

Trends in percutaneous coronary intervention and angiography in Ireland, 2004–2011: Implications for Ireland and Europe



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ABSTRACT

Background/objectives: To study temporal trends in crude and age standardised rates of cardiac catheterisation and percutaneous coronary intervention (PCI) in Ireland, 2004–2011.

Methods: Two data sources were used: a) a survey of publicly and privately funded hospitals with cardiac catheter laboratories to obtain the annual number of procedures performed and b) anonymised data from the Hospital In-Patient Enquiry (HIPE) for angiography and PCI in acute publicly funded hospitals; age standardised rates were calculated to study trends over time.

Results: From 2004 to 2011 the crude rate of angiography and PCI increased by 47.8% and 35.9% respectively, with rates of 6689 and 1825 per million population in 2011. Following age standardisation, however, PCI activity showed a non-significant decrease over time. The PCI to angiography ratio decreased from 30% to 27% and PCI was performed predominantly for stable coronary heart disease (54%) in 2011.

Conclusion: Angiography and PCI rates have increased in Ireland but PCI crude and age adjusted rates show divergent trends. While Ireland differs from USA and UK, with a higher proportion of PCI being performed for stable CHD in recent years, little systematic surveillance of cardiological interventions within Europe is available to benchmark improvements in Ireland.

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1. Background/objectives

Since PCI was first performed in 1977, it has undergone rapid evolution to become one of the most widely performed medical procedures, currently over 3 million annually worldwide [1]. PCI is a highly effective means of treating acute coronary disease. However its application as initial therapy in patients with stable disease is not superior to optimal medical therapy [2] and it is not as effective as CABG in patients with highly complex disease, particularly those with diabetes requiring multivessel revascularisation [3]. The evaluation of coronary disease has also evolved and contemporary clinical practice guidelines, such as the ESC guideline for Stable Coronary Disease 2012 [4], emphasise the importance of a more robust approach to the selection of patients for invasive angiography than simple treadmill testing (or no functional test at all), using pre-test risk stratification and stress imaging techniques where appropriate. In view of the steady stream of evidence challenging certain aspects of contemporary practice it is all the more surprising

that few comparative data on the temporal trend in provision of catheterisations and interventions are available, especially at a population level. This is particularly true for European countries. There are a number of studies from the USA, with the more recent work speculating that the volume of PCIs has started to decline [5].

Ireland has experienced significant improvements in the burden of disease from coronary heart disease (CHD) – mortality decreased after the mid-1980s [6] with previous work attributing the decrease in CHD mortality to both improvements in treatment uptake and changes in levels of the main cardiovascular risk factors [7]. Further a reduction in acute myocardial infarction hospitalisation rate has been reported with a decrease in ST elevation myocardial infarction (STEMI) hospitalisations and an increase in non-ST elevation myocardial infarction (NSTEMI) hospitalisation due to increased survival and an ageing population [8]. The first national cardiovascular policy in 1999 [9] recommended investment in cardiac catheterisation suites in Ireland and was followed by growth in public and private catheterisation facilities. To date little has been documented about the characteristics of this evolving and expensive service.

To understand temporal trends in cardiac interventions in Ireland, we examined angiography and PCI numbers and rates from 2004 to

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2011. Specifically we aimed to study: a) the time trend in number and rate (crude rate per million and age standardised rates) of angiography and percutaneous coronary intervention (PCI) provision in private and publicly funded hospitals and b) the epidemiological features (age, gender) of angiography and PCI provision in Irish publicly funded hospitals in the context of development of cardiac catheter laboratories in Ireland over the same period.

2. Methods

Ireland has a two tiered health system with public and private provision. Access to healthcare in Ireland is either via eligibility for a medical card permitting access to a wide range of health services and medicines free of charge (36% in 2010) or for the rest of the population to a range of community and hospital health services, either free of charge or at reduced cost. In addition, private health insurance to facilitate choice of access to private care in either publicly funded or private hospitals was held by 49% of the population in 2007 falling to 47% in 2010 [10].

