RAPID REPORT

The impacts of public reporting and external benchmarking in cardiac care: A rapid update of the literature

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IHE INSTITUTE OF HEALTH ECONOMICS
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Abbreviations

All abbreviations that have been used in this report are listed here unless the abbreviation is well known, has been used only once, or has been used only in tables or appendices, in which case the abbreviation is defined in the figure legend or in the notes at the end of the table.

ACE	angiotensin-converting enzyme
AHRQ	Agency for Healthcare Research and Quality
ARB	angiotensin-receptor blocker
CABG	coronary artery bypass graft
CI	confidence interval
OR	odds ratio
p	*p*-value statistic
PCI	percutaneous coronary intervention
STS	Society of Thoracic Surgeons

Glossary

The glossary terms listed below were obtained and adapted from the following sources:

- Cardiac Care Network, *Glossary* (*www.ccn.on.ca/ccn_public/FormsPublication/glossary.aspx*)
- Ettorchi-Tardy A, et al. (2012)[1]
- Institute of Medicine, et al., *Envisioning the National Health Care Quality Report* (2001) (*doi.org/10.17226/10073*)
- Qin X, et al. (2016)[2]
- Totten AM, et al. (2012)[3]
- US Department of Health and Human Services, *Quality Improvement* (2011) (*www.hrsa.gov/quality/toolbox/508pdfs/qualityimprovement.pdf*)

Acute myocardial infarction – Occurs when one or more regions of the heart muscle experience a severe or prolonged decrease in oxygen supply, caused by blocked blood flow.

Angiotensin-converting enzyme (ACE) inhibitor – A medication that lowers blood pressure.

Atrial fibrillation – A heart rhythm disorder that results in disorganized atrial activity in the atria that is fast and irregular. May also result in increased rate in the ventricle.

Congestive heart failure – An inability of the heart to pump effectively to meet the body's demands. With the heart's impaired ability, fluid may accumulate in the lungs and other tissues, causing swelling of the hands, legs, and feet.

Coronary artery bypass graft – A type of surgery (also called *open heart surgery*) that transplants a section of a vessel from another part of the body (usually the leg or breast) to make a detour around a blockage in a coronary artery.

External benchmarking – A process of comparative evaluation and identification of the underlying causes leading to high levels of performance. It involves a sustained effort to measure outcomes, compare these outcomes against those of other organizations to learn how those outcomes were achieved, and apply the lessons learned in order to improve.

Percutaneous coronary intervention (PCI) – A type of heart procedure that includes a balloon angioplasty (percutaneous transluminal coronary angioplasty) and stent. The balloon is used to open a blocked artery, and the stent is used to help keep the artery open after the balloon is removed.

Public reporting – Providing data about a healthcare structure, process, or outcome to the public or a broad audience free of charge or at a nominal cost, in order to be able to compare data across providers or to a national/regional data report on performance for which there are accepted standards or best practices.

Quality improvement – Systematic and continuous actions that lead to measurable improvement in healthcare services and the health status of targeted patient groups.

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1. Introduction

1.1. Issues

Public reporting and external benchmarking are two forms of comparative assessment that are thought to create incentives which drive quality improvement in the health system.[4, 5] Both public reporting and external benchmarking allow for comparisons against a standard, which is often an expected level of performance or a leading care provider.[5] The standard is meant to reflect best practice, and provides an opportunity for individual providers to compare their performance against others to identify strengths as well as areas that need improvement.[5] These comparisons create opportunities for collaboration between providers to support and share processes that enable the attainment of best practice, and provide a vehicle to learn and benefit from the progress of others.[5]

While both public reporting and external benchmarking are established quality improvement activities that have been widely adopted in jurisdictions across the globe,[3] neither practice is common in Canada. In Canada, there is limited reporting of health outcomes and processes in cardiac care for public consumption and benchmarking activities are limited to provincial initiatives and registries, resulting in minimal opportunity for interjurisdictional sharing and collaboration to promote quality improvement.

Both public reporting and external benchmarking are strategies that could support and promote clinical excellence across cardiac centres in Canada. However, the impact of public reporting on quality improvement remains unclear, and, to our knowledge, the impact of external benchmarking on quality improvement has not been studied in detail. Further, the majority of evidence has been collected in market driven, competitive health systems, and there are concerns around the applicability of these findings to publicly funded health systems.

The Institute of Health Economics (IHE) was commissioned by the Canadian Cardiovascular Society to provide a rapid update of the literature, to compare the impacts of public reporting and external benchmarking on selected outcomes, and to evaluate and describe the applicability of this body of research to non-competitive health systems, emphasizing perspectives and considerations regarding transferability to the Canadian context. This report will be used as a background document to inform a position statement paper proposed by the Canadian Cardiovascular Society.

1.2. Objectives and Project Scope

The objectives of this report are to:

1. Provide a rapid update of the evidence to assess the impacts of public reporting and external benchmarking on clinical outcomes, changes in delivery structures and processes, or changes in patient and provider behaviour in cardiac care (particularly for patients with acute myocardial infarction, atrial fibrillation, or heart failure treated with percutaneous coronary intervention [PCI], coronary artery bypass graft [CABG], or rehabilitation), and to identify contextual factors that influence the impacts of public reporting and external benchmarking.
2. Compare and assess the relative impact of public reporting on the outcomes of interest in comparison to external benchmarking.
3. Describe the applicability and transferability of the research findings to the Canadian context.

The project scope was defined according to the PICO model, using studies published during the last five years (January 2012 to July 2017):

- **Population**: all patients with cardiovascular conditions/diseases, with particular interest in those with acute myocardial infarction, atrial fibrillation, or heart failure who receive PCI, CABG, or rehabilitation
- **Intervention/Comparator**: public reporting versus external benchmarking; public reporting versus no public reporting; pre-public reporting versus post-public reporting; external benchmarking versus no external benchmarking; pre-external benchmarking versus post-external benchmarking
- **Outcome measures**: quality indicators and clinical outcomes

2. Background

2.1. Public Reporting

2.1.1. Definition

According to the Agency for Healthcare Research and Quality (AHRQ), public reporting is a mechanism of "providing data about a health care structure, process, or outcome to the public or a broad audience free of charge or at a nominal cost, in order to be able to compare data across providers or to a national/regional data report on performance for which there are accepted standards or best practices."[2]

2.1.2. History

Public reporting originated in the late 1980s with the introduction of CABG report cards by the New York State Department of Health as a program targeting risk adjusted post-operative mortality following CABG surgery.[6] In Europe, Scotland was the first country to adopt public reporting, in 1994, and the practice has since spread to numerous other countries.[6]

While public reporting was initially used to support quality improvement, it also has several other roles in health care and health policy, including creating transparency and accountability, engaging patients, and developing trust between patients and the health system.[3]

Public reporting is meant to convey information about providers, and to facilitate patients' ability to easily compare the quality of care provided by competing providers.[7] However, for public reporting to be effective, quality information needs to be accessible, understandable, relevant, and timely for a variety of audiences with different skills and abilities.[3] In addition, the impact of public reporting as a quality improvement strategy is complex and dependent on various factors such as the extent of patient choice and competition by individual clinicians and provider organizations.[3]

2.1.3. Purpose, potential benefits, and potential harms

Public reporting has been proposed as a mechanism to stimulate quality improvement, in addition to providing other functions such as increasing provider accountability, engaging patients, and driving transparency in the health system.[3, 6]

As a quality improvement activity, public reporting is thought to stimulate and support quality improvement by motivating patients to demand, and clinicians to provide, high quality care. However, as a social intervention, the impact is complex and can be difficult to measure and fully

comprehend.[3] While performance measurement and reporting can support improvements in care processes that decrease the incidence of mortality and other comorbidities and complications, there is also the possibility of unintended consequences and patient harms, which lead to deteriorations in the quality of care and effectiveness of the health system.

Potential benefits of public reporting that have been described include the following:[3]

- Improved patient outcomes
- Improved adherence to care processes
- Increased patient engagement and knowledge
- Decreased variation in care quality
- Increased adherence to clinical guidelines
- Increased transparency and provider accountability
- Changes in healthcare delivery structures and processes

Conversely, potential harms of public reporting that have been described include the following:[3, 8]

- Decreased access for high-risk patients
- Decreased quality of unmeasured aspects of care due to increased focus on aspects of care that are measured for public reporting (crowding out)
- Increased health disparities for patient groups with complex needs

Currently, the impact of public reporting on many of these outcomes are unclear,[3, 4, 6] despite being the focus of numerous studies and systematic reviews.

2.1.4. Public reporting and quality improvement

Public reporting can be used to initiate and promote quality improvement activities and guide patient choice.[6] Three theoretical pathways have been proposed to describe how public reporting may prompt quality improvement in the health system and lead to improved outcomes for patients and the health system; these pathways are commonly known as the *selection pathway*, the *change pathway*, and the *reputation pathway*.[6] Underlying these three pathways are two main assumptions or mechanisms: 1) given choices and information, patients will select high-quality providers; and 2) healthcare providers will aim to provide high-quality care when their performance is made available to the public.[3] The pathways and their mechanisms are described below in Table 1.

TABLE 1: Public reporting and quality improvement pathways and mechanisms

Pathway	Mechanism
Selection pathway[9]	Consumers will choose high-performing care providers, and providers will improve quality in order to attract more patients and increase their market share
Change pathway[9]	Care providers are motivated in their professional capacity to address substandard care and improve quality following the identification of quality deficits
Reputation pathway[10]	Providers identified as poor performers are motivated to improve quality in order to restore or improve their professional reputation

2.2. External Benchmarking

2.2.1. Definitions and types of benchmarking

Benchmarking is the process of establishing a standard of excellence by comparing a particular activity and its outcomes in one organization/unit with the same activity in another organization/unit.[11] In benchmarking, the unit of comparison can vary and may be individual clinicians, care teams, hospitals, regions, or provinces. The process involves a sustained effort to measure outcomes, compare these outcomes against those of other organizations/units to learn how those outcomes were achieved, and apply the lessons learned in order to improve.[5] Useful, valid, reliable, and up-to-date information is required to implement benchmarking.[1]

There are two types of benchmarking, *internal* and *external* benchmarking. Internal benchmarking covers two-way communication and sharing opinions between departments within the same organization or between organizations operating as part of a chain in different jurisdictions.[12] External benchmarking, on the other hand, requires a comparison of work with other organizations in order to discover new ideas, methods, products, and services; the objective is to continuously improve one's own performance by measuring how the organization performs, comparing it with that of others, and determining how others achieve their performance levels. This type of benchmarking provides opportunities for learning from the best practices and experiences of others who are leaders in the field.[12]

2.2.2. History

Benchmarking emerged in the United States and the United Kingdom with the imperative of comparing hospital outcomes to rationalize their funding.[1] Initially, benchmarking was essentially the comparison of performance outcomes to identify disparities. It later expanded to include the analysis of processes and success factors for producing higher levels of performance. The most recent modifications to the concept of benchmarking relate to the need to meet patients' expectations; the United Kingdom's Essence of Care program is an example in this respect.[1] The Essence of Care program is a sophisticated approach to clinical practice benchmarking aimed at becoming an integral and effective component of healthcare services standardization to support collaborative quality improvement in services and to increase patient satisfaction.[1] Today, external benchmarking is established as a continuous process that involves the collection of data to support indicator measurement, comparison of measures to a selected standard (benchmark), identification of gaps and future targets, development of approaches to reach future targets, organizational action, and monitoring of progress.[1]

2.2.3. Purpose, potential benefits, and potential harms

The purpose of benchmarking is to maintain care quality, patient satisfaction, and continuous improvement.[12]

Benchmarking can offer the following potential benefits:[12]

- Helps organizations understand where they have strengths and weaknesses, depending upon changes in supply, demand, and market conditions
- Allows organizations to realize what levels of performance are possible by looking at others, and how much improvement can be achieved

- Helps organizations improve their competitive advantage by stimulating continuous improvement in order to maintain world-class performance and to increase competitive standards
- Helps to better satisfy customer needs for quality, cost, product, and service by establishing new standards and goals
- Promotes changes and delivers improvements in quality, productivity, and efficiency, which in turn bring innovation and competitive advantage
- Is a cost-effective and time-efficient way of establishing a pool of innovative ideas from which the most applicable practical examples can be utilized
- Brings interest to new developments within the related area
- Improves the motivation of employees

On the other hand, a poorly executed benchmarking exercise could result in a waste of financial and human resources, and time.[12] Furthermore, there is no single best practice for benchmarking, and every organization differs in terms of mission, culture, environment, and technological tools available. Thus, there are risks involved in benchmarking and in adopting new standards into one's own organization. The "best practice" should be perceived or accepted to be among those practices producing superior outcomes and being judged as good examples within the area and time period.

2.2.4. Facilitators/barriers

Overall, benchmarking first requires senior management commitment, particularly to support actions arising from the exploration. Second, it requires staff to be trained and guided in the process to ensure that maximum benefit is obtained. Finally, it requires allocation of part of the relevant employees' time to enable it to be carried out.[12]

Time constraints, competitive barriers, costs, lack of both management commitment and professional human resources, resistance to change, poor planning, and short-term expectations are regarded as the main problems affecting successful benchmarking research.[12]

2.3. Evidence from Systematic Reviews

This rapid review is an update to a systematic review by Totten et al. (2012),[3] with a specific focus on cardiovascular conditions and interventions. The results of the systematic reviews presented in this section are not limited to the selected cardiovascular conditions and interventions assessed in this review. All of the identified systematic reviews focused on public reporting; we were unable to locate any systematic reviews that evaluated the impact of external benchmarking on quality indicators and clinical outcomes.

Several studies and systematic reviews have been completed to assess the impact of public reporting, in numerous healthcare settings and on a wide variety of outcomes.[3, 4, 6, 8] Overall, these reviews have found: mixed effects on patient outcomes;[6, 8] a modest decline in mortality;[3, 6] changes in provider behaviour to add services, change policy, and increase focus on clinical care;[3, 6] limited evidence of "crowding out" or declines in quality measures not included in the public report;[3] little impact on patients' selection of providers;[3] some evidence of unintended provider behaviour to artificially improve ratings by changing coding procedures;[3] and unclear or negative effects on patient access to necessary medical interventions,[3] although access restrictions have not been observed in the United Kingdom.[4] These findings vary across patient settings and health systems, and public reporting has

been found to have a greater impact on quality improvement in providers with lower quality before or at the first instance of reporting,[3, 4, 6] and for providers in competitive markets.[3]

TABLE 2: Evidence from systematic reviews

Author (Date)	Title	Databases	Years	Main findings
Totten et al. (2012)[3]	Closing the quality gap: Revisiting the state of the science (Vol. 5: Public reporting as a quality improvement strategy)	MEDLINE, Embase, EconLit, PsycINFO, Business Source Premier, CINAHL, PAIS, Cochrane, DARE, NHS EED, HEED, NY Academy of Medicine, AARP Ageline	1980-2011	PR is associated with a small decline in mortality, and general improvement in quality and process indicators. Providers and organizations respond to PR by adding services, changing policy, and increasing focus on clinical care. PR has unclear effects on patient access. PR has little impact on provider selection, referral patterns, market share, or volume. Greater improvement was reported for providers in competitive markets, and those with low baseline performance. Overall, harms from PR are not common or widespread; there was some evidence of up-coding patients, and little evidence of declines in unmeasured aspects of care.
Berger et al. (2013)[8]	Can public reporting impact patient outcomes and disparities? A systematic review	PubMed, Scopus, PsycINFO, Sociological Abstracts, Web of Science, EconLit, Anthropology Plus	Up to 2013	Evidence supporting the impact of PR on outcomes is mixed and of low quality. There was consistent evidence of positive effects of PR in the nursing home setting. Only one study was identified that assessed the impact of PR on disparities; they reported mixed results.
Behrendt et al. (2016)[4]	Mechanisms and effects of public reporting of surgeon outcomes: A systematic review of the literature	MEDLINE, EconLit, Embase	1980-2015	This was some evidence that PR can be an incentive for low-performing surgeons to improve quality. Negative selection of patients was not observed in the United Kingdom. Most studies are from the United States and cannot easily be transferred to other contexts.
Campanella et al. (2016)[6]	The impact of public reporting on clinical outcomes: A systematic review and meta-analysis	PubMed, Web of Science, Scopus	1991-2014	The effects of PR on clinical outcomes were mainly positive. There were mixed effects of PR on mortality. Meta-analysis: With high heterogeneity, the authors found that the risk of mortality was 14% lower in PR jurisdictions compared to non-PR (RR=0.86, 95% CI 0.80-0.92, I^2=99%). PR may simulate improvement in healthcare quality.

