Lost in Translation

Health Resource Variability in the Achievement of Optimal Performance and Clinical Outcome

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Background—An evidence-practice gap in acute coronary syndromes (ACS) is commonly recognized. System, provider, and patient factors can influence guideline adherence. Through using guideline facilitators in the clinical setting, the uptake of evidence-based recommendations may be increased. We hypothesized that facilitators of guideline recommendations (systems, tools, and workforce) in acute cardiac care were associated with increased guideline adherence and decreased adverse outcome.

Methods and Results—A cross-sectional evaluation of guideline facilitators was conducted in Australian hospitals. The population was derived from the Acute Coronary Syndrome Prospective Audit (ACACIA) and assessed performance, death, and recurrent myocardial infarction (death/re-MI) at 30 days and 12 months. Thirty-five hospitals and 2392 patients participated. Significant associations with decreased death/re-MI were observed with hospital strategies to facilitate primary percutaneous coronary intervention for ST-elevation MI patients (38/428 [8.9%] versus 30/154 [19.5%], \(P<0.001\)) and after adjustment (odds ratio [OR], 0.47 [95% confidence interval (CI), 0.24 to 0.90], \(P<0.023\)), electronic discharge checklists (none: 233/1956 [11.9%], integrated: 43/251 [17.1%], \(P=0.069\), electronic: 6/124 [4.8%], \(P<0.001\)) and after adjustment (integrated versus none: \(OR\), 1.66 [95% CI, 0.98 to 2.80], \(P=0.057\) and electronic versus none: \(OR\), 0.49 [95% CI, 0.35 to 0.68], \(P<0.001\)), and intensive cardiac care unit (ICCU) staff-to-patient ratios (neither: 200/1257 [15.9%], CCU: 135/1051 [12.8%], ICCU: 8/84 [9.5%], \(P=0.049\) and after adjustment (CCU versus neither: \(OR\), 0.74 [95% CI, 0.47 to 1.14], \(P=0.172\) and ICCU versus neither: \(OR\), 0.55; [95% CI, 0.38 to 0.81], \(P=0.003\)).

Conclusions—Facilitating uptake of evidence in clinical practice may need to consider quality improvement systems, tools and workforce to achieve optimal ACS outcomes. (Circ Cardiovasc Qual Outcomes. 2011;4:512-520.)

Key Words: acute cardiac care  ■  acute coronary syndromes  ■  guideline adherence  ■  knowledge translation  ■  quality improvement

Implementation of evidence-based guidelines can improve clinical outcomes in acute coronary syndrome (ACS) care, yet adherence with recommendations is often suboptimal.1-3 Professional organizations in the United States have developed systems and tools to increase the uptake of guideline-based care and have shown variable increases in optimal outcomes.4,5 This variability may be explained by local health service characteristics including geographical location, resources, and workforce capacity.1,2,6,7 In Australia, with a population of approximately 22 million, concentrated in coastal cities, health disparities exist for individuals living in rural and remote locations despite a universal health insurance system.8,9,10

Understanding health service characteristics that may facilitate evidence translation is an important issue to consider in the clinical practice environment and may be associated with outcomes. Six specific hospital strategies (Table 2) have been shown to facilitate primary percutaneous coronary intervention (PPCI) and increased rates of survival of patients with ST-segment elevation–myocardial infarction (STEMI).4,11 Quality improvement (QI) tools including ACS early invasive management algorithms, clinical pathways, or discharge checklists and resources, including clinical advocates and financial resources, have been observed to be associated with increased guideline adherence.6,12 Studies have reported that workforce is an important factor influencing adverse events and mortality. Nurse-to-patient ratios, hospitalization on a weekend versus a weekday, and access to invasive services have been shown to influence outcomes.7,13,14 The purpose of this research was to identify factors facilitating guideline adherence in the management of ACS. We hypothesized that guideline facilitators such as...
quality improvement systems, tools, resources, and workforce may be associated with increased guideline adherence (as measured by performance indicators for ACS care) and clinical outcomes within the acute cardiac care environment.

WHAT IS KNOWN

- Acute coronary syndrome (ACS) registry data have demonstrated substantial variation in the implementation of guideline recommendations.
- Little is known about the prevalence and heterogeneity of use of ACS quality improvement systems, tools, resources, and workforce, and the relationship between these and clinical outcomes, in routine clinical settings.

WHAT THE STUDY ADDS

- Among Australian hospitals with standardized systems and tools for delivering timely primary percutaneous coronary intervention, reminding clinicians to prescribe guideline discharge therapies and adequate levels of cardiac care staff to patient ratios, significantly lower rates of adverse outcomes at 30 days and 12 months were observed; in contrast, among hospitals with heterogeneous systems and tools, no relationship with outcome was found.
- The present study provides new insights into systems and process of care to facilitate translation of ACS evidence to outcome.

