Improved Clinical Outcome After Acute Myocardial Infarction in Hospitals Participating in a Swedish Quality Improvement Initiative

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Background—The Swedish quality improvement initiative Quality Improvement in Coronary Care previously demonstrated significant improvements in caregiver adherence to national guidelines for acute myocardial infarction. The associated impact on 1-year clinical outcome is presented here.

Methods and Results—During the baseline period July 2001 to June 2002, 6878 consecutive acute myocardial infarction patients <80 years were included at the 19 intervention and 19 control hospitals and followed for a mean of 12 months. During the postintervention period of May 2003 to April 2004, 6484 patients were included and followed in the same way. From baseline to postintervention, improvements in mortality and cardiovascular readmission rates (events per 100 patient-years) were significant in the intervention group (−2.82, 95% CI −5.26 to −0.39; −9.31, 95% CI −15.48 to −3.14, respectively). However, in the control hospitals, there were no significant improvements (0.04, 95% CI −2.40 to 2.47; −4.93, 95% CI −11.10 to 1.24, respectively). Bleedings in the control group increased in incidence (0.92, 95% CI 0.41 to 1.43), whereas the incidence remained unchanged in the intervention group (0.07, 95% CI −0.44 to 0.58). When the difference of changes between the study groups were evaluated, the results still were in favor of the intervention group, albeit significant only for bleeding complications (mortality: −2.70, 95% CI −6.37 to 0.97; cardiovascular readmissions: −6.85, 95% CI −16.62 to 2.93; bleeding complications: −0.82, 95% CI −1.66 to 0.01).

Conclusions—With a systematic quality improvement initiative aiming to increase the adherence to acute myocardial infarction guidelines, it is possible to achieve long-term positive effects on clinical outcome. (Circ Cardiovasc Qual Outcomes. 2009;2:458-464.)

Key Words: myocardial infarction ■ quality of care ■ outcomes assessment

Despite of continuous improvements of care delivered to patients with acute myocardial infarction (AMI), there is still a considerable gap between recommendations in evidence-based AMI guidelines and clinical practice.1–5 Because deviations from the guideline recommendations have negative effects on mortality and morbidity,6–9 it is crucial to find ways to improve the guideline adherence. Therefore, different methods and programs for quality improvement (QI) in this area have been suggested.10–12 The results from these studies have been varying, from modest21–22 to more substantial.8 Unfortunately, these studies did not include comparisons with concurrent control groups, which made it arguable whether the results primarily were an effect of the QI interventions per se, or maybe mere expressions of secular trends in AMI care.

As an attempt to improve the care given to Swedish AMI patients, the Quality Improvement in Coronary Care (QUICC) study was initiated in 2002. QUICC was a national controlled pre–post study in which volunteering teams from 19 hospitals of varying size were subject to a QI intervention, with the aim to improve the adherence to the national AMI guidelines. Another 19 matched hospitals were blinded controls, and the 19+19 intervention and control hospitals represented a major proportion of the total of 78 Swedish hospitals with coronary care facilities. The QI intervention was based on the Breakthrough model,10 a methodology well known to the study representatives, and also believed to be relatively straight-forward to implement in the AMI field.

The performance levels were evaluated by the analysis of 5 clinical quality indicators (use of angiotensin-converting enzyme inhibitors, statins, clopidogrel, heparin/low-molecular-weight heparin, and coronary angiography). For these quality indicators, significant improvements relative to baseline were achieved for all 5 in the hospitals participating in the QI initiative, and compared to the control hospitals the improvements were significantly higher for 4 of the 5 quality indicators.8

Key Words: myocardial infarction ■ quality of care ■ outcomes assessment
indicators (statins excluded). Another key marker of a positive impact of the intervention was that the variability across the intervention sites decreased.

Although improvements in processes measures are important, the ultimate goal of a clinical QI initiative is to improve the clinical outcome. Therefore, the aim of the present report was to evaluate whether the improvements in guideline adherence achieved at the QUICC hospitals compared to the control hospitals also correlated to improved clinical outcome (ie, lower all-cause mortality and cardiovascular [CV] readmission rates). Also, because the QUICC intervention was believed to cause an increased usage of antithrombotic therapies (clopidogrel), the prevalence of bleeding complications before and after the intervention was evaluated.