CI: confidence interval; PR: public reporting; RR: relative risk

3. Method

A preliminary literature search was conducted to identify relevant systematic reviews.[3, 4, 6, 8] The most thorough of these was a review published in 2012 by Totten et al., which explored six key questions and a range of outcomes.[3] Here we aim to provide a rapid update of the evidence with a focus on cardiac patients and care, and to describe the generalizability of the evidence to the Canadian context.

We conducted a search of MEDLINE and Embase with a combination of keywords and medical subject heading terms (see Appendix A for the complete search strategy). The search was conducted by an IHE Information Specialist on 14 July 2017 to identify studies published over the last five years (from 1 January 2012 onwards), and was limited to human studies published in English. No country limits were set. In addition, we conducted a brief search of NHS Evidence (*www.evidence.nhs.uk/*) and Google for relevant grey literature using the term *public reporting*. The first Google search was completed on 18 April 2017, and a second search was completed 18 July 2017. We also scanned through reference lists of previous reviews and studies included for full-text review to ensure relevant studies were included for screening and review. Titles/abstracts were screened by one reviewer (RC). Articles that appeared to be relevant were retrieved to determine final study eligibility based on predefined inclusion/exclusion criteria. Data from each selected study were extracted by one of the two reviewers (CM or BG) and synthesized narratively. A formal quality appraisal was not performed due to time constraints; however, important methodological issues are highlighted in this report.

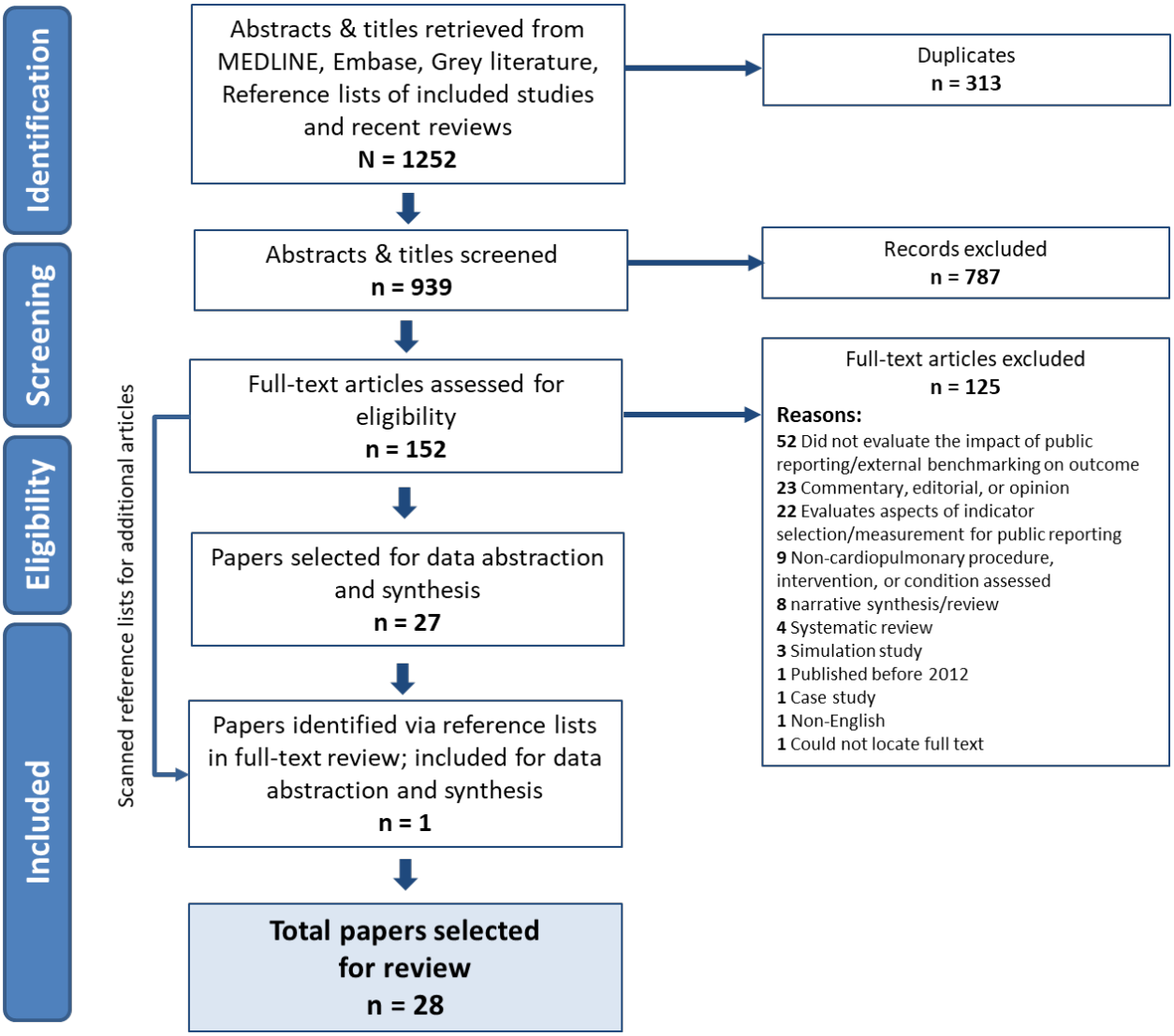
A detailed description of the approach used for the literature search (databases searched, search dates, and search terms), study selection, data extraction, and data analysis and synthesis is provided in Appendix A. Excluded studies and reasons for exclusion are listed in Appendix B. Summary tables of evidence from previously published systematic reviews and included primary studies are presented in Appendices C and D.

4. Results

4.1. Literature Search Results

Our search of MEDLINE and Embase returned 852 unique articles. In addition, 81 articles were identified through the grey literature search and 6 by reviewing the reference lists of previous systematic reviews, for a total of 939 studies. Of these, 152 studies met title and abstract screening criteria, and were included for full-text review. Following full-text review, 27 studies were included for data abstraction. In addition, one study was included from screening the reference lists of studies in full-text review, bringing the total number of included studies to 28. Of the 28 included studies, 23 assessed the impact of public reporting, and five evaluated the impact of external benchmarking. The most common reasons for exclusion during full-text review were: the study did not evaluate the impact of public reporting or external benchmarking on the outcome; the study was a commentary, editorial, or opinion; or the study evaluated aspects of indicator selection/measurement for public reporting. Figure 1 below summarizes the literature search results.

FIGURE 1: Study selection PRISMA flow chart



4.2. Evidence from Primary Studies

4.2.1. Public reporting

Description of included studies

Of the 23 studies that evaluated the impact of public reporting, 18 (78%) were conducted in the United States; the remaining five studies were from Germany, Norway, Italy, Japan, and the Netherlands. All studies were observational studies. The 23 studies varied in their objectives and aims. Thirteen studies compared public reporting jurisdictions to non-public reporting jurisdictions or time periods before and after public reporting implementation;[13-25] three studies assessed the impact of changing public reporting policy in the state of New York, where patients with select conditions were excluded from public reporting;[26-28] two studies assessed the role of competition on the impact of public reporting;[29, 30] two studies evaluated the impact of public reporting on negative outlier institutions;[31, 32] one study surveyed referring cardiologists;[33] one study assessed the impact of

public reporting on market share;[34] and one study evaluated the impact of public reporting in comparison to collaborative quality improvement.[35]

The results presented below are organized by the outcomes reported in the studies. Further details about each study are presented in Appendix C.

Summary of outcomes

Mortality

The impact of public reporting on mortality was evaluated in 15 studies, and was the most common outcome assessed. Of these, 13 studies were conducted in the United States.

Overall, the studies based in the United States reported mixed effects of public reporting on patient mortality. In three studies, the authors found that public reporting was associated with improvements in mortality.[13, 22, 35] Notably, one of these studies compared public reporting to collaborative quality improvement and found significantly decreased odds of mortality in public reporting jurisdictions compared to collaborative quality improvement.[35] Five studies reported that public reporting had no significant association with mortality,[14, 16, 17, 30, 36] one study found mixed effects for different patient groups,[21] and one study found that public reporting had negative effects on patient mortality.[25]

Three studies assessed the impact of changes in exclusion criteria for publicly reported measures in the state of New York. Two of these studies found a decrease in patient mortality following the exclusion of patients with cardiogenic shock from public reporting.[26, 27] In the other study, there was no association found between mortality and public reporting following the exclusion of cardiac arrest or coma from public reporting.[28]

Two studies were conducted in Norway and Italy. In the Norway study, public reporting was not associated with mortality.[19] Similarly, public reporting was not associated with mortality for most patient groups in the study conducted in Italy; however, an increase in patient mortality was reported for ST-segment elevation myocardial infarction (STEMI) patients not treated with PCI after implementation of public reporting.[20]

Readmissions

Hospital readmission was an outcome in three studies conducted in the United States. In one study, public reporting was associated with increased hospital readmission,[13] while the other two studies reported no association between public reporting and readmissions.[14, 36] In addition, one of the studies evaluated the impact of public reporting on post-discharge emergency department use; this study found a significant reduction in emergency department use following the implementation of public reporting.[36]

Readmissions and emergency department utilization were not outcomes reported on in any of the studies conducted outside of the United States.

Patient selection and access

Rates of PCI

Four studies assessed the impact of public reporting on PCI rates. Of these, two were conducted in the United States, one in Germany, and one in Italy. In both of the United States studies, public reporting was found to be associated with a significant reduction in the odds of PCI for patients.[16, 25]

However, in both non-United States studies, public reporting was found to be associated with increased PCI utilization.[18, 20]

Rates of CABG

One study conducted in the United States assessed the impact of public reporting on CABG rates.[16] No significant effect was found.

Patient case-mix

Four studies conducted in the United States specifically evaluated patient case-mix after public reporting implementation. One study found no evidence of risk aversion,[22] and one study found no difference in predicted mortality for patients undergoing PCI.[13] However, in a study comparing public reporting to collaborative quality improvement, PCI patients in public reporting states were less likely to have a history of cardiopulmonary comorbidities, and predicted mortality was significantly lower in patients from public reporting states, suggesting a degree of risk aversion in public reporting.[35] Similarly, in a study of hospitals identified in public reporting as negative outliers, predicted mortality of PCI patients was significantly lower in negative outlier hospitals, which may indicate a degree of risk avoidance among low-performing institutions following public reporting.[31]

Public reporting policy changes and access to cardiac interventions

In three studies conducted in the United States, the impact of policy change to exclude select patient groups from public reporting was assessed. Two studies evaluated the impact of excluding patients with cardiogenic shock from public reporting in the state of New York, and reported significantly increased odds (and likelihood) of PCI, CABG, and revascularization following the policy change.[26, 27] The third study assessed the impact of excluding patients with cardiac arrest or coma in public reporting, and found no impact of excluding patients with cardiac arrest or coma in public reporting on rates of PCI or coronary angiography.[28]

Process of care

The impact of public reporting on process of care measures was evaluated in three studies, two from the United States, and one from Japan. In one of the studies from the United States, the authors reported: a significant reduction in blood transfusion rates; increased rates of acetylsalicylic acid, ß-blocker, statin, and thienopyridine prescribing at discharge; decreased rates of angiotensin-converting enzyme (ACE) inhibitor and non-statin prescribing at discharge; and no significant difference in door-to-balloon time after public reporting.[13] Similarly, in the other study from the United States, the authors found a significant decrease in blood transfusion and increased rates of appropriate PCI in public reporting states, compared to collaborative quality improvement states.[35] In the study from Japan, qualitative improvements in five process indicators (acetylsalicylic acid at admission/discharge, ß-blockers at admission/discharge, and ACE inhibitors or angiotensin-receptor blockers [ARBs] during hospitalization) were observed, although the statistical significance of these changes was not reported.[23]

Surgical complications and adverse events

One study conducted in the United States evaluated the impact of public reporting on surgical complications and adverse events, comparing states with public reporting to states with collaborative quality improvement.[35] The study found that public reporting was associated with decreased odds of cardiogenic shock, congestive heart failure, and (any) vascular complications, compared to collaborative quality improvement.

Quality improvement

A descriptive study from the Netherlands described a physician-led initiative to develop a cardiac registry for public reporting, initial findings, and subsequent quality improvement activities following public reporting release, including: pre-hydration for patients with renal insufficiency; the adoption of safety checklists; and initiatives to lower the target vessel revascularization rate following PCI, reduce mortality after aortic valve replacement, cardiac tamponade after PCI, and deep sternal wound infections after CABG.[24]

In a study conducted in Norway, the authors described the initiation of a project to monitor adherence to clinical guidelines for acute myocardial infarction treatment.[19] The authors found that, in comparison to hospitals without public reporting programs, there was no significant difference in 30-day mortality. However, within hospitals, crude 30-day mortality declined after public reporting implementation, although the significance of the decline was not reported.

In all other studies, specific quality improvement initiatives implemented following public reporting were not described, and only general associations based on interjurisdictional comparisons or time trends are presented.

Context

Contextual factors that may influence the impact of public reporting were examined in eight studies conducted in the United States, and in one study conducted in Japan. In the United States studies, the most common contextual factor examined was the impact of competition. While two studies found that competition did not have a significant impact on mortality rates following public reporting,[17, 30] one study reported significant improvement in mortality in more competitive markets.[14] Increased competition was also correlated with higher costs and resource utilization per patient.[14, 30] In addition, one study found that public reporting had no impact on the market share of cardiologists, and no impact on cardiologists leaving practice.[34]

Other contextual factors examined in the studies included in this review were negative outlier status, the influence of travel distance to care providers, and awareness and use of public reporting data in cardiac surgery referrals. Two studies conducted in the United States examined mortality at outlier institutions and found that hospitals identified as negative outliers had improved mortality measures, and improved at a greater rate than non-outlier institutions following outlier designation in public reporting.[17, 32] Another study from the United States examined the influence of distance to care providers and found that travel burden for patients seeking "better" care may limit patient choice and reduce the impact of public reporting rankings.[29] Only one study evaluated the use of public reporting reports in cardiac surgery referrals; in this survey, conducted in the United States, the authors reported that, although there is high awareness of public reporting data among referring cardiologists, few cardiologists use risk-adjusted data to select surgeons to operate on their patients.[33]

Similar to the two United States studies that found greater rates of improvement in negative outlier institutions, the study conducted in Japan found that time trends in improvement were related to baseline performance, and low baseline performers tended to show stronger improvement after public reporting.[23]

4.2.2. External benchmarking

Description of included studies

Five of the studies selected for review, conducted in Australia,[37] Brazil,[38] Japan,[39] the Netherlands,[11] and the United States,[15] evaluated the impact of external benchmarking. All studies were observational studies. These studies included patients undergoing PCI,[37] CABG,[38, 39] or CABG plus other cardiac surgery.[11, 15] Registry databases were the most common data sources. Benchmarks included both single best practice and aggregated standards. Quality indicators or outcome measures targeted in these studies are listed below in Table 3.