Methods

Study Population and Data Collection
We used a cross-sectional objective design to evaluate hospital guideline facilitating factors and corresponding performance and clinical outcome. The study cohort comprised ACS patients derived from the Acute CoronArY syndrome Prospective Audit (ACACIA), the details of which have been described previously. Briefly, the study population comprised 3402 consenting patients from 39 Australian hospitals representing all states and territories, prospectively and consecutively enrolled between December 2005 and June 2006, with 12-month follow-up in 99.7% of patients. Hospitals were selected based on the volume of ACS patients and were representative of all states and territories in Australia and of metropolitan (76%), regional (21%), and rural (3%) hospital type. Participant hospitals were a combination of interventional (83%) or noninterventional (17%) centers, and 52% had cardiac surgical facilities. Patients were included who were experiencing suspected STEMI or unstable angina, as determined by the enrolling site, was confirmed by central adjudication of electrocardiograms and biomarkers using accepted definitions. This analysis was confined to patients with a final diagnosis of ACS (n = 2559), regardless of survival status. Specifically, events occurring among patients dying within the index hospitalization were included in the cumulative 30-day and 12-month outcomes.

We invited all hospitals that had previously participated in the ACACIA registry to participate in an evaluation of guideline facilitating factors. The head of department determined the required ethical and clinical governance approval. Subsequent to appropriate approval, a nominated liaison person, either the head nurse or the unit, provided information regarding the guideline facilitators that existed in their specific cardiac unit for the period of enrollment in the ACACIA registry. During the ACACIA registry, hospital sites were not given any feedback on performance and outcome audit data until the end of the study, thus limiting influence on guideline facilitators during the course of the enrolment period. A uniform method of data collection was applied using site visits or phone calls, conducted by an expert cardiovascular nurse using a standardized protocol (Table 1). Although questions were directed to the site liaison person regarding the presence of guideline facilitators, the specific purpose of either the site visit or phone call was to collect a paper copy of the QI tool, which was then graded according to predetermined definitions of guideline facilitators in an objectively assessable process (Table 2).

Guideline facilitators are defined in Table 2 and were derived from the literature and template documents of the Door to Balloon Alliance for Quality, the Can Rapid risk stratification of UnStable Angina patients Suppress Averse outcomes with Early implementation of the ACC/AHA guidelines (CRUSADE), and Guidelines Applied in Practice (GAP) QI tool templates and the European Society of Cardiology’s Working Group for Acute Cardiac Care. Concordance between site information and definition criteria was achieved by cross-checking the site protocol information.
Table 2. Definitions of Guideline Facilitating Factors

<table>
<thead>
<tr>
<th>Guideline Facilitating Factor</th>
<th>Definition</th>
<th>Evaluation Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital strategies for reducing door-to-balloon time&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Emergency medicine physician activates the cardiac catheterization laboratory (CCL). A single call to a central page operator activates the CCL. Emergency department (ED) activate CCL while patient is on route to hospital. Expectation that CCL staff arrive within 20–30 min of page. Attending cardiologist always on site.</td>
<td>Recorded as present or absent</td>
</tr>
</tbody>
</table>

| Risk stratification tool<sup>16</sup> | Assists with risk-based decision-making at admission according to ACS guidelines. | Symptoms, ECG, biomarkers comorbid risk, classifies as high-, intermediate-, or low-risk NSTEACS |

| Early invasive management algorithm<sup>6</sup> | Recommends urgent angiography within 24–48 hours for high-risk NSTEACS patients. | Criteria: elevated biomarkers, ST-deviation, recurrent ischemia with/without heart failure, hemodynamic instability, positive noninvasive stress test, PCI within the past 6 mo, prior CABG, left ventricular dysfunction, sustained VT. Admission: aspirin, heparin, glycoprotein IIb/IIIa receptor blockers, clopidogrel. Discharge: aspirin, clopidogrel or combination, β-blocker, lipid-lowering agents, ACE/ARB inhibition. |

| Clinical pathway<sup>12</sup> | Identifies in-hospital therapeutic, educational and rehabilitation milestones divided by time periods (1st 24 h, next 24 h and discharge). | Diagnostic tests, reperfusion, and interventional procedures, pharmacological therapies. Counseling, education, physical activity. |

| Discharge checklist<sup>6</sup> | A reminder tool for prescription of guideline therapies at discharge, which requires verification by a medical officer. | Recommends aspirin, clopidogrel, β-blocker, ACE/ARB inhibition, and lipid-lowering agents. Dietary targets, where to seek advice for smoking cessation, and exercise and physician appointment. |

| Clinical cardiology coadvocate<sup>6</sup> | A clinician leader who reviews, disseminates, and proposes new quality improvement initiatives. | Recorded as present or absent |

| Financial resource<sup>6</sup> | A staff position or quantum of money for QI initiatives. | Recorded as present or absent |


