ORGANISATIONAL MATTERS

The economic burden of complications during percutaneous coronary intervention

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Background: Technological advances have enabled percutaneous coronary intervention (PCI) to be applied with expanding indications. However, escalating costs are of concern. This study assessed the incremental medical costs of major in-hospital procedural complications incurred by patients undergoing PCI.

Methods: We considered all patients undergoing elective, urgent, or emergent PCI at Mayo Clinic Rochester between 3/1/1998–3/31/2003 in analyses. Clinical, angiographic, and outcome data were derived from the Mayo Clinic PCI Registry. In-hospital PCI complications included major adverse cardiac and cerebrovascular events (MACCE) and bleeding of clinical significance. Administrative data were used to estimate total costs in standardised, year 2004, constant-US dollars. We used generalised linear modeling to estimate costs associated with complications adjusting for baseline and procedural characteristics.

Results: 1071 (13.2%) of patients experienced complications during hospitalisation. Patients experiencing complications were older, more likely to present with emergent PCI, recent or prior myocardial infarction, multi-vessel disease, and comorbid conditions than patients who did not experience these events. Unadjusted total costs were, on average, \$27 865 ± \$39 424 for complicated patient episodes compared to \$12 279 ± \$6796 for episodes that were complication free ($p < 0.0001$). Adjusted mean costs were \$6984 higher for complicated PCIs compared with uncomplicated PCI episodes (95% CI of cost difference: \$5801, \$8168). Incremental costs associated with isolated bleeding events, MACCE, or for both bleeding and MACCE events were \$5883, \$5086, and \$15 437, respectively ($p < 0.0001$).

Conclusions: This high-volume study highlights the significant economic burden associated with procedural complications. Resources and systems approaches to minimising clinical and economic complications in PCI are warranted.

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Percutaneous coronary intervention (PCI) is a resource intensive and commonly performed procedure in the United States today. In 2003 an estimated 1.2 million PCI procedures were performed; an increase of 326% since 1987.¹ Innovations including glycoprotein IIb/IIIa inhibitors and bare metal stents have improved immediate outcomes, decreased in-hospital adverse ischemic events, and allowed for rapid expansion of PCI.^{2–7} A more recent innovation, drug-eluting stents, may offer additional clinical benefits from a patient and societal perspective with reduced need for repeat target vessel revascularisation (TVR) over time.^{8–10} From a provider perspective, however, increased supply and labour costs, changes in coronary artery bypass referral patterns, as well as escalating reimbursement pressures may, in some cases, have rendered previously strong institutions insolvent.¹¹

Some organisations have successfully reduced length of stay (LOS) and procedural costs through clinical pathway implementation and competitive bidding for high cost supplies.^{12–13} Practices changes aimed at reducing in-hospital complication rates for other procedures have also been successful in reducing costs, although published economic examples in interventional cardiology are limited.^{14–20} To test the hypothesis that clinical complications are important determinants of the cost of providing care we assessed the incremental direct costs associated with major in-hospital procedural complications incurred by patients undergoing PCI. Increased knowledge of the economic burden associated with complications may highlight areas ripe for quality improvement and lead to enhanced financial performance.

METHODS

Study population

All patients undergoing elective, urgent, or emergent PCI at Mayo Clinic Rochester, Minnesota between March of 1998 and

March of 2003 were included in the analysis. Patient inclusion dates were chosen to reflect 5 years PCI experience during a period of relative practice stability in terms of procedural supplies and adjunctive pharmacotherapy. Cohort termination was immediately prior to the release of drug-eluting stents into practice April of 2003. We chose to exclude drug-eluting stent-treated patients given known higher supply costs and the potential for confounding of costs attributed to the treatment of procedural complications. Controlled trials to date demonstrate similar in-hospital adverse events rates with use of drug-eluting or bare metal stents adjunctive to PCI.^{8–10}

Multiple qualifying procedures per patient during the study period were included but a repeat procedure on the same lesion (TVR) within the identified hospital episode was considered a complication of initial PCI and not a qualifying “index” PCI event. Elective, staged procedures during the same hospitalisation were excluded as atypical events ($n = 212$). We obtained Institutional Review Board approval for this study. As required by Minnesota statute, patients not granting authorisation for use of their records in research were excluded prior to data collection.

