Cardiac intervention rates for acute myocardial infarction patients in the US and Ontario, 2003-2013: a retrospective cohort study

Brief title: Cardiac intervention rates in US and Ontario

Laura C. Yasaitis, PhD[1], Dennis T. Ko, MD, MSc[2,3,4], Jun Guan, MSc[2], Amitabh Chandra, PhD[5,6], Therese A. Stukel, PhD [2,4,7]

1. Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia PA, USA
2. ICES, Toronto, Ontario, Canada
3. Department of Medicine, Schulich Heart Centre, Sunnybrook Health Sciences Centre, University of Toronto, Canada
4. Institute of Health Policy, Management and Evaluation, University of Toronto, Canada
5. The John F. Kennedy School of Government, Harvard University, Cambridge MA, USA
6. National Bureau of Economics Research, Cambridge MA, USA
7. The Dartmouth Institute for Health Policy and Clinical Practice, Geisel School of Medicine, Lebanon NH, USA

Corresponding Author Information:

Therese A. Stukel, PhD
stukel@ices.on.ca

Funding Statement

The study was supported through funding provided by a Foundation Grant (FDN 143303) from the Canadian Institutes of Health Research (CIHR) and by a grant from the U.S. National Institute on Aging, PO1 AG019783. The funding agencies had no role in the study design, the collection, analysis, or interpretation of data, the writing of the report, or the decision to submit the report for publication. The study was also supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health and Long-Term Care (MOHLTC). The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources. No endorsement by ICES or the Ontario MOHLTC is intended or should be inferred.

Competing Interests

No author has any relationship with industry or other conflicts of interest to disclose.

Abstract

Background: Previous work demonstrated higher cardiac intervention rates for acute myocardial infarction (AMI) patients in the US than Canada. Ontario, Canada, has a much lower supply of percutaneous coronary intervention (PCI) laboratories than the US (1.2 vs 7 per million residents, 2013). While PCI capabilities increased in both settings, improved timeliness of care associated with the increased supply of invasive cardiac resources is unknown.

Methods: Adults 66-99 years old in the US (N=414,216) and Ontario (N=112,484) between 2003-2013 were followed for 30 days after admission for incident AMI. Rates of cardiac catheterization, PCI and coronary artery bypass graft on the day and within 30 days of admission were calculated overall and according to AMI type (ST-elevation (STEMI), non-ST-elevation (NSTEMI)) and risk subgroup (low, medium, high predicted risk of 30-day mortality).

Results: Large disparities in cardiac intervention rates in 2003 mostly disappeared over time. By 2013, patients with STEMI received PCI at nearly identical rates in both countries on day of admission (US, 66.3% vs. Ontario, 63.8%). High-risk patients received PCI slightly earlier in the US; same day rates were 17.6% vs. 14.9% but high-risk STEMI patients received PCI more frequently in the US both on day of admission (55.5% vs. 44.7%) and by 30 days (60.5% vs. 55%).

Interpretation: Despite differences in resources and organization of delivery systems, timely receipt of PCI for Ontario AMI patients lags only slightly behind US patients. A higher supply of PCI centers in the US may facilitate earlier intervention among high-risk STEMI patients.

Introduction

Cardiovascular disease is responsible for substantial morbidity and mortality in both the US and Canada. Given the two countries' demographic and cultural similarities, there are frequent comparisons between health care trends in the two countries (1-10). Although cardiac testing and procedure rates among AMI patients increased rapidly in both countries between 1993 and 2001, capacity and procedure rates for invasive cardiac interventions were higher in the US than Ontario, Canada, throughout this period (1-8). As of the early 2000's, patients with acute myocardial infarction (AMI) received timely percutaneous coronary intervention (PCI) more frequently in the US than Canada (3-6).

By 2003, evidence from trials had demonstrated the superiority of percutaneous coronary intervention (PCI) over fibrinolytic therapy for ST-segment elevation AMI (STEMI), with the greatest benefit occurring immediately after symptom onset (11,12). Further studies demonstrated benefit of timely PCI for patients with non-ST-segment elevation MI (NSTEMI), particularly for high-risk patients (13-18). Rapid reperfusion is the guideline-recommended care in both countries (11,19). Although Canadian PCI capacity has increased substantially, the number of PCI-capable sites remains higher in the US. In the US, there were nearly seven PCI-capable sites per million residents by 2011 (20). In Ontario, the number rose from 12 in 2003 to 16 in 2012, or 1.2 per million residents; accompanying this expansion was a 2004 policy report recommending primary PCI as the first-line treatment for STEMI (19) after studies demonstrated the feasibility of transferring STEMI patients for PCI (21-23).

To see whether Ontario's efforts to improve rapid PCI for AMI closed the gap between the two

countries, we examined trends in rates and timing of PCI for elderly AMI patients using health administrative data from the US and Ontario. Additionally, we examined whether increases in early invasive cardiac services for elderly AMI patients were targeted to higher vs. lower severity patients.

Methods

Study Cohorts

Study patients comprised US and Ontario residents hospitalized with first (index) admission for AMI to an acute care hospital between January 1, 2003 and December 31, 2013, restricting to adults age 66 to 99. To capture incident admissions, we excluded patients admitted for AMI during the previous year. We excluded those with a stay of less than one day. We included the first eligible admission when patients had multiple admissions, and followed patients for 30 days after index admission date.

In the US, incident AMI was defined as the first inpatient claim with primary ICD-9 diagnosis code 410 (except 410.x2, which indicates readmission or follow-up care), an approach validated previously (24). We excluded patients with <12 months fee for service (FFS) Medicare coverage before their index event, allowing a one-year lookback for comorbidities and previous AMI admissions. For patients who switched into managed care Medicare plans after their index admission, the date of coverage change was noted.