TABLE 3: Quality indicators/outcome measures targeted in the selected studies

Quality indicators/ outcome measures	Eccleston et al. 2017[37]	Brouwers et al. 2017[11]	Silva et al. 2015[38]	Chu et al. 2015[15]	Miyata et al. 2012[39]
Mortality				✔	✔
Failure to rescue from postoperative morbidity				✔	
Morbidity					✔
Length of stay in ICU			✔		
Readmission to ICU			✔		
Blood transfusion rate		✔			
Blood product use		✔			
Time of mechanical ventilation			✔		
Reintubation			✔		
Evidence-based therapy			✔		
Compliance with guideline medication use	✔				

ICU: intensive care unit

The quality benchmarks from the Society of Thoracic Surgeons (STS) have proved to be a useful metric for improving adult cardiac surgical outcomes across the United States. Two studies included in this review used the STS registry database for external benchmarking.[15, 38]

The results presented below are organized by the outcomes reported in the studies. Further details about each study are presented in Appendix D.

Summary of outcomes

Mortality

Two studies examined the impact of external benchmarking on mortality outcomes, one from Japan and one from the United States.[15, 39] Both studies found a statistically significant reduction in mortality after external benchmarking initiatives.

In the study conducted in Japan, compared with halfway participating hospitals, initial participating hospitals had a significantly lower rate of operative mortality (OR=0.527; p=0.008) and major

morbidities (OR=0.820; p=0.047), after adjusting for the number of annual cases and preoperative risk.[39] However, the trend of improvement for morbidity rate was flat.

The study conducted in the Unites States specifically looked at failure to rescue rates, defined as the occurrence of any major postoperative complication captured by the STS Adult Cardiac Surgery Database resulting in death.[15] *Postoperative complications* included reoperation for bleeding or primary cardiac cause, deep sternal wound infection, cerebral vascular accident, prolonged ventilation exceeding 24 hours, pneumonia, renal failure, and need for new postoperative dialysis, as defined by the STS Adult Cardiac Surgery Database. The authors concluded that quality improvement initiatives significantly improve clinical outcomes without affecting failure to rescue.

Morbidities

Two studies, one from Brazil and one from the United States, examined the impact of external benchmarking on morbidities, including stroke, dialysis, infection, prolonged ventilation, reintubation, readmission to the intensive care unit, reoperation, and length of stay in the intensive care unit.[38, 39] Both studies found a statistically significant reduction in morbidities after external benchmarking initiatives.

The study conducted in Brazil reported a single private hospital experience with joining the STS Registry that originated in the United States.[38] This study demonstrated a significant reduction in the time of mechanical ventilation, length of stay in the intensive care unit, and increased use of evidence-based perioperative therapies. However, a slight reduction in reintubation and readmission to the intensive care unit did not reach statistical significance.

Blood transfusion rate

One study compared four hospitals in terms of the change in blood transfusion rate before and after external benchmarking.[11] Three of the four participating hospitals demonstrated a statistically significant decrease in blood transfusion rate after external benchmarking.

Although direct causal relationship cannot be established between the benchmarking activity and the decreased blood transfusion rate due to the observational nature of the study, it seems plausible that external benchmarking helped create more awareness on transfusion practice, and motivated hospitals to initiate strategies to improve transfusion practice. In all four participating hospitals, optimization of blood transfusion was achieved by the use of cell saver, continuous availability of thromboelastometry, protamine management, prevention of hemodilution, fibrinogen and prothrombin complex concentrates, intravenous administration of iron preoperatively in patients with iron deficiency anemia, and careful hemostasis. In addition, one hospital used perioperative normothermia and focused strongly on optimizing surgical technique to prevent blood loss. Another hospital used retrograde autologous priming of the bypass circuit and focused on optimizing the transfer from the operating room to the intensive care unit.

The authors concluded that benchmarking blood transfusion practices seems to be an effective way to improve awareness and to standardize transfusion practices in cardiac surgery. In addition, this study indicates that there are significant discrepancies in transfusion rates, in the use of specific blood products, and in costs associated with CABG, valve, and combined CABG and valve surgery, which seem to decrease over time.

Evidence-based practice

Two studies, one from Australia and one from Brazil, examined the impact of external benchmarking on the use of evidence-based clinical practice.[37, 38]

The Australia study used the aggregated study cohort and international standard as a benchmark for 10 private hospitals, and compared compliance with clinical practice guidelines on the use of medications such as statin, anti-platelet drugs, ß-blockers, ACE inhibitors, and ARBs in patients receiving PCI, before and after external benchmarking.[37] This study found a statistically significant increase in compliance with guidelines on the use of statin and ß-blockers at hospital discharge, and on the use of statin and anti-platelet drugs at 1-year follow-up.

The Brazil study also showed a statistically significant increase in the rate of evidence-based perioperative therapies after external benchmarking.[38]

5. Discussion

5.1. Main Findings

For both public reporting and external benchmarking, there is some evidence that these strategies may lead to improvements in patient outcomes and care quality and processes. However, for public reporting, the evidence often showed that public reporting did not have a significant impact on the outcomes of interest (i.e., a null effect), and was less often associated with improvements in patient outcomes. In many cases, public reporting was also associated with negative outcomes/unintended consequences, and, overall, the evidence base was highly inconsistent. In comparison, no negative outcomes were reported for external benchmarking, and all of the evidence demonstrated positive or null effects. However, it should be noted that adverse events and risk aversion were not explored in the external benchmarking studies included in this review.

In the 23 studies on public reporting included in this review, public reporting was largely not associated with mortality, although some mixed results were reported. Similarly, public reporting was not associated with hospital readmissions in most cases, although one study found an improvement in readmission rates, and one study found improvement in post-discharge acute care utilization. Overall, evidence showed mixed and highly inconsistent effects on access to PCI, no effect on CABG rates, and no significant effect on patient case-mix for patients undergoing PCI, although there was evidence of risk aversion following public reporting in outlier institutions, and in the United States. In addition, policy to exclude high-risk patients from public reporting for PCI, CABG, and revascularization largely resulted in increased rates of intervention following the policy change.

In the included studies, public reporting had mixed effects on processes of care, although improvements were observed in blood transfusion rates and many prescribing practices. Several contextual factors influencing the impact of public reporting were examined, including competition, travel distance, negative outlier status, and awareness and utilization of public reporting data by referring cardiologists. Competition had mixed effects on mortality, and was associated with higher costs and resource utilization per patient. Travel times appeared to limit patient choice, which may reduce the impact of public reporting rankings. Furthermore, low-performing hospitals were found to improve at greater rates following public reporting, and few cardiologists were found to use risk-adjusted data to select surgeons to operate on their patients.

Overall, our findings are largely consistent with those of Totten et al. (2012), who found a general improvement in process of care indicators, and a positive response of providers and organizations to develop services and change policy to improve clinical care.[3] However, in the studies included in our review, public reporting had more modest effects on mortality, and most studies found no association between public reporting and mortality. Additionally, there was greater evidence of reduced access to cardiac interventions for high-risk patients, although our results were also mixed and inconsistent. Provider behaviour to artificially improve ratings was not investigated in any of the included studies.

In comparison, evidence from five studies suggests that external benchmarking tends to have positive effects on mortality, morbidity, blood transfusion rate, and evidence-based clinical practice after initiating quality improvement activities in patients undergoing PCI, CABG, or other cardiac surgeries. However, no information was available in the included studies with respect to any adverse events or risk of aversion. Additionally, relatively few recent studies have investigated the impact of external benchmarking in cardiac care in comparison to public reporting.

We did not identify any studies that directly compared public reporting and external benchmarking. However, we identified one study that investigated the impact of public reporting in comparison to collaborative quality improvement.[35] Like external benchmarking, collaborative quality improvement involves a combination of measurement, sharing, and feedback of outcomes data to implement quality improvement initiatives.[35] In this study, the authors found that, in comparison with collaborative quality improvement, public reporting is associated with decreased utilization of PCI in high-risk patients (suggesting risk aversion); however, even in comparable samples (using propensity matched analysis), public reporting is still associated with decreased mortality and adverse events. The results highlight the complexity of public reporting as a quality improvement initiative, as well as its associations with both improvements in care and unintended outcomes. While these results may suggest that public reporting is more effective than collaborative quality improvement in improving patient outcomes, no firm conclusion could be drawn from this study due to its methodological limitations.

5.2. Study Limitations

These results should be interpreted with caution for several reasons. This report was a rapid review, and our search of the academic literature was limited to MEDLINE and Embase. While we believe we captured most relevant studies through the database searches and hand-searches of included reference lists, it is possible that we did not capture all of the relevant evidence. Further, due to project timeline constraints, a formal critical appraisal of each study was not completed. Consequently, the evidence presented here is not weighted to adjust for differences in study quality and risk of bias, as all the studies included in this review were observational studies. However, while a formal assessment of the risk of bias was not completed, general limitations were noted in the data extraction table and the following broad observations were made.

First, public reporting and external benchmarking studies were largely different in their designs. The external benchmarking studies tended to describe a quality improvement initiative implemented as the result of benchmarking activities, and described the changes in outcomes before and after the initiative. Only external benchmarking studies with positive results were identified, and this may indicate a publication bias towards initiatives that were highly successful. Alternatively, most public reporting studies utilized large administrative databases and described temporal associations between public reporting and the outcomes of interest. However, these studies did not describe and were not

able to adjust for individual quality improvement initiatives. Further, other quality improvement initiatives and policy changes unrelated to public reporting were not accounted for in these analyses. There was also variation in the objectives of each study included in the review, and our synthesis relied on the evaluation of the evidence in relation to other studies.

Secondly, similar outcomes were grouped together (e.g., mortality consisted of 30-day mortality, 120-day mortality, and in-hospital mortality), which resulted in heterogeneous outcome categories consisting of a variety of measures with different definitions and patient case-mix adjustments, and differences specific to each measure were not accounted for. We also only reported the number of studies finding improvements, no impact, or declines in specific outcomes, and did not account for or report variation in the effect size.

Lastly, patient groups differed substantially between studies. Some studies analyzed patients with emergent conditions, while others investigated patients undergoing elective procedures. Additionally, some studies assessed Medicare patients (over 65 years of age), while others examined all patients with a specific condition or undergoing cardiac surgery. These patient groups may have important differences that modify the impact of public reporting or external benchmarking on patient outcomes, and were not accounted for in our synthesis.

5.3. The Canadian Context

None of the studies included in our review were conducted in Canada. While the external benchmarking literature included in our review originated from a variety of countries, the public reporting literature is predominately from the United States, accounting for 18 (78%) of the 23 public reporting studies included in our review. Similarly, the majority of studies included in previously published systematic reviews were also conducted in the United States, and the applicability of these findings to the Canadian context, and other publicly funded health systems, is unclear.[4]

Several factors have been identified that impact the generalizability of these results to publicly funded health systems, including coverage and access, patient choice, payment mechanisms to providers, the number of surgeons and facilities providing select services, patient comprehension, provider competition, type and volume of procedures covered, data availability, timeliness of data, quality improvement capacity, and the presence of a national governing body to support quality improvement efforts.[4] In Canada, several of these factors deviate in important ways from the United States system, and, in general, the Canadian system has greater insurance coverage, decreased patient choice of providers, different payment mechanisms for providers, fewer facilities providing select services, and decreased provider competition. These differences may limit the direct transferability of the results of this and previous reviews to the Canadian context.

In particular, patient choice is more limited in Canada for patients undergoing elective procedures, and for emergency cases there is often little choice at all. Provider selection by patients is further limited by the relatively limited number of hospitals providing cardiac surgery services, and by the geographical dispersion of the Canadian population. In addition, there is relatively little competition for patients in the Canadian context and, in combination, these contextual factors may mitigate the impact of public reporting on quality improvement.[3]

However, public reporting also has other benefits aside from quality improvement, including increasing patient engagement, promoting transparency and trust, and generating greater provider accountability for the quality of care provided. In addition, public reporting may still incentivize

service providers through the change pathway[9] or the reputation pathway,[10] which rely on professional motivation and reputation to initiate quality improvement and improve performance. These mechanisms may also apply to external benchmarking.

Interestingly, in relation to the United States studies, studies conducted outside of the United States had similar results for external benchmarking but some conflicting results for public reporting. United States and non-United States studies had largely similar results for mortality, process of care, and context (impact of public reporting on negative outlier institutions); however, conflicting results were reported for PCI rates. Two United States studies found negative effects on PCI access following implementation of public reporting, and two non-United States studies found that public reporting had positive effects on PCI access. This evidence is based on a small number of studies, and should therefore be interpreted cautiously.

Although we found nonsignificant and largely mixed effects of public reporting on outcomes, both public reporting and external benchmarking have the potential to stimulate quality improvement but require focused action beyond performance evaluation and comparison. However, evidence at the population-level remains highly inconsistent, with mixed results. Notably, no negative effects were found for external benchmarking in the studies included in our review. This may be due to publication bias or an unwillingness of investigators to formally publish poor results, or, alternatively, could possibly represent a real phenomenon due to fundamental differences between public reporting and external benchmarking. By definition, external benchmarking is a continuous process that requires the identification of high performers, and a sustained effort to measure and compare outcomes against other organizations for shared learning and improvement.[1] Conversely, public reporting only requires the release of data for public consumption, with no requirement for follow-up comparison, planning, or action.[3] While both public reporting and external benchmarking are drivers of transparency and accountability, they are fundamentally different in the degree of commitment to quality improvement, which may explain some of the observed differences related to quality improvement reported here.

Finally, it is important to note that other quality improvement tools such as provider reminder systems, provider education, patient education, promotion of self-management, organizational change, financial incentives, regulation, and policy play important roles in health system quality improvement.[40] Public reporting and external benchmarking should be considered and integrated with other quality improvement tools and initiatives to align system incentives and drive excellence in care forward.[4]

6. Conclusion

Based on the evidence from recently published studies (all observational in nature), both public reporting and external benchmarking appear to be promising quality improvement strategies. However, the evidence from the 23 included public reporting studies was highly inconsistent, with a mix of positive, negative, and null reported effects that were largely consistent with previous systematic reviews. In comparison, none of the five external benchmarking studies reported negative outcomes, and all five reported positive or a mix of positive and null results, although adverse events and risk aversion were not necessarily explored in these studies.