Interventional procedures

PCI was performed using standard techniques.²¹ Patients received oral aspirin (325 mg) at the time of procedure. Glycoprotein IIb/IIIa inhibitors (abciximab, eptifibatide, or tirofiban) were administered as adjunctive therapy at the discretion of the operator. For patients undergoing stent

Abbreviations: GLM, generalised linear modelling; ICD-9, international classification of diseases, ninth revision; LOS, length of stay; MACCE, major adverse cardiac and cerebrovascular events; PCI, percutaneous coronary intervention; TVR, target vessel revascularisation

implantation, clopidogrel was given as a 300 mg loading dose and 75 mg daily for 4 weeks post procedure. Weight adjusted heparin was infused to maintain an activated clotting time of 200–250 seconds when used with a glycoprotein IIb/IIIa inhibitor and 250–300 seconds when used with unfractionated heparin alone. Heparin use was discontinued after the procedure. Only bare metals stents were used during the study time frame.

Data sources and definitions

All patients undergoing PCI at Mayo Clinic have been followed prospectively since 1979 according to a well-established protocol, the Mayo Clinic PCI Registry.²² This database contains baseline demographic, clinical, and angiographic data as well as information on patient outcomes during follow-up. All patients are interviewed in person or by telephone at 6 months and 12 months after PCI and yearly thereafter to assess major adverse cardiovascular events.

Angiographic characteristics and procedural success are determined and documented by the PCI operator. A blinded team of registered nurses and data coordinators collect and enter all pre- and post-procedural data including the occurrence of adverse clinical events. Blinded data adjudication is conducted as needed by an interventional cardiologist not the operator for the case in question. Ten percent of records are audited for quality assurance by the supervisor of the data coordinators. Medical records for care received for these events at Mayo Clinic and other institutions are obtained for review with the patient's written informed authorisation for release of such information.

Procedural episodes were categorised as complicated or free of complications conditional on whether the patient experienced a major adverse cardiac or cerebrovascular event (MACCE) or had bleeding of clinical significance during hospitalisation. MACCE events included: death, myocardial infarction, emergent coronary artery bypass surgery, target vessel revascularisation, and stroke. Myocardial infarction was defined as any two of the following criteria: an episode of prolonged angina lasting ≥ 20 minutes, a rise in the serum creatine kinase (CK)-MB isoenzyme greater than two-fold normal, or ST-segment/T-wave changes or new Q-waves on serial electrocardiograms indicative of myocardial damage. Bleeding events of clinical significance included blood loss requiring transfusion, aneurysm, hematoma, central nervous system bleed, gastrointestinal bleed, and retroperitoneal bleed.

Economic analyses were conducted from the provider perspective and focused on direct costs of care associated with hospital and physician services during inpatient stay. Administrative data sources were used to track medical resource utilisation and related expenditures for these PCI episodes of interest. Utilisation was valued using standard methods by grouping services into the Medicare Part A and B classification: Part A billed charges were adjusted using hospital cost-to-charge ratios at the departmental level and wage indexes.²³ Costs associated with Part B physician services were proxied based on Medicare reimbursement rates. Direct hospital (technical costs) were "fully loaded" and included costs associated with overhead. Accounting practices remained unchanged during the study duration. All cost presented have been adjusted to reflect 2004 constant US dollars.

Statistical analysis

We report continuous variables as mean $\pm$ standard deviation and categorical variables as frequencies and percentages. Patient characteristics and observed economic outcomes were compared between groups using t-tests and chi-square tests, as appropriate. Observed complication rates are reported as

percentage of PCI episodes observed with complication of interest out of the entire sample of PCI hospitalisations. Multivariate regression techniques were used to evaluate the independent effect of complications on costs adjusting for demographic, clinical, angiographic, and procedural characteristics.

Demographic variables of interest included age and gender. Clinical characteristics included clinical presentation (elective or emergent PCI), recent or prior history of myocardial infarction, prior PCI or coronary artery bypass graft surgery, pre-procedural shock, body mass index, and history of smoking (current or former smoker). Co-morbid conditions were also considered in analyses such as presence of angina, diabetes (treated with medication or diet), hypertension (blood pressure greater than 140/90 mmHg treated with medication), congestive heart failure, peripheral vascular disease, history of cerebrovascular accident, stroke, or a transient ischemic attack, chronic renal failure, peptic ulcer disease, cancer, and the presence of a prophylactic intra-aortic balloon pump at baseline. Additional covariates included procedural characteristics such as the date of the procedure, presence of multi-vessel disease, complexity of lesion (B2 or C type), thrombus containing lesion, calcium in any stenosis, number of vessels and segments treated, number of stents placed, glycoprotein IIb/IIIa inhibitor usage, vein graft intervention, and whether PCI was performed on the proximal left anterior descending coronary artery. Finally, for more complete risk adjustment, cost prediction models also included baseline clinical and economic summary severity measures (Expected Mortality Score, Overall Resource Demand Scale, and LOS Scale) shown to predict mortality and economic outcomes in a development database containing approximately 15 million patient records.²⁴

