to another hospital, to a care home or left against medical advice or discontinued care independently increased the odds of readmission. The comparison of causes of readmission by age group are shown in Table 4. With increasing age, an increase in non-cardiac causes for readmissions (Figure 3). For cardiac causes, the most common diagnoses were coronary artery disease including angina and acute myocardial infarction in the two younger age groups, whilst in older patients heart failure was the most common cause of cardiac readmission. For non-cardiac causes, non-cardiac chest pain was most common in youngest age group. Infection and gastrointestinal causes were the most common readmit diagnoses for patient ≥75 years. We performed an additional review of codes to evaluate the nature of the gastrointestinal causes that accounted for the unplanned readmission (Supplementary Table 4) and found that 28.4% were caused by gastrointestinal bleeding; other conditions such as non-specific GI symptoms, oesophageal disease and cholecystitis, gallbladder disease and bile duct disease were other common causes.

Discussion

Our study of over 2 million patients who underwent PCI in the nationally representative database in the US has shown age-related differences in both temporal trends, predictors, causes and outcomes for unplanned 30-day readmission following PCI. For the first time, we show that unplanned readmission rates, highest among older people (12.6%),

have remained relatively static over time, whilst rates of unplanned readmissions have declined in younger patients. Several factors including gender and comorbidities were independently associated with increased readmissions across all age groups. The causes for unplanned readmission following PCI appear to differ according to the age group studied, with an increase in non-cardiac causes for readmission observed with increasing age. Younger patients were more likely to be readmitted for coronary artery disease including angina, acute myocardial infarction and non-cardiac chest pain whilst older patients have a greater prevalence of readmissions due to heart failure, infections and gastrointestinal causes, particularly gastrointestinal bleeding events. These findings suggest that measures designed to reduce readmissions in PCI should be age-specific.

We observe that older patients represent the highest proportion of patients that are readmitted, but do not observe a decline in readmission rates over time as observed in the younger age groups. The reason for this observation is likely to be multifactorial. First, older people patients may have more complex and extensive coronary disease, burden of comorbidity and greater prevalence of frailty. While cardiac care for heart conditions may be standardized for patients from all age groups, the needs of older people may not be fully addressed prior to discharge leading to an early readmission. Secondly, older people may also require care in the community and if these are not sufficiently in place they may be readmitted. Interestingly a phenomenon, termed "post-hospital syndrome" has described a transient period of increased susceptibility to a range of adverse health events that older patients seem to experience which may be secondary to the stress of hospital admission.[14] This stress may reduce a patients' natural reserve and increase their vulnerability to a range of illness and conditions leading to readmission. Physician related factors might have contributed to our findings. A previous study suggests that primary care physicians find the care of older patients difficult because of their medical complexity and chronicity, and increased vulnerability to adverse events[15] and may lower their threshold to send elderly patients to hospital. Additionally, older patients have greater care needs because of their frailty and impaired mobility or self-care.[16] If these care needs were not adequately addressed, elderly patients may be readmitted for welfare and safety concerns.

Older people were more likely to be readmitted for infection and gastrointestinal disease. It has been reported that aging is accompanied by a gradual decline of the immune system, which may increase the propensity for infections.[17,18] For gastrointestinal causes of readmission, our detailed analysis of specific causes revealed that more than 1 in 4 were due to bleeding in the gastrointestinal tract. This is likely due to dual antiplatelet therapy

following PCI, and age is an important contributor to the risk of bleeding,[19-22] as well as other GI symptoms such as heartburn and indigestions which may raise concern for atypical ischemic chest pain symptoms which are not uncommon in older patients thus leading to an unplanned readmission.

Our results suggest that there may be potential for reduction in readmissions by tailoring discharge strategies according to age group. One previous study has shown that post-PCI readmissions could be reduced with an intervention involving patient education videos, scheduled follow-up clinic appointments and automated notification to cardiologists when their patient presents to the emergency department,[23] but it is unclear if the efficacy of this intervention was limited to certain age groups and was more effective in reducing certain causes of readmission. We found that younger patients have more admissions related to non-cardiac chest pain. Prior to discharge these patients may be educated about chest pain symptoms. Perhaps future chest pain pathways could be developed in emergency departments to better facilitate rapid management, thus avoiding admission. We have shown that older patients have more readmissions related to comorbidities and greater effort to manage comorbidities during index PCI may reduce readmissions. Use of a discharge checklist to review the management of common comorbidities such as blood sugar control in diabetes or renal function in chronic kidney disease may reduce readmission. In addition, pathways could be developed to include input from other non-cardiac specialists during the inpatient stay or early outpatient follow-up in the community. Older patients may benefit from comprehensive geriatric assessment as this multidimensional assessment includes evaluation of physical symptoms, mental health symptoms, social support network available, living environment, level of participation and individual concern and the compensatory mechanisms and resourcefulness of the individual to respond to frailty.[24] Research has shown that this improves independence, survival and cognition and reduce likelihood of institutionalization.[24] This is important as the additional cost of increased length of stay to manage comorbid conditions in the older people may reduce the expenditure related to readmissions.

Survivorship is an important factor influencing the observations in the current study. Mortality within 30-days of PCI that occurs outside of hospital settings is not captured in the dataset which may lead to an under estimation of readmissions. The post discharge mortality rates of elderly patients who frailer and more comorbid will be greater compared to the lower risk younger patients, leading to under-estimation of readmissions related to comorbidities in the elderly. In addition, the prognostic impact of a major PCI complication may relate to age, result in different mortality rates depending on the age of patient. For example, a post-

procedural stroke or major bleed in an elderly patient may lead to death whilst in a younger patient they may survive the complication and be readmitted for management of the complication. This may lead to fewer readmissions in elderly patients for serious complications in comparison to those for younger patients, biasing readmission rates and / or causes of readmission.

Our study has several strengths. First, this is the largest study to date of readmissions after PCI, which enables sufficient sample size to consider age groups individually. Secondly, the Nationwide Readmission Database is 99% complete for the variables in the current study. The data is designed to be generalizable to hospitals in the United States rather than specific to a geographic area. Finally, we were able to consider the effect of a variety of patient characteristics, hospital-related, PCI-related and outcome-related variables and how they influence readmission rates.

Our study has a few limitations. Firstly, the data is derived from five unique datasets corresponding to each year period between 2010 to 2014 so there is no possible linkage between years. In order to ensure adequate 30-day follow up therefore patients discharged in the month of December were excluded. Secondly, the database does not capture data regarding medications, which may influence complications after PCI. Third, the present analysis is retrospectively collected data from administrative claims from 21 states where regional heterogeneity could not be explored. However, such random variation would not influence the overall results. In addition, we cannot exclude possible bias from coding errors and we had to use the primary discharge diagnosis code for cause of readmissions which may be subject to bias.

In conclusion, our results demonstrate that older people are at high risk of early readmission after PCI. For the first time, we show that causes of readmission are specific to age groups in PCI, and older patients are more likely to be readmitted for heart failure, infections and gastrointestinal disease, the most common of which was gastrointestinal bleeding. These findings suggest that interventions to reduce readmissions should be tailored according to the age of patients. Given that older people has various needs in addition to medical care, whether a model of comprehensive geriatric assessment instituted in PCI setting would prevent unplanned readmissions and related adverse outcomes among older patients requires further investigation.