It is important to consider contextual factors when applying these findings to other jurisdictions such as Canada. Most studies were conducted in the United States, and the transferability of those findings to publicly funded health systems such as that in Canada remains to be determined. In

Canada, patient choice of cardiac care providers is limited and the selection pathway of public reporting is negated, which may modify the impact of public reporting in Canada. Additionally, other factors such as limited competition may reduce the impact of public reporting on quality improvement by minimizing the effects of the change pathway. On the other hand, although currently available evidence is limited, external benchmarking has been associated with few adverse consequences and may be considered a more appropriate alternative for the Canadian cardiac care system because of its focus on establishing leadership, engaging multidisciplinary teams, increasing care providers' awareness of their own performance, improving internal processes, and monitoring changes.

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Appendix A: Methodology

Literature Search

The literature search was conducted by an IHE Information Specialist for publications published between 2012 and 2017. The search was developed and carried out prior to the study selection process. In addition to the strategy outlined below, reference lists of retrieved articles were reviewed for potential studies.

TABLE A.1: Literature search strategy

Database	Edition or date searched	Search terms[††]
Core databases		
Ovid MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) 1946 to Present	14 Jul 2017 **523 results**	1. Benchmarking/ or Information Services/ or Information Dissemination/ or Disclosure/ or Access to Information/ or Mandatory Reporting/ 2. benchmark*.ti. 3. exp "Quality of Health Care"/ or exp Quality Assurance, Health Care/ or exp Quality Indicators, Health Care/ or exp Hospitals/sn or Hospitalization/sn or "Outcome Assessment (Health Care)"/ or Hospital Mortality/ 4. (quality or improve*).ti. 5. (1 or 2) and (3 or 4) 6. ((Dissem* or Disclos* or Profil* or Inform* or Report*) adj5 (perform* or assessment* or evaluat* or quality or indicator* or Metric* or Rank* or Compar* or Score* or Rating* or Rate* or data or measure* or criteria or standard* or account* or outcome* or mortality)).ti,ab,kf. 7. (public* or consumer*).ti,ab,kf. 8. 6 and 7 9. 5 or 8 10. exp Percutaneous Coronary Intervention/ 11. percutaneous coronary intervention.ti,ab,kf. 12. exp Myocardial Infarction/ 13. (acute adj3 myocardial infarction).ti,ab,kf. 14. Cardiac Rehabilitation/ 15. (cardiac adj2 rehabilitat*).ti,ab,kf. 16. Atrial Fibrillation/ 17. atrial fibrillation.ti,ab,kf. 18. Heart Failure/ 19. heart failure.ti,ab,kf. 20. Coronary Artery Bypass/ 21. (cabg or coronary artery bypass).ti,ab,kf. 22. or/10-21 23. 9 and 22 24. limit 23 to (english language and yr="2012 -Current")
OVID Embase 1996 to 2017 Week 28	14 Jul 2017 **642 results**	1. benchmarking/ or information service/ or information dissemination/ or interpersonal communication/ or access to information/ or mandatory reporting/

Database	Edition or date searched	Search terms††
		2. benchmark*.ti. 3. exp health care quality/ or exp hospital/ or hospitalization/ or outcome assessment/ or hospital mortality/ 4. (improv* or quality* or perform*).ti. 5. (1 or 2) and (3 or 4) 6. ((Dissem* or Disclos* or Profil* or Inform* or Report*) adj5 (perform* or assessment* or evaluat* or quality or indicator* or Metric* or Rank* or Compar* or Score* or Rating* or Rate* or data or measure* or criteria or standard* or account* or outcome* or mortality)).ti,ab,kw. 7. (public* or consumer*).ti,ab,kw. 8. 6 and 7 9. 5 or 8 10. exp percutaneous coronary intervention/ 11. percutaneous coronary intervention.ti,ab,kw. 12. (acute adj3 myocardial infarction).ti,ab,kw. 13. heart rehabilitation/ 14. (cardiac adj2 rehabilitat*).ti,ab,kw. 15. atrial fibrillation/ 16. atrial fibrillation.ti,ab,kw. 17. heart failure/ 18. heart failure.ti,ab,kw. 19. coronary artery bypass graft/ 20. (cabg or coronary artery bypass).ti,ab,kw. 21. or/10-20 22. 9 and 21 23. limit 22 to (english language and yr="2012 -Current") 24. limit 23 to conference abstracts 25. 23 not 24
Grey literature		
Google *www.google.ca*	18 Apr 2017 **10 results**	public reporting and national health service or uk Browsed results
	18 Jul 2017 **71 results**	external benchmarking coronary OR cabg OR myocardial* OR cardiac OR atrial OR heart "public reporting" Language: English Any Country Date range: Jan1, 2012-Dec31, 2017
NHS Evidence	18 Apr 2017 **0 results**	Public reporting Browsed results

†† "*", "# ", and "?" are truncation characters that retrieve all possible suffix variations of the root word e.g., surg* retrieves surgery, surgical, surgeon, etc.

Study Selection

Definition of *public reporting*

For consistency, we adopted the AHRQ's following definition of public reporting:[3]

> "Public reporting is a mechanism of providing data, publicly available or available to a broad audience free of charge or at a nominal cost, about a health care structure, process, or outcome at any provider level (individual clinician, group, or organizations [i.e., hospitals, private practice]) or at the health plan level. While public reporting is generally understood to involve comparative data across providers, for purposes of this review, we are adopting a broader approach to include findings in which one provider is compared to a national/regional data report on performance for which there are accepted standards of best practices."

Definition of *external benchmarking*

In the context of healthcare, external benchmarking has been described as:[1]

> "a process of comparative evaluation and identification of the underlying causes leading to high levels of performance. Benchmarking must respond to patients' expectations. It involves a sustained effort to measure outcomes, compare these outcomes against those of other organizations to learn how those outcomes were achieved, and apply the lessons learned in order to improve."

The concept of benchmarking arose out of industry, and few definitions have been adapted to the healthcare context.[5] We chose this definition based on the recommendation of a recent review of the history of benchmarking, and its evolution in the healthcare sector.[1]

Title and abstract screening

Titles and abstracts were screened by a single reviewer (RC). To be included, the title or abstract needed to describe the effects of public reporting, or external benchmarking at any level (e.g., surgeon-specific, care-team, hospital) on one or more outcomes. If unclear, the study was included for full-text review.

Full-text review

The full-text of studies that met title and abstract screening criteria were reviewed by a single reviewer (RC) to determine their eligibility for inclusion, based on predefined inclusion and exclusion criteria (see Table A.2). To be included for data abstraction, the study was required to document the impact of a form of public reporting or external benchmarking on outcomes including: patient clinical outcomes (e.g., mortality, re-admission, morbidity); harms or negative events to the patient, provider, purchaser, or system (e.g., access, selection, costs); changes in delivery structure or processes; changes in the behaviour of patients, their representatives, or organizations that purchase care (e.g., provider choice/selection, quality improvement initiatives); and characteristics and contextual factors that influence the impact of public reporting on quality of care. The outcomes of interest were guided by a previous report,[3] but may expand outside of those.

In addition, the studies were required to address a specified procedure or condition of interest in cardiac care (i.e., PCI, CABG, acute myocardial infarction, atrial fibrillation, heart failure, or rehabilitation) to be included for data abstraction. Other procedures or conditions in cardiac care or relating to cardiopulmonary health were flagged for follow-up with the study team. We excluded

studies investigating outcomes of public reporting for procedures and conditions unrelated to cardiac care.

Only primary research studies were included, and reviews, commentaries, editorials, opinion articles and conference abstracts were excluded. We only included studies published in English.

TABLE A.2: Study selection criteria

Inclusion criteria	1. Describes impact of public reporting or external benchmarking on: a. Clinical outcomes (including benefits and harms) b. Changes in delivery structure/processes c. Changes in patient, provider, purchaser behaviour OR Describes characteristics and contextual factors that influence the impact of public reporting on quality of care 2. Studies **MUST** address a specified procedure or condition of interest in cardiac care (PCI, CABG, acute myocardial infarction, atrial fibrillation, heart failure, rehabilitation) a. Other procedures or conditions relating to cardiac care or cardiopulmonary health will be flagged for follow-up with the study team 3. Primary research 4. Published in English
Exclusion criteria	1. Commentary, editorial, opinion article, or conference abstract 2. Non-cardiopulmonary procedure, intervention, or condition assessed 3. Published in language other than English 4. Evidence synthesis or review (systematic reviews, rapid reviews, narrative reviews, meta-analyses) 5. Descriptive analyses (no comparator group, jurisdictions, or time-period assessed)

Data Extraction

Studies that met inclusion criteria were included for data abstraction. A single reviewer (CM or BG) abstracted the following fields from included studies: title, first author, date of publication, study dates, country, study type, population, specified cardiopulmonary condition/intervention assessed, name and details of the public reporting initiative studied, comparison group, outcomes and effect size, and the presence of any contextual factors that may influence the impact of public reporting on quality of care, as well as important contextual factors to consider before applying the results to the Canadian context.

Quality appraisal

Due to time constraints, we did not complete a formal quality appraisal for each study. However, we presented high-level observations of the quality and limitations of the evidence included in this review.

Data Analysis and Synthesis

Following data extraction, study results were categorized according to the outcomes studied. The analysis was completed at a high level, and results were examined for significant or nonsignificant changes in the selected outcomes. If no statistical difference was observed, we reported no effects or association between public reporting and the outcome. Specific outcomes were grouped into larger categories (e.g., mortality consisted of outcomes such as 30-day mortality, 120-day mortality, and in-

hospital mortality), and the number of studies reporting improvements, declines, or no significant difference in outcomes were reported.

Appendix B: Excluded Studies and Reasons for Exclusion

Full-text articles excluded (N=125)

Did not evaluate the impact of public reporting/external benchmarking on outcome (n=52)

1. Aggarwal B, et al. Cause of death within 30 days of percutaneous coronary intervention in an era of mandatory outcome reporting. *Journal of the American College of Cardiology* 2013;62(5):409-15.
2. Badhwar V, et al. The Society of Thoracic Surgeons mitral repair/replacement composite score: A report of the Society of Thoracic Surgeons Quality Measurement Task Force. *Annals of Thoracic Surgery* 2016;101(6):2265-71.
3. Bardach NS, et al. The relationship between commercial website ratings and traditional hospital performance measures in the USA. *BMJ Quality and Safety* 2013;22(3):194-202.
4. Bates ER, et al. 2015 ACC/AHA/SCAI focused update on primary percutaneous coronary intervention for patients with ST-elevation myocardial infarction: An update of the 2011 ACCF/AHA/SCAI guideline for percutaneous coronary intervention and the 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: A report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. *Catheterization and Cardiovascular Interventions* 2016;87(6):1001-19.
5. Beckmann A, et al. Cardiac surgery in Germany during 2014: A report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *The Thoracic and Cardiovascular Surgeon* 2015;63(4):258-69.
6. Beckmann A, et al. Cardiac surgery in Germany during 2012: A report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *The Thoracic and Cardiovascular Surgeon* 2014;62(1):5-17.
7. Bridges JFP, et al. *Public reporting of cost measures in health: An environmental scan of current practices and assessment of consumer centeredness*. Rockville (MD): Agency for Healthcare Research and Quality (US); 2015.
8. Chang AM, et al. Associations of emergency department length of stay with publicly reported quality-of-care measures. *Academic Emergency Medicine* 2017;24(2):246-50.
9. Chen LM, et al. Association between a hospital's quality performance for in-hospital cardiac arrest and common medical conditions. *Circulation: Cardiovascular Quality & Outcomes* 2013;6(6):700-7.
10. D'Agostino RS, et al. The Society of Thoracic Surgeons Adult Cardiac Surgery Database: 2017 update on outcomes and quality. *Annals of Thoracic Surgery* 2017;103(1):18-24.
11. Davies RR, Pizarro C. Using the UNOS/SRTR and PHTS databases to improve quality in pediatric cardiac transplantation. *World Journal for Pediatric and Congenital Heart Surgery* 2012;3(4):421-32.
12. Degano IR, et al. A European benchmarking system to evaluate in-hospital mortality rates in acute coronary syndrome: The EURHOBOP project. *International Journal of Cardiology* 2015;182:509-16.

13. DeLia D, et al. Post-discharge follow-up visits and hospital utilization by Medicare patients, 2007-2010. *Medicare & Medicaid Research Review* 2014;4(2).
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15. Dy SM, et al. Patient perspectives of care and process and outcome quality measures for heart failure admissions in US hospitals: How are they related in the era of public reporting? *International Journal for Quality in Health Care* 2016;28(4):522-8.
16. Epstein AM, et al. Access to coronary artery bypass graft surgery under pay for performance: Evidence from the premier hospital quality incentive demonstration. *Circulation: Cardiovascular Quality & Outcomes* 2014;7(5):727-34.
17. Funkat A, et al. Cardiac surgery in Germany during 2013: A report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *The Thoracic and Cardiovascular Surgeon* 2014;62(5):380-92.
18. Girotra S, et al. Patient satisfaction at America's lowest performing hospitals. *Circulation: Cardiovascular Quality & Outcomes* 2012;5(3):365-72.
19. Goodrich K, et al. Hospitalist utilization and hospital performance on 6 publicly reported patient outcomes. *Journal of Hospital Medicine* 2012;7(6):482-8.
20. Groene O, et al. Patient experience shows little relationship with hospital quality management strategies. *PLoS ONE* 2015;10(7):e0131805.
21. Hakkinen U, et al. Health care performance comparison using a disease-based approach: The EuroHOPE project. *Health Policy* (Amsterdam, Netherlands) 2013;112(1-2):100-9.
22. Hao Y, et al. Rationale and design of the Improving Care for Cardiovascular Disease in China (CCC) project: A national effort to prompt quality enhancement for acute coronary syndrome. *American Heart Journal* 2016;179:107-15.
23. Heidenreich PA, et al. 2016 ACC/AHA clinical performance and quality measures for adults with atrial fibrillation or atrial flutter. *Circulation: Cardiovascular Quality and Outcomes* 2016;9(4):443-88.
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25. Jacobs JP, Jacobs ML. Transparency and public reporting of pediatric and congenital heart surgery outcomes in North America. *World Journal for Pediatric and Congenital Heart Surgery* 2016;7(1):49-53.
26. Jha AK, et al. The long-term effect of premier pay for performance on patient outcomes. *New England Journal of Medicine* 2012;366(17):1606-15.
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28. Khot UN, et al. A hospital-wide system to ensure rapid treatment time across the entire spectrum of emergency percutaneous intervention. *Catheterization & Cardiovascular Interventions* 2016;88(5):678-89.
29. Kumbhani DJ, Nallamothu BK. PCI volume benchmarks: Still adequate for quality assessment in 2017? *Journal of the American College of Cardiology* 2017;69(24):2925-8.

30. Lagu T, et al. A mixed-methods analysis of patient reviews of hospital care in England: Implications for public reporting of health care quality data in the United States. *Jt Comm J Qual Patient Saf* 2013;39(1):7-15.

31. Lopez JG, Keegan R. National registry of catheter ablation 2010. *Revista Argentina de Cardiologia* 2014;82(3):198-204.

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35. Nguyen OK, et al. Relationship between hospital financial performance and publicly reported outcomes. *Journal of Hospital Medicine* 2016;11(7):481-8.

36. Rao C, et al. The Chinese Cardiac Surgery Registry: Design and data audit. *Annals of Thoracic Surgery* 2016;101(4):1514-20.

37. Ryan A, et al. Does winning a pay-for-performance bonus improve subsequent quality performance? Evidence from the Hospital Quality Incentive Demonstration. *Health Services Research* 2014;49(2):568-87.