PCI indicates percutaneous coronary intervention; CABG, coronary artery bypass surgery; VT, ventricular tachycardia; and ACE/ARB inhibition, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker.

with the content criteria taken from the literature, a role performed by the same researcher who conducted the site evaluations. A site algorithm, pathway, or checklist had to meet the definition of the tool according to the literature and tool templates and have all variables present in the content. In the assessment of QI tools, in addition to content evaluation, each tool was classified by how it was deployed within the workflow and coded as “reference” (information available but not part of the workflow), “integrated into the workflow” (information available at the point of care), or electronic. To determine levels of workforce, a combination score (nursing full-time equivalent, head of department, and number of doctors on ward round) was calculated from the information obtained from the site evaluation and compared against the ESC Workforce recommendations to code each site as an intensive cardiac care unit (ICCU), intermediate cardiac care unit (CCU), or neither.<sup>18</sup>

**Outcomes**

The primary outcome for this study was the combined clinical events of death and recurrent myocardial infarction (death/re-MI). Death was defined as death from any cause at any time during the study period. Recurrent MI was defined as a further >25% rise and/or >50% rise in the Troponin (I or T) and CK-MB, respectively, 24 hours after admission. After PCI and coronary artery bypass graft
surgery, a level of CK-MB >3 times and >5 times the upper limit of normal within 48 hours or new Q-waves were used, respectively. These outcomes were assessed at 30 days and 12 months.

The secondary outcome for this study was guideline adherence as measured by the performance indicators of door-to-balloon time, invasive management, and prescription of discharge guideline therapies. Door-to-balloon time was defined as time from hospital presentation to first balloon inflation in a PPCI procedure. Invasive management was defined as cardiac catheterization within 48 hours of hospital presentation. Guideline medications were defined as the number prescribed at the time of discharge, unless a stated contraindication, including antplatelet (aspirin, thienopyridine), angiotensin-converting enzyme (ACE) inhibition/angiotensin receptor (AR) antagonists, β-blockers, and statin therapies among patients discharged alive.

**Statistical Analysis**

The prevalence of guideline facilitators are described as counts (%). The proportion of patients with a door-to-balloon time of ≤90 minutes, receiving early invasive management and 4 or more guideline therapies by the presence or absence of each guideline facilitator, were compared by χ² test. For assessment of patient outcome variability across sites, we measured 6-month mortality from the ACACIA registry compared with the predicted site-specific median Global Registry of Acute Coronary Events (GRACE) risk score for death/re-MI at 6-months. GRACE score variables included age, heart rate, systolic blood pressure, serum creatinine, heart failure Killip class, cardiac arrest at admission, ST-segment deviation, elevated cardiac enzymes at both admission and discharge, as well as history of MI and in-hospital PCI or coronary artery bypass graft.

To account for baseline patient risk, the availability of hospital services and the multicenter nature of the patient sample, adjusted analyses including the GRACE risk score, the presence of onsite angiography, interventional cardiology, and cardiac surgical services were undertaken using logistic regression clustered by hospital, therefore using standard error estimates that allow for intrahospital correlation. The interaction between workforce characteristics and the presence of quality improvement tools were also assessed in these models. The workforce analysis was restricted to metropolitan hospitals with all coronary revascularization services, staffing levels for ICCU criteria (Table 2), with adjustment for staffing levels by patient risk profile.

Using the known baseline rate of early invasive management of 70%, a median level of guideline facilitator use of 3.9 of 5, a prevalence of QI tools of approximately 50% and a total sample size of 2392, this study had a 90% power to detect a difference of at least a 0.15 deviation, elevated cardiac enzymes at both admission and discharge, included age, heart rate, systolic blood pressure, serum creatinine, heart failure Killip class, cardiac arrest at admission, ST-segment deviation, elevated cardiac enzymes at both admission and discharge, as well as history of MI and in-hospital PCI or coronary artery bypass graft.19

To account for baseline patient risk, the availability of hospital services and the multicenter nature of the patient sample, adjusted analyses including the GRACE risk score, the presence of onsite angiography, interventional cardiology, and cardiac surgical services were undertaken using logistic regression clustered by hospital, therefore using standard error estimates that allow for intrahospital correlation.19 The interaction between workforce characteristics and the presence of quality improvement tools were also assessed in these models. The workforce analysis was restricted to metropolitan hospitals with all coronary revascularization services, staffing levels for ICCU criteria (Table 2), with adjustment for staffing levels by patient risk profile.