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Supplementary Table 4: Causes of gastrointestinal readmission in the older people

Table 1: Key patient characteristics according to readmission status and age group

Variable	Age group <55 years			Age group 55-64.9 years			65-74.9 years			≥75 years		
	Not readmitted	Readmitted	p-value	Not readmitted	Readmitted	p-value	Not readmitted	Readmitted	p-value	Not readmitted	Readmitted	p-value
Women, %	24.1%	32.9%	<0.001	27.0%	34.5%	<0.001	33.3%	39.6%	<0.001	43.3%	48.2%	<0.001
Year			<0.001			<0.001			<0.001			0.4
2010	22.1%	23.4%		21.7%	22.4%		21.9%	21.8%		21.9%	21.5%	
2011	20.6%	21.4%		20.3%	21.0%		20.2%	21.0%		20.5%	20.9%	
2012	19.0%	19.3%		19.1%	18.9%		19.2%	18.7%		19.1%	19.3%	
2013	19.6%	19.1%		19.7%	19.6%		20.3%	19.5%		20.1%	20.0%	
2014	18.7%	16.8%		19.2%	18.0%		18.4%	19.0%		18.4%	18.3%	
Elective	10.9%	7.8%	<0.001	15.3%	10.2%	<0.001	20.9%	13.3%	<0.001	20.1%	12.6%	<0.001
Weekend	23.4%	23.6%	0.57	20.9%	21.8%	0.002	18.5%	20.6%	<0.001	18.8%	21.2%	<0.001
Diagnosis of acute myocardial infarction	63.7%	56.4%	<0.001	53.8%	50.4%	<0.001	44.8%	47.1%	<0.001	44.9%	50.4%	<0.001
Primary expected payer			<0.001			<0.001			<0.001			<0.001
Medicare	10.8%	20.6%		18.6%	30.4%		83.5%	85.8%		93.0%	93.8%	
Medicaid	15.0%	22.4%		11.3%	17.2%		2.0%	2.5%		1.3%	1.2%	
Private	51.5%	36.4%		54.5%	38.8%		12.5%	9.8%		4.5%	3.8%	
Uninsured	15.0%	12.9%		8.1%	6.9%		0.4%	0.3%		0.2%	0.2%	
No charge	1.9%	2.0%		1.2%	1.1%		0.03%	0.04%		0.02%	0.02%	
Other	5.8%	5.7%		6.3%	5.7%		1.6%	1.6%		1.0%	0.9%	
Median household income (percentile)			<0.001			<0.001			<0.001			0.23
0-25th	30.5%	34.5%		28.8%	32.7%		28.8%	31.0%		26.8%	27.0%	
26-50th	25.5%	26.4%		25.1%	25.4%		25.2%	25.3%		25.3%	25.0%	
51-75th	23.9%	21.9%		24.1%	23.2%		23.9%	23.1%		24.2%	24.6%	
76-100th	20.1%	17.2%		22.1%	18.8%		22.1%	20.7%		23.8%	23.4%	
Smoker	56.9%	54.8%	<0.001	46.9%	46.0%	0.008	37.0%	37.7%	0.029	25.8%	26.6%	0.003
Alcohol misuse	4.5%	5.3%	<0.001	3.4%	4.0%	<0.001	1.9%	2.3%	<0.001	0.8%	0.9%	0.094
Dyslipidemia	68.9%	66.3%	<0.001	72.5%	68.5%	<0.001	74.1%	70.3%	<0.001	70.5%	67.5%	<0.001
Hypertension	65.6%	70.9%	<0.001	73.3%	77.3%	<0.001	77.9%	80.1%	<0.001	79.8%	80.7%	<0.001
Diabetes mellitus	31.2%	42.1%	<0.001	37.3%	48.5%	<0.001	40.3%	49.2%	<0.001	34.4%	38.5%	<0.001
Obesity	20.9%	22.2%	<0.001	18.4%	19.9%	<0.001	15.5%	17.3%	<0.001	8.5%	8.6%	0.41
Heart failure	0.7%	1.2%	<0.001	1.1%	2.2%	<0.001	1.7%	2.9%	<0.001	2.4%	3.0%	<0.001
Known coronary artery disease	92.2%	92.6%	0.044	94.0%	94.2%	0.21	95.2%	94.8%	0.014	95.0%	94.3%	<0.001
Previous myocardial infarction	12.9%	15.7%	<0.001	14.2%	16.2%	<0.001	14.7%	15.7%	<0.001	14.5%	15.0%	0.023
Previous percutaneous coronary intervention	17.4%	20.6%	<0.001	20.8%	22.2%	<0.001	22.6%	22.0%	0.053	22.3%	21.1%	<0.001
Previous coronary artery bypass graft	3.6%	5.6%	<0.001	6.5%	8.3%	<0.001	9.6%	10.8%	<0.001	10.8%	10.7%	0.66
Previous valve disease	0.1%	0.3%	<0.001	0.3%	0.5%	<0.001	0.5%	0.8%	<0.001	0.9%	1.2%	<0.001
Atrial fibrillation	3.1%	4.8%	<0.001	6.8%	10.9%	<0.001	12.5%	19.1%	<0.001	22.0%	29.4%	<0.001
Previous transient ischemic attack/stroke	3.3%	6.2%	<0.001	5.4%	9.1%	<0.001	7.5%	10.7%	<0.001	10.2%	11.9%	<0.001
Peripheral vascular disease	4.7%	7.9%	<0.001	8.8%	13.6%	<0.001	13.2%	18.2%	<0.001	16.4%	19.7%	<0.001
Pulmonary circulatory disorder	0.1%	0.2%	0.001	0.2%	0.4%	<0.001	0.3%	0.6%	<0.001	0.5%	0.6%	0.008
Peptic ulcer disease	0.01%	0.01%	0.82	0.02%	0.03%	0.34	0.03%	0.02%	0.69	0.04%	0.04%	0.68
Chronic lung disease	11.1%	17.9%	<0.001	15.5%	23.9%	<0.001	18.8%	28.0%	<0.001	18.3%	24.9%	<0.001
Renal failure	5.8%	13.3%	<0.001	9.1%	19.4%	<0.001	14.2%	25.0%	<0.001	21.5%	29.9%	<0.001
Liver disease	1.4%	2.4%	<0.001	1.7%	2.9%	<0.001	1.1%	1.9%	<0.001	0.6%	0.9%	<0.001
Hypothyroidism	4.4%	6.0%	<0.001	6.8%	8.5%	<0.001	9.8%	11.6%	<0.001	14.9%	16.9%	<0.001
Fluid and electrolyte disorders	10.2%	15.7%	<0.001	10.8%	18.0%	<0.001	11.9%	19.1%	<0.001	15.0%	20.5%	<0.001
Anemia	5.7%	11.9%	<0.001	7.6%	15.7%	<0.001	10.7%	20.0%	<0.001	16.4%	24.1%	<0.001
Cancer	0.6%	1.2%	<0.001	1.3%	2.2%	<0.001	2.1%	3.4%	<0.001	2.7%	3.6%	<0.001
Depression	6.7%	11.3%	<0.001	7.1%	10.2%	<0.001	6.1%	8.9%	<0.001	5.5%	6.9%	<0.001
Dementia	0.1%	0.1%	0.011	0.3%	0.6%	<0.001	1.3%	2.5%	<0.001	5.8%	7.9%	<0.001
Charlson comorbidity index	0.8±1.1	1.3±1.5	<0.001	1.1±1.3	1.7±1.6	<0.001	1.4±1.5	2.0±1.7	<0.001	1.6±1.5	2.0±1.7	<0.001