Cardiac catheterisation procedures are carried out in both publicly and privately funded hospitals. Two data streams were employed in this study. The first, a survey of aggregate data from all publicly funded and private hospitals with cardiac catheter laboratories in Ireland over the period 2004–2011 provided a picture of procedural activity in the country. The second, using routine data from publicly funded hospitals on individual hospitalisations allowed age standardised analysis.

The survey requested hospitals to provide aggregate data on procedures undertaken each year in their labs, in patients aged 20 years and over, for the years 2004–2011. A standard questionnaire was employed to collect the number of angiograms and PCIs as well as the number of catheter labs.

The second source employed cross-sectional data on hospitalisations, including procedures and diagnosis extracted from the Economic and Social Research Institute's (ESRI) national Hospital In-Patient Enquiry (HIPE) system covering care in all publicly funded acute hospitals. All participating hospitals use the same dataset and software, with a range of procedures directed at safeguarding data quality integrated into the software [11]. The data coverage in HIPE exceeds 96% in these hospitals. Private hospitals ($n = 9$) do not contribute to HIPE. Also, private hospitals, until the late 2000s, lacked emergency departments resulting in few treatments for acute coronary syndrome (B Maurer, personal communication).

Data extracted from HIPE covered the years 2004–2011. ICD-9 codes were used for 2004 (PCI codes 3601, 3602, 3605; angiography codes 38215.00, 38218.00–38518.02; IHD diagnosis codes 410, 411, 412, 413, 414) and ICD-10 codes for 2005 onwards (PCI codes 38300, 38303, 38306; angiography codes 8850, 8852–8858; CHD diagnosis codes I20, I21, I22, I23, I24). No specific validation of clinical diagnosis or coding was undertaken and co-morbidity was not explored.

Descriptive statistics are presented as frequencies (percentages) for category data. The crude rate per million population (pmp), taking no account of the age structure of the population, was calculated using the census 2006 applied to the data for years 2004–2008 and census 2011 applied to the data for 2009–2011 (www.cso.ie). Discharge rates were age-standardised to the European standard population and calculated using the direct method for those aged 25–84 years. Cochrane Armitage Trend test was used to compare proportions over time. Crude ratios of numbers of PCI to angiography were calculated, and examined over time using Poisson regression analysis. The statistical package, SAS (v9.1, SAS Institute, Cary, USA), was used for analysis and significance at $p < 0.05$ was assumed. Ethical approval was not required as all data were either aggregated (survey) or anonymised (HIPE), the latter released under a confidentiality agreement with the ESRI.

3. Results

In Ireland, the number of hospitals with catheterisation laboratories increased from 12 in 2004 to 16 in 2011 with a greater increase in private sector (Table 1). A further three public hospitals provided a limited angiography only service using mobile cardiac catheterisation laboratories. A greater number of cases undergoing diagnostic angiography and PCI were performed in the public sector throughout the study period, although the proportion undergoing PCI in the public sector declined significantly from 76% (2004) to 66% (2011) ($p < 0.001$). The number of hospitals undertaking ≤ 200 PCI procedures annually fluctuated and then decreased by 2011 (Table 1). However, the proportion of hospitals performing a high volume of ≥ 400 PCIs per year decreased from 67% (8 / 12) in 2004 to 50% (8 / 16) in 2011 with the public sector hospitals (67%, 6 / 9) more likely to undertake high volumes than the private sector (29%, 2 / 7).

3.1. Demography

Patients undergoing angiography in the public sector (HIPE) in 2011 were younger (mean age 62 years) than PCI patients (mean age 63.2 years) with little change over the eight years in either group (Table 1). Younger patients (under 65 years) were significantly more likely to undergo PCI over time ($p = 0.012$). Women, whether undergoing angiography or PCI, were on average older than men (Table 1) though the age gap was larger for PCI (4.4 years in 2011) compared to angiography (2.4 years in 2011). While the majority of both procedures were carried out on males (Table 1) the proportion was greater for PCI and increasingly so over the eight years in the public sector ($p < 0.0001$).