In Ontario, incident AMI was defined as the first hospitalization with most responsible diagnosis

(MRD) ICD-10-CA code I21 between April 1, 2003 (the first day of the Canadian fiscal year) and December 31, 2013. This approach has good performance in identifying AMI and AMI subtype (25,26). To assess prior comorbidities, we excluded patients with <12 months of Ontario Health Insurance Plan (OHIP) eligibility prior to the index admission. We also excluded admissions where AMI was an inhospital complication.

In both countries, we created an index episode of care beginning at initial admission and ending at final discharge, incorporating transfers. The index admission could not be a transfer. In the US, transfers were identified as a hospitalization whose admission date matched the discharge date of a previous hospitalization, or where the admission source indicated a transfer. In Ontario, a 12-hour rule was used to distinguish transfers from readmissions. In the US, of 455,816 potential index admissions, 34,914 were excluded due to being transferred, and 6,686 with length of stay <1 day; in Ontario, of 131,516 potential index admissions, 15,765 and 3,267 were excluded for these reasons, respectively.

Outcomes

The primary outcomes were invasive cardiac procedures, specifically, coronary angiography or cardiac catheterization, percutaneous coronary intervention (PCI) and coronary artery grafting (CABG) on day of admission and 3 and 30 days after index admission. Rates were calculated using Kaplan-Meier (KM) estimates, separately by country. We censored for HMO entry (US cohorts) and death. Procedure codes are provided in Appendix Tables 1 and 2.

Covariates

Comorbidities were identified from all hospitalizations during the 12 months prior to and during the index admission. In the US, diagnosis codes were aggregated to create indicators for selected hierarchical condition code (HCC) categories (27) from a previously validated AMI mortality risk prediction model (28). In Ontario, comorbidity groups were created that closely matched the HCC categories. Rurality of patient residence was determined. In the US, the ZIP code of residence was classified as rural or urban based on the ZIP code Rural-Urban Commuting Areas geographic taxonomy (29). In Ontario, patient rurality was measured using the Rurality Index of Ontario (RIO) which accounts for population size and travel time, categorized as urban (RIO 0–9) or nonurban (RIO ≥10) (30).

Data sources

The US cohort was identified using claims from a 20% random sample of FFS Medicare beneficiaries. These claims contain information about inpatient, outpatient and physician services. MedPAR and Carrier claims were used to identify whether a patient received a cardiac catheterization, PCI or CABG and the date it was performed. Patient comorbidities were identified from the first and second diagnosis codes of hospitalizations.

In Ontario, patient records were linked using unique, anonymized, encrypted identifiers across multiple Ontario health administrative databases containing information on all publicly insured, medically necessary hospital and physician services. These include the Discharge Abstract Database (DAD) for hospital admissions, procedures and transfers that includes the most responsible diagnosis (MRD) for length of stay, secondary diagnosis codes, comorbidities present upon admission, complications during the hospital stay; the National Ambulatory Care

Reporting System (NACRS) for same day surgeries; OHIP for physician billings that includes diagnosis codes and procedures; and the Registered Persons Database (RPDB) for patient demographic information and deaths. Comorbidities were identified using secondary DAD diagnosis fields, excluding index admission complications. Cardiac procedure dates were determined from DAD and NACRS, supplementing with OHIP billing dates when necessary. Except for AMI subtype, which was not coded in Ontario health administrative data before 2007, no covariates had missing values.

Statistical Analyses

For each cohort, we developed a baseline patient severity score using logistic regression to predict 30-day mortality, incorporating all baseline patient characteristics and comorbidities (*c*=0.73 and 0.80, US and Ontario, respectively). Mean predicted mortality was used as a summary measure of patient severity because it incorporated all measured patient risk factors as in other studies (31). The 30-day predicted risk score was categorized as low (<10%), medium (10-20%) and high (>20%).

We compared age-sex standardized procedure rates across patients within subtypes of AMI (STEMI vs. NSTEMI) and within predicted risk groups. Ontario did not code type of AMI until 2007, so these analyses focused on the later years. In secondary analyses, we compared rates across high-risk patients according to AMI type, and among STEMI patients residing in urban vs. rural settings to assess the potential role that access to PCI facilities may play. Our sample is so large that absolute rate differences of <0.5% in the smallest subgroup are statistically significant at the 0.1% level. We have therefore not reported p-values and comment on clinically

important differences.

Sensitivity analyses

In sensitivity analyses, we re-estimated the rates in several ways. We estimated uncensored proportions rather than Kaplan-Meier rates to examine sensitivity to censoring. Due to concerns that different distributions of predicted risk between the two countries might bias our estimates, we re-weighted the Ontario cohort to closely resemble the US using a nonparametric approach. The risk scores at each Ontario percentile were determined, and the proportion of US patients falling within each risk score interval was used to re-weight the Ontario percentiles (32). KM rates were re-estimated with these new weights.

The Ontario study was approved by the Research Ethics Board of Sunnybrook Health Sciences Centre. The US study was approved by the Institutional Review Board of the National Bureau of Economic Research, Cambridge, MA. Data use restrictions in both countries prohibited exporting individual-level data so we were unable to pool the data into a single analytic dataset.

Results

During 2003-2013, there were 414,216 patients with incident AMI in the US, and 112,484 in Ontario who met our inclusion criteria. The cohorts had similar age distributions, mean baseline severity (predicted 30-day mortality risk, 13.57% vs. 13.75%), and proportions of high-risk patients (Table 1). Nearly one quarter of patients in each country had a STEMI. The number of AMI patients declined in both countries over time. Comorbidity prevalences were generally similar between the two countries (Table 2).

We compared overall rates of each cardiac procedure within 30 days of incident AMI admission over 2003 to 2013. The large differences in rates for all procedures in 2003 steadily diminished over time (Figure 1). By 2013, same-day PCI rates were only slightly higher in the US (22.3% US vs. 19.2% Ontario) while 30-day rates were slightly higher in Ontario (41.3% US vs. 44.0% in Ontario). Three-day rates are reported in Appendix Table 3. The gap in 30-day CABG rates decreased as well; this was associated with a decline in US rates while Canadian rates held steady. Cardiac catheterization rates mirrored patterns of PCI rates.