Mean number of comorbidities	4.3±1.9	5.0±2.1	<0.001	4.7±2.0	5.4±2.2	<0.001	5.0±2.1	5.7±2.3	<0.001	5.1±2.1	5.6±2.2	<0.001
Bed size			<0.001			<0.001			<0.001			<0.001
Small	5.5%	4.7%		5.6%	4.4%		5.8%	5.2%		6.0%	5.4%	
Medium	21.3%	21.0%		20.7%	20.5%		20.5%	20.4%		20.3%	20.6%	
Large	73.1%	74.3%		73.7%	75.1%		73.6%	74.4%		73.8%	74.0%	
Location			0.34			0.013			0.62			0.75
Rural	0.2%	0.2%		0.2%	0.1%		0.2%	0.2%		0.2%	0.2%	
Urban	99.8%	99.8%		99.8%	99.9%		99.8%	99.8%		99.8%	99.8%	
Teaching status		<0.001				0.65			0.007	Teaching status		0.001
Nonteaching	44.4%	45.0%		44.1%	44.2%		45.5%	46.4%		47.2%	48.2%	
Teaching status	55.6%	55.0%		55.9%	55.8%		54.5%	53.6%		52.8%	51.8%	
Discharged location			<0.001			<0.001			<0.001			<0.001
Home (self-care)	95.6%	91.0%		93.5%	86.6%		89.0%	78.4%		76.0%	63.6%	
Short term hospital	0.3%	0.7%		0.5%	0.7%		0.4%	0.7%		0.5%	0.8%	
Transfer to other institution	0.9%	1.6%		1.8%	3.5%		3.8%	7.4%		9.9%	15.2%	
Care home	2.4%	4.9%		3.8%	8.2%		6.6%	13.0%		13.4%	20.1%	
Left against medical advice or discontinue care	0.8%	1.8%		0.4%	0.9%		0.3%	0.5%		0.1%	0.3%	
Court or law enforcement	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Destination unknown	0.01%	0.01%		0.01%	0.00%		0.02%	0.03%		0.04%	0.01%	
Length of stay, days	3.2±4.6	3.7±3.3	<0.001	3.5±5.2	4.2±3.8	<0.001	3.7±5.3	4.7±4.1	<0.001	4.5±6.1	5.1±4.2	<0.001
Cost for first admission	$20531±16558	$21738±13598	<0.001	$21367±17795	$23116±14862	<0.001	$21851±23950	$23950±15568	<0.001	$23162±19516	$24252±14826	<0.001
Cost of readmission	-	$11055±16781	-	$0	$12157±17592	-	-	$12499±17483	-	-	$11890±15655	-

Table 2: Outcomes for readmitted patients according to age group

Variable	<55 years	55-64.9 years	65-74.9 years	≥75 years	p-value
Death during readmission	174 (1.0%)	410 (1.9%)	762 (3.0%)	1,225 (4.2%)	<0.001
Length of stay during readmissions	3.4±4.9	4.0±5.5	4.5±5.7	4.8±5.3	<0.001
Cost of readmission	$11,055±16,781	$12,158±17,592	$12499±17,483	$11,890±15,655	<0.001

Table 3: Key factors associated with readmission within age groups

Variable	OR (95%CI) for <55 years	p-value	OR (95%CI) for 55-64.9 years	p-value	OR (95%CI) for 65-74.9 years	p-value	OR (95%CI) for ≥75 years	p-value
Female	1.29 (1.23-1.36)	<0.001	1.19 (1.14-1.24)	<0.001	1.18 (1.14-1.23)	<0.001	1.19 (1.15-1.23)	<0.001
Smoking	0.90 (0.87-0.94)	<0.001	0.93 (0.89-0.96)	<0.001	-	NS	-	NS
Hypertension	1.07 (1.02-1.11)	0.006	1.08 (1.03-1.13)	0.001	1.06 (1.02-1.11)	0.005	-	NS
Diabetes	1.26 (1.20-1.31)	<0.001	1.23 (1.18-1.28)	<0.001	1.24 (1.20-1.28)	<0.001	1.10 (1.06-1.14)	<0.001
Previous CABG	1.18 (1.08-1.29)	<0.001	1.10 (1.04-1.17)	0.002	1.09 (1.03-1.15)	0.002	-	NS
Atrial fibrillation	1.39 (1.26-1.53)	<0.001	1.38 (1.30-1.46)	<0.001	1.43 (1.37-1.49)	<0.001	1.31 (1.27-1.36)	<0.001
Previous stroke/TIA	1.22 (1.12-1.34)	<0.001	1.23 (1.16-1.31)	<0.001	1.18 (1.11-1.25)	<0.001	1.07 (1.02-1.13)	0.006
Chronic lung disease	1.36 (1.29-1.44)	<0.001	1.33 (1.27-1.40)	<0.001	1.39 (1.34-1.45)	<0.001	1.29 (1.24-1.34)	<0.001
Renal failure	1.46 (1.36-1.57)	<0.001	1.53 (1.45-1.61)	<0.001	1.47 (1.41-1.54)	<0.001	1.31 (1.26-1.36)	<0.001
Liver disease	1.44 (1.26-1.64)		1.32 (1.18-1.47)	<0.001	1.28 (1.13-1.45)	<0.001	1.25 (1.06-1.48)	0.007
Depression	1.39 (1.31-1.49)	<0.001	1.17 (1.11-1.24)	<0.001	1.21 (1.13-1.29)	<0.001	1.07 (1.01-1.14)	0.03
Drug eluting stent	0.87 (0.83-0.90)	<0.001	0.85 (0.82-0.88)	<0.001	0.87 (0.83-0.90)	<0.001	0.87 (0.84-0.90)	<0.001
Emergency CABG	0.77 (0.65-0.92)	0.004	0.80 (0.69-0.93)	0.004	0.75 (0.65-0.85)	<0.001	0.68 (0.58-0.79)	<0.001
Discharge location vs home								
Short term hospital	2.04 (1.58-2.65)	<0.001	1.27 (1.03-1.56)	0.024	1.46 (1.18-1.81)	0.001	1.69 (1.40-2.04)	<0.001
Transfer to other institution	-	NS	-	NS	1.32 (1.22-1.43)	<0.001	1.42 (1.34-1.50)	<0.001
Care home	1.29 (1.16-1.43)	<0.001	1.39 (1.29-1.48)	<0.001	1.57 (1.48-1.66)	<0.001	1.46 (1.40-1.52)	<0.001
Left against medical advice or discontinue care	1.97 (1.69-2.29)	<0.001	1.73 (1.43-2.09)	<0.001	1.79 (1.42-2.24)	<0.001	2.60 (1.96-3.44)	<0.001

NS=not significant

Table 3: Causes of readmission by age group

A) Causes of readmissions

Cause	<55 years	55-64.9 years	65-74.9 years	≥75 years
Cardiac	45.88	45.19	43.44	42.9
Non-cardiac	54.12	54.81	56.56	57.1

