# Chapter 20: In-hospital outcomes after percutaneous coronary intervention in Canada: 1992/93 to 2000/01

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**BACKGROUND:** Despite existing research on outcomes of cardiac care in Canada, little is known about Canada-wide trends and interprovincial differences in outcomes after percutaneous coronary intervention (PCI).
**OBJECTIVES:** To examine Canadian trends in rates of in-hospital mortality and same-admission coronary artery bypass grafting (CABG) after PCI and to compare provincial risk-adjusted in-hospital death and same-admission CABG rates.
**METHODS:** Hospital discharge abstract data were obtained from the Canadian Institute for Health Information and were used to identify cohorts of patients who underwent PCI in eight provinces in fiscal years 1992/93 through 2000/01. Crude data from Quebec hospitals were available for calendar years 1998 and 1999. Logistic regression modelling was used to calculate risk-adjusted in-hospital death and same-admission CABG rates by year and province.
**RESULTS:** A total of 127,103 PCI cases performed in 23 hospitals across eight provinces were examined, with an overall unadjusted death rate of 1.4% and an overall unadjusted CABG rate of 1.6%. A national trend of stable in-hospital mortality rates was observed with a risk-adjusted death rate of 1.4% in 1992/93 versus 1.4% in 2000/01. An overall decline was seen in rates of same-admission CABG with a risk-adjusted rate of 2.7% in 1992/93 versus 0.9% in 2000/01 (relative decrease 67%, P<0.01). New Brunswick, Manitoba and British Columbia achieved overall declines in risk-adjusted death rates over the study period, while the other provinces experienced a slight increase (Newfoundland, Nova Scotia, Ontario, Alberta and Saskatchewan). All provinces displayed a similar decline in risk-adjusted same-admission CABG rates post-PCI.
**INTERPRETATION:** Risk-adjusted rates of in-hospital death after PCI in Canada have remained stable over nine years, while risk-adjusted rates of same-admission CABG have decreased. The presence of interprovincial differences in risk-adjusted outcomes raises the possibility of variable quality of care for patients undergoing PCI across the Canadian provinces.

**Key Words:** *Angioplasty; Canada; Coronary artery bypass grafting; Mortality; Percutaneous coronary intervention*

## Les issues des patients hospitalisés après une intervention coronarienne percutanée au Canada : De 1992-93 à 2000-01

**HISTORIQUE :** Malgré les recherches existantes sur les issues des soins cardiaques au Canada, on ne sait pas grand-chose des tendances canadiennes et des différences interprovinciales relativement aux issues après une intervention coronarienne percutanée (ICP).
**OBJECTIFS :** Examiner les tendances canadiennes quant au taux de mortalité des patients hospitalisés et au taux de pontage aortocoronarien (PAC) pendant la même hospitalisation après une ICP et comparer les taux de décès hospitaliers provinciaux rajustés selon le risque et de PAC pendant la même hospitalisation.
**MÉTHODOLOGIE :** Les données de résumés sur les congés hospitaliers ont été obtenues auprès de l'Institut canadien d'information sur la santé et ont été utilisées pour repérer des cohortes de patients ayant subi une ICP dans huit provinces au cours des exercices 1992-1993 à 2000-2001. Des données brutes provenant d'hôpitaux québécois étaient disponibles pour les années civiles 1998 et 1999. La modélisation par régression logistique a été utilisée pour calculer les taux de décès des patients hospitalisés rajustés selon le risque et les taux de PAC pendant la même hospitalisation selon l'année et la province.
**RÉSULTATS :** Au total, ont été examinés 127 103 cas d'ICP exécutés dans 23 hôpitaux des huit provinces, représentant un taux global et non rajusté de décès de 1,4 %, et un taux global et non rajusté de PAC de 1,6%. Une tendance nationale de stabilité du taux de mortalité des patients hospitalisés a été observée, d'après un taux de décès rajusté selon le risque de 1,4 % en 1992-1993 par rapport à 1,4 % en 2000-2001. Une diminution globale a été constatée pour ce qui est des taux de PAC pendant la même hospitalisation, accompagnés d'un taux rajusté selon le risque de 2,7 % en 1992-1993 par rapport à 0,9 % en 2000-2001 (diminution relative de 67 %, P < 0,01). Le Nouveau-Brunswick, le Manitoba et la Colombie-Britannique ont affiché une diminution globale du taux de décès rajusté selon le risque pendant la période de l'étude, tandis que les autres provinces ont présenté une légère augmentation (Terre-Neuve, Nouvelle-Écosse, Ontario, Alberta et Saskatchewan). Toutes les provinces affichaient une réduction similaire du taux de PAC pendant la même hospitalisation après une ICP.
**INTERPRÉTATION :** Les taux de décès des patients hospitalisés rajustés selon le risque après une ICP au Canada sont demeurés stables pendant neuf ans, tandis que les taux rajustés de PAC pendant la même hospitalisation ont diminué. La présence de différences interprovinciales quant aux issues rajustées selon le risque soulèvent la possibilité d'une qualité variable de soins pour les patients subissant une ICP dans les provinces canadiennes.