Figure 2 compares timing of PCI from 2007 to 2013 by AMI type. While there were substantial differences for STEMI patients in 2007, these largely disappeared by 2013, when same-day and 30-day rates were almost identical in the two countries (66.3% vs. 63.8%, and 73.2% vs. 76.6%, respectively). The US had higher same-day PCI rates for NSTEMI patients (11.3% vs. 3.9%) although 30-day rates were almost identical (33.3% vs 32.8%). Three-day rates are reported in Appendix Table 4.

We examined relative changes in PCI rates over 2003–2013 for subgroups of patients according to predicted risk (Figure 3). There were large differences across countries for all risk groups in 2003. By 2013, the differences narrowed substantially although US rates remained higher. For high-risk patients, same-day PCI rates were 17.6% vs. 14.9% in the US vs. Ontario, and 27.7% vs. 24.4% at 30 days. PCI rates for low risk patients were almost identical by 2013.

In secondary analyses, we examined differences for high-risk patients by AMI subtype (Figure

4). High-risk STEMI and NSTEMI patients received PCI earlier and more frequently in the US, although rates increased over time in both countries and the gap narrowed considerably by 2013. Same-day PCI rates for high-risk STEMI patients were 55.5% vs. 44.7%, and 30-day rates were 60.5% vs. 55.0% in the US vs. Ontario, respectively. High-risk NSTEMI patients received PCI earlier and more frequently in the US, with same day rates of 4.9% and 1.5% in the US vs. Ontario, and 30-day rates of 17.5% vs. 10.4%.

Finally, we examined PCI rates for STEMI patients according to urban and rural residence (Figure 5). PCI rates for urban dwelling STEMI patients in Ontario were higher than for urban US patients. However, rural US STEMI patients received PCI at higher rates than those in Ontario, especially on the same day.

In sensitivity analyses, alternative estimation approaches revealed negligible differences from the primary analyses. Unadjusted and adjusted KM rates were nearly identical. Re-weighting the Ontario patient population to have a similar predicted mortality distribution to that of the US made little difference to our findings.

Discussion

We compared rates and timing of cardiac procedures for elderly AMI patients in the US and Ontario over 2003-2013. US PCI rates were substantially higher in 2003 but Ontario largely closed the gap by 2013, especially for STEMI patients. Same-day PCI rates increased substantially in both the US and Ontario, likely due to increased capacity and a greater emphasis on early PCI for STEMI patients. There was a dramatic increase in same-day rates among

STEMI patients in Ontario. This suggests that Ontario's policy of increasing PCI capability and staffing, and its hub and spoke model of invasive cardiac care where AMI patients are transported to PCI facilities for same-day procedures and transferred back to their primary hospital as soon as feasible, resulted in STEMI patients' having timely access to cardiac catheterization and PCI. However, given the limited evidence for utility of PCI after the immediate post-AMI period, higher rates of PCI after 3 days may include some procedures with limited benefit.

For high-risk NSTEMI patients, PCI rates were higher in the US than in Ontario, one of the few remaining differences between the two countries, although both countries' absolute rates were low for this subgroup. Numerous factors may cause PCI rates to be lower than desired. Sicker patients may require care in a cardiac intensive care unit (CICU) rather than a short stay unit; higher demand for CICU beds may increase delays in care. In Ontario, because some patients required same-day transportation to a PCI facility, sicker patients may have been deemed too unstable for transfer. Higher PCI rates among high-risk US NSTEMI patients likely reflects the greater supply of PCI-capable facilities. Higher rates among rural US patients likely reflects the fact that rural regions in northern Ontario are extremely remote, often requiring helicopter transport of patients to the nearest PCI facility. Interpretation is challenging since the characterization of rurality differs by country.

This study has several limitations. As in all studies using administrative claims, data on patients' clinical presentation were limited to recorded diagnoses. Lack of full clinical data and inability to combine datasets from the two countries, precluded us from directly comparing other important

outcomes such as mortality. Comparisons of mortality would have required fine adjustment for confounding for unobserved factors such as disease severity, smoking status, and clinician judgment regarding who might benefit to affect which patients received PCI. This lack of clinical data also prevented us from exploring appropriateness of care. Our study is limited to Ontario so findings may not generalize to other Canadian provinces; yet, given Ontario's size and diversity, and similar regulation of invasive cardiac resources, these findings likely reflect trends in the rest of the country.

In summary, substantial initial disparities in 2003 in cardiac intervention rates for AMI, especially STEMI patients, in the US and Ontario largely disappeared by 2013 despite differences in resources and organization of delivery systems. Higher supply of PCI-capable centers in the US may facilitate earlier and more interventions, especially among patients who are difficult to transfer promptly for treatment.

References

1 Tu JV, Pashos CL, Naylor CD, Chen E, Normand S, Newhouse JP, et al. Use of cardiac procedures and outcomes in elderly patients with myocardial infarction in the United States and Canada. N Engl J Med 1997;336(21):1500-1505.

2 Fu Y, Chang WC, Mark D, Califf RM, Mackenzie B, Granger CB, et al. Canadian-American differences in the management of acute coronary syndromes in the GUSTO IIb trial: one-year follow-up of patients without ST-segment elevation. Global Use of Strategies to Open Occluded Coronary Arteries (GUSTO) II Investigators. Circulation 2000 Sep 19;102(12):1375-1381.

3 Kaul P, Armstrong PW, Chang WC, Naylor CD, Granger CB, Lee KL, et al. Long-term mortality of patients with acute myocardial infarction in the United States and Canada: comparison of patients enrolled in Global Utilization of Streptokinase and t-PA for Occluded Coronary Arteries (GUSTO)-I. Circulation 2004 Sep 28;110(13):1754-1760.

4 Alter DA, Stukel TA, Newman A. Proliferation of cardiac technology in Canada. Circulation. 2006 Jan 24;113(3):380-7.

5 Lucas FL, DeLorenzo MA, Siewers AE, Wennberg DE. Temporal trends in the utilization of diagnostic testing and treatments for cardiovascular disease in the United States, 1993-2001. Circulation 2006 Jan 24;113(3):374-379.