Using the known baseline rate of early invasive management of 70%, a median level of guideline facilitator use of 3.9 of 5, a prevalence of QI tools of approximately 50% and a total sample size of 2392, this study had a 90% power to detect a difference of at least 6% in the rate of early invasive management use and at least a 0.15 change in mean number of guideline therapies and 80% power to detect a 5% or more difference in 12-month death/re-MI among patients treated in hospitals with or without guideline facilitators. A multivariable logistic regression statistical model was used. All analyses were conducted with STATA 10.1 (College Station, TX), and a probability level of <0.05 was considered to be statistically significant.

**Results**

Of the 39 Australian hospitals that participated in the ACACIA registry and were invited to participate in this study, 35 (90%) accepted. There were 26 (74%) metropolitan hospitals and 9 (26%) rural/regional hospitals; details of hospital characteristics are presented in Table 3. Of the 4 hospitals that did not participate, 2 declined due to lack of staff members who could determine what tools and resources were available during the study time period, 2 did not reply to follow-up phone calls, and all 4 were of regional hospital type. Of the 2559 ACACIA patients with a final discharge diagnosis of STEMI, non-STEMI, or unstable angina, 2392

Table 3. Cardiac Services in Metropolitan and Regional/Rural Hospitals

<table>
<thead>
<tr>
<th>Hospital Services</th>
<th>Metropolitan</th>
<th>Regional/Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cath lab only</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Angioplasty services</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Cardiothoracic surgery</td>
<td>15</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>ACS presentations/y</td>
<td>700 (550–1000)</td>
<td>334 (186–560)</td>
<td>600 (400–800)</td>
</tr>
<tr>
<td>Staff cardiologist/physicians</td>
<td>10 (8–14)</td>
<td>3.5 (1–8)</td>
<td>6 (6–13)</td>
</tr>
<tr>
<td>Angiography laboratories</td>
<td>2 (1–2)</td>
<td>5 (0–1)</td>
<td>2 (1–2)</td>
</tr>
<tr>
<td>Angiograms/y</td>
<td>1600 (900–2200)</td>
<td>0 (0–1200)</td>
<td>1250 (140–2000)</td>
</tr>
<tr>
<td>Interventional cardiologists</td>
<td>5 (4–6)</td>
<td>0 (0–2)</td>
<td>4</td>
</tr>
<tr>
<td>Interventions/y</td>
<td>531 (444–794)</td>
<td>0 (0–300)</td>
<td>437 (0–600)</td>
</tr>
<tr>
<td>Surgeons</td>
<td>2 (0–3)</td>
<td>0 (0–5)</td>
<td>1 (0–3)</td>
</tr>
<tr>
<td>CCU beds</td>
<td>10 (8–14)</td>
<td>7 (5–8)</td>
<td>8.5 (6–12)</td>
</tr>
</tbody>
</table>

Cath lab indicates cardiac catheterization laboratory; ACS, acute coronary syndrome; and CCU, cardiac care unit. Values are expressed as median, interquartile range.

Patients were included in this analysis from participating sites.

**Patient Outcome Variability**

For each participating hospital, we measured the median expected rate of 6-month death/re-MI by GRACE score minus the observed rate of 6-month death/re-MI from the ACACIA registry (Figure 1). Thus, a negative range represents actual observed event rates that are higher than the expected rate, based on patient risk characteristics. This assessment observed substantial variability, with the majority of hospital sites displaying higher observed event rates than expected (Figure 1).

**Quality Improvement Systems**

Only 20 (57.1%) hospitals had at least 1 of the 6 assessed hospital strategies to facilitate PPCI for STEMI patients, and 3 was the maximum at a single hospital. The presence of strategies were associated with a lower but nonsignificant door to balloon time (median minutes, interquartile range:

![Figure 1](http://circoutcomes.ahajournals.org/)

Proportion of hospitals with expected minus observed rates of 6-month death and recurrent myocardial infarction by Global Registry of Acute Coronary Events score.
The presence of a risk stratification tool (Table 2) was associated with significantly lower rates of angiography, (tool 780/1175 (66.4%) versus no tool 885/1217 (72.7%), \( P = 0.001 \)) and 12-months (55/428 (12.8%) versus 34/154 (22.1%), \( P = 0.006 \)), which persisted at 30 days after adjusting for patient risk and the presence of invasive facilities within the presenting hospital, (30 days: odds ratio (OR), 0.47 [95% confidence interval (CI), 0.24 to 0.90], \( P = 0.023 \) and 12-months: OR, 0.59 [95% CI, 0.34 to 1.05], \( P = 0.076 \)).