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42. Smith IR, et al. Use of graphical statistical process control tools to monitor and improve outcomes in cardiac surgery. *Heart, Lung & Circulation* 2013;22(2):92-9.

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Appendix C: Summary of Evidence on Public Reporting

TABLE C.1: Summary of evidence on public reporting

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
Bangalore et al. 2016[26] United States **Objective:** To evaluate whether the referral rates for cardiac catheterization, PCI, or CABG have improved in NY since cardiogenic shock was excluded form PR in 2008 **Study design:** Observational study (before/after and case-control) **Study period:** 2002-2011 **Funding:** AHRQ grant **Competing interest**: Yes, reported	**No. of participating hospitals:** NA **No. of patients:** 2,817 in NY; 1,587 in Michigan Patients were matched using propensity methods **Conditions/treatment:** Patients with cardiogenic shock complicating AMI	**PR system:** NY cardiac surgery reporting system and NY PCI reporting system **Data sources:** NIS **Comparison:** Rates of cardiac catheterization, PCI, or CABG before/after cardiogenic shock was removed from reporting, and between states with/without PR of surgical outcomes **Initiatives taken after PR:** Patients with cardiogenic shock removed from PR	**Rates of PCI after cardiogenic shock removed (after vs. before):** OR=1.50 [95% CI 1.12-2.01, p=0.005] **Rates of invasive management after cardiogenic shock removed (after vs. before):** OR=1.84 [95% CI 1.37-2.47, p<0.001] **Rates of revascularization after cardiogenic shock removed (after vs. before):** OR=1.66 [95% CI 1.23-2.20, p<0.001] **Rates of CABG after cardiogenic shock removed:** OR=1.28 [95% CI 0.87-1.88, p=0.16] **Mortality rate after cardiogenic shock removed:** OR=0.57 [95% CI 0.43-0.76 p=0.001] **Odds of right-heart catheterization after cardiogenic shock removed:** OR=2.06 [95% CI 1.32-3.21, p=0.001] **Difference-in-differences comparison (trends in NY vs. Michigan):** Rates at each time point in NY compared to Michigan: PCI – significantly lower in NY (p=0.02); invasive management – nss (p=0.27); revascularization – nss (p=0.08); CABG – nss (p=0.10); mortality – nss	**Limitations** Use of billing codes that are susceptible to misclassification, uncertain about accuracy. Right-heart catheterization is subject to under coding in administrative databases. Healthcare cost and utilization project discourages state-to-state comparison since the NIS sampling scheme is not stratified by state. **Conclusion** Although rates of PCI, invasive management, and revascularization have increased substantially after the exclusion of cardiogenic shock from PR in NY, these rates remain consistently lower than those observed in other states without PR.

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
Boyden et al. 2015[35] United States **Objective:** To compare patient selection, quality of care, and patient outcomes in two American states with different approaches to the use and publication of quality data: NY, a pioneer in PR vs. Michigan, a leader in continuous quality improvement. Prior studies have shown that PR may have an adverse impact on patient selection **Study design:** Observational study (case-control) **Study period:** Jan 2011-Sep 2012 **Funding:** ACC's NCDR **Competing interest:** NR	**No. of hospitals:** 43/59 non-federal hospitals in NY; all Michigan hospitals **No. of patients:** 51,938 in NY; 53,528 in Michigan Propensity methods were used to create a matched cohort with similar baseline characteristics **Conditions/treatment:** Patients receiving PCI	**PR system:** PR system not described for NY; CQI system not described for Michigan **Data sources:** NCDR, CathPCI Registry **Comparison:** PCI rate in NY vs. Michigan **Initiatives taken after PR:** NR	**Mortality rate (PR vs. CQI):** OR=0.72 [95% CI 0.63-0.83] **Rate of appropriate PCI (PR vs. CQI):** OR=1.10 [95% CI 1.04-1.17, p<0.0001] **Rate of cardiogenic shock (PR vs. CQI):** OR=0.33 [95% CI 0.26-0.42, p<0.0001] **Rate of CABG (PR vs. CQI):** OR=0.67 [95% CI 0.51-0.89, p=0.0002] **Rate of CHF (PR vs. CQI):** OR=0.34 [95% CI 0.26-0.42, p<0.0001] **Rate of blood transfusion (PR vs. CQI):** OR=0.70 [95% CI 0.61-0.82. p<0.0001] **Rate of any vascular complication (PR vs. CQI):** OR=0.66 [95% CI 0.46-0.95, p=0.0092] Significantly lower percentage of patients with extremely high predicted risk of mortality underwent PCI in NY compared with Michigan (p<0.0001) NY PCI patients were also significantly less likely to have a history of MI, CHF, hypertension, dyslipidemia, cerebrovascular disease, peripheral vascular disease, and chronic lung disease (for all, p<0.0001)	**Limitations** Not all hospitals in NY participate in the NCDR. There could be self-selection of hospitals in NY affecting results. The PR system and CQI system are not described. These may focus on other aspects of care that are not measured here. Michigan hospitals undergo more rigorous data audit, which may lead to more accurate identification of adverse events and clinical outcomes. **Conclusion** PR of PCI data is associated with fewer high-risk patients undergoing PCI compared with CQI. However, in comparable samples of patients, PR is also associated with a lower risk of mortality and adverse events.
Brown et al. 2013[33] United States **Objective:** To survey NY cardiologists to understand current opinions on cardiac surgery report cards and their use 20 years after their	**No. of participating hospitals:** NA **No. of patients:** NA **No. of cardiologists:** 287/1,375 members of the ACC **Condition/intervention:**	**PR system:** NY **Data sources:** Survey **Comparison:** NA **Initiatives taken after PR:** NA	**Physician views of the importance of report cards:** Not or minimally important=57%; moderately important=25%; very or extremely important=18% **Influence of report card data on referrals:** None=48%;	**Limitations** Low response rate. Based entirely on patient self-report. Limited to opinions of referring cardiologists in NY.

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
introduction in NY **Study design:** Observational study, cross-sectional survey **Study period:** Jun-Sept 2011 **Funding:** NR **Competing interest:** None declared	Cardiologists in NY registered with the ACC were invited to respond to the survey		minimal=27%; moderate=21%; substantial=4% **Percentage of patients with whom respondent discussed report card data:** None=71%; 1 to 10 percent=16%; >10 percent=13%	**Conclusion** Although awareness of report cards is nearly universal, few cardiologists use risk-adjusted mortality data to select cardiac surgeons to operate on their patients, and very few shared these reports with their patients as they engaged with them in decision-making.
Cavender et al. 2015[13] United States **Objective:** To evaluate the relationship between mandatory PR and patient selection for PCI, and mortality by identifying differences in patient characteristics, cardiac status, and indications for PCI in states with/without mandatory PR **Study design:** Observational study, cohort **Study period:** Jul 2009-Jun 2011 **Funding:** ACC's NCDR and the NHLBI **Competing interest:** Yes, reported	**No. of hospitals:** 1,227 **No. of patients:** 1,340,213 patients receiving PCI **States with mandatory PR included:** NY, Pennsylvania, Massachusetts **States without mandatory PR:** Maine, Ohio, Kentucky, Texas, Utah, Nevada, California, Colorado, Hawaii **Conditions/treatment:** Patients receiving PCI	**PR system:** State PR systems not described **Data sources:** CathPCI **Comparison:** States with mandatory PR **Initiatives taken after PR:** NR	**In-hospital mortality rate (PR vs. no-PR):** OR=0.80 [95% CI 0.74-0.88, p<0.001] **In-hospital mortality rate after elective PCI (PR vs. no-PR):** OR=0.71 [95% CI 0.58-0.87, p=0.001] **In-hospital mortality rate after PCI for ACS (PR vs. no-PR):** OR=0.81 [95% CI 0.74-0.89, p<0.001] **In-hospital mortality rate after PCI for shock (PR vs. no-PR):** OR=0.86 [95% CI 0.77-0.96, p=0.007] **180-day mortality rate (PR vs. no-PR):** OR=0.85 [95% CI 0.79-0.92, p=<0.001] **Hospital readmission rate (PR vs. no-PR):** OR=1.08 [95% CI 1.03-1.12, p=0.001] **Revascularization rate:** nss **MI 180-days post-PCI:** nss **Predicted mortality for patients undergoing PCI:** nss (p=0.17) **Blood transfusion, ACE inhibitor use, and non-statin use between PR and no-PR:** Significant reductions (for all p<0.001) **ASA, ß-blocker, statin, and**	**Limitations** Unable to account for unmeasured confounders or bias that could affect the precision of the models used to predict mortality. Could not ascertain the outcomes of patients who had an indication for PCI but were instead treated with medical management. Providers in states with PR could be more likely to defer revascularization in high-risk patients. PR systems used were not uniform and differed in their implementation and requirements. **Conclusions** Patients who underwent PCI in states with mandated PR of outcomes had similar predicted risks but significantly lower observed risks of death during hospitalization and in the 6 months after PCI. These findings support considering PR as a potential strategy for improving outcomes of patients who

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
			thienopyridine use: Significant increase (for all p<0.001) **Reported door-to-balloon time:** No difference (p=0.87)	underwent PCI although further studies are warranted to delineate the reasons for these differences.
Chen et al. 2012[34] United States **Objective:** To examine data from NY to address: 1) How well do public performance reports on PCI forecast future performance? 2) What is their impact on cardiologists' and hospitals' market share? 3) Is report performance associated with physicians' decisions to leave practice? **Study design:** Observational **Study period:** 1998-2007 **Funding:** Veterans Affairs Center for Clinical Management Research, VA Ann Arbor Healthcare System (Michigan) **Competing interest:** None declared	**No. of participating hospitals:** 48 **No. of patients:** NR **Conditions/treatment:** Patients receiving PCI	**PR system:** NY Department of Health reports **Data sources:** Annual reports, American Association Annual Survey Database, state physician registration databases, and other publicly available online databases **Comparison:** Among 48 participating hospitals and 351 cardiologists **Initiatives taken after PR:** NR	**Average RAMR after non-emergent PCI for hospitals:** Difference in RAMR between the best- and worst-performing hospitals ranged from 0.35 to 1.03%, depending on the year **Change in market share for hospitals or cardiologists:** PR had no impact on the market share of hospitals or cardiologists **Proportion of cardiologists leaving practice:** 6% in the top performance quartile vs. 7% in the lowest performance quartile (p=0.71)	**Limitations** Associations between PR and future performance, market share, and practice decisions; causality cannot be determined. Changes over time in the actual procedures that comprise PCIs and in NY State's definition of RAMRs prevented a clear interpretation as to whether quality actually improved over time. Insufficient sample size limited ability to detect small differences in physicians leaving practice across performance quartiles. **Conclusion** PR on non-emergent PCI in NY identifies very high and low performers but provides insufficient information to differentiate between most hospitals. It appears to have had no effects on market share or physicians' decisions to leave practice. The utility of PR on RAMRs may differ for different conditions and procedures.
Chou et al. 2014[14] United States **Objective:** To study the relationship between online performance grades, competition, and the quality	**No. of participating hospitals:** NR **No. of patients:** 76,862 Medicare patients **Conditions/treatment**: Patients receiving	**PR system:** Report cards rating the quality of CABG programs; online in 1998 **Data sources:** PHC4 Inpatient Database	**In-hospital mortality:** Before=0.034; after=0.027; change=-0.007 *p-value: NR **Readmission rate:** Before=0.206; after=0.180; change=-0.026	**Limitations** NR. **Conclusion** After the report cards went online, hospitals in more competitive markets used more

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
of health services by examining how the online publication of hospital report cards affected health outcomes for Medicare patients living in Pennsylvania hospital markets with different degrees of competition **Study design:** Observational **Study period:** 1995-2004 **Funding:** NR **Competing interest:** NR	CABG	**Comparison:** Before/after report card online **Initiatives taken after PR:** Hospitals spent more resources on all patients receiving CABG	*p-value: NR No evidence of cream skimming reported	resources per patient and achieved lower mortality among more severely ill patients.
DeVore et al. 2016[15] United States **Objective:** To assess trends of 30-day readmission rates and evaluate post-discharge care since the implementation of CMS PR **Study design:** Observational study, time series **Study period:** Jul 2006-Jun 2012 **Funding:** AHRQ grant **Competing interest:** Yes, reported	**No. of participating hospitals:** >4,100 **No. of patients:** 37,829 AMI; 100,189 heart failure **Condition/treatment:** Medicare-enrolled patients ≥65 years of age who were discharged home from a hospitalization for AMI or heart failure	**PR system:** CMS PR **Data sources:** Medicare Administrative Claims Database **Comparison:** Before/after implementation of CMS PR **Initiatives taken after PR:** NR	**30-day readmission rate following PR implementation:** nss for AMI patients (p=0.72), heart failure patients (p=0.19) **30-day mortality after the implementation of PR:** nss for AMI patients (p=0.75), or heart failure patients (p=0.15) **Any post-discharge emergency department visits for heart failure patients after PR implementation:** Decreased from 2.3% to -0.8% (p=0.007)	**Limitations** Retrospective analysis of claims data. Interventions aimed at reducing hospital readmissions implemented as a consequence of this policy decision may have taken effect before PR or in the months after this change. Focused on PR as an isolated intervention, but it is part of a larger policy agenda implemented over multiple years, including P4P schemes. Results are based on data from Medicare patients ≥65 years of age, and may not be applicable to other patient groups. **Conclusions** The release of the CMS PR of hospital readmission rates was not associated with any measurable change in 30-day readmission trends for AMI and

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
				heart failure, but post-discharge it was associated with less hospital-based acute care for heart failure.
Glick et al. 2015[30] United States **Objective:** To study the relationship between competition and quality in hospitals providing procedural cardiac care and participating in a national quality database, and to test the hypothesis that hospitals in more competitive environments would be more likely to compete on quality and thus perform better on such measures **Study design:** Observational study, comparison of two independent cohorts **Study period:** 2007-2008 **Funding:** University funding **Competing interest:** Yes, reported	**No. of participating hospitals:** 653 hospitals performing >10 HVS; 1,898 hospitals caring for >10 cases of AMI; 24 states included in the database **No. of patients:** NA **Condition/treatment:** Hospitals performing HVS and treating AMI patients	**PR system:** United States Department of Health and Human Services Hospital Compare database **Data sources:** United States Department of Health and Human Services Hospital Compare database **Comparison:** Comparisons between hospitals in markets with varying degrees of competition **Initiatives taken after PR:** NR	**Odds of costs above the median for HVS (most competitive vs. least competitive):** OR=7.8 [95% CI 4.6-13.3] **Odds of costs above the median for AMI (most competitive vs. least competitive):** OR=15.3 [95% CI 10.7-22.0] **Rate of preventative antibiotics (most competitive vs. least competitive):** OR=0.97 [95% CI 0.45-2.11] **Rate of correct antibiotics (most competitive vs. least competitive):** OR=0.61 [95% CI 0.28-1.27] Competition did not correlate with HVS quality measure performance, and was not significantly different across competitive quartiles No significant relationship between competition and HVS mortality was observed: OR=0.68 [95% CI 0.43-1.07] Increased competition correlated with high average Medicare costs for HVS patients (p<0.001) Competition was positively correlated with costs in AMI care (p<0.001)	**Limitations** Focused on hospitals in the Hospital Compare database, which excludes non-participating hospitals, and others not meeting inclusion criteria. Risk adjustment for this database was not publicly available, and the authors could not assess the validity of mortality and morbidity metrics. The analysis did not stratify results by states with/without certificate of need laws. Medicare data were used as a proxy for per-case hospital costs. Adjustments for variability in the cost of living among geographical areas may not have been adequate. **Conclusion** Hospitals in a more geographically competitive environment did not have better scores on PR quality measures, lower mortality, or lower costs with respect to HVS or AMI care. Rather, hospitals with more competitors were more likely to have higher per-admission Medicare costs even after controlled for median household income for the same zip code. The results suggest that, in contemporary American health