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Over the past decade, there has been a substantial increase in the use of percutaneous coronary intervention (PCI) (1). Numerous studies have examined outcomes after PCI in the United States, but little is known about outcome trends or province-specific outcomes in Canada.

In this study, we used national hospital discharge abstract data to create a clearer profile of PCI outcomes and case-mix in Canada. Our specific objectives were 1) to study trends in mortality and same-admission coronary artery bypass grafting (CABG) post-PCI over time and 2) to compare provincial rates of observed (ie, crude) and risk-adjusted in-hospital mortality and same-admission CABG.

## METHODS

### Data sources

Hospital discharge abstract data were used for this Canada-wide study of PCI outcomes because a more detailed national database for PCI does not exist. Although some reports have shown that better risk adjustment is possible when prospectively collected clinical databases are available (2-6), Landon et al (7) have demonstrated that reasonable risk adjustment for CABG surgery outcomes is achievable with hospital discharge abstract data. Similarly, Ghali et al (8) compared two CABG outcome report cards for Ontario – one derived from clinical data and the other from Canadian administrative data – and found general similarities between report cards, confirming that risk adjustment for CABG surgery outcomes is possible with Canadian administrative databases. In the context of CABG surgery outcome reporting, these findings do not necessarily apply to PCI but they do encourage continuation of work focused on PCI.

The data for this study were obtained from the Canadian Institute for Health Information (CIHI), which compiles discharge records of acute care hospital admissions in all Canadian provinces and territories. Data for fiscal years 1992/93 through 2000/01 were studied (Quebec data were available only for calendar years 1998 and 1999).

PCI cases were identified through screening of all hospital discharges for *Canadian Classification of Procedures* (9) codes 48.02, 48.03 and 48.09. All cases performed in patients aged 18 years or older, and cases where discharge occurred from a hospital that actually performs PCI were included. This latter criterion resulted in the exclusion of a number of PCI procedures coded in discharge abstract records from hospitals that do not actually perform PCI. These cases reflect an anticipated care practice of occasionally transferring patients to PCI tertiary care centres for typically brief procedural stays while their hospital care in surrounding community hospitals is ongoing. Recognizing that ascertainment of in-hospital outcomes may be incomplete in cases involving interhospital transfers, and that such cases may differ systematically from more typical cases where the entire PCI hospital care episode occurs in a tertiary care centre, the present analysis was confined to hospital discharges from centres that actually perform PCI.

### Statistical analysis

The outcomes of interest were the observed (ie, crude) and risk-adjusted rates of in-hospital death and same-admission CABG. These events were judged to be indicative of adverse outcomes after PCI and were considered to be possible quality indicators. Logistic regression modelling was used to adjust death rates for differences across years and provinces in sociodemographic, comorbidity and condition-specific indicators of average severity of illness (10,11).

The sociodemographic variables studied were age and sex. For comorbidity, an *International Classification of Diseases*, 9th revision (12) coding scheme was used to identify the 17 comorbidity variables that constitute the Charlson comorbidity index (13). A condition was considered present only when the 'diagnosis-type' indicator (in CIHI data) was consistent with diagnoses that were present at time of admission (14).

Data for years 1992/93 through 2000/01 were pooled for the multivariable risk adjustment analysis. Because Quebec reported observed data only for 1998 and 1999 without information on type of diagnosis, it was excluded from this multivariable analysis. All potential variables were included in a backward elimination analysis that retained only significant variables at $P<0.05$. Sequential elimination of the least significant variables was performed until only the significant variables remained. The resulting models are presented in Appendix 1 (for in-hospital mortality) and Appendix 2 (for same-admission CABG).

To assess the discrimination of the risk adjustment models, c statistics were calculated for each model (15). The risk adjustment models were used to calculate the predicted probability of in-hospital death (or same-admission CABG) for each patient who underwent PCI. The average of the predicted probabilities in a given year (or province) was calculated to yield an expected rate (E). The observed (ie, crude) rate (O) was then divided by E to generate an O/E ratio. To calculate the risk-adjusted rate for a given year (or province), the year-specific (or province-specific) O/E ratio was multiplied by the overall rate for the nine years studied.

The statistical significance of differences in adjusted rates between years and provinces was tested by examination of increments in the –2 log likelihood $\chi^2$ statistic when dummy variables for year and province were added to the risk adjustment model.

All analyses were performed using SAS version 8.1 (SAS Institute, USA).

## RESULTS

The authors studied 127,103 cases performed in 23 hospitals across eight provinces, excluding Quebec. No procedures were performed in Prince Edward Island or the territories because patients residing in those regions were referred to surrounding provinces for treatment. The number of patients undergoing PCI per year and meeting study inclusion criteria almost doubled in this time period, from 10,129 in 1992/93 to 20,067 in 2000/01 (Table 1). The proportion of PCI patients over the age of 65 increased from 37% in 1992/93 to almost 45% in 2000/01. An increasing number of patients with acute coronary syndromes (ie, unstable angina or a recent myocardial infarction) are being treated with PCI and these conditions increased in prevalence among PCI patients from 55% in 1992/93 to 73% in 2000/01. The use of PCI in the setting of a primary diagnosis of acute myocardial infarction increased from 13.5% to 22.9%. The prevalence of diabetes and prior CABG also increased. Observed unadjusted mortality rates increased somewhat (1.1% in 1992/93 versus 1.7% in 2000/01) but this increase coincided with increases in mean patient age and severity of illness. Same-admission CABG rates, meanwhile, decreased considerably (2.7% in 1992/93 versus 0.9% in 2000/01, $P<0.01$).