6 Ayanian JZ. Rising rates of cardiac procedures in the United States and Canada: too much of a good thing? Circulation 2006 Jan 24; 113(3): 333-335

7 Ko DT, Krumholz HM, Wang Y, Foody JM, Masoudi FA, Havranek EP, et al. Regional differences in process of care and outcomes for older acute myocardial infarction patients in the United States and Ontario, Canada. Circulation 2007 Jan 16;115(2):196-203.

8 Ko DT, Tu JV, Samadashvili Z, Guo H, Alter DA, Cantor WJ, et al. Temporal trends in the

use of percutaneous coronary intervention and coronary artery bypass surgery in New York State and Ontario. Circulation 2010 Jun 22;121(24):2635-2644.

9 Ko DT, Tu JV, Austin PC, Wijeysundera HC, Samadashvili Z, Guo H, et al. Prevalence and extent of obstructive coronary artery disease among patients undergoing elective coronary catheterization in New York State and Ontario. JAMA. 2013 Jul 10;310(2):163-9.

10 Smith-Bindman R, Kwan ML, Marlow EC, Theis MK, Bolch W, Cheng SY, et al. Trends in Use of Medical Imaging in US Health Care Systems and in Ontario, Canada, 2000-2016. JAMA. 2019 Sep 3;322(9):843-56.

11 Antman EM, Anbe DT, Armstrong PW, Bates ER, Green LA, Hand M, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the 1999 Guidelines for the Management of Patients with Acute Myocardial Infarction). J Am Coll Cardiol. 2004 Aug; 44(3):E1-E211.

12 Keeley EC, Boura JA, Grines CL. Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review of 23 randomised trials. The Lancet 2003 Jan 4;361(9351):13-20.

13 Cannon CP, Weintraub WS, Demopoulos LA, Vicari R, Frey MJ, Lakkis N, et al. Comparison of early invasive and conservative strategies in patients with unstable coronary syndromes treated with the glycoprotein IIb/IIIa inhibitor tirofiban. N Engl J Med 2001 Jun 21;344(25):1879-1887.

14 Fox K, Poole-Wilson P, Henderson R, Clayton T, Chamberlain D, Shaw T, et al. Interventional versus conservative treatment for patients with unstable angina or non-ST-elevation myocardial infarction: the British Heart Foundation RITA 3 randomised trial. The

Lancet 2002 Sep 7;360(9335):743-751.

15 Solomon DH, Stone PH, Glynn RJ, Ganz DA, Gibson CM, Tracy R, et al. Use of risk stratification to identify patients with unstable angina likeliest to benefit from an invasive versus conservative management strategy. J Am Coll Cardiol 2001 Oct 1;38(4):969-976.

16 Braunwald E. Application of current guidelines to the management of unstable angina and non-ST-elevation myocardial infarction. Circulation 2003 Oct 21;108(16 Suppl 1):III28-37.

17 Bach RG, Cannon CP, Weintraub WS, DiBattiste PM, Demopoulos LA, Anderson HV, et al. The effect of routine, early invasive management on outcome for elderly patients with non–ST-segment elevation acute coronary syndromes. Ann Intern Med 2004 Aug 3;141(3):186-195.

18 Mehta SR, Granger CB, Boden WE, Steg PG, Bassand J, Faxon DP, et al. Early versus delayed invasive intervention in acute coronary syndromes. N Engl J Med 2009 May 21;360(21):2165-2175.

19 Ontario Health Technology Advisory Committee. OHTAC recommendation. Primary Angioplasty 2004:1-5.

20 Langabeer JR, Henry TD, Kereiakes DJ, Dellifraine J, Emert J, Wang Z, et al. Growth in percutaneous coronary intervention capacity relative to population and disease prevalence. J Am Heart Assoc 2013 Oct 28;2(6):e000370.

21 Cantor WJ, Fitchett D, Borgundvaag B, Ducas J, Heffernan M, Cohen EA, et al. Routine early angioplasty after fibrinolysis for acute myocardial infarction. N Engl J Med 2009 Jun 25;360(26):2705-2718.

22 Le May MR, So DY, Dionne R, Glover CA, Froeschl MP, Wells GA, et al. A citywide protocol for primary PCI in ST-segment elevation myocardial infarction. N Engl J Med 2008 Jan 17;358(3):231-240.

23 Andersen HR, Nielsen TT, Rasmussen K, Thuesen L, Kelbaek H, Thayssen P, et al. A comparison of coronary angioplasty with fibrinolytic therapy in acute myocardial infarction. N Engl J Med 2003 Aug 21;349(8):733-742.

24 Kiyota Y, Schneeweiss S, Glynn RJ, Cannuscio CC, Avorn J, Solomon DH. Accuracy of Medicare claims-based diagnosis of acute myocardial infarction: estimating positive predictive value on the basis of review of hospital records. American heart journal. 2004 Jul 1;148(1):99-104.

25 Juurlink D, Preyra C, Croxford R, Chong A, Austin P, Tu JV, Laupacis A. Canadian Institute for Health Information discharge abstract database: a validation study. Toronto: Institute for Clinical Evaluative Sciences, 2006.

26 Patel AB, Quan H, Welsh RC, Deckert-Sookram J, Tymchak W, Sookram S, et al. Validity and utility of ICD-10 administrative health data for identifying ST-and non-ST-elevation myocardial infarction based on physician chart review. CMAJ open. 2015 Oct;3(4):E413.

27 Pope GC, Kautter J, Ellis RP, Ash AS, Ayanian JZ, Iezzoni LI, et al. Risk adjustment of Medicare capitation payments using the CMS-HCC model. Health Care Financ Rev 2004;25(4):119-142.