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
				care, hospitals do not meaningfully compete on publicly reported quality measure performance. The positive correlation between competition and cost, and lack of relationship between competition and quality, suggest that hospitals may compete on factors other than cost or quality. Such factors may include patient amenities, nicer accommodations, or better food.
Joynt et al. 2012[16] United States **Objective:** To examine the association between PR and rates of PCI among patients with AMI **Study design:** Observational study, before/after retrospective study **Study period:** 2002-2010 **Funding:** NHLBI grant **Competing interest:** Yes, reported	**No. of participating hospitals:** NR **No. of patients:** 31,581 PR (Massachusetts); 48,142 no-PR (Maine, Vermont, New Hampshire, Connecticut, Rhode Island, Maryland, Delaware) **Condition/treatment:** >65 years of age with a primary discharge diagnosis of AMI	**PR system:** Unnamed (Massachusetts PR system) **Data sources:** Medicare Provider Analysis and Review **Comparison:** PR vs. no-PR **Initiatives taken after PR:** NR	**Inter-state cross-sectional comparisons** **Rate of PCI for all patients (PR states vs. no-PR states):** OR=0.82 [95% CI 0.71-0.93, p=0.003] **Rate of PCI for patients with non-STEMI (PR states vs. no-PR states):** OR=0.87 [95% CI 0.73-1.04, p=0.12] **Rate of PCI for patients with STEMI (PR states vs. no-PR states):** OR=0.73 [95% CI 0.59-0.89, p=0.002] **Rate of PCI for patients with cardiogenic shock (PR states vs. no-PR states):** OR=0.79 [95% CI 0.64-0.98, p=0.03] **Rate of CABG for all patients (PR states vs. no-PR states):** OR=1.01 [95% CI 0.80-1.26, p=0.95] **Rate of CABG for patients with non-STEMI (PR states vs. no-PR states):** OR=0.98 [95% CI 0.77-1.23, p=0.84] **Rate of CABG for patients with STEMI (PR states vs. no-PR states):** OR=1.17 [95% CI 0.78-	**Limitations** Could not determine whether PR was associated with a mortality benefit for patients without AMI. Heterogeneity within the PR states, and it is unclear if the results could be generalized to other jurisdictions. It could not be determined whether PCI was the most appropriate treatment in any specific clinical situation due to the use of administrative data. Administrative data has limited ability to fully account for potential up-coding by hospitals in PR states. Limited to Medicare patients (>65 years of age). It is unclear if the findings could be extended to a younger patient population. **Conclusion** Among Medicare beneficiaries with AMI, the use of PCI was lower for patients treated in 3 states with PR of PCI outcomes compared with patients treated in

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
			1.77, p=0.45] **Rate of CABG for patients with cardiogenic shock (PR states vs. no-PR states):** OR=0.97 [95% CI 0.68-1.38, p=0.85] **Before/after longitudinal comparisons** There was a significant decrease in the odds of PCI between PR and no-PR states after the implementation of PR for all patients (p=0.03), for non-STEMI patients (p=0.03), and for patients with cardiogenic shock (p=0.03); no difference was observed for STEMI patients (p=0.17) There was a significant increase in the odds of CABG in PR vs. no-PR states for all patients (p=0.01), and for non-STEMI patients (p=0.006); no difference was observed for STEMI patients (p=0.32) or patients with cardiogenic shock (p=0.38) There was no overall difference in 30-day mortality between PR and no-PR states after implementation of PR (p=0.10)	7 regional control states without PR. These differences were particularly large in the highest-risk patients. However, we found no evidence that PR was associated with better overall mortality for patients with AMI.
Joynt et al. 2016[17] United States **Objective:** To determine whether PR of mortality rates which started in 2008 was associated with lower mortality rates for AMI, CHF, and pneumonia among Medicare beneficiaries **Study design:** Observational study, pre-	**No. of participating hospitals:** 3,970, representing 85% of United States acute care hospitals **No. of patients:** 20,707,266 **Condition/treatment:** >65 years of age with discharge diagnosis of AMI, CHF, or pneumonia	**PR system:** CMS Hospital Compare program **Data sources:** Medicare inpatient files **Comparison:** PR vs. no-PR (before/after mortality reporting) **Initiatives taken after PR:** NR	**Trend for AMI mortality:** Difference in trend=0.15 [95% CI 0.12-0.18, p<0.001]; mortality decreased at a faster rate prior to introduction of mortality reporting **Trend for CHF mortality:** Difference in trend=0.15 [95% CI 0.13-0.16, p<0.001]; mortality decreased at a faster rate prior to introduction of mortality reporting Hospitals identified as outliers for AMI, CHF, or pneumonia had	**Limitations** Administrative data may be limited in its ability to account for differences in severity of illness between hospitals and across time. No access to sociodemographic data such as education, income, and housing that might affect patient outcomes. There was not a control group with a pretrend identical to that in

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
post comparison **Study period:** 2005-2012 **Funding:** NHLBI grant **Competing interest:** Yes, reported			improvements in mortality rates for that condition during the reporting period Competition did not have a significant effect on improvement in mortality rates (and improvement in mortality also decreased after implementation of mortality reporting)	the intervention group. Findings may not apply to hospitals that have newly opened since 2009. A longer follow-up time may be needed to identify benefits, mortality may take longer than 5 years to improve. Risk adjustment models may not adequately adjust for longitudinal changes in the sickness profile of inpatients. **Conclusions** Hospital Compare's switch from reporting only processes of care to also reporting 30-day mortality rates for common medical conditions was not associated with significant improvements in mortality rates for reported conditions in United States hospitals. Although CMS is increasingly moving toward P4P as a quality improvement strategy, PR remains a mainstay of its efforts as it moves into outcomes measurement across additional conditions in the hospital. The findings suggest that expectations for performance improvement from reporting alone should remain limited.

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
Kraska et al. 2016[18] Germany **Objective:** To examine the impact of PR on changes in the quality of hospital care in Germany **Study design:** Observational study, pre-post design **Study period:** 2006-2012 **Funding:** NR **Competing interest:** Yes, reported	**No. of participating hospitals:** 595 **No. of patients:** 28,859 **Condition/treatment:** Hospitals continuously reporting on 6 quality indicators of interest were included	**PR system:** eQS **Data sources:** eQS reports and quality reports from Federal joint committee, Gemeinsamer Bundesausschuss **Comparison:** PR vs. no-PR **Initiatives taken after PR:** NR	**Rate of PCI (achieving recanalization, PR vs. no-PR):** % difference=+1.7%, p=0.015	**Limitations** No interrupted time series as only 6 explorable published quality indicators were examined. The evaluable sample contained less for-profit hospitals in private ownership compared to the national average. The restriction to hospitals which continuously provided data for analysed QI in quality reports from 2006 to 2012 might result in bias. Administrative data may be upcoded. Improvement in indicator values may not reflect actual quality improvement. **Conclusion** Results indicate positive effects of PR on hospital care, independent of a hospital's profit orientation. Improvements in the quality of care were registered for all observed QI over time, but PR stimulated accelerated QI.
Kristoffersen et al. 2015[19] Norway **Objective:** To evaluate survival curves (Kaplan-Meier) as a means of identifying areas in the clinical pathway amenable to quality improvement (measured by mortality reduction) **Study design:** Observational before/after	**No. of participating hospitals:** 61 Norwegian somatic hospitals **No. of outlier-hospitals with significant higher mortality**: 3/12 outliers with lower/higher mortality **No. of patients:** 44,448 AMI; 31,257 cerebral stroke	**PR system:** Website of the Norwegian Directorate of Health, as part of the Norwegian Quality Indicator System authorized by the Ministry of Health **Data sources:** Patient administrative data and national registry **Comparison:** Outlier-hospital vs. non-outlier	**All-cause mortality in-and-out-of-hospitals within 30 days of administration:** Compared to other hospitals, no difference after intervention; before/after comparison within each hospital, crude 30-day mortality declined and no longer outliers for risk-adjusted 30-day mortality for 2013 (*p-value: NR)	**Limitations** Short follow-up period. Results could be due to other initiatives other than those initiated by use of the survival curve or regression-to-the-mean effect. **Conclusion** Survival curves as a supplement to 30-day mortality may be useful for identifying suboptimal care in the clinical pathways, and thus

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
study **Study period:** 2008-2009 ('before') vs. 2012-2013 ('after') **Funding** Carried out by the Norwegian Knowledge Centre for the Health Services (NOKC) and the hospitals: Telemark Hospital Trust Skien, Østfold Hospital Trust and Innlandet Hospital Trust Gjøvik **Competing interest:** None declared	**Conditions/treatment:** First time AMI (1 hospital), cerebral stroke (2 hospitals)	hospital; before/after comparison within each outlier-hospitals **QI action taken after PR:** Initiated a process to monitor adherence to guidelines; an improvement project was designed that included: allocating beds in the ICU to cardiac patients; following the ambulance ECG, sending patients with STEMI or cardiac arrest directly to a PCI hospital (implemented); implementing the revised European guidelines for the treatment of AMI (implemented); monitoring clinical practice by joining the Norwegian Myocardial Infarction Registry		informing design of quality improvement project.
McCabe et al. 2013[31] United States **Objective:** To evaluate the impact of PR of hospitals as negative outliers on PCI case-mix selection. **Study design:** Observational study, case-control **Study period:** 2003-2010 **Funding:** NR **Competing interest:** Yes, reported	**No. of hospitals:** 24 (4 outlier, 20 non-outlier) **No. of patients:** 116,227 **Condition/treatment:** Patients undergoing PCI procedures	**PR system:** Mass-DAC **Data sources:** NCDR, Mass-DAC **Comparison:** PCI case-mix selection in outlier vs. non-outlier institutions **Initiatives taken after PR:** NR	**Expected mortality rate after PCI:** Significantly lower at negative outlier institutions following negative outlier labelling: (1.08% +/-0.23% vs. 1.58% +/-0.29%, p<0.001) **Expected mortality for shock or STEMI patients:** nss after labelling as a negative outlier institution: (5.22% +/-1.28% vs. 5.31% +/-2.02%, p=0.87) **Overall observed mortality:** Decreased from 1.70% to 1.34% (p=0.02 for trend)	**Limitations** Patient-level clinical information not incorporated; cannot account for the patients who might have qualified for PCI during the study period but who did not receive it as a result of risk-aversive behaviour. Unable to directly account for specific risk factors. Up-coding may be common and has the potential to falsely inflate predicted patient mortality rate, and therefore dilute any change in quantifiable risk aversion after outlier status identification.

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
				Could not account for the exact timing of outlier status (could bias toward the null). **Conclusion** The PR of in-hospital mortality after PCI and the practice of public identification of hospitals as negative outliers may increase risk avoidance in a manner inconsistent with best practices.
McCabe et al. 2016[27] United States **Objective:** To examine the effects of the NY shock-exclusion policy change on rates of revascularization and mortality for patients with AMI complicated by cardiogenic shock **Study design:** Observational study (before/after and case-control) **Study period:** 2002-2012 **Funding:** Massachusetts General Hospital's Hassenfeld Scholar Award and the Richard and Susan Smith Center for Outcomes Research **Competing interest:** Yes, reported	**No. of participating hospitals:** NR PR: NY No-PR: California, Massachusetts, Michigan, New Jersey **No. of patients:** 45,977 **Condition/treatment:** Patients with AMI and shock	**PR system:** NY **Data sources:** State inpatient database **Comparison:** Rates before/after exclusion of shock from PR, and also differences in changes between NY and comparator states **Initiatives taken after PR:** Patients with cardiogenic shock excluded from PR	**Likelihood of PCI (after vs. before):** NY aRR=1.28 [95% CI 1.19-1.37, p<0.001]; comparators aRR=1.09 [95% CI 1.05-1.13, p<0.001]; difference-in-differences p<0.001 **Likelihood of revascularization (after vs. before):** NY aRR=1.15 [95% CI 1.09-1.22, p<0.001]; comparators aRR=1.03 [95% CI 1.00-1.06, p=0.72]; difference-in-differences p=0.001 **Likelihood of In-hospital mortality (after vs. before):** NY aRR=0.76 [95% CI 0.72-0.81, p<0.001]; comparators aRR=0.91 [95% CI 0.87-0.94, p<0.001], difference-in-differences p<0.001	**Limitations** Patients were identified in administrative data sets. Multivariable adjustment for the severity of illness could only be performed based on claims-based data, comorbidities may differ between the various strata that are not captured by the data set but could potentially explain some differences in procedural management and outcomes. Differences before and after the policy change may reflect differences in illness severity among patients coded as having shock rather than a true effect of the policy change on physician behaviour. Causality could not be established. **Conclusion** After the NY policy change in 2006, in which very high-risk patients were censored from the PR, there was an immediate increase in the use of PCI therapy for patients with AMI and cardiogenic shock. There was

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
				also an improvement in the in-hospital survival of such patients that surpassed secular changes seen in comparator states.
Renzi et al. 2014[20] Italy **Objective:** To evaluate whether PR of performance data was associated with a change over time in quality indicators for AMI in Italian hospitals **Study design:** Observational study (before/after) **Study period:** 2006-2009 **Funding:** National Outcome Program, Ministry of Health, Italy **Competing interest:** NR	**No. of participating hospitals:** NR **No. of patients:** 24,800 treated in Lazio; 39,350 treated in other regions **Condition/treatment:** Patients treated for AMI	**PR system:** Hospitals in one province (Lazio) before/after implementation of the Regional Outcome Evaluation Program (P.Re.Val.E.) **Data sources:** Hospital information system **Comparison:** PR vs. no-PR **Initiatives taken after PR:** NR	**Likelihood of PCI within 48 hrs for STEMI patients (Lazio, after vs. before):** RR=1.56 (p<0.0001) **Likelihood of PCI within 48 hrs for non-STEMI patients (Lazio, after vs. before):** RR=1.57 (p<0.0001) **Likelihood of PCI within 48 hrs for AMI patients (Lazio, after vs. before):** RR=0.85 (p=0.401) **Likelihood of PCI within 48 hrs for STEMI patients (other regions, after vs. before):** RR=1.13 (p<0.0001) **Likelihood of PCI within 48 hrs for non-STEMI patients (other regions, after vs. before):** RR=1.16 (p<0.0001) **Likelihood of PCI within 48 hrs for AMI patients (other regions, after vs. before):** RR=1.38 (p<0.001) 30-day mortality after AMI was not significantly different after PR implemented 30-day mortality after AMI treated with PCI within 48 hrs was not significantly different after PR implemented 30-day mortality after AMI, for patients not treated with PCI, was not significantly different for non-STEMI, and AMI code 410.9 patients after PR implemented. However, for STEMI patients in Lazio, risk adjusted 30-day mortality after AMI for patients not treated with PCI was	**Limitations** Limited information regarding AMI severity. Low prevalence of some comorbidities suggests underreporting of detailed clinical information. Factors other than PR are plausible explanations for the observed increases. Reorganization of hospital services for AMI took place during the last decade in various Italian regions. Lazio started from a lower baseline proportion of timely PCI in 2006/07 compared to other regions (31.3% and 51.5%, respectively); the higher baseline percentage in the control regions might partially explain their relatively small increase in timely PCI. **Conclusion** The results suggest that PR may have contributed to increasing the proportion of STEMI patients treated with timely PCI; however, 30-day mortality after AMI and for patients treated with PCI did not improve. 30-day mortality increased among STEMI patients not treated with PCI in Lazio.