The prevalence of specific clinical characteristics varied across provinces (Table 2). Saskatchewan had the highest percentage of PCI patients over 65 (51%) while Newfoundland had the lowest (33%). More urgent admission patients were

**TABLE 1**
**Clinical characteristics of patients undergoing percutaneous coronary intervention from 1992/93 to 2000/01**

| | Fiscal year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1992 n=10,129 | 1993 n=10,858 | 1994 n=11,650 | 1995 n=12,142 | 1996 n=13,496 | 1997 n=14,833 | 1998 n=16,421 | 1999 n=17,507 | 2000 n=20,067 |
| Age ≥ 65 years | 36.7 | 38.0 | 39.9 | 40.6 | 40.6 | 41.7 | 43.7 | 43.5 | 44.6 |
| Female sex | 26.6 | 27.9 | 27.4 | 28.4 | 28.3 | 29.0 | 28.4 | 28.5 | 28.0 |
| Urgent admission | 53.5 | 54.4 | 56.5 | 61.3 | 63.1 | 63.4 | 62.5 | 67.3 | 66.9 |
| Unstable angina | 31.0 | 33.4 | 34.9 | 34.3 | 37.1 | 37.5 | 37.7 | 37.3 | 37.1 |
| Recent myocardial infarction | 24.2 | 24.8 | 25.8 | 27.9 | 29.9 | 30.6 | 30.8 | 33.4 | 35.7 |
| Hypertension | 22.2 | 21.3 | 20.5 | 21.7 | 24.5 | 25.8 | 29.0 | 31.6 | 33.0 |
| Old myocardial infarction | 16.8 | 15.2 | 13.0 | 13.3 | 13.7 | 15.4 | 14.2 | 12.7 | 12.1 |
| Primary diagnosis acute myocardial infarction | 13.5 | 12.8 | 14.1 | 14.7 | 16.7 | 17.8 | 19.3 | 21.7 | 22.9 |
| Diabetes | 10.7 | 11.6 | 10.2 | 11.3 | 11.7 | 12.7 | 13.9 | 15.8 | 17.5 |
| Prior CABG | 4.2 | 4.1 | 4.4 | 12.0 | 13.4 | 13.7 | 13.3 | 12.4 | 13.9 |
| Congestive heart failure | 3.6 | 4.1 | 4.1 | 4.7 | 5.2 | 5.3 | 5.5 | 5.5 | 6.0 |
| Chronic lung disease | 3.3 | 2.8 | 3.2 | 3.1 | 3.7 | 3.7 | 4.0 | 4.2 | 4.1 |
| Cardiac arrest | 2.4 | 2.7 | 2.4 | 2.7 | 2.8 | 2.5 | 2.0 | 2.0 | 2.3 |
| Peripheral vascular disease | 2.1 | 1.8 | 1.6 | 1.7 | 1.9 | 1.8 | 2.3 | 1.9 | 1.7 |
| Cerebrovascular disease | 1.4 | 1.1 | 1.2 | 1.4 | 1.5 | 1.6 | 1.5 | 1.1 | 1.3 |
| Chronic renal disease | 0.6 | 0.6 | 0.7 | 0.7 | 0.6 | 0.8 | 0.9 | 1.0 | 1.1 |
| Neoplasia | 0.6 | 0.5 | 0.6 | 0.7 | 0.7 | 0.7 | 0.9 | 0.9 | 1.0 |
| Diabetes with complications | 0.4 | 0.6 | 0.5 | 0.4 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 |
| Metastatic disease | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Mild liver disease | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.1 | 0.0 |

*CABG Coronary artery bypass grafting*

treated in Newfoundland than in any other province. In Alberta, PCI was more likely to be performed in patients with a primary diagnosis of acute myocardial infarction.

### In-hospital mortality

The observed death rates, expected death rates (derived from the risk adjustment model shown in Appendix 1) and risk-adjusted death rates (adjusted for variables included in the same model) are presented by province in Table 3 for the entire nine-year study period. The observed death rates varied from 1.0% in New Brunswick to 2.7% in Manitoba, and the expected death rates varied from 1.0% in Ontario to 2.3% in Alberta. The risk-adjusted death rates in the last column of Table 3 varied significantly (P<0.01), ranging from 1.1% in Alberta to 2.0% in Manitoba. The same risk-adjusted rates are presented in graphical form in Figure 1.

Figure 2 shows a plot of the observed versus expected death rates by province for the entire study period. The observed death rate for Alberta was lower than expected, whereas Manitoba's observed death rate was higher than expected. Meanwhile, other provinces fell close to the diagonal line in the figure, indicating observed death rates that approximate expected death rates. The expected death rate for a given province reflects the average severity of illness of patients undergoing PCI in the province. Ontario and Alberta had, respectively, the lowest and highest average severity of illness. In provinces in the lower left quadrant of the figure (Ontario, New Brunswick, Nova Scotia, British Columbia and Newfoundland), PCI was performed on younger and healthier patients. Saskatchewan, Manitoba and Alberta had higher expected death rates, ie, older and sicker patients were more likely to be treated in those provinces.