B) Causes of non-cardiac readmissions

Causes of non-cardiac readmission	<55 years	55-64.9 years	65-74.9 years	≥75 years
Infections	7.7	9.3	11.7	13.9
Gastrointestinal	9.5	10.3	11.1	11.5
Non-specific chest pain	31.4	20.6	14.0	9.9
Respiratory	5.2	8.0	9.4	8.5
Bleeding	2.9	4.6	6.1	7.4
TIA/stroke	3.3	4.0	4.6	5.1
Peripheral vascular disease	3.4	4.4	4.6	4.7
Renal failure	1.9	3.0	4.0	4.6
Genitourinary	1.4	2.1	2.9	4.2
Hematological/neoplasm	1.2	2.5	3.3	3.8

C) Causes of cardiac readmissions

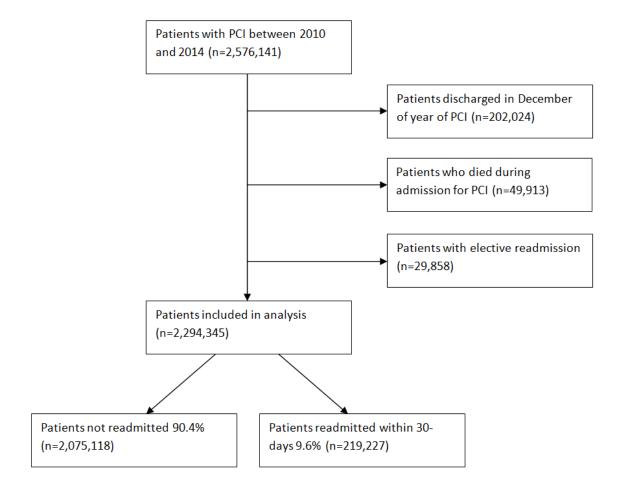| Causes of cardiac readmission	<55 years	55-64.9 years	65-74.9 years	≥75 years
Heart failure	11.9	18.0	23.9	34.6
Coronary artery disease including angina	51.3	43.2	35.9	25.7
Arrhythmias	8.6	13.4	16.1	17.8
Acute myocardial infarction	23.4	20.9	19.0	15.7
Valve disorders	0.2	0.4	0.6	1.9
Conduction disorders	0.2	0.5	0.6	1.1
Pericarditis	2.1	1.4	1.2	1.1
Hyper/hypotension	0.0	0.0	0.0	0.0

Figure 1: Flow diagram of patients
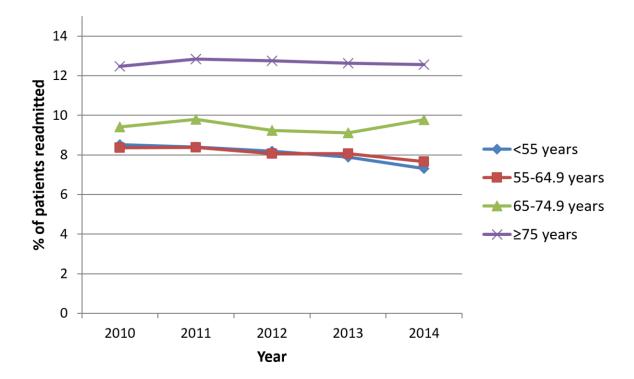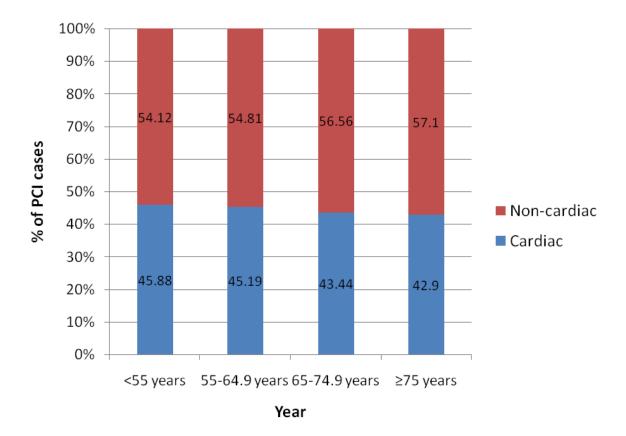
Figure 2: Unplanned readmission by age group

Figure 3: Cardiac and non-cardiac causes of readmission by age group

Supplementary Table 1: Classification of Clinical Classifications Software (CCS) Codes for Readmissions Causes

Causes of Readmission	CCS code	Diagnosis
Respiratory	127	Chronic obstructive pulmonary disease and bronchiectasis
	128	Asthma
	130	Pleurisy, pneumothorax, pulmonary collapse
	131	Respiratory failure, insufficiency and arrest
	132	Lung disease due to external agents
	133	Other lower respiratory disease
	134	Other upper respiratory disease
	221	Respiratory distress syndrome
Infection	1	Tuberculosis
	2	Septicemia
	3	Bacterial infection
	4	Mycoses
	5	Human Immunodeficiency Virus (HIV) infection
	6	Hepatitis
	7	Viral infection
	8	Other infection
	9	Sexually transmitted infection
	76	Meningitis
	77	Encephalitis
	78	Other central nervous system infection and poliomyelitis
	90	Inflammation or infection of eye
	122	Pneumonia
	123	Influenza
	124	Acute and chronic tonsillitis
	125	Acute bronchitis
	126	Other upper respiratory infections
	129	Aspiration pneumonitis
	135	Intestinal infection
	197	Skin and subcutaneous tissue infections
	201	Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted disease)
Bleeding	60	Acute posthemorrhagic anemia
	153	Gastrointestinal hemorrhage
	182	Hemorrhage during pregnancy; placental abruption; placenta previa
Peripheral vascular disease	114	Peripheral and visceral atherosclerosis
	115	Aortic, peripheral and visceral artery aneurysms
	116	Aortic and peripheral arterial embolism or thrombosis
	117	Other circulatory disease
	118	Phlebitis, thrombophlebitis and thromboembolism
	119	Varicose veins of lower extremities
Genitourinary	159	Urinary tract infection

	160	Calculus of the urinary tract
	161	Other diseases of kidney and ureters
	162	Other diseases of bladder and urethra
	163	Genitourinary symptoms and ill-defined conditions
	164	Hyperplasia of prostate
	165	Inflammatory conditions of the male genital organs
	166	Other male genital disorders
	170	Prolapse of female genital organs
	175	Other female genital disorders
	215	Genitourinary congenital anomalies
Renal disease	156	Nephritis; nephrosis; renal sclerosis
	157	Acute and unspecified renal failure
	158	Chronic kidney disease
Gastrointestinal	138	Esophageal disorders
	139	Gastroduodenal ulcer (except hemorrhage)
	140	Gastritis and duodenitis
	141	Other disorders of stomach and duodenum
	142	Appendicitis and other appendiceal conditions
	143	Abdominal hernia
	144	Regional enteritis and ulcerative colitis
	145	Intestinal obstruction without hernia
	146	Diverticulosis and diverticulitis
	147	Anal and rectal conditions
	148	Peritonitis and intestinal abscess
	149	Biliary tract disease
	150	Liver disease; alcohol-related
	151	Other liver diseases
	152	Pancreatic disorders (not diabetes)
	154	Noninfectious gastroenteritis
	155	Other gastrointestinal disorders
	214	Digestive congenital anomalies
	222	Hemolytic jaundice and perinatal jaundice
	250	Nausea and vomiting
	251	Abdominal pain
Transient ischemic attack/stroke	109	Acute cerebrovascular disease
	110	Occlusion of stenosis of precerebral arteries
	111	Other and ill-defined cerebrovascular disease
	112	Transient cerebral ischemia
	113	Late effects of cerebrovascular disease
Trauma	207	Pathological fracture
	225	Joint disorders and dislocations; trauma-related
	226	Fracture of neck of femur (hip)
	227	Spinal cord injury
	228	Skull and face fractures
	229	Fracture of upper limb