28 Krumholz HM, Wang Y, Mattera JA, Wang Y, Han LF, Ingber MJ, et al. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with an acute myocardial infarction. Circulation. 2006 Mar 20;113(13):1683-1692.

29 Hart G. Temporary ZIP RUCA 3.10 file access page [Internet]. Grand Forks (ND): University of North Dakota Center for Rural Health; 2014 Aug 4 [cited 2018 August 28]. Available from: https://ruralhealth.und.edu/ruca

30 Kralj B. Measuring Rurality -- RIO2008_BASIC: Methodology and Results. Toronto: Ontario

Medical Association; 2009

31 Stukel TA, Fisher ES, Alter DA, Guttmann A, Ko DT, Fung K, et al. Association of hospital spending intensity with mortality and readmission rates in Ontario hospitals. JAMA. 2012 Mar 14;307(10):1037-45.

32 Barsky R, Bound J, Charles KK, Lupton JP. Accounting for the black–white wealth gap: a nonparametric approach. Journal of the American statistical Association 2002 Sep 1;97(459):663-673.

Figures:

Figure 1: Rates of selected procedures on day of admission and 30 days after AMI

Numbers represent Kaplan-Meier rate estimates, censoring for death or entry into a managed care Medicare plan (US patients only).

Figure 2: PCI rates on day of admission and 30 days after AMI, by type of AMI

Numbers represent Kaplan-Meier rate estimates, censoring for death or entry into a managed care Medicare plan (US patients only).

Figure 3: PCI rates on day of admission and 30 days after AMI, by risk category

Numbers represent Kaplan-Meier rate estimates, censoring for death or entry into a managed care Medicare plan (US patients only). Risk groups were determined based on predicted 30-day mortality as low <10%, medium 10-20%, and high > 20%.

Figure 4: PCI rates on day of admission and 30 days after AMI among high-risk patients, by type of AMI

Numbers represent Kaplan-Meier rate estimates, censoring for death or entry into a managed care Medicare plan (US patients only).

Figure 5: PCI rates on day of admission and 30 days after AMI for rural and urban residents with STEMI in the US and Ontario

Numbers represent Kaplan-Meier rate estimates, censoring for death or entry into a managed care Medicare plan (US patients only).

Table 1: Characteristics of the study cohort in US and Ontario

	Ontario	US
N	112484	414216
Male	60,921 (54.2%)	207,968 (50.2%)
Age category		
66-70	20,223 (18.0%)	75,202 (18.2%)
71-75	21,584 (19.2%)	79,364 (19.2%)
76-80	23,725 (21.1%)	83,816 (20.2%)
81-85	23,306 (20.7%)	81,194 (19.6%)
86-90	15,757 (14.0%)	60,094 (14.5%)
91-99	7,889 (7.0%)	34,546 (8.3%)
Predicted risk of 30 day mortality		
Mean (± SD)	13.75 ± 15.04	13.57 ± 10.32
Risk groups:		
low (<10)	64,374 (57.2%)	191,419 (46.2%)
medium (10-20)	26,930 (23.9%)	141,434 (34.1%)
high (>20)	21,180 (18.8%)	81,363 (19.6%)
Year of index event		
2003 (9 months Canada)	8,771 (7.8%)	48007 (11.6%)
2004	11,511 (10.2%)	45845 (11.1%)
2005	11,111 (9.9%)	43166 (10.4%)
2006	10,182 (9.1%)	39844 (9.6%)
2007	10,181 (9.1%)	37622 (9.1%)
2008	10,689 (9.5%)	36241 (8.8%)
2009	9,738 (8.7%)	33577 (8.1%)
2010	10,108 (9.0%)	33651 (8.1%)
2011	9,877 (8.8%)	33021 (8.0%)
2012	10,087 (9.0%)	32554 (7.9%)
2013	10,229 (9.1%)	30688 (7.4%)
AMI type (post-07 for CDN)		
STEMI	16,388 (23.9%)	100,802 (24.3%)
Non-STEMI	50,667 (74.0%)	313,414 (75.7%)
Missing	1,456 (2.1%)	
Pre-FY 2007 (CDN)	43,973 (39.1%)	

Values represent a 20% sample of US Medicare fee-for-service beneficiaries and 100% sample of Ontario patients.

Table 2: Prevalence of comorbidities in the study cohort in the US and Ontario

	Ontario	United States
History of PCI	944 (0.8%)	8,380 (2.0%)
History of CABG	301 (0.3%)	1,706 (0.4%)
History of heart failure (CHF)	28,993 (25.8%)	111,053 (26.8%)
Unstable Angina	4,444 (4.0%)	12,112 (2.9%)
Atherosclerosis and other ischemic heart disease	30,064 (26.7%)	81,293 (19.6%)
Shock and cardiorespiratory failure	8,215 (7.3%)	37,850 (9.1%)
Valvular heart disease	2,248 (2.0%)	14,038 (3.4%)
Hypertension	8,729 (7.8%)	24,822 (6.0%)
Cerebrovascular disease	2,980 (2.6%)	11,684 (2.8%)
Renal disease	12,216 (10.9%)	45,262 (10.9%)
COPD or bronchitis	7,274 (6.5%)	30,767 (7.4%)
Pneumonia	10,501 (9.3%)	38,972 (9.4%)
Diabetes	7,415 (6.6%)	19,437 (4.7%)
Protein calorie malnutrition	739 (0.7%)	2,501 (0.6%)
Dementia	2,120 (1.9%)	5,354 (1.3%)
Hemiplegia, paraplegia, paralysis, function disability	1,317 (1.2%)	4,397 (1.1%)
Peripheral vascular disease	2,772 (2.5%)	12,070 (2.9%)
Metastatic cancer	1,237 (1.1%)	4,959 (1.2%)
Trauma	3,461 (3.1%)	12,078 (2.9%)
Psychiatric disorders, major	1,158 (1.0%)	2,299 (0.6%)
Liver disease, acute/chronic	520 (0.5%)	638 (0.2%)

Comorbidities include conditions identified from claims associated with the index admission and admissions in previous 1 year except history of PCI or CABG where only claims prior to the index admission were used.