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
			significantly higher (RR=1.21, p=0.002) following implementation of PR	
Ryan et al. 2012[21] United States **Objective:** To estimate the effect of Hospital Compare (PR) on 30-day mortality for heart attack, heart failure, and pneumonia **Study design:** Observational study (interrupted time series) **Study period:** 2000-2008 **Funding:** AHRQ grant **Competing interest:** NR	**No. of participating hospitals:** NR **No. of patients:** 2,330,637 admissions for AMI; 5,218,728 admissions for heart failure **Condition/treatment**: Medicare beneficiaries admitted to United States short-stay acute care hospitals for AMI or heart failure	**PR system:** CMS Hospital Compare **Data sources:** Medicare Provider Analysis and Review Data, the Beneficiary Annual Summary File **Comparison:** PR vs. no-PR **Initiatives taken after PR:** NR	**Likelihood of mortality for heart attack patients (PR vs. no-PR):** aRR=1.01 [95% CI 0.99-1.03] **Likelihood of mortality for heart failure patients (PR vs. no-PR):** aRR=0.97 [95% CI 0.95-0.99] There was a statistically significant impact on mortality for heart failure and AMI patients when adjusting for patient characteristics only; this relationship was largely attenuated after adjusting for time trends for publicly reported and non-reported diagnoses	**Limitations** Limited to Medicare patients. It is possible that PR with Hospital Compare may have different effects on other outcomes, including 30-day mortality, complications, or functional status. Use of secondary diagnoses to adjust for patient severity does not fully account for variation in patient risk. Not all United States hospitals participated in Hospital Compare; critical-access hospitals participated at lower rates; some acute care hospitals chose not to participate. Did not evaluate whether changes in the design of Hospital Compare affected the impact of the program. **Conclusion** Medicare's PR initiative for hospitals has had a minimal impact on patient mortality.
Shahian et al. 2015[22] United States **Objective:** To evaluate participant characteristics and outcomes during the first 4 years of the STS PR program **Study design:** Observational	**No. of participating hospitals:** 1,000 **No. of patients:** NR **Conditions/treatment:** Patients receiving CABG	**PR system:** STS voluntary PR, starting 2010 **Data sources:** Robust, audited clinical registry data **Comparison:** PR participating sites vs. non-PR participating sites	**Risk-adjusted isolated CABG mortality rate** **At participant level:** **2010:** PR (n=210): mean 1.8%, median 1.7% (Q1-Q3: 0.8%, 2.5%) vs. non-PR (n=734): mean 2.2%, median 1.9% (Q1-Q3: 1.0%, 3.0%); p=0.015 **2014:** PR (n=377): mean 2.1%,	**Limitations** NR. **Conclusion** STS programs that voluntarily participate in PR have significantly higher volumes and performance. No evidence of risk aversion was found.

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
Study period: 2010-2014 **Funding:** NR **Competing interest:** None declared		**Initiatives taken after PR:** NR	median 1.7% (Q1-Q3: 1.0%, 2.7%) vs. non-PR (n=640): mean 2.4%, median 2.0% (Q1-Q3: 1.0%, 3.2%); p=0.033 **At patient level (mean):** **2010:** PR 1.70% vs. non-PR 2.03%; p=0.0006 **2014:** PR 1.76% vs. non-PR 2.11%; p<0.0001 **Composite CABG score:** Significantly higher in PR (p<0.0001) at each time period; the lowest scoring programs in each period were consistently in the non-PR groups **Risk aversion:** No evidence showed risk aversion	
Strom et al. 2017[28] United States **Objective:** To evaluate the effects of excluding patients with cardiac arrest and coma from publicly reported mortality statistics after PCI on rates of coronary angiography, revascularization, and mortality among patients with AMI and cardiac arrest **Study design:** Observational **Study period:** Jan 2003-Dec 2013 (Jan 2003-Dec 2011 for California) **Funding:** Ruth Kirschstein National Research Service Award and a Mentored Patient-Oriented Research Career Development Award	**No. of participating hospitals:** NR **No. of patients:** 26,379 **Conditions/treatment**: Patients with AMI and cardiac arrest treated by coronary angiography, revascularization	**PR system:** State Inpatient databases **Data sources:**Group of comprehensive, all-payer, de-identified, inpatient discharge records from hospitals within a given state **Comparison:** NY (PR) vs. other states (non-PR) before (2003-2010) and after (2010-2013) 2010 **Initiatives taken after PR:** Patients with cardiac arrest and coma excluded from PR	**Rates of coronary angiography:** NY vs. other states: aRR 0.93 [95% CI 0.88-0.99], p=0.035 pre-2010 vs. aRR 0.90 [95% CI 0.84-0.96], p=0.003 post-2010; interaction p=0.323 **Rate of PCI:** NY vs. other states: aRR 0.79 [95% CI 0.73-0.85], p<0.001 pre-2010 vs. aRR 0.82 [95% CI 0.76-0.89], p<0.001 post-2010; interaction p=0.359 **In-hospital all-cause mortality:** NY: post- vs. pre-2010 aRR 0.94 [95% CI 0.87-1.02], p=0.152; comparator states: aRR 0.88 [95% CI 0.84-0.92], p<0.001; interaction p =0.103 **In-hospital mortality for AMI with cardiac arrest:** NY vs. comparator states: pre-2010: aRR 0.86 [95% CI, 0.80-0.92]; p<0.001; post-2010: aRR 0.92 [95% CI 0.85-1.00]; p=0.52; p interaction= 0.103	**Limitations** Data abstracted from claims data might include potential errors in coding, inability to capture all relevant comorbidities, and limited data on prehospital and post-resuscitative measures that may be potential confounders. The ICD-9 code for cardiac arrest is not specific for out-of-hospital cardiac arrest and may include inpatient cardiac arrests as well, for whom physician decision-making may differ. Despite an analysis controlling for secular trends through a difference-in-difference approach, causal relationships between the NY policy change and subsequent outcomes cannot be assumed with an observational study.

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
and the Richard and Susan Smith Center for Outcomes Research in Cardiology **Competing interest:** Yes, reported				Focused only on in-hospital outcomes. **Conclusion** Exclusion of selected cardiac arrest cases from PR was not associated with changes in rates of PCI or in-hospital mortality in NY. Rates of revascularization in NY for cardiac arrest patients were lower throughout.
Subramanian et al. 2017[29] United States **Objective:** To estimate patient travel burden as the additional 1-way distance traveled for older adults to receive care at a hospital ranked better than their closest hospital **Study design:** Observational **Study period:** Oct 2015 **Funding:** Supported in part by a grant to Joseph A Hyder from the Anesthesia Patient Safety Foundation and the Anesthesia Quality Institute **Competing interest:** None declared	**No. of participating hospitals:** 4,656 **No. of patients:** NR **Conditions/treatment**: Not clear	**PR system:** 3 major hospital rating systems – US News Top Hospitals, STS composite rating for coronary artery bypass grafting (STS-CABG), and CMS Hospital Consumer Assessment of Healthcare Providers and Services (HCAHPS) **Data sources:** NR **Comparison:** NR **Initiatives taken after PR:** NR	**Additional 1-way travel distances to a better-rated hospital:** Commonly >25 miles overall: HCAHPS (23.7%), STS-CABG (36.7%), US News Top Hospitals (81.8%); more common for the roughly 9.5 million older adults living in rural areas: HCAHPS (35.9%), STS-CABG (48.9%), US News Top Hospitals (98.5%)	**Limitations** No data describing factors such as health plan coverage that may constrain patients' choices in hospitals. Although these analyses do not specifically address the travel burden associated with volume-based referral and regionalization of surgical care and markets, the concept of travel burden may affect the success of such innovations. **Conclusion** Significant travel burden is common for older adults seeking ''better'' care and is an important limitation of current hospital ratings for empowering patient choice.
Ukawa et al. 2014[23] Japan **Objective:** To elucidate hospital characteristics associated with hospital performance and time trends in quality of care using multilevel	**No. of participating hospitals:** 114 QIP hospitals in Japan **No. of patients:** 26,210 **Conditions/treatment**: AMI treated with ASA, β-blockers, ACE inhibitor or ARB	**PR system:** QIP public disclosure of performance measures (starting Dec 2010) **Data sources:** Diagnostic Procedure Combination reimbursement system	**Percentage scores of the five AMI quality measurement (before vs. after; mean change)** **ASA at admission:** 84.1 vs. 85.7; 1.6 **ASA at discharge:** 74.8 vs. 88.7; 13.9 **β-blockers at admission:** 20.0 vs.	**Limitations** NR. **Conclusion** Time trends in improvement were related to baseline performance and several hospital characteristics. Hospitals that had agreed to disclose their

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
multivariable analysis of longitudinal data **Study design:** Observational study (retrospective longitudinal) **Study period:** Jan 2008-Dec 2011 **Funding:** Health Sciences Research Grant from the Ministry of Health, Labour and Welfare of Japan, and a Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Science **Competing interest:** None declared		for acute care hospitals in Japan **Comparison:** before (2008) and after (2011) PR **QA action taken after PR:** NR	25.6; 5.6 **β-blockers at discharge:** 34.0 vs. 50.9;16.9 **ACE inhibitor or ARB during hospitalization:** 71.3 vs. 63.5;-7.8 **Composite score (calculated from above five AMI process measures):**56.9 vs. 62.7; 5.8 *p-values for changes were not presented	performance were more likely to have better quality of care at the initial point of public disclosure.
van Veghel et al. 2016[24] Netherlands **Objective:** To assess patient-relevant outcomes of delivered cardiovascular care by focusing on disease management as determined by a multidisciplinary heart team, to establish and share best practices by comparing outcomes, and to embed value-based decision-making to improve quality and efficiency in Dutch heart centres **Study design:** Observational study (before/after) **Study period:** Jan 2009-Dec 2013 for CABG, AVR, and TAVI; Jan 2011-Dec 2013 for PCI	**No. of participating hospitals:** 12 heart centres **No. of patients:** 86,000 **Conditions/treatment:** CAD (CABG, PCI, OMT), AVD (AVR, TAVI, OMT)	**PR system:** Registry for the Dutch cardiothoracic surgical community that contains elements of the European system for cardiac operative risk evaluation, the in-hospital mortality and morbidity of all Dutch cardiothoracic centres, and published these data since 2013 **Data sources:** Mortality from electronic databases of the regional municipal administration registration; QoL from a survey of patients 2 months before and 10-14 months after intervention. **Comparison:** Between 12 participating hospitals **QA action taken after**	**RAMR (120-day) for consolidated AVD:** nss **Hospital readmission due to MI within 30-day:** nss **RAMR (120-day) after CABG:** Significant low in 1 heart centre ($p<0.05$) **RAMR (120-day) after PCI:** nss **Long-term (5 year) survival:** The heart centre with the highest survival rate had a significant higher survival rate than 3 other heart centres ($p<0.05$) **QoL (measured by SF-36 or SF-14):** Data available only for one heart centre	**Limitations** NR. **Conclusion** Annual data collection on follow-up of patient-relevant outcomes of cardiovascular care, initiated and organized by physicians, appears feasible. Transparent publication of outcomes drives the improvement of quality within heart centres. The system of using a limited set of patient-relevant outcome measures enables reliable comparisons and exposes the quality of decision-making and the operational process. Transparent communication on outcomes is feasible, safe, and cost-effective, and stimulates professional decision-making and disease management.

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
Funding: Supported exclusively by the participating heart centres **Competing interest:** None declared		**PR:** Process improvements such as pre-hydration for patients with renal insufficiency and the need of target vessel revascularization within a year		
Waldo et al. 2015[25] United States **Objective:** To evaluate the association between PR with procedural management and outcomes among patients with AMI **Study design:** Observational study (cohort) **Study period:** 2005-2011 **Funding:** Career development award from NHLBI; in part by the Hassenfeld Scholars Program and the Richard and Susan Smith Center for Outcomes Research in Cardiology **Competing interest:** None declared	**No. of participating hospitals:** 2 states with PR vs. 6 states without PR **No. of patients:** 84,121 **Conditions/treatment:** AMI treated with PCI	**PR system:** No details **Data sources:** NIS database **Comparison:** PR states vs. no-PR states **Initiatives taken after PR:** Procedural management	**PCI rates:** PR states vs. non PR states: OR 0.81 [95% CI 0.67-0.96] **Adjusted in-hospital mortality rates:** PR states vs. non PR states: OR 1.21 [95% CI 1.06-1.37]; patients not undergone PCI in PR states: OR 1.30 [95% CI 1.13-1.50]	**Limitations** Use of administrative dataset and billing code to identify patients with diagnosis of interest. Sampling scheme designed to be representative of acute care hospitals but does not necessary represent all hospitals performing PCI. Regional sample process in this dataset prevented the accurate analysis of temporal trend within a state. Multivariate adjustment for the severity of illness could only performed based on claim-based data, thus comorbidities that differ between PR and non-PR states may not be captured but could explain the difference-in-outcomes. The dataset was limited to the in-patient setting, thus preventing comparing long-term mortality. The observational analysis could only evaluate the association between PR and outcomes but cannot prove causality. **Conclusion** PR is associated with reduced PCI and increased in-hospital mortality among patients with

Study	Population	Intervention	Outcomes	Methodological limitations/ conclusion
				AMI, particularly among patients not selected for PCI.
Waldo et al. 2017[32] United States **Objective:** To evaluate the procedural management and in-hospital outcomes of patients treated for AMI before and after a hospital had been publicly identified as a negative outlier **Study design:** Observational study (before/after) **Study period:** 2002-2012 **Funding:** Career development award from NHLBI; in part by the Hassenfeld Scholars Program and the Richard and Susan Smith Center for Outcomes Research in Cardiology **Competing interest:** None declared	**No. of participating hospitals:** 86 in two states (Massachusetts and NY) **No. of outlier hospitals with excess mortality:** 31/86 Compared to non-outliers, outlier hospitals are larger (p<0.05), treating more AMI (p<0.05), performing more PCI (p<0.05) **No. of patients:** 507,672 **Conditions/treatment:** AMI treated with PCI	**PR system:** No details **Data sources:** NIS database **Comparison:** Outlier hospital vs. non-outlier hospital **Initiatives taken after PR:** Procedural management	**Likelihood of PCI after PR:** Outliers: RR=1.13 [95% CI 1.12-1.15]; non-outliers: RR=1.13 [95% CI 1.11-1.14]; interaction p=0.50 **Likelihood of in-hospital mortality after PR:** Decreased in both outliers (to a greater degree) and non-outliers; outliers: RR=0.83 [95% CI 0.81-0.85] ; non-outliers: RR=0.90 [95% CI 0.87-0.92]; interaction p<0.001 **In-hospital mortality of patients undergoing PCI before-and-after PR:** Outliers: RR=0.72 [95% CI 0.66-0.79]; non-outliers: RR=0.87 [95% CI 0.80-0.96]; interaction p<0.001	**Limitation** Use of billing codes that are susceptible to misclassification, uncertain about their accuracy. **Conclusion** After outlier designation, in-hospital mortality declined at outlier institutions to a greater extent than was observed at non-outlier institutions. PR of outlier status may prompt outlier facilities to improve case selection and employ systems improvements that optimize patient care and improve in-hospital mortality among patients with MI.