	230	Fracture of lower limb
	231	Other fractures
	232	Sprains and strains
	233	Intracranial injury
	234	Crushing injury or internal injury
	235	Open wounds of head; neck; and trunk
	236	Open wounds of extremities
	239	Superficial injury; contusion
	244	Other injuries and conditions due to external causes
	260	All (external causes of injury and poisoning)
Endocrine/metabolic	48	Thyroid disorders
	49	Diabetes mellitus without complication
	50	Diabetes mellitus with complication
	51	Other endocrine disorders
	53	Disorders of lipid metabolism
	58	Other nutritional and endocrine/metabolic disorders
	186	Diabetes or abnormal glucose tolerance complicating pregnancy; childbirth; or the puerperium
Neuropsychiatric	79	Parkinson's disease
	80	Multiple sclerosis
	81	Other hereditary and degenerative nervous system conditions
	82	Paralysis
	83	Epilepsy, convulsions
	84	Headache including migraine
	85	Coma, stupor and brain damage
	95	Other nervous system disorders
	216	Nervous system congenital anomalies
	650	Adjustment disorders
	651	Anxiety disorders
	652	Attention-deficit, conduct, and disruptive behavior disorders
	653	Delirium, dementia, and amnestic and other cognitive disorders
	654	Developmental disorders
	655	Disorders usually diagnosed in infancy and childhood or adolescence
	656	Impulse control disorders, NEC
	657	Mood disorders
	658	Personality disorders
	659	Schizophrenia and other psychotic disorders
	660	Alcohol-related disorders
	661	Substance-related disorders
	662	Suicide and intentional self-inflicted injury
	663	Screening and history of mental health and substance abuse codes
	670	Miscellaneous mental health disorders
Hematological/neoplastic	11	Cancer of head and neck
	12	Cancer of esophagus
	13	Cancer of stomach

	14	Cancer of colon
	15	Cancer of rectum and anus
	16	Cancer of liver and intrahepatic bile ducts
	17	Cancer of pancreas
	18	Cancer of other GI organs, peritoneum
	19	Cancer of bronchus, lung
	20	Cancer of other respiratory and intrathoracic
	21	Cancer of bone and connective tissue
	22	Melanoma of skin
	23	Other non-epithelial cancer of skin
	24	Cancer of breast
	25	Cancer of uterus
	26	Cancer of cervix
	27	Cancer of ovary
	28	Cancer of other female genital organs
	29	Cancer of prostate
	30	Cancer of testis
	31	Cancer of other male genital organs
	32	Cancer of bladder
	33	Cancer of kidney and renal pelvis
	34	Cancer of other urinary organs
	35	Cancer of brain and nervous system
	36	Cancer of thyroid
	37	Hodgkin's disease
	38	Non-Hodgkin's lymphoma
	39	Leukemia
	40	Multiple myeloma
	41	Cancer, other and unspecified primary
	42	Secondary malignancies
	43	Malignant neoplasm without specification of site
	44	Neoplasm of unspecified nature or uncertain behavior
	46	Benign neoplasm of uterus
	47	Other and unspecified benign neoplasm
	59	Deficiency and other anemias
	61	Sickle cell anemia
	62	Coagulation and hemorrhagic disorders
	63	Disease of white blood cells
	64	Other hematologic conditions
Rheumatology problem	54	Gout and other crystal arthropathies
Ophthalmology problem	86	Cataract
	87	Retinal detachment defects, vascular occlusion and retinopathy
	88	Glaucoma
	89	Blindness and vision defects
	91	Other eye disorders

ENT problem	92	Otitis media and related conditions
	93	Conditions associate with dizziness or vertigo
	94	Other ear and sense organ disorder
Non-specific chest pain	102	Non-specific chest pain
Oral health problem	136	Disorders of teeth and jaw
	137	Diseases of mouth; excluding dental
Obstetric admission including pregnancy	174	Female infertility
	176	Contraceptive and procreative management
	177	Spontaneous abortion
	178	Induced abortion
	179	Postabortion complication
	180	Ectopic pregnancy
	181	Other complications of pregnancy
	184	Early or threatened labor
	185	Prolonged pregnancy
	187	Malposition; malpresentation
	188	Fetopelvic disproportion; obstruction
	189	Previous C-section
	190	Fetal distress and abnormal forces of labor
	191	Polyhydramnios and other problems of amniotic cavity
	192	Umbilical cord complication
	193	OB-related trauma to perineum and vulva
	194	Forceps delivery
	195	Other complications of birth; puerperium affecting management of mother
	196	Other pregnancy and deliver including normal
	218	Liveborn
	219	Short gestation; low birth weight; and fetal growth retardation
	220	Intrauterine hypoxia and birth asphyxia
	223	Birth trauma
	224	Other perinatal conditions
Dermatology problem	198	Other inflammatory condition of skin
	199	Chronic ulcer of skin
	200	Other skin disorders
Poisoning	241	Poisoning by psychotrophic agents
	242	Poisoning by other medication and drugs
	243	Poisoning by nonmedical substances
Syncope	245	Syncope
Other non-cardiac	10	Immunization and screening for infectious disease
	45	Maintenance chemotherapy, radiotherapy
	52	Nutritional deficiencies
	55	Fluid and electrolyte disorders
	56	Cystic fibrosis
	57	Immunity disorder
	120	Hemorrhoids
	121	Other diseases of veins and lymphatics

	167	Nonmalignant breast conditions
	168	Inflammatory disease of female pelvic organs
	169	Endometriosis
	172	Ovarian cyst
	173	Menopausal disorders
	202	Rheumatoid arthritis and related disease
	203	Osteoarthritis
	204	Other non-traumatic joint disorders
	205	Spondylosis; intervertebral disc disorders; other back problems
	206	Osteoporosis
	208	Acquired foot deformities
	209	Other acquired deformities
	210	Systemic lupus erythematosus and connective tissue disorders
	211	Other connective tissue disease
	212	Other bone disease and musculoskeletal deformities
	217	Other congenital anomalies
	237	Complication of device; implant or graft
	238	Complications of surgical procedure or medical care
	240	Burns
	246	Fever of unknown origin
	247	Lymphadenitis
	248	Gangrene
	252	Malaise and fatigue
	253	Allergic reactions
	254	Rehabilitation care; fitting of prostheses; and adjustment of devices
	255	Administrative/social admission
	256	Medical examination/evaluation
	257	Other aftercare
	258	Other screening for suspected conditions (not mental disorders or infectious disease)
	259	Residual codes; unclassified
Heart failure	108	Congestive heart failure non-hypertensive
Arrhythmia	106	Cardiac dysrhythmias
	107	Cardiac arrest and ventricular fibrillation
Conduction disorder	105	Conduction disorders
Valve disorders	96	Heart valve disorder
Hyper/hypotension	98	Essential hypertension
	99	Hypertension with complications and secondary hypertension
	183	Hypertension complicating pregnancy; childbirth and the puerperium
	249	Shock
Pericarditis	97	Peri-, endo- and myocarditis, cardiomyopathy
Coronary artery disease including angina	101	Coronary atherosclerosis and other heart disease
Acute myocardial infarction	100	Acute myocardial infarction
Others (cardiac)	103	Pulmonary heart disease
	104	Other and ill-defined heart disease