3.2. Angiography and PCI to angiography ratio

Overall, angiography provision, on survey, in private and publicly funded hospitals in Ireland increased from 4899 to 6689 crude rate per million population (pmp) – an increase of 47.8% over the eight years studied (Table 2).

However, allowing for demographic changes in the last decade in Ireland the age standardised rate (ASR), using just HIPE data for publicly funded hospitals accounting for 63% of provision in 2011, showed a more modest, though significant increase of 9.2% over time ($p = 0.006$). The ASR rose significantly over the time period in both those under and over 65 years (Table 2).

The PCI to angiography ratio, on survey, decreased significantly from 30% to 27% in the 8 years ($p = 0.0015$). This trend in fewer interventions to diagnostic tests was significant in private hospitals ($p = 0.0003$) starting in 2008 to 2010 (Table 2) though not in publicly funded hospitals. The lowest ratio was seen in 2010 in the private sector (22%).

3.3. Percutaneous coronary intervention activity

PCI provision, on survey, increased at a population level in Ireland from 1454 to 1825 per million population (pmp) – an increase of 35.9% in 8 years across public and private hospitals (Table 2). This increase was more marked in the private (75%) compared to the publicly funded (22%) sector.

However, while the crude rate per million increased, the age standardised rate on HIPE analysis, accounting for 66% of 2011 provision, showed a non-significant decrease (–6.8%) overall (25–84 years) and in the younger population (under 65 years). In the population aged 65 years and over (Table 2), on the other hand, the decrease was significant ($p = 0.04$) in this data from publicly funded hospitals. No gender pattern was found (M, $p = 0.27$ for the trend; F, $p = 0.051$ for trend).

Table 1
Facilities, volume of activity and demographic data in those undergoing angiography and PCI.

	2004	2005	2006	2007	2008	2009	2010	2011	p-Value
<i>Facilities and volume</i>									
No of hosps with Cath labs									
Public	8	8	8	8	9	9	9	9	
Private	4	4	4	6	7	7	7	7	
Total	12	12	12	14	16	16	16	16	
No of hosps performing PCIs									
Less than 200	3	1	0	2	5	2	1	2	
200–399	1	4	5	5	4	7	7	6	
400 and over	8	7	7	7	7	7	8	8	
<i>Demography (HIPE)</i>									
<i>Angiography</i>									
Mean age	61.8	61.1	61.7	61.4	61.7	61.9	61.9	62.0	p = 0.11
Mean age (M)	61.1	60.7	61.2	60.9	61.2	61.3	61.3	61.4	p = 0.07
Mean age (F)	63.0	61.9	62.5	62.3	62.7	63.0	62.7	63.1	p = 0.24
% males	65.7%	63.2%	62.8%	64.0%	65.1%	64.9%	61.9%	65.4%	p < 0.001
<i>Demography (HIPE)</i>									
<i>PCI</i>									
Mean age	63.2	63.2	62.9	63.0	63.4	63.1	62.9	63.2	NS
Mean age (M)	62	62.2	61.7	61.9	62.3	62.1	62.0	62.2	NS
Mean age (F)	66.6	66.1	66.4	66.1	66.4	66.2	65.8	66.6	NS
% males	73.0%	74.0%	74.3%	74.7%	74.2%	75.5%	77.1%	76.7%	p < 0.0001
% under 65 years	51.2%	51.0%	52.4%	52.1%	51.2%	52.7%	53.7%	52.8%	p = 0.012
% under 65 years (M)	56.4%	55.6%	57.5%	57.3%	56.2%	57.2%	58.3%	57.1%	p = 0.14
% under 65 years (F)	37.4%	38.8%	38.8%	38.9%	37.5%	39.0%	41.2%	38.6%	p = 0.33

NS = non-significant.