Patient level estimated severity measures were obtained by using the listed international classification of diseases, ninth revision, clinical modification (ICD-9-CM) diagnosis codes for pre-existing conditions, age, sex, and admission status (noted in administrative data) processed through Disease Staging software.²⁴ Disease Staging software assigns a disease category and stage of disease to every diagnosis code on the patient inpatient record. Patient level combinations of disease and severity correspond to the pre-determined scales shown to predict the outcomes of interest. Resource Demand Scale, for example, is a measure of expected resource consumption conditional on known co-morbidities and severity of illness at baseline scaled to average 100 across all patients in the development database. An estimated Resource Demand Scale of 125, therefore, implies 25% higher expected resource consumption (charges) compared with the average of predicted charges taken across all patients in the database. Further details on this Disease Staging process, development of the predictive scales, as well as a bibliography of research involving Disease Staging are available online (<http://www.hcup-us.ahrq.gov/db/nation/nis/Disease%20Staging%20V5.22%20Reference%20Guide.pdf>).

Models were developed separately to assess incremental costs associated with experiencing at least one of the selected complications, MACCE only events, only bleeding events, and MACCE and bleeding events. Generalised linear modelling (GLM) was used to assess costs to account for the non-negative and typically skewed nature of economic outcomes.²⁵ Cost models assumed a logarithmic link function and an inverse Gaussian distribution function. Choice of family distribution was determined empirically based on the modified Park test recommended by Manning and Mullahy.²⁶ Although the percentage of missing values per covariate was small (no greater than 10%), data were unavailable on at least one covariate in 30.9% of the PCI episodes. We considered alternative methods for handling these missing data (case

Table 1 Baseline and procedural characteristics of PCI patients by complication status*

Variable	Uncomplicated PCI (n = 7038)	Complicated PCI (n = 1071)	p Value
Age, years	65.8 ± 11.9	71.0 ± 11.7	<0.001
Male gender (No./%)	5089 (72)	628 (59)	<0.001
Body Mass Index	29.7 ± 5.6	28.7 ± 5.7	<0.001
Unstable angina	4353 (62)	583 (54)	<0.001
MI 1–7 days before procedure	975 (14)	196 (18)	<0.001
Pre-procedural shock	145 (2)	167 (16)	<0.001
MI day of procedure or ≤ 24 hours	1017 (15)	296 (28)	<0.001
Urgency of PCI			<0.001
Elective	2486 (35)	252 (24)	
Urgent	3422 (49)	460 (43)	
Emergency	1130 (16)	359 (34)	
CHF on presentation	599 (9)	231 (22)	<0.001
Diabetes	1696 (24)	276 (26)	0.23
Hypertension	4665 (66)	753 (70)	0.004
Peripheral vascular disease	681 (10)	164 (15)	<0.001
Moderate/severe renal disease§	162 (2)	85 (8)	<0.001
Current smoker	1258 (18)	165 (67)	<0.001
Prior MI	3781 (54)	721 (67)	<0.001
Prior PCI	2387 (34)	296 (28)	<0.001
Prior CABG	1536 (22)	243 (23)	0.52
EF ≤ 40	708 (10)	162 (15)	<0.001
Number diseased vessels (70/50 definition)¶			<0.001
0	156 (2)	12 (1)	
1	1957 (28)	230 (22)	
2	2561 (36)	374 (35)	
3	1892 (27)	408 (38)	
B2 or C type lesion	4959 (71)	794 (74)	<0.001
Thrombus in lesion	1859 (26)	463 (43)	<0.001
Calcified artery	2052 (29)	414 (39)	<0.001
Eccentric lesion	4807 (68)	718 (67)	0.09
Bifurcation lesion	815 (12)	152 (14)	0.01
Ulcerated lesion	572 (8)	118 (11)	<0.001
Ostial lesion	1090 (16)	202 (19)	0.01
Moderate or severe bend in lesion	1938 (28)	372 (35)	<0.001
Major side-branches in lesion	1249 (18)	244 (23)	<0.001
Number of segments treated	1.5 ± 0.7	1.7 ± 0.9	<0.001
Total number of vessels treated**	1.2 ± 0.4	1.2 ± 0.4	<0.001
Glycoprotein IIb/IIIa inhibitor use	3872 (55)	695 (65)	<0.001
Total number of stents placed	1.4 ± 1.0	1.6 ± 1.3	<0.001

*For variables with missing data, the percentages reflect the percent of those with data available.