	213	Cardiac and circulatory congenital anomalies

Supplementary Table 2: All patient characteristics according to readmission status and age group

Variable	Age group <55 years			Age group 55-64.9 years			65-74.9 years			≥75 years		
	Not readmitted	Readmitted	p-value	Not readmitted	Readmitted	p-value	Not readmitted	Readmitted	p-value	Not readmitted	Readmitted	p-value
Women, %	24.1%	32.9%	<0.001	27.0%	34.5%	<0.001	33.3%	39.6%	<0.001	43.3%	48.2%	<0.001
Year			<0.001			<0.001			<0.001			0.4
2010	22.1%	23.4%		21.7%	22.4%		21.9%	21.8%		21.9%	21.5%	
2011	20.6%	21.4%		20.3%	21.0%		20.2%	21.0%		20.5%	20.9%	
2012	19.0%	19.3%		19.1%	18.9%		19.2%	18.7%		19.1%	19.3%	
2013	19.6%	19.1%		19.7%	19.6%		20.3%	19.5%		20.1%	20.0%	
2014	18.7%	16.8%		19.2%	18.0%		18.4%	19.0%		18.4%	18.3%	
Elective	10.9%	7.8%	<0.001	15.3%	10.2%	<0.001	20.9%	13.3%	<0.001	20.1%	12.6%	<0.001
Weekend	23.4%	23.6%	0.57	20.9%	21.8%	0.002	18.5%	20.6%	<0.001	18.8%	21.2%	<0.001
Diagnosis of acute myocardial infarction	63.7%	56.4%	<0.001	53.8%	50.4%	<0.001	44.8%	47.1%	<0.001	44.9%	50.4%	<0.001
Primary expected payer			<0.001			<0.001			<0.001			<0.001
Medicare	10.8%	20.6%		18.6%	30.4%		83.5%	85.8%		93.0%	93.8%	
Medicaid	15.0%	22.4%		11.3%	17.2%		2.0%	2.5%		1.3%	1.2%	
Private	51.5%	36.4%		54.5%	38.8%		12.5%	9.8%		4.5%	3.8%	
Uninsured	15.0%	12.9%		8.1%	6.9%		0.4%	0.3%		0.2%	0.2%	
No charge	1.9%	2.0%		1.2%	1.1%		0.03%	0.04%		0.02%	0.02%	
Other	5.8%	5.7%		6.3%	5.7%		1.6%	1.6%		1.0%	0.9%	
Median household income (percentile)			<0.001			<0.001			<0.001			0.23
0-25th	30.5%	34.5%		28.8%	32.7%		28.8%	31.0%		26.8%	27.0%	
26-50th	25.5%	26.4%		25.1%	25.4%		25.2%	25.3%		25.3%	25.0%	
51-75th	23.9%	21.9%		24.1%	23.2%		23.9%	23.1%		24.2%	24.6%	
76-100th	20.1%	17.2%		22.1%	18.8%		22.1%	20.7%		23.8%	23.4%	
Smoker	56.9%	54.8%	<0.001	46.9%	46.0%	0.008	37.0%	37.7%	0.029	25.8%	26.6%	0.003
Alcohol misuse	4.5%	5.3%	<0.001	3.4%	4.0%	<0.001	1.9%	2.3%	<0.001	0.8%	0.9%	0.094
Dyslipidemia	68.9%	66.3%	<0.001	72.5%	68.5%	<0.001	74.1%	70.3%	<0.001	70.5%	67.5%	<0.001
Hypertension	65.6%	70.9%	<0.001	73.3%	77.3%	<0.001	77.9%	80.1%	<0.001	79.8%	80.7%	<0.001
Diabetes mellitus	31.2%	42.1%	<0.001	37.3%	48.5%	<0.001	40.3%	49.2%	<0.001	34.4%	38.5%	<0.001
Obesity	20.9%	22.2%	<0.001	18.4%	19.9%	<0.001	15.5%	17.3%	<0.001	8.5%	8.6%	0.41
Heart failure	0.7%	1.2%	<0.001	1.1%	2.2%	<0.001	1.7%	2.9%	<0.001	2.4%	3.0%	<0.001
Known coronary artery disease	92.2%	92.6%	0.044	94.0%	94.2%	0.21	95.2%	94.8%	0.014	95.0%	94.3%	<0.001
Previous myocardial infarction	12.9%	15.7%	<0.001	14.2%	16.2%	<0.001	14.7%	15.7%	<0.001	14.5%	15.0%	0.023
Previous percutaneous coronary intervention	17.4%	20.6%	<0.001	20.8%	22.2%	<0.001	22.6%	22.0%	0.053	22.3%	21.1%	<0.001
Previous coronary artery bypass graft	3.6%	5.6%	<0.001	6.5%	8.3%	<0.001	9.6%	10.8%	<0.001	10.8%	10.7%	0.66
Previous valve disease	0.1%	0.3%	<0.001	0.3%	0.5%	<0.001	0.5%	0.8%	<0.001	0.9%	1.2%	<0.001
Atrial fibrillation	3.1%	4.8%	<0.001	6.8%	10.9%	<0.001	12.5%	19.1%	<0.001	22.0%	29.4%	<0.001
Previous transient ischemic attack/stroke	3.3%	6.2%	<0.001	5.4%	9.1%	<0.001	7.5%	10.7%	<0.001	10.2%	11.9%	<0.001
Peripheral vascular disease	4.7%	7.9%	<0.001	8.8%	13.6%	<0.001	13.2%	18.2%	<0.001	16.4%	19.7%	<0.001
Pulmonary circulatory disorder	0.1%	0.2%	0.001	0.2%	0.4%	<0.001	0.3%	0.6%	<0.001	0.5%	0.6%	0.008
Peptic ulcer disease	0.01%	0.01%	0.82	0.02%	0.03%	0.34	0.03%	0.02%	0.69	0.04%	0.04%	0.68
Chronic lung disease	11.1%	17.9%	<0.001	15.5%	23.9%	<0.001	18.8%	28.0%	<0.001	18.3%	24.9%	<0.001
Renal failure	5.8%	13.3%	<0.001	9.1%	19.4%	<0.001	14.2%	25.0%	<0.001	21.5%	29.9%	<0.001
Liver disease	1.4%	2.4%	<0.001	1.7%	2.9%	<0.001	1.1%	1.9%	<0.001	0.6%	0.9%	<0.001
Hypothyroidism	4.4%	6.0%	<0.001	6.8%	8.5%	<0.001	9.8%	11.6%	<0.001	14.9%	16.9%	<0.001
Fluid and electrolyte disorders	10.2%	15.7%	<0.001	10.8%	18.0%	<0.001	11.9%	19.1%	<0.001	15.0%	20.5%	<0.001
Anemia	5.7%	11.9%	<0.001	7.6%	15.7%	<0.001	10.7%	20.0%	<0.001	16.4%	24.1%	<0.001
Cancer	0.6%	1.2%	<0.001	1.3%	2.2%	<0.001	2.1%	3.4%	<0.001	2.7%	3.6%	<0.001
Depression	6.7%	11.3%	<0.001	7.1%	10.2%	<0.001	6.1%	8.9%	<0.001	5.5%	6.9%	<0.001