The trends in crude rate per million (survey) and ASR (HIPE) were similar with divergence only in last three years 2009–2011 with crude rate showing an increase but ASR remaining stable (Fig. 1).

In patients aged 25–84 years HIPE analysis for publicly funded hospitals showed PCI, performed on patients with coronary heart disease, was carried out predominantly for stable disease (53.73% in 2011). PCI was performed for ACS in 34.70% of cases in 2005 rising to 47.40% in 2009 with subsequent decline (Fig. 2).

4. Discussion

We found an increase in numbers and crude rate of coronary diagnostic and interventional procedures culminating in a PCI provision of 1825 per million population (pmp) in 2011 in context of expansion in the cardiac interventional capacity in Ireland. Following age adjustment, however, PCI activity showed a decrease from 2004 to 2011 significant in those aged 65 years and over. Males were more likely to undergo PCI than females. There is a trend towards more diagnostic procedures compared with interventions over time, significantly increased in the

private sector, resulting in an overall PCI to angiography ratio of 27.38% in 2011. Variation in volume of PCI per centre occurred due in part to expansion of the number of cardiac catheterisation facilities, though only half of the hospitals undertook a high volume of ≥ 400 PCIs per year in 2011. One third of diagnostic and interventional provision occurred in the private sector and was not captured in the routine administrative data sets.

The increase in provision of coronary diagnostic and interventional procedures in Ireland should be seen in the context of a country which had the highest premature death rate from CHD in the EU in the 1990s. In 1999 the first national heart strategy, Building Healthier Hearts [9], was published and among its recommendations was to increase PCI provision in Ireland to a target of 1200 pmp by 2002. Our finding of 1825 pmp in 2011 demonstrates a sizeable increase on that target and is comparable to the current OECD average across 21 EU countries of 1910 pmp [12]. Furthermore our finding is remarkably similar to that reported for Northern Ireland of 1751 pmp though higher than the UK rate of 1405 pmp [13]. Comparison with the USA is difficult due, in the main, to different reporting methodologies. However one

Table 2
Trend in angiography, PCI and PCI to angiography ratio, 2004–2011, Ireland.

	2004	2005	2006	2007	2008	2009	2010	2011	p-Value
Angiography numbers (survey)	20,770	22,874	24,479	25,676	25,754	27,819	30,587	30,690	
Crude rate per million (survey)	4899	5395	5774	6056	6074	6063	6666	6689	
Angiography numbers (HIPE)	13,929	13,497	14,874	15,215	16,073	16,529	18,008	18,388	
ASR 25–84 (HIPE)	592.3	557.5	601.5	597.6	612.3	610.9	649.7	646.8	p = 0.006
ASR < 65 years (HIPE)	408.7	386.6	403.8	402.6	407.1	402.4	435.2	431.6	p = 0.04
ASR 65+ years (HIPE)	1565.3	1463.0	1651.6	1630.7	1699.9	1716.1	1786.7	1787.5	p = 0.003
PCI numbers (survey)	6163	6819	7253	6967	6878	7187	8123	8373	
Crude rate per million (survey)	1454	1608	1711	1643	1622	1566	1770	1825	
PCI % public provision (survey)	76%	69%	68%	64%	65%	66%	68%	66%	p < 0.001
PCI numbers (HIPE)	4189	4372	4513	4293	4321	4465	4933	4741	
PCI ASR 25–84 (HIPE)	177.4	179.5	182.3	168.5	179.4	164.7	176.7	165.9	p = 0.131
PCI ASR < 65 years (HIPE)	114.2	114.6	118.1	107.7	113.0	107.2	117.8	109.6	p = 0.46
PCI ASR 65+ years (HIPE)	512.3	523.4	522.3	490.9	531.1	469.5	488.7	464.6	p = 0.044
<i>PCI: angiography ratio</i>									
Public hosps (survey)	30.6%	30.5%	30.3%	27.0%	27.7%	27.3%	29.4%	28.5%	p = 0.12
Private hosps (survey)	27.5%	28.3%	28.3%	27.3%	25.0%	23.3%	22.1%	25.3%	p = 0.0003
Total	29.7%	29.8%	29.6%	27.1%	26.7%	25.8%	26.6%	27.3%	p = 0.0015