### Quality Improvement Tools

The prevalence of QI tools and the way they were deployed in the workflow are described in Figure 2. Only 19 (54%) hospitals had at least 1 of the 4 assessed QI tools and 3 was the maximum at a single hospital.

The presence of a risk stratification tool (Table 2) was associated with significantly lower rates of angiography, (tool 780/1175 (66.4%) versus no tool 885/1217 (72.7%), \( P = 0.001 \)) but not prescription of discharge guideline therapies (4 or more guideline therapies; tool 815/1175 (69.4%) versus no tool 852/1217 (70.0%), \( P = 0.172 \)). Among patients treated in a hospital with a risk stratification tool, there were significantly higher rates of 12-month death/re-MI, but after adjustment this was no longer significant (tool versus no tool: OR, 1.33 [95% CI, 0.89 to 2.00], \( P = 0.155 \)) (Table 4).

The presence of an early invasive management algorithm (EIMA) (Table 2) was significantly associated with lower rates of angiography, (tool 421/633 (66.5%) versus no tool 1244/1759 (70.7%), \( P = 0.048 \)) but not prescription of discharge guideline therapies, (4 or more guideline therapies; tool 815/1175 (69.4%) versus no tool 852/1217 (70.0%), \( P = 0.172 \)). Among patients treated in a hospital with an EIMA, there was no association with 30-day and 12-month death/re-MI (Table 4) nor in the way tools were deployed in the workflow (Table 5).

The presence of a clinical pathway (Table 2) observed no association with rates of angiography, (tool 701/989 (70.9%) versus no tool 964/1403 (68.7%), \( P = 0.256 \)) or with prescription of discharge guideline therapies, (4 or more guideline therapies; tool 667/989 (67.4%) versus no tool 1000/1403 (71.2%), \( P = 0.110 \)). Among patients who were treated in a hospital with a clinical pathway there was no association with 30-day or 12-month death/re-MI (Table 4), nor in the way tools were deployed in the workflow (Table 5).

### Table 4. Quality Improvement Tools and 30-Day and 12-Month Death/Re-MI

<table>
<thead>
<tr>
<th>QI Tools</th>
<th>Tool</th>
<th>No Tool</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk stratification</td>
<td>12-mo death/re-MI</td>
<td>115/1175 (9.8)</td>
<td>94/1217 (7.7)</td>
</tr>
<tr>
<td></td>
<td>30-d death/re-MI</td>
<td>193/1175 (16.4)</td>
<td>150/1217 (12.3)</td>
</tr>
<tr>
<td>EIMA</td>
<td>30-d death/re-MI</td>
<td>47/633 (7.4)</td>
<td>162/1759 (9.2)</td>
</tr>
<tr>
<td></td>
<td>12-mo death/re-MI</td>
<td>87/633 (13.7)</td>
<td>256/1759 (14.5)</td>
</tr>
<tr>
<td>Clinical pathway</td>
<td>30-d death/re-MI</td>
<td>90/989 (9.1)</td>
<td>119/1403 (8.5)</td>
</tr>
<tr>
<td></td>
<td>12-mo death/re-MI</td>
<td>144/989 (14.6)</td>
<td>199/1403 (14.2)</td>
</tr>
<tr>
<td>Discharge checklist</td>
<td>30-d death/re-MI</td>
<td>26/375 (6.9)</td>
<td>123/1956 (6.3)</td>
</tr>
<tr>
<td></td>
<td>12-mo death/re-MI</td>
<td>49/375 (13.1)</td>
<td>233/1956 (11.9)</td>
</tr>
</tbody>
</table>

EIMA indicates early invasive management algorithm; death/re-MI, combined end point of death and recurrent myocardial infarction.

Unadjusted values are expressed as n/N (%).

The presence of a discharge checklist (Table 2) was not associated with prescription rates of discharge guideline therapies, (4 or more guideline therapies; tool 262/375 (69.9%) versus no tool 1403/1956 (71.7%), \( P = 0.631 \)). However, at one site that had an electronic discharge checklist, we observed a nonstatistically significant increased rate of prescription of discharge guideline therapies (4 or more guideline therapies; electronic 91/124 (73.4%) versus nonelectronic 1647/2372(69.4%), \( P = 0.351 \)). Among patients who were treated in a hospital with a discharge checklist and discharged alive, there was no association with 30-day or 12-month death/re-MI (Table 4). However, in the same hospital with an electronic discharge checklist, deployment of such a tool showed a significantly lower rate of 12-month death/re-MI (Table 5), which persisted after adjustment at 30 days, (integrated versus none: OR, 1.46 [95% CI, 0.95 to 2.23], \( P = 0.078 \) and electronic versus none: OR, 0.57 [95% CI, 0.40 to 0.79], \( P = 0.001 \)) and 12 months, (integrated versus none: OR, 1.66 [95% CI, 0.98 to 2.80], \( P = 0.057 \) and electronic versus none: OR, 0.49 [95% CI, 0.35 to 0.68], \( P < 0.001 \)).