Dementia	0.1%	0.1%	0.011	0.3%	0.6%	<0.001	1.3%	2.5%	<0.001	5.8%	7.9%	<0.001
Charlson comorbidity index	0.8±1.1	1.3±1.5	<0.001	1.1±1.3	1.7±1.6	<0.001	1.4±1.5	2.0±1.7	<0.001	1.6±1.5	2.0±1.7	<0.001
Mean number of comorbidities	4.3±1.9	5.0±2.1	<0.001	4.7±2.0	5.4±2.2	<0.001	5.0±2.1	5.7±2.3	<0.001	5.1±2.1	5.6±2.2	<0.001
Bed size			<0.001			<0.001			<0.001			<0.001
Small	5.5%	4.7%		5.6%	4.4%		5.8%	5.2%		6.0%	5.4%	
Medium	21.3%	21.0%		20.7%	20.5%		20.5%	20.4%		20.3%	20.6%	
Large	73.1%	74.3%		73.7%	75.1%		73.6%	74.4%		73.8%	74.0%	
Location			0.34			0.013			0.62			0.75
Rural	0.2%	0.2%		0.2%	0.1%		0.2%	0.2%		0.2%	0.2%	
Urban	99.8%	99.8%		99.8%	99.9%		99.8%	99.8%		99.8%	99.8%	
Teaching status		<0.001				0.65			0.007	Teaching status		0.001
Nonteaching	44.4%	45.0%		44.1%	44.2%		45.5%	46.4%		47.2%	48.2%	
Teaching status	55.6%	55.0%		55.9%	55.8%		54.5%	53.6%		52.8%	51.8%	
In-hospital procedures and procedural details												
Multivessel disease	14.3%	14.7%	0.23	15.8%	15.9%	0.7	16.9%	16.9%	0.99	17.3%	17.0%	0.19
Bifurcation	2.7%	2.6%	0.53	2.9%	2.7%	0.22	3.0%	2.8%	0.12	2.9%	2.8%	0.2
Circulatory support	2.9%	4.4%	<0.001	2.9%	4.4%	<0.001	2.8%	4.3%	<0.001	3.0%	3.6%	<0.001
Vasopressor use	0.4%	0.5%	0.16	0.4%	0.6%	<0.001	0.4%	0.7%	<0.001	0.5%	0.6%	0.034
Intra-aortic balloon pump	2.7%	4.1%	<0.001	2.7%	4.1%	<0.001	2.5%	3.8%	<0.001	2.5%	3.2%	<0.001
Fractional flow reserve	1.7%	2.1%	<0.001	2.0%	2.1%	0.067	2.1%	2.1%	0.71	1.8%	1.8%	0.8
Intravascular ultrasound	6.6%	7.0%	0.037	6.9%	7.0%	0.5	7.4%	7.0%	0.02	7.2%	6.8%	0.01
Drug eluting stent	73.0%	67.9%	<0.001	76.1%	69.9%	<0.001	77.1%	71.3%	<0.001	70.3%	64.4%	<0.001
In-hospital outcomes												
Complete heart block	0.7%	0.8%	0.014	0.8%	1.1%	0.001	1.0%	1.2%	0.009	1.5%	1.5%	0.6
Transient ischemic attack/stroke	1.1%	1.5%	<0.001	2.1%	2.8%	<0.001	3.6%	4.3%	<0.001	5.0%	5.3%	0.081
Cardiogenic shock	2.4%	3.6%	<0.001	2.7%	4.1%	<0.001	2.6%	4.0%	<0.001	2.9%	3.6%	<0.001
Cardiac arrest	2.1%	2.4%	0.017	1.9%	2.1%	0.013	1.6%	1.9%	<0.001	1.5%	1.6%	0.26
Acute kidney injury	0.3%	0.4%	0.016	0.4%	0.8%	<0.001	0.6%	1.0%	<0.001	0.9%	1.3%	<0.001
Major bleeding	0.4%	0.5%	0.017	0.5%	0.9%	<0.001	0.7%	1.2%	<0.001	0.9%	1.4%	<0.001
Blood transfusion	0.04%	0.05%	0.75	0.05%	0.06%	0.3	0.05%	0.15%	<0.001	0.04%	0.07%	0.018
Vascular complication	0.6%	0.8%	<0.001	0.7%	0.9%	<0.001	0.9%	1.2%	<0.001	1.0%	1.3%	<0.001
Emergency coronary artery bypass graft	1.3%	1.4%	0.15	1.6%	1.8%	0.041	1.5%	1.8%	<0.001	1.0%	1.0%	0.52
Discharged location			<0.001			<0.001			<0.001			<0.001
Home (self-care)	95.6%	91.0%		93.5%	86.6%		89.0%	78.4%		76.0%	63.6%	
Short term hospital	0.3%	0.7%		0.5%	0.7%		0.4%	0.7%		0.5%	0.8%	
Transfer to other institution	0.9%	1.6%		1.8%	3.5%		3.8%	7.4%		9.9%	15.2%	
Care home	2.4%	4.9%		3.8%	8.2%		6.6%	13.0%		13.4%	20.1%	
Left against medical advice or discontinue care	0.8%	1.8%		0.4%	0.9%		0.3%	0.5%		0.1%	0.3%	
Court or law enforcement	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Destination unknown	0.01%	0.01%		0.01%	0.00%		0.02%	0.03%		0.04%	0.01%	
Length of stay, days	3.2±4.6	3.7±3.3	<0.001	3.5±5.2	4.2±3.8	<0.001	3.7±5.3	4.7±4.1	<0.001	4.5±6.1	5.1±4.2	<0.001
Cost for first admission	$20531±16558	$21738±13598	<0.001	$21367±17795	$23116±14862	<0.001	$21851±23950	$23950±15568	<0.001	$23162±19516	$24252±14826	<0.001
Cost of readmission	-	$11055±16781	-	$0	$12157±17592	-	-	$12499±17483	-	-	$11890±15655	-