The risk adjustment model was also used to study Canada-wide trends in adjusted death rates after PCI (Figure 3). Observed death rates increased during this time period. On risk adjustment, however, the death rate remained generally stable at about 1.4%. This indicates that in spite of the sicker patients undergoing PCI, risk-adjusted mortality remained stable.

Outcomes were asssessed for the 16,968 PCI cases from Quebec for calendar years 1998 and 1999. Only observed (ie, unadjusted) in-hospital death rates were reported. During this time, observed in-hospital mortality in Quebec increased from 1.6% to 1.9%. These percentages were comparable with those of other provinces. More detailed analyses of Quebec outcomes were not possible because Quebec data did not include diagnosis-type indicators, and only selected years were compiled by CIHI.

### Same-admission CABG rates

The observed and expected same-admission CABG rates are presented by province in Table 4. The observed same-admission CABG rates varied from 1.0% in New Brunswick to 4.2% in Newfoundland and the expected same-admission CABG rates (derived from the risk adjustment model shown in Appendix 2) varied from 1.6% in Alberta, British Columbia and Ontario to 2.2% in Manitoba. The corresponding risk-adjusted same-admission CABG rates ranged from 0.9% in New Brunswick to 3.7% in Newfoundland (P<0.01) (last column, Table 4). These rates are also graphically presented in Figure 4.

**TABLE 2**
**Clinical characteristics of patients undergoing percutanous coronary intervention by province**

| | Canada | Newfound-land | Nova Scotia | New Brunswick | Ontario | Manitoba | Saskat-chewan | Alberta | British Columbia |
|---|---|---|---|---|---|---|---|---|---|
| | n=127,103 | n=2210 | n=6461 | n=6104 | n=54,490 | n=3760 | n=7072 | n=19,266 | n=27,733 |
| Age ≥ 65 years | 41.6 | 32.6 | 40.0 | 38.7 | 37.8 | 45.2 | 50.9 | 42.1 | 47.4 |
| Female sex | 28.2 | 28.9 | 32.8 | 28.2 | 28.7 | 29.8 | 28.6 | 26.0 | 27.1 |
| Primary diagnosis acute myocardial infarction | 17.8 | 5.7 | 12.7 | 11.9 | 13.8 | 13.9 | 22.5 | 36.4 | 15.4 |
| Chronic lung disease | 3.7 | 3.9 | 6.1 | 1.6 | 3.1 | 4.1 | 2.2 | 7.6 | 2.2 |
| Unstable angina | 36.0 | 40.7 | 39.9 | 34.1 | 37.6 | 48.5 | 27.6 | 37.5 | 31.4 |
| Urgent admission | 62.0 | 88.3 | 74.3 | 78.6 | 49.9 | 69.0 | 64.9 | 77.1 | 64.7 |
| Recent myocardial infarction | 30.0 | 26.1 | 27.0 | 26.8 | 24.0 | 39.3 | 39.7 | 43.7 | 30.3 |
| Hypertension | 26.5 | 21.9 | 44.2 | 7.7 | 23.2 | 28.5 | 12.6 | 43.1 | 25.0 |
| Old myocardial infarction | 13.9 | 10.6 | 13.3 | 0.1 | 11.6 | 8.5 | 18.3 | 27.4 | 12.0 |
| Diabetes | 13.3 | 10.4 | 18.8 | 4.6 | 13.1 | 16.3 | 10.2 | 16.0 | 13.2 |
| Prior CABG | 10.9 | 4.5 | 18.6 | 5.0 | 10.4 | 12.1 | 10.1 | 16.7 | 7.7 |
| Congestive heart failure | 5.0 | 3.4 | 4.8 | 3.2 | 3.8 | 8.6 | 5.1 | 10.4 | 3.8 |
| Peripheral vascular disease | 1.9 | 1.5 | 2.8 | 0.9 | 1.6 | 2.9 | 0.9 | 3.3 | 1.5 |
| Cerebrovascular disease | 1.3 | 1.1 | 1.6 | 0.6 | 1.3 | 2.1 | 1.2 | 2.1 | 1.0 |
| Chronic renal disease | 0.8 | 0.9 | 1.9 | 0.6 | 0.8 | 1.0 | 0.9 | 0.6 | 0.7 |
| Neoplasia | 0.8 | 0.5 | 0.9 | 0.5 | 0.7 | 1.1 | 0.5 | 1.3 | 0.6 |
| Diabetes with complications | 0.6 | 0.5 | 0.6 | 0.2 | 0.5 | 0.7 | 0.4 | 1.2 | 0.5 |
| Metastatic disease | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 |
| Mild liver disease | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |

*CABG Coronary artery bypass grafting*

**TABLE 3**
**In-hospital mortality rates by province for 1992/93 to 2000/01**

| Province | Volume | Observed death rate* (%) | Expected death rate† (%) | Adjusted death rate‡ (95% CI) |
|---|---|---|---|---|
| Newfoundland | 2210 | 1.4 | 1.1 | 1.8 (1.2 to 2.3) |
| Nova Scotia | 6461 | 1.3 | 1.3 | 1.4 (1.1 to 1.7) |
| New Brunswick | 6104 | 1.0 | 1.2 | 1.2 (0.9 to 1.5) |
| Ontario | 54,490 | 1.1 | 1.0 | 1.5 (1.3 to 1.6) |
| Manitoba | 3760 | 2.7 | 1.9 | 2.0 (1.7 to 2.3) |
| Saskatchewan | 7072 | 1.9 | 1.8 | 1.5 (1.2 to 1.7) |
| Alberta | 19,266 | 1.7 | 2.3 | 1.1 (0.9 to 1.2) |
| British Columbia | 27,733 | 1.6 | 1.4 | 1.6 (1.4 to 1.7) |
| Canada | 127,103 | 1.4 | 1.4 | 1.4 (1.3 to 1.5) |

**Observed (ie, crude) death rate is crude, unadjusted death rate (observed numbers/volume percutaneous coronary intervention patients); †Expected death rate is calculated by regression model (expected numbers/volume percutaneous coronary intervention patients); ‡Adjusted death rate is observed death rate adjusted for risk*

Figure 5 is a plot of the observed versus expected CABG rates by province for the study period. New Brunswick had an observed CABG rate that was lower than expected, whereas Newfoundland and Saskatchewan had observed CABG rates that were higher than expected. Other provinces fell closer to the diagonal line.

The risk adjustment model was used to study Canada-wide trends in adjusted rates of same-admission CABG after PCI (Figure 6). There was a significant decline in the rate of same-admission CABG adjusted for risk, from 2.7% in 1992/93 to 0.9% in 2000/01 (relative decrease of 67%) (P<0.01).

Only observed same-admission CABG rates were reported for the province of Quebec for calendar years 1998 and 1999. During this time, the observed same-admission CABG rate in Quebec increased slightly, from 1.2% to 1.3%. These percentages were comparable with those of other provinces.

## DISCUSSION AND CONCLUSIONS

On a national level, risk-adjusted, in-hospital, post-PCI death rates were constant between 1992/93 and 2000/01. There were significant differences in risk-adjusted and expected death rates (as measured by our risk adjustment model) across provinces. In contrast, the national trend of decreasing rates of same-admission CABG after PCI between 1992/93 and 2000/01 reflected decreasing risk-adjusted event rates in all provinces across the years studied.

The national trend of stable mortality and decreasing use of CABG after PCI, despite an increase in use and severity of illness, is encouraging and similar to favourable outcome trends reported from the United States (16). However, our finding of no significant decrease in risk-adjusted death rate is different from the 37% decrease found in United States Medicare beneficiaries from 1987 to 1990 (17), perhaps because of the different time periods studied and the restricted age range of United States Medicare beneficiaries. Peterson et al (16) discussed several potential explanations for improved outcomes in the United States. First, PCI may have been applied to healthier patients with fewer comorbid conditions. Second, the improved outcomes may have resulted from increasing experience in performing this procedure (18). Third, procedural improvements, such as the introduction of stents and use of glycoprotein IIb/IIIa inhibitors, may account for the decrease in adverse events (19-24).

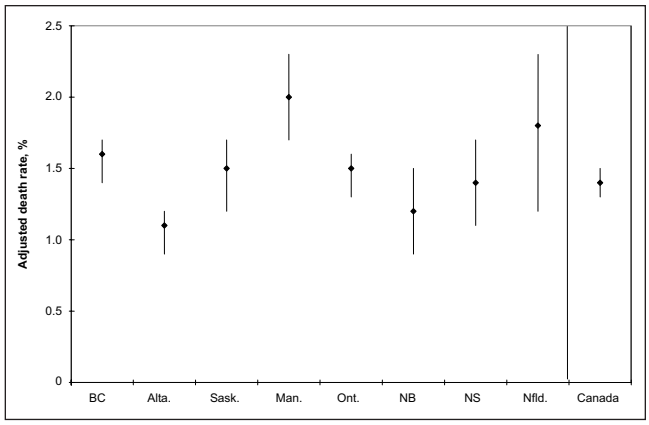


**Figure 1)** *Risk-adjusted in-hospital death rates by province for fiscal years 1992/93 to 2000/01. Alta. Alberta; BC British Columbia; Man. Manitoba; NB New Brunswick; Nfld. Newfoundland; NS Nova Scotia; Ont. Ontario; Sask. Saskatchewan*