§Moderate/severe renal disease defined as serum creatinine >3 mg/dL.

¶Number of diseased vessels with at least one vessel having ≥70% stenosis and subsequent vessels with at least ≥50% stenosis; the left main and left anterior descending vessels were counted as one vessel.

**Numbers in table have been rounded to the nearest tenth decimal place. Observed rates are 1.16 ± 0.40 and 1.21 ± 0.44 for uncomplicated and complicated PCI, respectively.

CABG, coronary artery bypass graft; CHF, congestive heart failure; EF, ejection fraction; MI, myocardial infarction; PCI, percutaneous coronary intervention.

deletion, mean imputation, as well as more sophisticated multiple imputation methods), however results did not differ substantially by approach used. For simplicity and brevity, we present only results obtained using the mean imputation method.²⁷ All statistical tests were two-sided, and p values less than 0.05 were considered significant. SAS version 9.1 (SAS Institute Inc., Cary, NC, USA) was used in the analyses.

RESULTS

Patient characteristics

A total of 8109 PCIs were performed on 7027 patients during the study duration; 1071 (13.2%) of the identified 8109 PCIs were associated with at least one complication. Table 1 presents the baseline and procedural characteristics of the study population according to whether the patient experienced at least one of the selected complications during hospitalisation. “Complicated” patients were older (71 vs 66 years of age), more likely female (41% vs 28%), more likely to present with emergent PCI (34% vs 16%), pre-procedural shock (16% vs 2%), had a higher number of recent or prior myocardial infarctions (28% vs 15%; myocardial infarction within 24 hours of PCI), more likely to have multi-vessel disease (75% vs 65%), along

with other high-risk angiographic characteristics (such as B2/C type lesions, thrombus containing lesion, calcium in any stenosis, ulcer or moderate or severe angulated bends at treatment sites). With the exception of diabetes, all co-morbid conditions of interest (for example, hypertension, congestive heart failure, renal disease, and cancer) were more prevalent among patients who experienced complications compared with patients who were free of these adverse events. While both groups were as likely to receive an intracoronary stent (86%), complicated procedures had more stents placed per procedure (1.6 vs 1.4), more liberal glycoprotein IIb/IIIa inhibitor usage (65% vs 55%), as well as had more vessels and target segments treated.

Observed complication rates

Table 2 provides a breakdown of observed adverse events by complication category. MACCE events occurred in 7.1% of PCI episodes. Myocardial infarction was the most common MACCE to occur among the complicated episodes followed by death (5.2% and 1.6%, respectively). The composite of bleeding complications occurred in 7.9% of PCIs with 6.0% requiring transfusion and 2.5% developing an access site hematoma.

Table 2 Observed in-hospital adverse events by complication category

Complication	n (%)
Any complication	1071 (13.2)
MACCE complications	577 (7.1)
Death	130 (1.6)
Myocardial infarction	419 (5.2)
Emergent CABG	35 (0.4)
Target vessel revascularisation	33 (0.4)
Stroke	35 (0.4)
Bleeding complications	641 (7.9)
Blood loss requiring transfusion	484 (6.0)
Hematoma	203 (2.5)
Aneurysm	62 (0.8)
Central nervous system bleed	0 (0)
Gastrointestinal bleed	76 (0.9)
Retriperitoneal bleed	23 (0.3)
Bleeding only	494 (6.1)
MACCE only	430 (5.3)
MACCE and bleeding	147 (1.8)

CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention; MACCE, major adverse cardiovascular and cerebrovascular events

Simultaneous occurrence of both MACCE and bleeding events within a procedural episode were rare, occurring in less than 2% of PCI hospitalisations.