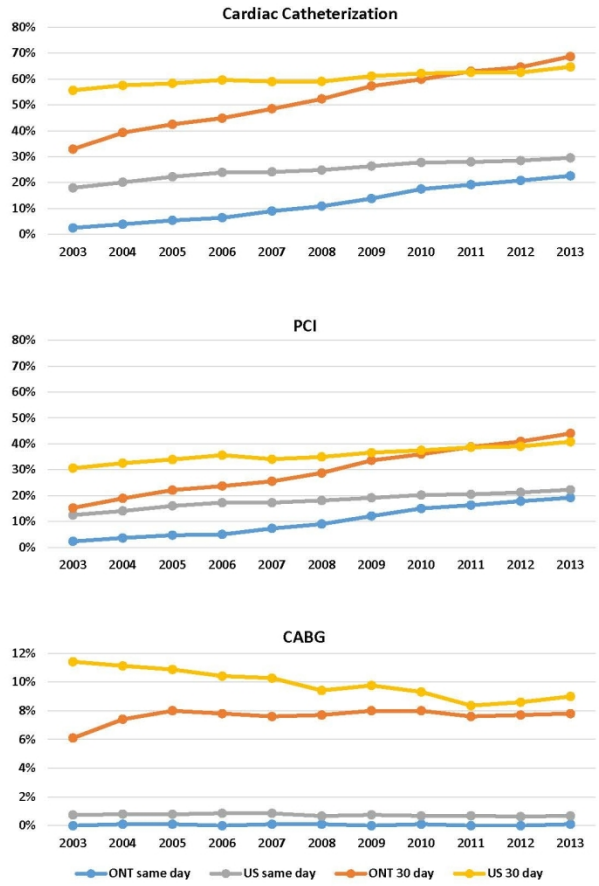

Figure 1 - Rates of selected procedures on day of admission and 30 days after AMI

215x279mm (200 x 200 DPI)

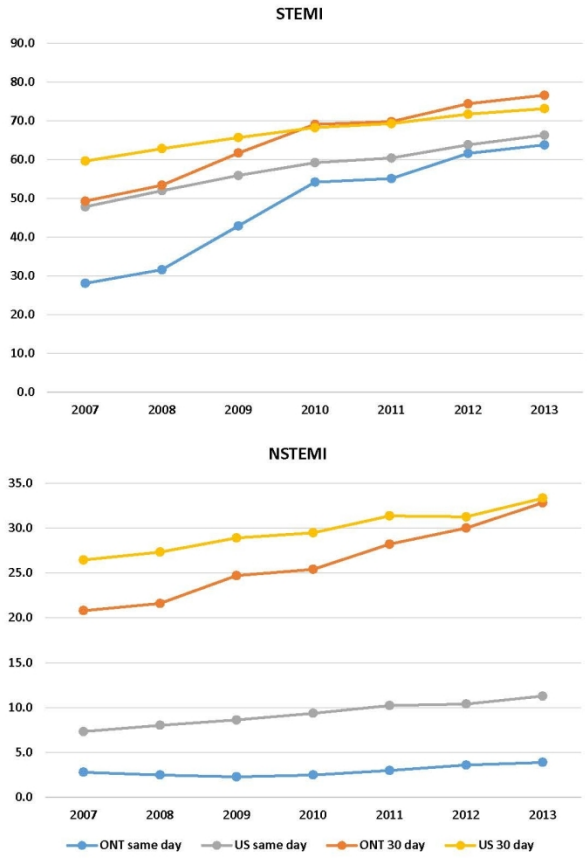

Figure 2- PCI rates on day of admission and 30 days after AMI, by type of AMI

215x279mm (200 x 200 DPI)

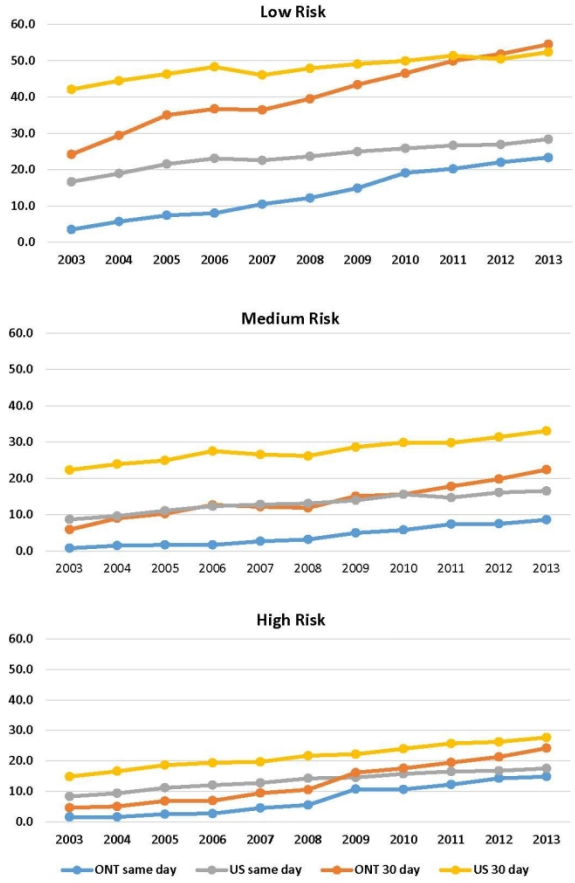

Figure 3 - PCI rates on day of admission and 30 days after AMI, by risk category

215x279mm (200 x 200 DPI)