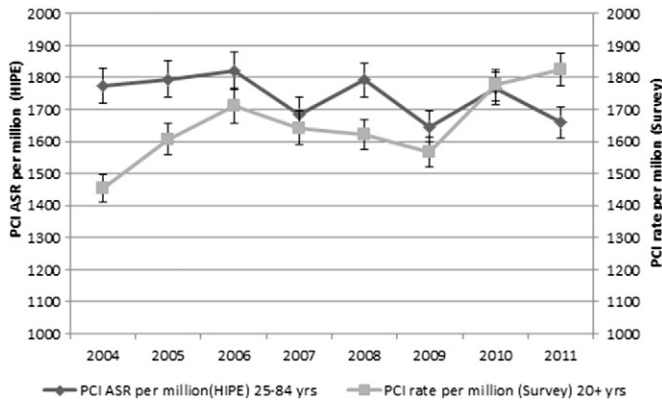


Fig. 1. Trend in age standardised rate (ASR) per million (95% CI) on HIPE and crude rate per million on survey, 2004–2011.

American study, using a population approach, reported a crude rate of 2980 pmp in 2009 [14] and the OECD noted a crude rate in the USA (2009) of 3770 pmp [15].

The finding of a consistently increasing trend in crude rate per million population in PCI provision in Ireland over the eight years has also been reported in the UK [13] up to 2011. Similarly the OECD documents an increase in crude rate of PCI provision in all contributing countries for the period 2000 to 2010 averaging 9.4% overall [12]. However the crude rate takes no account of the age structure of a population, a particularly important feature in comparing across countries at different stages in the CHD epidemic. Following age adjustment we report a non-significant decreasing trend in the PCI rate in Ireland. While data from the USA [5,14,16] has reported this decreasing trend from the mid-2000 onwards and two recent studies [17,18] have noted stable rates we are not aware of any other attention given to this trend especially in Europe.

The trend towards fewer interventions to angiography seen in both private and publicly funded hospitals in Ireland is in contrast to reports from the USA [14] and the UK [13]. The greater application of non-invasive functional and anatomic imaging (stress echocardiography, stress perfusion scintigraphy and CT angiography) may account for some reduction in invasive angiography in the USA [19]. Also recognition of the low yield of diagnostic coronary angiography performed in lower risk patients, emphasised in the latest ESC guideline for management of stable coronary artery disease [4], may contribute to falling numbers in some countries [20].

The COURAGE trial in 2007 demonstrated that a strategy of PCI as initial therapy in patients with stable disease was not superior to

optimal medical therapy [2]. Subsequently a number of US studies have shown a significant and sustained decline in the use of PCI to treat patients with stable angina [21,22]. In 2012 a similar trend was reported in the UK, with two thirds of PCIs undertaken for acute disease [23]. It is difficult to explain our findings of a limited increase in the proportion of PCIs undertaken for acute disease from 2005 to 2009 with a fall off thereafter. The historical context of a country with high CHD mortality and late, though rapid, expansion in provision of interventional cardiology after the 1999 strategy, is likely to be a factor in the increased number of procedures but does not account for the predominance of interventions for stable disease. Furthermore, while the expansion was greatest in the private sector accounting for one third of provision, no data is available for analysis of the clinical indication in this patient group posing problems in assessing the complete national picture. Nonetheless it seems likely that an even greater proportion of PCI performed in the private sector will have been for stable disease, given the clinical profile of patients admitted to private facilities and the fact that most private facilities did not have emergency facilities until the late 2000s. Lastly, a failure to accept or apply the implications of new evidence from contemporary trials such as COURAGE [2] and FREEDOM [24] may contribute to continued disproportionately high rates of PCI in the population with stable coronary artery disease.