### WHAT IS KNOWN

- Although the care of patients with acute myocardial infarction is continuously improving, several studies performed in different countries and in different types of health care systems have shown that the adherence to evidence based treatments is suboptimal.
- It has repeatedly been shown that systematic quality improvement initiatives can improve the adherence to national acute myocardial infarction guidelines. However, studies verifying that quality improvement initiatives also improve clinical outcome are few and have so far only used historical controls.

### WHAT THE STUDY ADDS

- With the combination of an interactive, real-time feedback generating national quality registry and a systematic quality improvement collaborative, it was not only possible to significantly improve the adherence to national acute myocardial infarction guidelines. However, studies verifying that quality improvement initiatives also improve clinical outcome are few and have so far only used historical controls.
- Our findings are in line with those from other studies, but because our study included a matched control group of hospitals, it is likely that the improvements in mortality and cardiovascular readmissions are a result of the intervention and not from ongoing secular trends.
- The 2.7 and 9.1 per 100 patient-years fewer deaths and events of the combined end point, respectively, seen in hospitals in the intervention group compares favorably with what can be seen in most current randomized clinical trials of new drugs.

### Methods

#### Study Design

The design of the QUICC study as well as the results from the initial evaluation have been previously described. In short, before the initiation of the study, an invitation was sent to each and every of the 73 Swedish hospitals caring for AMI patients and participating in the Register of Information and Knowledge about Swedish Heart Intensive Care Admissions (RIKS-HIA; www.uwr.se/riksbia/RIKS-HIA). Nineteen volunteering hospitals were randomized to 1 or 2 intervention groups, where the intervention differed somewhat both in design and intensity. When the analyses of the adherence rates of these 2 subgroups (A and B) revealed that no significant differences occurred, all further analyses were made on the combination of these (A+B).

Nineteen other nonvolunteering Swedish hospitals were, based on size and historical treatment levels, matched to the study hospitals and included as blinded controls. During the study, caregivers from those hospitals entered consecutive patient data into RIKS-HIA according to preexisting routines.

After the intervention period of 6 months, data from the ensuing 12 months were for both hospital groups compared with a preintervention baseline period of 12 months (for timelines, see below).

#### Quality Intervention

The QI intervention has previously been described. Briefly, multidisciplinary teams consisting of critical care unit nurses and cardiologists were assigned at each of the 19 volunteering hospitals. These 19 teams of 4 to 5 persons then met at 4 (group A) or 2 (group B) training sessions during which they were educated by QI experts in a methodology based on the improvement model presented in the Breakthrough Series curricula. The teams were also trained in how to optimize their use of the modified web-based Swedish quality registry for cardiac intensive care, RIKS-HIA. The modification of RIKS-HIA made it possible to get local and national real-time performance data, a prerequisite for the teams to be able to detect, and react on, local changes in clinical performance levels.

The learning sessions took place during 6 months, November 1, 2002, through April 30, 2003, and between these meetings the teams developed locally adapted improvement plans, presumed to be tested and implemented at home. At the meetings the teams reported both successes and set-backs, which in a collaborative way was of great help for the other teams when improving their own plans. During the 12 months after the condensed intervention period of 6 months, the intervention teams met at 2 follow-up meetings, where new results, lessons learned, and ongoing activities were presented. During the same time the teams also were supported by video and telephone conferences, as well as being encouraged by regular visits and telephone calls by a coach from the study management group.

#### Sample Selection and Follow-Up

In brief, all consecutive patients <80 years of age at admittance and a with a discharge diagnosis of AMI (I21) according to the International Classification of Diseases, 10th Revision (ICD-10) were eligible, and included. The age limit was introduced to reduce confounding factors difficult to control for, such as comorbidities and variations in the tendency to admit the very oldest patients to the coronary care units.

All patients included during the baseline period, July 1, 2001, through June 30, 2002, were followed until December 31, 2002. The patients included during the postintervention period, May 1, 2003, through April 30, 2004, were followed until October 31, 2004. The mean follow-up thus was 12 months for both hospital groups in both measurement periods.