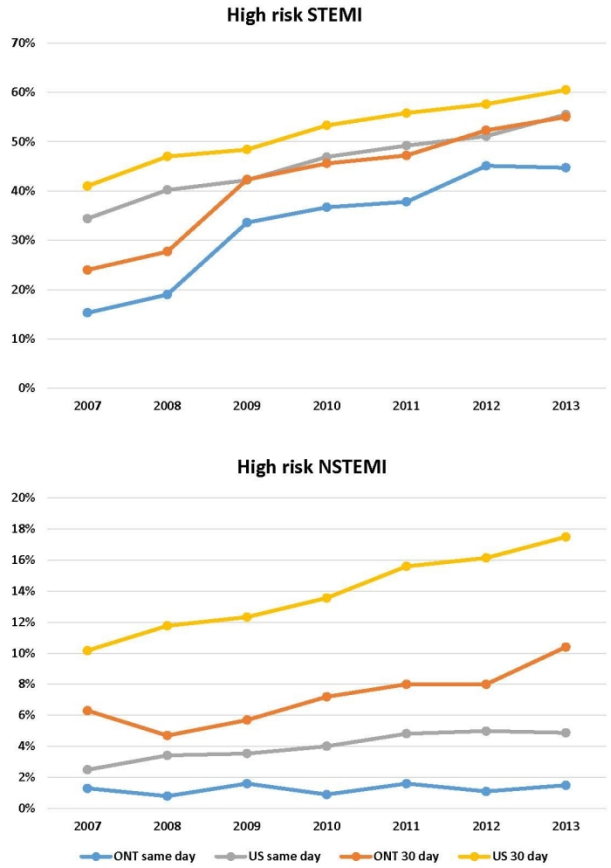

Figure 4 - PCI rates on day of admission and 30 days after AMI among high risk patients, by type of AMI

215x279mm (200 x 200 DPI)

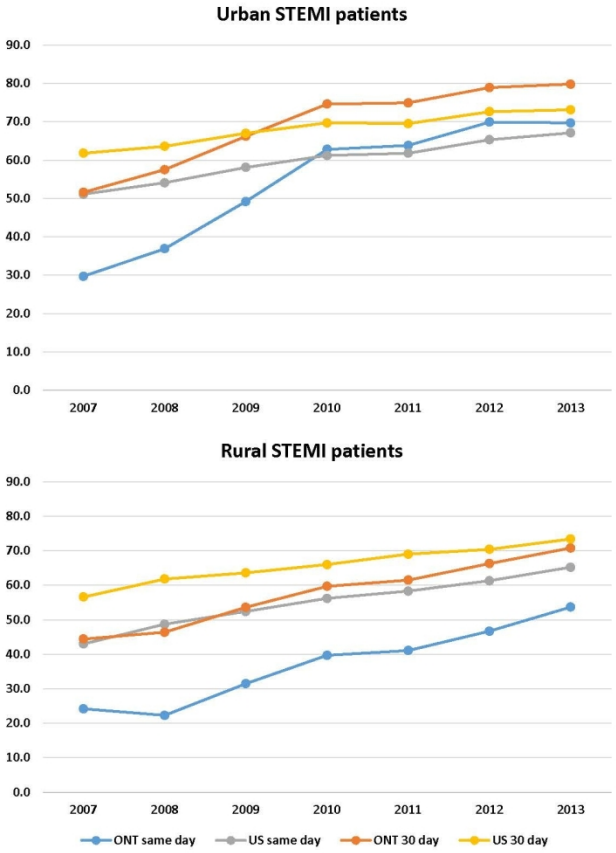

Figure 5 - PCI rates on day of admission and 30 days after AMI for rural and urban residents with STEMI in the US and Ontario

215x279mm (200 x 200 DPI)

Appendix Table 1a: CPT codes used to identify cardiac catheterization procedures, US:

CPT code	Description
Procedure years before 2011	
93508	Coronary Angiogram
93510	Left Heart Catheterization
93543	LV Injection
93555	Supervision & Interpretation for LV angio
93526	RLHC
93545	Coronary Injection
93556	S&I Cor Ing
93539	Injection Arterial Conduits
93540	Injection SVG's
Procedure years after 2011	
93452	Left heart catheterization including intraprocedural injection(s) for left ventriculography; imaging supervision and interpretation, when performed
93453	Combined right heart cath and left heart catheterization including intraprocedural injection(s) for left ventriculography, imaging supervision and interpretation, when performed
93454	Catheter placement in coronary artery(s) for coronary angiography, including intraprocedural injection(s) for coronary angiography, imaging supervision and interpretation
93455	Catheter placement in coronary artery(s) for coronary angiography, including intraprocedural injection(s) for coronary angiography, imaging supervision and interpretation; with catheter placement(s) in bypass graft(s) (internal mammary, free arterial venous grafts) including intraprocedural injection(s) for bypass graft angiography
93456	Catheter placement in coronary artery(s) for coronary angiography, including intraprocedural injection(s) for coronary angiography, imaging supervision and interpretation; with right heart catheterization
93457	Catheter placement in coronary artery(s) for coronary angiography, including intraprocedural injection(s) for coronary angiography, imaging supervision and interpretation;with catheter placement(s) in bypass graft(s) (internal mammary, free arterial, venous grafts) including intraprocedural injection(s) for bypass graft angiographyand right heart catheterization
93458	Catheter placement in coronary artery(s) for coronary angiography, including intraprocedural injection(s) for coronary angiography, imaging supervision and interpretation;with left heart catheterization including intraprocedural injection(s) for left ventriculography, when performed
93459	Catheter placement in coronary artery(s) for coronary angiography, including intraprocedural injection(s) for coronary angiography, imaging supervision and interpretation;with left heart catheterization including intraprocedural injection(s) for left ventriculography, when performed,catheter placement(s) in bypass graft(s) (internal mammary, free arterial, venous grafts) with bypass graft angiography
93460	Catheter placement in coronary artery(s) for coronary angiography, including intraprocedural injection(s) for coronary angiography, imaging supervision and interpretation;with right and left heart catheterization including intraprocedural injection(s) for left ventriculography, when performed
93461	Catheter placement in coronary artery(s) for coronary angiography, including intraprocedural injection(s) for coronary angiography, imaging supervision and interpretation;with rightand left heart catheterization including intraprocedural injection(s) for left ventriculography, when performed,catheter placement(s) in bypass graft(s) (internal mammary, free arterial, venous grafts) with bypass graft angiography