### Quality Improvement Resources

Eleven (31.4%) hospitals had a QI resource, either as a clinical advocate (Table 2) [9 (26.0%)] or a financial resource (Table 2) [9 (26.0%)] and 7 (20.0%) hospitals had both. The presence of a clinical advocate was not associated with rates of angiography, (present 503/727 (69.2%) versus not present 1162/1,665 (69.8%), \( P = 0.769 \)) or prescription of discharge guideline therapies, (4 or more guideline therapies; present 487/727(67.0%) versus not present 1180/1665(70.9%), \( P = 0.115 \)). Among patients treated in a hospital with a clinical advocate, there was no association with 30-day and 12-month death/re-MI (Table 6).

The presence of a financial resource was not associated with rates of angiography, (present 515/751 (68.6%) versus not present 1150/1641 (70.1%), \( P = 0.458 \)) but was significantly associated with lower rates of discharge guideline...
therapies, (4 guideline therapies: present 516/751 (68.7%) versus not present 1151/1641 (70.1%) P=0.042). Among patients treated in a hospital with a financial resource there was a nonsignificant, decreased rate of 12-month death/re-MI (Table 6).

Workforce Capacity
Among hospitals that qualified to be either an ICCU or intermediate CCU (Table 2) there was no association with rates of angiography, (neither: 807/1133 (71.2%), CCU: 802/1175 (68.3%), ICCU: 56/84 (66.7%), P=0.251), or prescription of discharge guideline therapies, (4 or more guideline therapies; neither: 771/1133 (68.0%), CCU: 837/1175 (71.2%), ICCU:59/84 (70.2%), P=0.733) either on weekdays or weekends.

Among patients who were treated in hospitals that qualified to be either an ICCU or CCU, there was a significant association with decreased rates of 30-day death/re-MI on a weekend, (neither: 132/1257 (10.5%), CCU: 75/1051 (7.1%), ICCU: 284 (2.4%), P=0.002), which persisted after adjustment, (CCU versus neither: OR, 0.71 [95% CI, 0.41 to 1.23], P=0.230 and ICCU versus neither: OR, 0.13 [95% CI, 0.05 to 0.38], P<0.001). Analysis for patients on weekdays showed a similar relationship (Table 7). There were also decreased rates of 12-month death/re-MI for patients on a weekend (neither: 200/1257 (15.9%), CCU: 135/1051 (12.8%), ICCU: 8/84 (9.5%), P=0.049), which persisted after adjustment, (CCU versus neither: OR, 0.74 [95% CI, 0.47 to 1.14], P=0.172 and ICCU versus neither: OR 0.55 [95% CI, 0.38 to 0.81], P=0.003). Analysis for patients on weekdays showed a similar relationship (Table 7).

Among patients treated in a hospital that qualified to be an ICCU, there were also significantly decreased rates of adjusted 30-day and 12-month death/re-MI, when the unit had an early invasive management algorithm (P<0.001) or an electronic discharge checklist (P<0.001).

We also assessed whether having more guideline facilitators (n=8) per site were associated with a greater decrease in rates of death/re-MI. As expected, among a heterogeneous set of guideline facilitators, there was a nonlinear association between number of cumulative facilitators per site and average 6-month death/re-MI.

Discussion
In an audit of Australian hospitals from the ACACIA registry, we found considerable variation and greater rates of observed versus expected death and recurrent MI in the majority of hospitals. There were significant associations with decreased rates of 30-day and 12-month death/re-MI when patients were cared for in a unit that had (1) specific hospital strategies to facilitate PPCI, (2) an electronic discharge checklist, (3) ICCU levels of medical and nursing staff, and (4) both ICCU

Table 6. Quality Improvement Resources and 30-Day and 12-Month Death/Re-MI

<table>
<thead>
<tr>
<th>QI Resource</th>
<th>Present</th>
<th>Not Present</th>
<th>P Value</th>
<th>Adjusted OR* (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical advocate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-d death/re-MI</td>
<td>60/727</td>
<td>149/1665</td>
<td>0.579</td>
<td>0.86 (0.54–1.36)</td>
<td>0.524</td>
</tr>
<tr>
<td>12-mo death/re-MI</td>
<td>96/727</td>
<td>247/1665</td>
<td>0.295</td>
<td>0.80 (0.48–1.33)</td>
<td>0.400</td>
</tr>
<tr>
<td>Financial resource</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-d death/re-MI</td>
<td>70/751</td>
<td>139/1641</td>
<td>0.494</td>
<td>0.99 (0.65–1.50)</td>
<td>0.979</td>
</tr>
<tr>
<td>12-mo death/re-MI</td>
<td>104/751</td>
<td>239/1641</td>
<td>0.643</td>
<td>0.83 (0.54–1.28)</td>
<td>0.417</td>
</tr>
</tbody>
</table>

Death/re-MI indicates combined end point of death and recurrent myocardial infarction. Unadjusted values are expressed as n/N (%).