Observed economic outcomes

Unadjusted inpatient costs and length of stay by selected complication are shown in table 3. Mean observed total costs per episode were markedly higher for patients who experienced a complication compared with those who were complication free (\$27 865 vs \$12 279; 95% CI of cost difference: \$14 579, \$16 593). Length of stay was also markedly longer among complicated PCI episodes with an observed mean difference of 4.5 days between complicated and uncomplicated PCIs (6.4 days vs 1.9 days; $p < 0.0001$, respectively). Both MACCE-only events and bleeding-only events significantly contributed to prolonged length of stays and increased costs of care (unadjusted incremental cost differences of \$9096 and \$13 092, on average, respectively, compared to uncomplicated episodes). Multiple complications were associated with the highest in-hospital costs. Episodes complicated by both MACCE and bleeding events cost, on average, nearly \$43 000 more per

PCI hospitalisation (\$55 230 vs \$12 279; 95% CI of cost difference: \$40 593, \$45 310). Direct medical costs for all PCI episodes of interest totalled \$116 260 325; 25.7% of which (\$29 843 246) was incurred by the 13.2% of procedural episodes with complications.

Adjusted incremental costs

In all adjusted analyses, procedural complications were strongly associated with inpatient costs of care. Table 4 presents the estimated incremental costs associated with treatment of these selected complications with adjustment for differences in patient demographic, clinical, and procedural characteristics. A large and significant cost differential between complicated and uncomplicated procedures persisted even after adjustment for other factors. For instance, adjusted mean total costs were estimated to be \$6984 higher for hospitalisations where the patient experienced at least one of the selected complications compared with complication free hospitalisations (95% CI of cost difference: \$5801, \$8168). Similarly, incremental inpatient costs associated with only bleeding events, only MACCE, or for episodes where the patient experiencing both bleeding and MACCE events were \$5883, \$5086, and \$15 437, respectively ($p < 0.0001$).

DISCUSSION

Our objective was to assess the incremental costs of treating major in-hospital procedural complications among patients undergoing PCI in recent clinical practice. Observed and adjusted results suggest that resource utilisation and treatment costs are substantially greater during PCI hospitalisation when complications occur. On average, complications more than double the costs of uncomplicated PCI. Adjusted excess costs associated with procedural complications ranged, on average, from a low of \$5086 for episodes with MACCE events to over \$15 000 for episodes complicated by MACCE and bleeding events. Bleeding complications alone were observed to be major contributors to cost, with mean observed costs of \$25 371 compared to observed costs of \$12 279, on average, for uncomplicated procedural episodes. Interestingly, incremental costs associated with bleeding slightly surpassed those associated with ischemic events (adjusted mean incremental costs of \$5883 and \$5086, respectively). This is unlikely a reflection of increased bleeding complications at our facility as previous studies have demonstrated similar rates of bleeding

Table 3 Observed inpatient costs and length of stay by selected complication

	Total costs (\$)	
	Mean (median) $\pm$ SD	Difference (95% CI)
All PCI episodes	14 337 (11 380) $\pm$ 16 524	–
Uncomplicated PCI	12 279 (10 776) $\pm$ 6 796	–
Any complication	27 865 (18 462) $\pm$ 39 424	15 586 (14 579, 16 593)
Bleeding only	25 371 (18 234) $\pm$ 21 193	13 092 (12 315, 13 869)
MACCE only	21 375 (16 366) $\pm$ 17 954	9 096 (8 329, 9 864)
MACCE and bleeding	55 230 (30 714) $\pm$ 89 598	42 952 (40 593, 45 310)
	Length of stay (days)	
	Mean (median) $\pm$ SD	Difference (95% CI)
All PCI episodes	2.5 (1.0) $\pm$ 4.7	–
Uncomplicated PCI	1.9 (1.0) $\pm$ 2.2	–
Any complication	6.4 (4.0) $\pm$ 11.0	4.5 (4.2, 4.8)
Bleeding only	6.2 (4.0) $\pm$ 7.0	4.4 (4.1, 4.6)
MACCE only	4.1 (3.0) $\pm$ 4.3	2.2 (2.0, 2.5)
MACCE and bleeding	13.5 (7.0) $\pm$ 24.7	11.6 (10.9, 12.3)

CI, confidence interval; PCI, percutaneous coronary intervention; MACCE, major adverse cardiovascular and cerebrovascular events; SD, standard deviation

complications to ours (7.9%), with rates ranging from 2.2% to 14%.^{28–33} Ischemic event rates are also similar.^{6,9,29,34}

Comparison to previous work

While much clinical research to date has focused on the incidence of PCI procedural complications, economic research on the associated cost burden is just emerging. Nikolsky *et al*³⁵ recently assessed the economic impact of in-hospital acquired thrombocytopenia in patients undergoing primary PCI for acute myocardial infarction. Findings suggested that patients who developed thrombocytopenia versus those who did not had higher in-hospital rates of major hemorrhagic complications, greater blood transfusion requirements, incurred longer hospital stays, and increased inpatient costs (median \$14 466 vs \$11 629, $p = 0.001$).