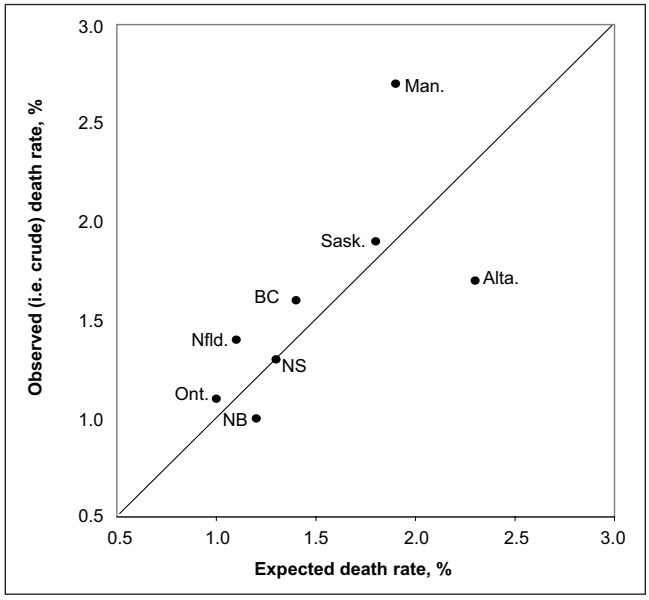


**Figure 2)** *Observed (ie, crude) versus expected in-hospital death rates post-percutaneous coronary intervention (PCI) by province. Observed death rate is crude, unadjusted death rate (observed numbers/volume of PCI patients); expected death rates are calculated using logistic regression model (expected numbers/volume of PCI patients)*

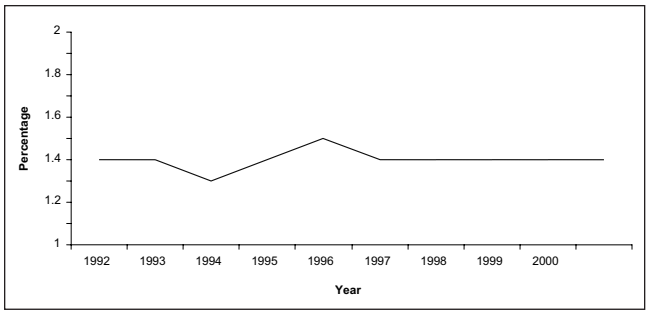


**Figure 3)** *Risk-adjusted in-hospital death rates in post-percutaneous coronary intervention patients*

**TABLE 4**
**Same-admission CABG rates by province for 1992/93 to 2000/01**

| Province | Volume | Observed CABG rate* (%) | Expected CABG rate† (%) | Adjusted CABG rate‡ (95% CI) |
|---|---|---|---|---|
| Newfoundland | 2,210 | 4.2 | 1.8 | 3.7 (3.2 to 4.2) |
| Nova Scotia | 6,461 | 1.9 | 1.7 | 1.8 (1.5 to 2.1) |
| New Brunswick | 6,104 | 1.0 | 1.7 | 0.9 (0.6 to 1.2) |
| Ontario | 54,490 | 1.7 | 1.6 | 1.7 (1.6 to 1.9) |
| Manitoba | 3,760 | 2.3 | 2.2 | 1.7 (1.3 to 2.0) |
| Saskatchewan | 7,072 | 2.3 | 1.7 | 2.2 (1.9 to 2.5) |
| Alberta | 19,266 | 1.2 | 1.6 | 1.2 (1.0 to 1.4) |
| British Columbia | 27,733 | 1.3 | 1.6 | 1.3 (1.2 to 1.5) |
| Canada | 127,103 | 1.6 | 1.6 | 1.6 (1.5 to 1.7) |

*CABG Coronary artery bypass grafting. *Observed (ie, crude) death rate is crude, unadjusted death rate (observed numbers/volume percutaneous coronary intervention patients); †Expected death rate is calculated by regression model (expected numbers/volume percutaneous coronary intervention patients); ‡Adjusted death rate is observed death rate adjusted for risk*

No studies have directly examined outcomes after PCI across Canada. However, Rankin et al (24) analyzed one-year follow-up data for all PCI patients in British Columbia to determine whether the use of coronary stenting was associated with improved outcomes. Stent use increased from 14.2% to 58.7%. The authors concluded that the introduction of stents was coincident with a 21% adjusted reduction in the composite end point of adverse cardiac events. This was accompanied by a 28% adjusted reduction in the rate of target vessel revascularization after PCI (24).

Another potential contributor to improved outcomes is the adoption of outcome reporting for cardiac procedures and cardiac care. Indeed, some have suggested that outcome reporting and report cards can lead to improved outcomes (25). Among Canadian provinces, British Columbia, Alberta and Nova Scotia have provincial databases that can be used to track and study outcomes after PCI.

Although Canada has seen improvement in outcomes after PCI, our finding of differing adjusted death rates across provinces suggests that some provinces may be lagging behind the others. By adjusting death rates, we have sought to create a level playing field for the comparison of outcomes. The adjusted rates reflect those that would be seen if the provinces were caring for patient populations with similar average severity of illness.

Our results suggest that average severity of illness varies across the provinces. Possible explanations for this finding include differences in underlying population characteristics, variation in PCI referral and patient selection practices, and variable coding of clinical diagnoses used to characterize severity of illness. The first possibility is unlikely to fully explain the difference seen across provinces. Variation in referral and patient selection practices may be an important contributor, and while this possibility can be partially explored by assessing population rates of PCI per 100,000 by province, further study of patient cohorts eligible for (but not necessarily selected for) PCI is needed to clarify the extent to which variable referral and selection criteria account for the differences seen in average severity of illness.