ACC: American College of Cardiology; ACE: angiotensin-converting enzyme; ACS: acute coronary syndrome; AHRQ: Agency for Healthcare Research and Quality; AMI: acute myocardial infarction; ARB: angiotensin-receptor blocker; aRR: adjusted relative risk; ASA: acetylsalicylic acid; AVD: aortic valve disease; AVR: aortic valve replacement; CABG: coronary artery bypass graft; CAD: coronary artery disease; CHF: congestive heart failure; CI: confidence interval; CMS: Centers for Medicare & Medicaid Services; CQI: collaborative quality improvement; ECG: electrocardiogram; eQS: External Quality Assurance; hrs: hours; HVS: heart valve surgery; ICU: intensive care unit; Mass-DAC: Massachusetts Data Analysis Center; MI: myocardial infarction; NA: not applicable; NCDR: National Cardiovascular Data Registry; NHLBI: National Heart, Lung, and Blood Institute; NIS: National Inpatient Sample; no.: number; NR: not reported; nss: not statistically significant; NY: New York (state); OMT: optimal medical therapy; OR: odds ratio; p: *p*-value statistic; P4P: pay-for-performance; PCI: percutaneous coronary intervention; PR: public reporting; QI: quality improvement; QIP: Quality Indicator/Improvement Project; QoL: quality of life; RAMR: risk-adjusted mortality rate; RR: relative risk; STEMI: ST-segment elevation myocardial infarction; STS: Society of Thoracic Surgeons; TAVI: transcatheter aortic valve implantation

Appendix D: Summary of Evidence on External Benchmarking

TABLE D.1: Summary of evidence on external benchmarking

Study	Population	Intervention	Outcomes (pre- vs. post-QI)	Methodological limitations/ conclusion
Barros Silva et al. 2015[38] Brazil **Objective:** To report the first 3 years of experience and initial local changes on quality indicators through QI programs based on STS database reports in a Brazilian hospital **Study design:** Observational study **Study period:** Jul 2011-Jun 2014 **Funding:** No financial support **Competing interest:** NR	**No. of participating hospitals:** 1 private hospital **No. of patients:** 947 consecutive **Conditions/intervention:** Patients undergoing CABG	**Benchmark:** Best hospitals in the STS report **Data sources:** STS registry database that includes data from >1,000 hospitals in a wide range of quality indicators **QI initiatives:** Multifaceted and continuous education program based on STS report was implemented in 2012; 3 target indicators chosen by a multidisciplinary team (including clinicians, surgeons, nurses, ICU staff, anesthesiologist and physiotherapist); multidisciplinary team developed an institutional protocol for the appropriate use of perioperative medication and implemented a systematic assessment to the first 6 hrs after surgery using objective criteria for extubation; a case manager nurse was responsible to prospectively collect the data from each patient, enter the data in the institutional database and STS database, and check the indicators, making interventions with the team in case of non-adherence to hospitals **Comparison:** Pre-QI (Jul 2011-Dec 2012) (n=519) vs. post-QI (Jan 2013-Jun 2014) (n=428)	**Time of mechanical ventilation (hours):** 10.4 vs. 7.1, p<0.01 **LOS in ICU:** 64.9 vs. 54.2, p<0.01 **Evidence-based perioperative therapies:** 87.4% vs. 95.3, p<0.01 **Reintubation:** 2.9% vs. 2.1%, p=0.53 **Readmission to ICU:** 4.4% vs. 2.8%, p=0.22	**Limitations** Lack of randomized control group makes the current analysis of endpoints vulnerable to confounding factors. The interventions were specific to 3 indicators. This was a single centre experience only. **Conclusion** The initial experience with STS registry in a Brazilian hospital was associated with improvement in most of targeted quality-indicators.

Study	Population	Intervention	Outcomes (pre- vs. post-QI)	Methodological limitations/ conclusion
Brouwers et al. 2017[11] Netherlands **Objective:** To provide a benchmark for transfusion practice by inter-hospital comparison of transfusion rates, blood product use, and costs related to patients undergoing CABG, valve surgery, or combined CABG + valve surgery **Study design:** Retrospective longitudinal study **Study period:** 2010-2013 **Funding:** Department of Cardiothoracic Surgery of the VU University Medical Center **Competing interest:** None declared	**No. of participating hospitals:** 4 (2 academic, 2 non-academic) **No. of patients:** 11,150 **Patient characteristics:** Significant differences between the hospitals in: gender, age, preoperative Hb values, lowest intraoperative Hb values, discharge Hb values, 24 hr blood loss, and total and postoperative stay in hospital **Conditions/intervention:** Adult patients (≥18 years of age) undergoing CABG, valve surgery, or combined CABG + valve surgery	**Benchmark:** Hospital report **Data sources:** Electronic health record system of the hospitals, collected annually in 2010, 2011, 2012-2013 **QI initiatives:** Hospitals received a report of blood transfusion rate and cost annually with comparison between hospitals; benchmark meetings with representatives from each hospital who were involved in blood transfusion practice in cardiac surgery patients to discuss the report results, share experiences, create awareness, and stipulate reduction strategies for the coming year **Comparison:** Between the 4 hospitals	**Blood transfusion rate:** Hospitals A and B: decreased significantly for all surgical procedures over time (CABG: p<0.001, valve: p<0.001, CABG + valve: p≤ 0.02, in both hospitals); hospital C: decreased significantly for CABG surgery (p=0.03) and combined CABG + valve surgery (p=0.006), but did not for valve surgery (p=0.26); hospital D: no significant decrease for CABG (p=0.79), valve (p=0.74), and combined CABG + valve surgery (p=0.12) **Blood product use:** Significant differences between the hospitals in the median number of transfused units of RBC, FFP, and platelets per patient in CABG, valve surgery, or combined CABG + valve surgery (p< 0.001, p=0.001 and p= 0.023, respectively)	**Limitations** Significant differences in demographic and surgical characteristics of the patients between the hospitals, which could have affected transfusion rates. Unable to correct for other differences in patient mix such as disease severity (i.e., EuroScore) and comorbidity. Did not collect information on possible wastage of blood products after the products had been issued from the blood transfusion laboratory, and on the use of alternatives for FFP. Did not link the use of transfused blood products to the health outcomes of the patients, such as number of re-operations and survival after surgery. **Conclusion** This study indicates that benchmarking blood product usage stimulates awareness of transfusion behaviour, which may lead to better patient safety and lower costs.
Chu et al. 2015[15] United States **Objective:** To examine the effect of a quality improvement initiative guided by STS quality measures on outcomes and FTR **Study design:**	**No. of participating hospitals:** NR **No. of patients:** 3,065 consecutive **Conditions/intervention:** Patients undergoing non-emergency cardiac operation (excluding shock, endocarditis, and	**Benchmark:** STS benchmarks **Data sources:** STS registry database **QI initiatives:** A comprehensive QI initiative was established that included: STS evidence-based measures on preoperative optimization and protocolized postoperative management, including standardized order	<u>For all cardiac operations</u> **STS PROM, %:** 2.9 ± 3.7 vs. 3.1 ± 4.0 p=0.21 **Observed mortality:** 46/1,489 (3.1%) vs. 31/1,576 (2.0%) p=0.05 **STS composite PROMM, %:** 17.8± 12.1 vs. 18.3 ±12.4 p=0.24 **Observed mortality/morbidity:**	**Limitations** Selection, time, personnel bias, and other unmeasured patient or hospital-level characteristics, including the Hawthorne effect, of process implementation may be potential confounding variables in the study. Given similar preoperative STS PROM and PROMM in both

Study	Population	Intervention	Outcomes (pre- vs. post-QI)	Methodological limitations/ conclusion
Observational retrospective review **Study period:** Jan 2010-Jan 2014 **Funding:** NR **Competing interest:** NR	transplantation)	sets; standardization of the approach to preoperative pulmonary, renal, and bowel preparation, postoperative pharmacologic management, clinical activity pathways, monitoring, and discharge protocols **Comparison:** Pre-QI (before Jan 2012) (n1=1,489) vs. post-QI (after Jan 2012) (n2=1,576)	301/1,489 (20.2%) vs. 168/1,576 (10.7%) p=0.0001 ***FTR for any complication**: 35/290 (12.1%) vs. 19/156 (12.2%), p=1.00 **For CABG only** **STS PROM, %:** 2.1 ± 3.7 vs. 2.2 ± 4.0 p=0.21 **Observed mortality:** 27/950 (2.8%) vs. 15/941 (1.6%) p=0.09 **STS composite PROMM, %:** 15.0±12.1 vs. 15.8±12.4 p=0.25 **Observed mortality/morbidity:** 179/950 (18.8%) vs. 83/941 (8.8%) p=0.0001 ***FTR for any complication**: 22/174 (12.6%) vs. 9/77 (11.7%), p=1.00	groups, selection bias was unlikely to exist in this cohort. **Conclusion** Implementation of quality improvement initiatives significantly improves outcomes without affecting FTR rates. Further study is needed to determine if FTR provides additive value to quality assessment over existing STS metrics.
Eccleston et al. 2017[37] Australia **Objective:** To examine whether measurement and local reporting of data would improve patient outcomes through improving compliance with guideline therapies **Study design:** Observational cohort study **Study period:** NR **Funding:** GenesisCare provided seed funding; ongoing development and	**No. of participating hospitals:** 10 private hospitals **No. of patients:** 6,720 **Conditions/intervention:** Patients undergoing PCI	**Benchmark:** Aggregated study cohort and international standard **Data sources:** A prospective Australian clinical quality Registry (Genesis Cardiovascular Outcomes Registry) that details pre-hospital assessment and management, patients demographics, admission diagnosis, medical history, indication for the PCI, peri-procedural therapies, lesion and device characteristics, post-procedural management and in hospital morbidity and mortality. Follow-up at 30 days and annually documents major adverse cardiovascular events (death, MI, repeat revascularization, heart failure, device implantation), medication	**Compliance with guideline medications (pre- vs. post-QI) at discharge** **Statin rates:** Improved significantly (92.1% vs. 94.4%, p<0.03) **Anti-platelet drug:** 98.7% vs. 99.1% (p=0.25) **β-blockers:** 57.1% vs. 61.5% (p<0.01) **ACE inhibitor/ARB:** 73.5% vs. 76.2% (p=0.06) **Compliance with guideline medications (pre- vs. post-QI) at 1 year:** **Statin rates post PCI:** Improved significantly (87.0% vs. 92.2%, p<0.001) **Anti-platelet rate:** Improved	**Limitations** One limitation of the registry is a feature of GCOR that is still evolving, i.e., the devolution of responsibility for centres that appear to perform less effectively than their peers. The sustainability of the registry as it expands the depth and duration of data collected. **Conclusion** This large-scale collaboration provides a platform for the development of quality improvement initiatives. Establishment of this clinical quality registry improved patient care by identifying and monitoring gaps in delivery of appropriate therapies, driving

Study	Population	Intervention	Outcomes (pre- vs. post-QI)	Methodological limitations/ conclusion
maintenance supported by local practices **Competing interest:** NR		compliance, participation in cardiac rehabilitation, risk reduction interventions, and QoL as measured by the EQ-5D **QI initiatives:** Using reported reports, individual centres are against aggregate measures, but not against other individual hospitals; data are fed back to senior local practice medical staff that have the opportunity to address identified evidence treatment gaps **Comparison:** 2010 (pre-QI) vs. 2014	significantly (90.7% vs. 94.3%, p<0.001)	key practice change.
Miyata et al. 2012[39] Japan **Objective:** To examine the effect of benchmarking projects on the outcomes of CABG surgery to clarify challenges and prospects regarding the quality improvement initiative **Study design:** Observational study **Study period:** 2004-2007 **Funding:** Japanese Society for Cardiovascular Surgery, Japanese Association for Thoracic Surgery, Japan Heart Foundation, and Japanese Health and	**No. of participating hospitals:** n1=44 initial participating hospitals (began submitting data before 2005); n2=55 halfway participating hospitals (began submitting data after 2005) **No. of patients:** n1=8,224 between 2004 and 2007; n2=1,825 **Conditions/intervention:** Patients undergoing CABG	**Benchmark:** Feedback report in real-time through the JCVSD web-based system **Data sources:** JCVSD, which includes 255 variables **QI initiatives:** Participating hospitals entered data into the database; participating hospitals used the feedback report in real time that includes risk-adjusted outcomes compared with all participating hospitals; Site Visit Working group verified data accuracy **Comparison:** Time trend of initial participating hospitals (2004, 2005, 2006, vs. 2007); initial participating hospitals vs. halfway participating hospitals	**Time-trend outcomes of initial participating hospitals (2004-2007) (n=44)** **Operative mortality:** OR of surgery year: 0.878 [95% CI 0.758-1.017] (p=0.083) **Major morbidities (reoperation, stroke, dialysis, infection, and prolonged ventilation):** OR of surgery year 0.972 [95% CI 0.915-1.033] (p=0.361). **Initial participating hospitals 2004 (n=44) vs. halfway participating hospitals 2007 (n=55)** **Operative mortality:** OR of surgery year: 0.705 [95% CI 0.457-1.087] (p=0.114) **Major morbidities (reoperation, stroke, dialysis, infection, and prolonged ventilation):** OR of surgery year 0.874 [95% CI 0.717-1.065] (p=0.180) **Initial participating hospitals**	**Limitations** NR. **Conclusion** This study demonstrated that a quality improvement initiative for cardiovascular surgery has positive effects on risk-adjusted outcomes. Although the primary target of benchmarking was 30-day mortality in Japan, major morbidities were less affected by those activities.

Study	Population	Intervention	Outcomes (pre- vs. post-QI)	Methodological limitations/ conclusion
Labour Sciences Research grants **Competing interest:** None declared			**2007 (n=44) vs. halfway participating hospitals 2007 (n=55)** **Operative mortality:** OR 0.527 [95% CI 0.327-0.847] (p=0.008) **Major morbidities (reoperation, stroke, dialysis, infection, and prolonged ventilation):** OR 0.820 [95% CI 0.674-0.997] (p=0.047)	

**FTR* was defined as the occurrence of any major postoperative complication captured by the STS Adult Cardiac Surgery Database resulting in death; complications included reoperation for bleeding or primary cardiac cause, deep sternal wound infection, cerebral vascular accident, prolonged ventilation exceeding 24 hours, pneumonia, renal failure, and need for new postoperative dialysis

ACE: angiotensin-converting enzyme; ARB: angiotensin-receptor blocker; CABG: coronary artery bypass graft; CI: confidence interval; FFP: fresh frozen plasma; FTR: failure to rescue; Hb: hemoglobin; ICU: intensive care unit; JCVSD: Japan Cardiovascular Surgery Database; LOS: length of stay; MI: myocardial infarction; n/no.: number; NR: not reported; OR: odds ratio; p: *p*-value statistic; PCI: percutaneous coronary intervention; PROM: predicted risk of mortality; PROMM: predicted risk of mortality and morbidity; QI: quality improvement; QoL: quality of life; RBC: red blood cells; STS: Society of Thoracic Surgeons

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