*Adjusted values are expressed as odds ratio (OR) and 95% confidence intervals (CI). Adjustment covariates include admission Global Registry of Acute Coronary Events risk score and the presence of invasive services in the presenting hospital.
levels of staffing and the deployment of a QI tool. Quality improvement tools and resources were not prevalent, and when they were, they were generally not significantly associated with performance or clinical outcome. These observations have implications for the design of health systems that are more able to translate the ACS evidence base into clinical practice and outcome.

**Quality Improvement Systems**

Bradley et al identified 6 specific hospital strategies and measured the degree to which they decreased door-to-balloon time. Of the 6, a cardiac catheterization laboratory team that arrives within 20 to 30 minutes of being paged produced the greatest decrease (19.3 minutes, \( P = 0.002 \)). In our study, this strategy was the most prevalent 19 (54.2%) as well as 20 (57%) hospitals with at least 1 strategy and only 3 (8.6%) with a maximum of 3 strategies. Importantly however, we observed a 54% and 42% decrease in relative risk in 30-day and 12-month death/re-MI, respectively. Though we lacked statistical power to see small differences, this highlights the importance of validating QI interventions by measuring both performance indicators and clinical outcomes and sharing the successful results. Quality improvement collaboratives such as the Door-to-Balloon Alliance have formed a network to share tools, resources, and data reporting.

**Quality Improvement Tools and Resources**

Prior studies such as GAP and CRUSADE observed increased rates of performance indicators with QI tool use and resources when a standardized QI intervention was implemented and supported by resourced local project leaders who monitored and encouraged QI tool use. Our research expanded this work by studying what already existed in the clinical setting in the absence of a structured QI program and found a nonstandardized collection of systems and tools and included measurement of clinical as well as performance indicator outcomes.

In our study, QI tools were heterogeneous in content and application and observed no association with clinical outcome with the exception of an electronic discharge checklist. In fact, given the increased rates of death and recurrent MI observed at 12 months associated with some unvalidated risk stratification tool deployment (Table 4), an increase in risk associated with tools cannot be excluded in this relatively small sample size. Such observations argue for the prospective and ongoing validation of QI tools across the spectrum of hospital performance characteristics to ensure a positive impact on poor performing hospitals without a concurrent negative impact on well-performing hospitals.

We also observed a nonsignificant association with decreased rates of 30-day and 12-month death/re-MI in the presence of a financial resource. Hospitals face significant challenges in implementing quality initiatives, developing sustainable processes, and identifying an operational framework for successful implementation. Quality improvement resources such as personnel, clinical advocates, and funding allocations are needed to assist with these challenges; however their value needs to be validated.

**Workforce Capacity**

Although prior literature shows that there are decreased rates of mortality and adverse events when nurse to patient ratios are high, we included medical staff in the evaluation of workforce capacity. Furthermore Kostis et al found higher mortality rates in patients with MI admitted on the weekend, suggesting more appropriate staffing and access to invasive services are needed. Our study observed that clinical outcome is associated with ICCU levels of nursing and medical workforce; however, in resource-constrained health systems, the problems of an affordable but expert workforce remain.

In our study, ICCU level workforce on week days observed a 54% and 42% decrease in relative risk in 30-day and 12-month death/re-MI, respectively. Though we lacked statistical power to see small differences, this highlights the importance of validating QI interventions by measuring both performance indicators and clinical outcomes and sharing the successful results. Quality improvement collaboratives such as the Door-to-Balloon Alliance have formed a network to share tools, resources, and data reporting.

**Clinical Decision Support Systems**

The observation that an electronic decision support tool deployed at discharge was associated with decreased rates of adverse outcome highlights the potential role of electronic systems in increasing expert capacity at the point of care. A systematic review by Kawamoto et al found that the key to a successful and sustainable clinical decision support system (CDSS) is that it must minimize the effort required by clinicians to receive and act on system recommendations. The 4 key features of CDSS critical for improving clinical practice are that it is automatically part of clinical workflow, available at the time and location of the decision-making, provides an individual recommendation, and is electronic.