With an increase in PCI provision in Ireland there has been a decrease in centres undertaking very low volume. The optimal minimum standard of 400 PCIs per facility advocated in the USA [25] and in the UK [13] was met in half of the Irish institutions and compares favourably with 51% in USA in 2012 [26] and 65% (NHS and private) in the 2012 BCIS audit [23].

There is little recent published data on trends in interventional cardiology outside North America [5,14,16,18] and a paper from Sweden [17]. Our study is the first to our knowledge to report temporal trends in angiography and PCI combining private and public statistics across a population in Europe. Further it is the first to use and compare crude and age standardised rate trends in diagnostic and interventional cardiology, highlighting the limitations of the former approach which continues to be the most common methodology in existing reports of PCI in Europe. Using two data sources a fuller picture of a treatment in evolution is available for Ireland and accordingly updates and corrects the international record of Irish PCI provision by the OECD in 2012 (900 pmp) [12] and Eurostat 2009 (836 pmp) [27].

The study findings should be viewed in light of some limitations. Of the two data sources one involved collating aggregate survey data with no attempt at detailed definitions and therefore possible variation in quality of submitted information. Nonetheless this survey clarifies the total number of procedures across public and privately funded hospitals

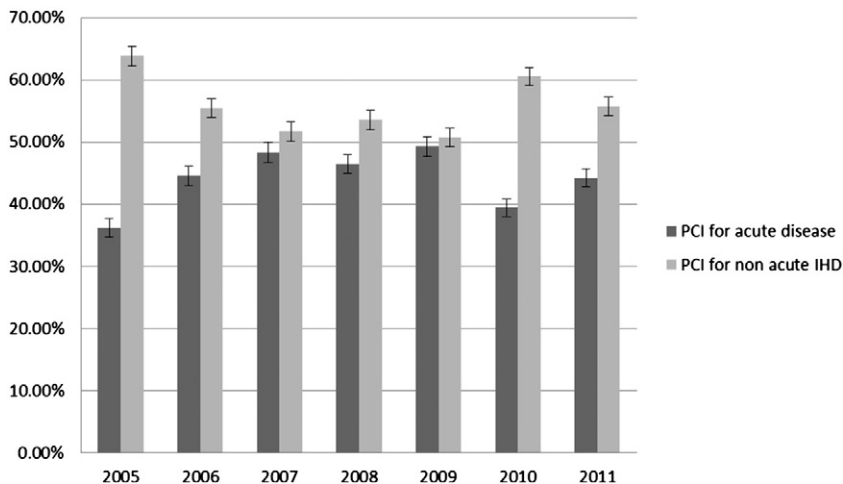


Fig. 2. Trend in percentage (95% CI) clinical indication (acute or non-acute disease) for PCI in patients admitted with CHD, 2005–2011 in Ireland.

for the first time in Ireland. The second data source provided detail on age, gender and diagnosis but only two thirds of the population were admitted to public hospitals leaving a significant gap in our knowledge of the characteristics of the other one third in the private sector. In spite of quality control mechanisms in place for the HIPE process, we found variability across hospitals in coding angiography in patients who had a subsequent PCI in the earlier years 2004–2006.

With increasing survival and ageing populations, many countries are undergoing considerable health services reform. In addition, Ireland has a relatively high prevalence of obesity, diabetes and other chronic diseases in middle and older age groups [28]. From 2008 onwards the country experienced a sharp economic downturn, with increased unemployment and associated risks to cardiovascular health. It is important to consider trends in coronary interventions against that background and to address the deficits in health information identified in our study.

We find very little comparative interventional cardiology surveillance outside of North America. With a changing and costly clinical activity there is a need for more prospective data collection and systematic surveillance methodologies, as envisaged with the CARDS [29] initiative during the 2004 EU Presidency, to understand current rate of uptake of an expensive technology, to promote implementation of the evidence and to facilitate international comparison. Our findings and subsequent deliberations may assist the recently formed ESC Task Force on CVD data standardisation as well as the inventory of registries [30].

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