Kugelmass *et al*³⁶ also noted significantly higher resource use among Medicare beneficiaries associated with acute PCI complications (major adverse ischemic events, vascular complications, acute renal failure, septicemia, and adult respiratory distress syndrome). Estimated incremental costs associated with complications ranged from a high of \$33 030 for septicemia patients to a low estimate of \$4278 for patients developing vascular complications. Key study limitations noted by the authors include a selected Medicare population and reliance on administrative data (ICD-9 billing codes) for identification of complications and patient characteristics.

In contrast, our study focused on a large unselected population and had access to detailed clinical registry data including the occurrence of adverse clinical events (with blinded data adjudication by clinicians as needed). This wealth of patient registry data also allowed us to control for a number of angiographic and procedural characteristics (for example stent usage) that potentially confound the effect of complications on costs. These methodological differences likely contribute to our varying nominal results. In general, however, our study results confirm those reported by Kugelmass *et al*³⁶ highlighting that complications contribute significantly to inpatient costs of care. Furthermore, both studies suggest that the economic impact of vascular complications may be similar to incremental costs associated with the treatment of some major ischemic events (such as death) and that heightened clinical awareness towards reduced bleeding event rates is clearly warranted.

While use of improved stents and antithrombotic strategies has reduced the incidence of ischemic events following PCI, access-site bleeding has now evolved as one of the more common procedural complications.^{2–10,29} Bleeding after PCI comprises a wide range of possible events, from a minor access-site hematoma or need for blood transfusion, to a fatal intracranial hemorrhage. The need for blood transfusion was previously found to be the strongest post-procedure predictor of LOS.³⁷

Certain patient characteristics appear to be associated with higher risks of bleeding. Kinnaird, *et al*³⁸ discovered that age

greater than 80 years and chronic renal insufficiency were strongly associated with bleeding complications. Female gender and prolonged PCI times were also independently associated with increased bleeding risk.³⁹ Using these identifiable characteristics to create an integer risk score for bleeding complications, not unlike that done for ischemic complications, may assist in establishing patients at greatest risk for these events.⁴⁰ Continued investigation into ways of reducing bleeding complications such as changes in peri-procedural anticoagulation, closure-mediated devices, or procedural technique (that is radial versus femoral access) is warranted.^{20,34,41–43} Results presented here suggest the interests of patients, hospital administrators, and physicians are perfectly aligned with respect to reduction of procedural complication rates; successful quality improvement will likely lead to enhanced expense management.

Limitations

Although we had access to both comprehensive clinical and administrative data, it is possible we failed to control for all factors likely to influence procedural costs biasing our incremental cost estimates. Our study also reflects the experience of a single, high-volume referral centre. Patients and results may differ in other centres and practice settings.

CONCLUSIONS

Although relatively infrequent events, the economic burden associated with acute procedural complications is significant. Greater than 25% of the total costs associated with PCI in our case were attributed to complicated procedural episodes. Yet in only 13% of episodes did complications occur. In today's fiscally restricted healthcare environment, identifying methods of cost-containment while preserving or even improving clinical outcomes has become increasingly essential to provider financial stability. Results presented here suggest that interventions to reduce the risk of adverse events will likely enhance financial as well as clinical performance. Resources and systems approaches to minimising clinical and economic complications in PCI are warranted.

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Table 4 Adjusted mean incremental medical costs associated with select complications

Complication	Incremental cost* (95% CI)
Any complication	\$6,984 (\$5801, \$8168)
Bleeding only	\$5883 (\$5498, \$6269)
MACCE only	\$5086 (\$4739, \$5433)
MACCE and bleeding	\$15437 (\$14 010, \$16 864)

*Separate GLM models assessing costs were estimated for each of the selected complications controlling for patient characteristics. CI, confidence interval; GLM, generalised linear modeling; MACCE, major adverse cardiovascular and cerebrovascular events.

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