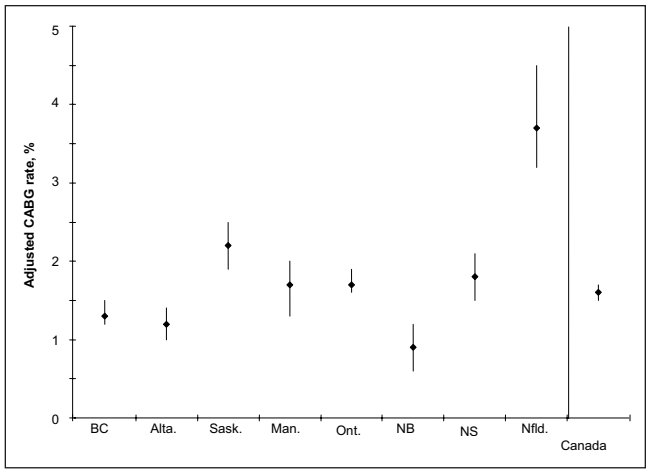


**Figure 4)** *Risk-adjusted same-admission coronary artery bypass graft (CABG) rates by province for fiscal years 1992/93 to 2000/01. Alta. Alberta; BC British Columbia; Man. Manitoba; NB New Brunswick; Nfld. Newfoundland; NS Nova Scotia; Ont. Ontario; Sask. Saskatchewan*

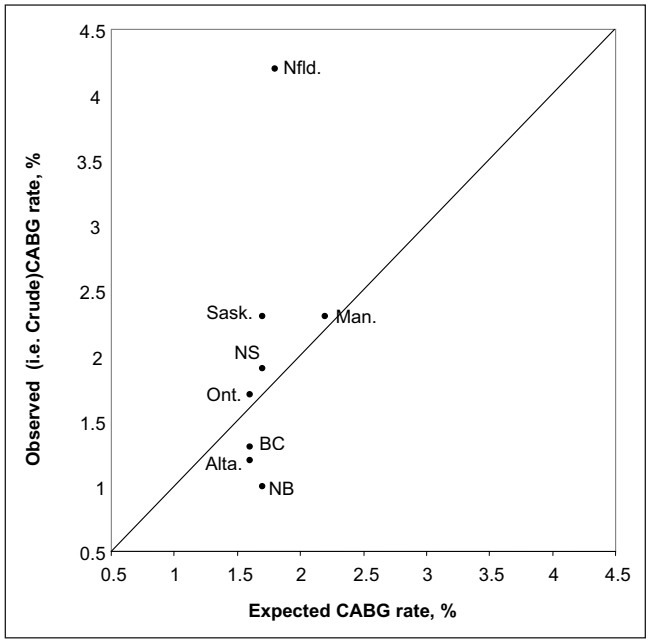


**Figure 5)** *Observed (ie, crude) versus expected same-admission coronary artery bypass graft (CABG) rates post-percutaneous coronary intervention (PCI) by province. Observed death rate is crude, unadjusted death rate (observed numbers/volume of PCI patients); expected death rate is calculated using the logistic regression model (expected numbers/volume of PCI patients). Alta. Alberta; BC British Columbia; Man. Manitoba; NB New Brunswick; Nfld. Newfoundland; NS Nova Scotia; Ont. Ontario; Sask. Saskatchewan*

The third possibility, variable coding of diagnoses across provinces, seems a likely contributor to the imbalances seen in Table 2, and indeed, our reliance on administrative data is an acknowledged study limitation. Clearly, a national clinical database for PCI would be a valuable resource for cardiac outcome research in Canada and would bypass many of the recognized limitations of administrative data such as interhospital variations in coding practices, the lack of key clinical data

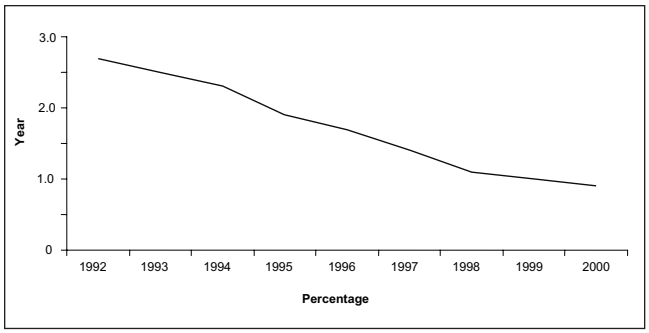


**Figure 6)** *Risk-adjusted same-admission coronary artery bypass graft rates in post-percutaneous coronary intervention patients*

elements (eg, left ventricular ejection fraction, specific vessels involved, lesion characteristics) and other issues outlined below.

We remind readers that to achieve a reasonably homogeneous PCI case definition from administrative data, we confined our outcome analyses to coded PCI cases in patients discharged from hospitals where PCI actually occurred – an approach that resulted in the omission of cases where PCI was coded in day procedure data from tertiary care centres or where it was coded in hospital discharge abstract data from community hospitals that do not perform PCI. Furthermore, the administrative hospital discharge abstract data used for this study are limited in providing information only on short term in-hospital outcomes during the index stay, when longer term outcomes are also of great interest. In the face of these many caveats surrounding administrative data, our adjusted mortality and same-admission CABG estimates should therefore be interpreted cautiously; they should be considered merely possible indicators of quality of care that need to be corroborated by focused follow-up studies using richer clinical data sources or evaluating processes of care.