### Table 7. Workforce Capacity on Weekdays and 30-Day and 12-Month Death/Re-MI

<table>
<thead>
<tr>
<th>Workforce Capacity</th>
<th>Weekday</th>
<th>30-d</th>
<th>12-mo</th>
<th>( P ) Value</th>
<th>( \text{Adjusted OR}^* ) (95% CI)</th>
<th>( P ) Value</th>
<th>( \text{Adjusted OR}^* ) (95% CI)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neither</td>
<td>CCU</td>
<td>ICCU</td>
<td>CCU</td>
<td>ICCU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekday</td>
<td>112/1133 (9.9)</td>
<td>95/1175 (8.1)</td>
<td>2/84 (2.4)</td>
<td>0.034</td>
<td>0.7 (0.45–1.24)</td>
<td>0.264</td>
<td>0.13 (0.05–0.38)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>12-mo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekday</td>
<td>169/1133 (14.9)</td>
<td>166/1175 (14.1)</td>
<td>8/84 (9.5)</td>
<td>0.380</td>
<td>0.8 (0.51–1.31)</td>
<td>0.414</td>
<td>0.58 (0.38–0.88)</td>
<td>0.011</td>
</tr>
</tbody>
</table>

Death/re-MI indicates combined end point of death and recurrent myocardial infarction; ICCU, intensive cardiac care unit.

Unadjusted values are expressed as n/N (%).

*Adjusted values are expressed as odds ratio (OR) and 95% confidence intervals (CI). Adjustment covariates include admission.

GRACE risk score and the presence of invasive services in the presenting hospital.
Our study found clinical association with the use of an electronic discharge checklist with the knowledge that this tool was integrated into the workflow consistent with Kawamoto’s 4 successful CDSS features (Thomson D, unpublished data, 2009).21

Next Steps
Building on the existing literature, these observations suggest that the optimal translation of ACS evidence may depend on health service capacity including guideline facilitators such as QI systems and tools, workforce, and expertise. This is supported by the observed association between decreased rates of adverse outcomes and quality improvement tools in the presence of greater workforce capability. Further, despite the importance of workforce on health, this has had scant attention in cardiology settings. Decision support systems offering guideline recommendations in the workflow, measuring performance and outcome and delivering feedback are not commonly available in the clinical environment. Increasing the capability for rapid, risk-based decision-making at the point of care could be achieved with an ACS electronic clinical decision support tool and may have relevance in the developing world and in societies that are geographically challenged.22

Although such tools have the potential to bring best practice care to the clinician irrespective of their practice location and level of expertise or workforce capacity, it is necessary to conduct objective validation, including cost-effectiveness. Large-scale attempts to validate the comparative effectiveness of such interventions have several benefits: first, it may help address discrepancies in care identified in registries by providing guideline recommendations at the point of care. Second, it can provide a prospective real-time platform which automatically feeds data into collaborative registries. Third, it could increase equity of outcome by supporting the potential for more patients to receive best practice care. Fourth, it could provide a potentially cost-effective infrastructure as an alternative to the costly problem of providing an expert and adequately staffed workforce across the full diversity of health services.22

Limitations
There are several limitations to our study. These findings are hypothesis generating due to the observational nature of the study design and thus limit the ability to infer direct causality between guideline facilitators and outcome. The evaluation data were reported by a single respondent at the hospital who recalled retrospective data and reported policies and practices which were not independently confirmed, with the exception of QI tools. These issues can be further explored in an upcoming prospective, randomized study. Our study may have been underpowered; however, we included approximately 30% of metropolitan, adult, acute hospitals in Australia. Although this study does exclude a large benefit from an eclectic collection of tools, associations were seen with the more standardized definitions of workforce and hospital strategies for facilitation of PPCI; hence standardized systems, tools, and deployment may provide meaningful value. With a population the size of Australia’s and approximately 80,000 ACS hospital admissions per year,23 a large-scale study would require a national ACS registry effort to ensure a high level of hospital participation, with a significant financial, collaborative, and government commitment.22 Despite these limitations, this study’s strength is that it has undertaken a systematic evaluation of factors enabling guideline adherence and has observed associations with decreased adverse patient outcomes. Elucidating these factors is critical in developing rigorous evidence-based quality improvement initiatives.

Conclusion
We studied the role of guideline facilitators (QI systems, tools, resources, and workforce) in translating evidence into practice and found clinical associations with strategies to facilitate PPCI, an electronic discharge checklist, and ICCU levels of workforce. To deliver equitable and optimal care to patients, innovative quality improvement solutions that are proven, sustainable, and cost-effective are required.

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Disclosures
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