Appendix Table 1b: CPT codes used to identify PCI, US:

CPT code	Description
Procedure years before 2013:	
Nonstent and stent procedures combined for all statistics:	
Nonstent	
92982	Angioplasty, initial vessel
92984	Angioplasty, each additional vessel
92995	Atherectomy, initial vessel
92996	Atherectomy, each additional vessel
Stent:	
92980	Stent placement, initial vessel
92981	Stent placement, each additional vessel
C1874	Stent, Coated/Covered, With Delivery System
C1875	Stent, Coated/Covered, Without Delivery System
G0290	Drug eluting stent, initial vessel
G0291	Drug eluting stent, each additional vessel
Procedure year after 2013:	
nonstent:	
92920	Angioplasty, single artery or branch
92921	Angioplasty, each additional
92924	Atherectomy, single artery or branch
92925	Atherectomy, each additional
stent:	
92928/C9600	Stent placement, single artery or branch
92929/C9601	Stent placement, each additional
92933/C9602	Atherectomy with stent, single artery or branch
92934/C9603	Atherectomy with stent, each additional
grafts, acute occlusion, and CTO	
92937/C9604	Graft revascularization, single vessel
92938/C9605	Graft revascularization, each additional branch
92941/C9606	Revascularization of acute total/subtotal occlusion during myocardial infarction, single vessel
92943/C9607	Revascularization of CTO, single vessel, native coronary artery, branch or bypass graft
92944/C9608	Revascularizaiton of CTO, each additional native coronary artery, branch or bypass graft

Appendix Table 1c: ICD-9 procedure codes used to identify CABG procedure, US:

ICD-9	Description
361	Bypass anastomosis for heart revascularization
3610	Aortocoronary bypass for heart revascularization, not otherwise specified
3611	(Aorto)coronary bypass of one coronary artery
3612	(Aorto)coronary bypass of two coronary arteries
3613	(Aorto)coronary bypass of three coronary arteries
3614	(Aorto)coronary bypass of four or more coronary arteries
3615	Single internal mammary-coronary artery bypass
3616	Double internal mammary-coronary artery bypass
3617	Abdominal - coronary artery bypass
3619	Other bypass anastomosis for heart revascularization

Appendix Table 2: Procedure Codes used in Ontario claims:

CCI	Description	Feecode	Description
CABG			
1IJ76	BYPASS, CORONARY ARTERIES	R742	HEART PERI.-CORONARY ARTERY REPAIR-SINGLE
1IJ80	REPAIR, CORONARY ARTERIES	R743	HEART PERI.-CORONARY ARTERY REPAIR-DOUBLE
PCI			
1IJ50	DILATION, CORONARY ARTERIES	Z434	ANGIOGRAPHY-TRANSLUMINAL CORONARY ANGIOPLASTY
		G298	CORONARY ANGIOPLAST STENT
Cardiac Catheterization			
3IP10	Xray, heart with coronary arteries	Z442	D&TPROC.-CARDIOVASC.SELECTCORONARY CATHERIZ'N INC'L INJ.
		Z440	HAEMODYNAMIC/FLOW/METABOLIC STUDIES LT.HEART RETROG.AORT
		G297	D./T.PROC.CARDIAC CATH.-ANGIOGRAMS ONLY2 1 RT.HEART 1 LEFT

Appendix Table 3: Overall rates of procedures at 3 days after index AMI admission, US and Ontario

	US PCI	ONT PCI	US cath	ONT cath	US CABG	ONT CABG
2003	25.4	5.2	46.5	11.9	5.0	0.4
2004	27.5	7.8	48.8	16.1	5.1	0.4
2005	29.3	10.5	50.3	20.4	4.9	0.6
2006	31.0	11.9	52.2	23.8	5.1	0.4
2007	30.3	16.2	51.9	30.5	5.0	0.5
2008	31.1	19.1	52.3	34.3	4.3	0.5
2009	32.8	23.2	54.6	39.2	4.5	0.5
2010	33.8	26.3	56.0	42.2	4.4	0.8
2011	34.9	29	56.7	45.5	4.0	0.6
2012	35.5	31.4	56.9	47.6	4.0	0.6
2013	36.1	34.6	57.1	51.8	4.0	0.6

Numbers represent Kaplan-Meier rate estimates, censoring for death and for entry into a managed care Medicare plan (US patients only).

Appendix Table 4: Rates of PCI at 3 days after index AMI admission, by predicted risk and AMI type, US and Ontario

	Ontario			United States		
	By AMI type			By AMI type		
	STEMI	NSTEMI		STEMI	NSTEMI	
2007	41.1	11.6		57.2	21.4	
2008	44.4	11.8		60.4	22.4	
2009	55.0	13.0		63.8	24.0	
2010	64.3	14.2		66.4	24.8	
2011	66.0	16.3		67.3	26.6	
2012	70.8	18.5		70.1	26.8	
2013	73.2	21.3		71.5	27.3	
	By predicted risk			By predicted risk		
	Low	Medium	High	Low	Medium	High
2003	8.4	1.7	2.6	35.5	17.1	12.2
2004	12.5	3.3	2.8	38.4	18.7	13.7
2005	17.5	3.8	3.9	40.8	20.2	15.9
2006	19.5	4.5	4.3	42.8	22.6	16.8
2007	23.8	6.7	6.6	41.7	22.1	17.0
2008	27.0	6.4	7.5	43.4	22.0	18.9
2009	30.0	9.3	14.0	44.8	24.3	19.6
2010	34.8	9.7	13.4	46.0	25.6	21.2
2011	37.9	11.6	15.1	47.4	25.7	22.4
2012	40.4	12.7	17.7	46.7	27.3	23.5
2013	43.6	15.4	19.0	47.3	27.6	24.0

Numbers represent Kaplan-Meier rate estimates, censoring for death and for entry into a managed care Medicare plan (US patients only).