A second limitation of our study is the lack of data for all years studied for the province of Quebec. Quebec hospitals do not routinely submit their data to CIHI, and their data do not contain the diagnosis-type indicators that we used in our risk adjustment analysis.

A third study limitation is our inability to distinguish primary PCI from PCI done for other reasons. CIHI data do not contain information for the precise timing of myocardial infarction relative to PCI. Instead, cases were identified where PCI occurred in a hospitalization and an acute myocardial infarction was also coded. This subgroup included patients who underwent a true, primary PCI, as well as those who underwent PCI some time during hospitalization but not immediately after onset of myocardial infarction. Future research into outcomes after PCI will need to address this issue because primary PCI for myocardial infarction is in many ways a different procedure from elective or semielective PCI for revascularization.

Another caveat to our findings is that the performance of same-admission CABG does not always indicate that PCI has been accompanied by an adverse outcome. We assessed same-admission CABG as an adverse outcome because it has been an outcome measure of interest in prior PCI outcome studies. However, with increasing use of PCI as an early intervention in acute coronary syndromes, use of CABG surgery soon afterwards does not necessarily indicate an adverse outcome. At

least some PCI patients will go on to have planned surgical revascularization once their acute coronary syndrome stabilizes. Rates of same-admission CABG therefore need to be viewed with some caution.

A final statistical caveat is that our analyses focused on individual PCI procedures rather than on individual patients, because our data do not permit us to link multiple PCI hospitalizations occurring in individual patients. This analysis approach leads to a slight underestimation of the variance surrounding estimates of risk-adjusted mortality.

Despite these limitations and caveats, our study provides useful information on national PCI outcome trends and interprovincial differences in outcomes after PCI. Our findings suggest that PCI use has increased in Canada and that the average patient is older, sicker and suffering from a higher acuity of illness. Despite this, adjusted post-PCI rates of in-hospital mortality have remained the same and rates of same-admission CABG have decreased from 1992/93 to 2000/01. Our findings of interprovincial differences in in-hospital PCI outcomes raise the possibility of quality of care differences across provinces. Interprovincial collaboration in cardiac outcome studies is now required for us to better understand the factors that affect PCI outcomes in Canada.

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**APPENDIX 1**
**Logistic regression model for the prediction of in-hospital mortality after percutaneous coronary intervention**

| Variable | Coefficient | Odds ratio (95% CI) |
|---|---|---|
| Intercept | –6.77 | |
| Mild liver disease | 1.59 | 4.89 (1.48 to16.21) |
| Metastatic disease | 1.85 | 6.39 (3.68 to 11.08) |
| Recent myocardial infarction | 1.70 | 5.47 (4.80 to 6.24) |
| Chronic renal disease | 1.42 | 4.13 (3.26 to 5.24) |
| Congestive heart failure | 1.41 | 4.09 (3.67 to 4.57) |
| Cerebrovascular disease | 1.30 | 3.66 (2.99 to 4.47) |
| Age over 65 years | 1.06 | 2.88 (2.58 to 3.21) |
| Urgent admission | 0.93 | 2.53 (2.12 to 3.03) |
| Neoplasia | 0.69 | 1.99 (1.42 to 2.80) |
| Diabetes with complications | 0.48 | 1.62 (1.13 to 2.33) |
| Peripheral vascular disease | 0.44 | 1.55 (1.21 to 2.00) |
| Diabetes | 0.22 | 1.25 (1.11 to 1.41) |
| Female sex | 0.25 | 1.28 (1.15 to 1.42) |
| Prior CABG | –0.30 | 0.74 (0.61 to 0.91) |
| Unstable angina | –0.71 | 0.49 (0.43 to 0.56) |

*CABG Coronary artery bypass grafting. c statistic =0.878; H-L $\chi^2$=21.3209; df=8; P=0.0063*

**APPENDIX 2**
**Logistic regression model for the prediction of same-admission CABG after percutaneous coronary intervention**

| Variable | Coefficient | Odds ratio (95% CI) |
|---|---|---|
| Intercept | –4.54 | |
| Ventricular aneurysm | 1.31 | 3.71 (2.66 to 5.17) |
| Cerebrovascular disease | 0.98 | 2.68 (2.13 to 3.36) |
| Congestive heart failure | 0.90 | 2.45 (2.13 to 2.82) |
| Chronic lung disease | 0.27 | 1.31 (1.08 to 1.59) |
| Recent myocardial infarction | 0.96 | 2.60 (2.35 to 2.88) |
| Unstable angina | 0.50 | 1.66 (1.52 to 1.81) |
| Prior CABG | –0.71 | 0.49 (0.41 to 0.59) |
| Primary diagnosis acute myocardial infarction | –1.12 | 0.33 (0.28 to 0.38) |

*CABG Coronary artery bypass grafting. c statistic =0.670; H-L $\chi^2$=21.8894; df=6, P=0.0013*

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