Supplementary Table 3: All factors associated with readmission within age groups

Variable	OR (95%CI) for <55 years	p-value	OR (95%CI) for 55-64.9 years	p-value	OR (95%CI) for 65-74.9 years	p-value	OR (95%CI) for ≥75 years	p-value
Female	1.29 (1.23-1.36)	<0.001	1.19 (1.14-1.24)	<0.001	1.18 (1.14-1.23)	<0.001	1.19 (1.15-1.23)	<0.001
Year of PCI vs 2010								
2011	-	NS	0.94 (0.88-1.00)	0.049	-	NS	-	NS
2012	-	NS	0.89 (0.83-0.94)	<0.001	0.93 (0.88-0.98)	0.013	-	NS
2013	0.91 (0.85-0.97)	0.003	0.89 (0.83-0.94)	<0.001	0.89 (0.84-0.94)	<0.001	-	NS
2014	0.81 (0.76-0.86)	<0.001	0.80 (0.75-0.85)	<0.001	0.91 (0.86-0.97)	0.002	0.90 (0.84-0.95)	<0.001
Elective	0.60 (0.55-0.65)	<0.001	0.61 (0.57-0.65)	<0.001	0.64 (0.61-0.67)	<0.001	0.67 (0.63-0.71)	<0.001
Acute myocardial infarction	0.80 (0.76-0.84)	<0.001	0.89 (0.86-0.93)	<0.001	-	NS	1.07 (1.03-1.11)	<0.001
Primary expected payer vs Medicare								
Medicaid	0.94 (0.89-1.00)	0.047	-	NS	1.22 (1.10-1.35)	<0.001	-	NS
Private	0.56 (0.53-0.60)	<0.001	0.62 (0.59-0.65)	<0.001	0.85 (0.80-0.90)	<0.001	0.88 (0.81-0.95)	0.002
Uninsured	0.64 (0.60-0.88)	<0.001	0.68 (0.63-0.73)	<0.001	-	NS	-	NS
No charge	0.77 (0.67-0.88)	<0.001	0.77 (0.66-0.91)	0.002	-	NS	-	NS
Other	0.71 (0.64-0.77)	<0.001	0.69 (0.64-0.75)	<0.001	-	NS	-	NS
Income vs 0-25th centile								
26-50th	-	NS	-	NS	0.93 (0.89-0.97)	0.002	-	NS
51-75th	0.94 (0.89-0.99)	0.024	-	NS	0.92 (0.88-0.97)	0.001	-	NS
Smoking	0.90 (0.87-0.94)	<0.001	0.93 (0.89-0.96)	<0.001	-	NS	-	NS
Alcohol	1.15 (1.05-1.25)	0.003	-	NS	-	NS	-	NS
Dyslipidemia	0.91 (0.87-0.95)	<0.001	0.87 (0.84-0.91)	<0.001	0.88 (0.84-0.91)	<0.001	0.94 (0.91-0.97)	<0.001
Hypertension	1.07 (1.02-1.11)	0.006	1.08 (1.03-1.13)	0.001	1.06 (1.02-1.11)	0.005	-	NS
Diabetes	1.26 (1.20-1.31)	<0.001	1.23 (1.18-1.28)	<0.001	1.24 (1.20-1.28)	<0.001	1.10 (1.06-1.14)	<0.001
Obesity	0.92 (0.88-0.96)	<0.001	0.95 (0.91-0.99)	0.017	0.95 (0.91-0.99)	0.023	0.90 (0.85-0.95)	<0.001
Heart failure	-	NS	0.84 (0.74-0.97)	0.017	-	NS	0.83 (0.74-0.92)	0.001
Previous CABG	1.18 (1.08-1.29)	<0.001	1.10 (1.04-1.17)	0.002	1.09 (1.03-1.15)	0.002	-	NS

Atrial fibrillation	1.39 (1.26-1.53)	<0.001	1.38 (1.30-1.46)	<0.001	1.43 (1.37-1.49)	<0.001	1.31 (1.27-1.36)	<0.001
Previous stroke/TIA	1.22 (1.12-1.34)	<0.001	1.23 (1.16-1.31)	<0.001	1.18 (1.11-1.25)	<0.001	1.07 (1.02-1.13)	0.006
Peripheral vascular disease	1.19 (1.10-1.28)	<0.001	1.21 (1.15-1.27)	<0.001	1.17 (1.11-1.25)	<0.001	1.12 (1.08-1.17)	<0.001
Chronic lung disease	1.36 (1.29-1.44)	<0.001	1.33 (1.27-1.40)	<0.001	1.39 (1.34-1.45)	<0.001	1.29 (1.24-1.34)	<0.001
Renal failure	1.46 (1.36-1.57)	<0.001	1.53 (1.45-1.61)	<0.001	1.47 (1.41-1.54)	<0.001	1.31 (1.26-1.36)	<0.001
Liver disease	1.44 (1.26-1.64)		1.32 (1.18-1.47)	<0.001	1.28 (1.13-1.45)	<0.001	1.25 (1.06-1.48)	0.007
Fluid and electrolyte disorder	1.17 (1.11-1.24)	<0.001	1.21 (1.15-1.27)	<0.001	1.13 (1.08-1.19)	<0.001	1.07 (1.02-1.12)	0.004
Anemia	1.27 (1.19-1.37)	<0.001	1.30 (1.22-1.38)	<0.001	1.31 (1.25-1.37)	<0.001	1.24 (1.19-1.29)	<0.001
Cancer	1.47 (1.22-1.77)	<0.001	1.49 (1.32-1.69)	<0.001	1.47 (1.33-1.62)	<0.001	1.14 (1.05-1.25)	0.002
Depression	1.39 (1.31-1.49)	<0.001	1.17 (1.11-1.24)	<0.001	1.21 (1.13-1.29)	<0.001	1.07 (1.01-1.14)	0.03
Dementia	-	NS	-	NS	1.26 (1.12-1.41)	<0.001	1.07 (1.01-1.14)	0.021
Teaching hospital	0.94 (0.90-0.99)	0.009	-	NS	-	NS	-	NS
Urban location	-	NS	1.70 (1.07-2.71)	0.024	-	NS	-	NS
Cardiogenic shock	-	NS	-	NS	-	NS	0.90 (0.82-0.99)	0.031
Cardiac arrest	-	NS	-	NS	-	NS	0.87 (0.76-0.99)	0.03
Circulatory support	1.49 (1.06-2.08)	0.02	-	NS	-	NS	-	NS
IABP	-	NS	1.44 (1.07-1.92)	0.015	-	NS	-	NS
FFR	1.19 (1.04-1.36)	0.009	-	NS	-	NS	-	NS
Drug eluting stent	0.87 (0.83-0.90)	<0.001	0.85 (0.82-0.88)	<0.001	0.87 (0.83-0.90)	<0.001	0.87 (0.84-0.90)	<0.001
Emergency CABG	0.77 (0.65-0.92)	0.004	0.80 (0.69-0.93)	0.004	0.75 (0.65-0.85)	<0.001	0.68 (0.58-0.79)	<0.001
Discharge location vs home								
Short term hospital	2.04 (1.58-2.65)	<0.001	1.27 (1.03-1.56)	0.024	1.46 (1.18-1.81)	0.001	1.69 (1.40-2.04)	<0.001
Transfer to other institution	-	NS	-	NS	1.32 (1.22-1.43)	<0.001	1.42 (1.34-1.50)	<0.001
Care home	1.29 (1.16-1.43)	<0.001	1.39 (1.29-1.48)	<0.001	1.57 (1.48-1.66)	<0.001	1.46 (1.40-1.52)	<0.001
Left against medical advice or discontinue care	1.97 (1.69-2.29)	<0.001	1.73 (1.43-2.09)	<0.001	1.79 (1.42-2.24)	<0.001	2.60 (1.96-3.44)	<0.001

NS=not significant

Supplementary Table 4: Causes of gastrointestinal readmission in the older people

Causes of GI readmission in older people	%
GI bleeding including diverticulitis, gastritis and angiodysplasia	28.4
Non-specific GI symptoms constipation, diarrhoea, nausea, vomiting abdominal pain	13.2
Esophageal disease including esophagitis	12.2
Cholecysitis, gallbladder and bile duct disease	11.0
Hernia, volvulus, intestinal obstruction, ileus and faecal impaction	8.5
Other	7.2
Peptic ulcer and gastritis	5.5
Diverticulosis/diverticulitis of intestines/colon	4.4
Gastroenteritis	4.2
Pancreatitis and pancreatic disease	4.1
Liver disorder including cirrhosis, hepatic encephalopathy, portal hypertension and hepatorenal syndrome	1.3