#### Measures

The mortality outcome measure corresponds to death of any cause that occurs after index admission. Cardiovascular readmission was defined as hospitalization with a diagnosis of acute myocardial infarction (ICD-10: I21), angina pectoris (I20), heart failure (I50), or cardiac arrest with successful resuscitation (I46.0). Bleeding complication was defined as hospitalization with a diagnosis of bleeding (eg, intracranial, gastrointestinal, urogenital, or respiratory bleeding). Complete specifications of these bleeding complications are available from the authors on request.

#### Data Source and Accuracy

According to preexisting routines, all QUICC centers as well as control centers continuously submitted information to RIKS-HIA about every patient admitted to the coronary care unit. For each
Table 1. Patient and Hospital Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Control Hospitals (n=19)</th>
<th>QUICC Intervention Hospitals (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Postintervention</td>
</tr>
<tr>
<td>n (per hospital)</td>
<td>165 (72–216)</td>
<td>165 (77–204)</td>
</tr>
<tr>
<td>Age, mean, y</td>
<td>66.5 (66.1–67.1)</td>
<td>66.7 (66.2–67.4)</td>
</tr>
<tr>
<td>Male sex, %</td>
<td>65 (63–69)</td>
<td>69 (67–72)</td>
</tr>
<tr>
<td>Current or previous smoker, %</td>
<td>53 (51–62)</td>
<td>54 (51–58)</td>
</tr>
<tr>
<td>Hypertension, %</td>
<td>38 (34–46)</td>
<td>37 (34–44)</td>
</tr>
<tr>
<td>Diabetes, %</td>
<td>22 (20–26)</td>
<td>21 (19–22)</td>
</tr>
<tr>
<td>Previous AMI, %</td>
<td>26 (24–27)</td>
<td>23 (21–27)</td>
</tr>
</tbody>
</table>

The values represent the median hospital in each group. The intervals in parenthesis correspond to the span between the 25th and the 75th percentile hospitals.

Results

Statistical Analysis

Results were summated for each hospital, and all calculations were made with hospitals as units of analysis. The incidence was calculated as an incidence rate (ie, the number of events divided by the total person-time at risk). For each period and hospital the incidence of 4 outcomes, death, CV readmission rate, death/CV readmission, and bleeding, were calculated. For each of the outcomes the effect of intervention was modeled in a linear mixed-effect model with fixed effect factors, QUICC-hospital (yes/no), period (before/after intervention), and interaction between QUICC-hospital and period. To allow for different baseline levels and changes within hospitals, the intercept and slope was introduced as random effects. The effect of intervention was found in the estimate of interaction between QUICC-hospital and period. Furthermore, we analyzed the effect of the intervention in an augmented model adjusting for the mean age, proportion of males, proportion of smokers, proportion of hypertension, proportion of diabetes, and proportion of previous renal failure considered as fixed effect covariates at each hospital within each period.

All statistical analyses were performed using the statistical program package R.16

Results

Patient Characteristics and Changes in Treatment Levels

During the baseline period July 1, 2001, through June 30, 2002, 6878 consecutive AMI patients <80 years were included at the intervention and control hospitals. These patients had a mean follow-up period of 12 months. During the postintervention period of May 1, 2003, through April 30, 2004, 6484 patients were included and followed up in the same way. The patient characteristics did not differ significantly, neither between hospital groups nor between measurement periods (Table 1).

The proportion of patients receiving AMI treatments during the baseline and post intervention periods in the 2 groups of hospital are presented in Table 2.

Clinical Outcome

Clinical outcomes expressed as mortality, CV readmission rate, combined mortality/CV readmissions, and occurrence of bleeding complications are presented in Table 3 and Figure 1. In the QUICC intervention group, baseline to postintervention comparisons demonstrated significant improvements (expressed as events per 100 patient-years) in mortality (−2.82, 95% CI −5.26 to −0.39), CV readmission rate (−9.31, 95% CI −15.48 to −3.14), and the combined mortality/readmission indicator (−11.80, 95% CI −20.94 to −2.67). In contrast, no significant improvement could be demonstrated in the control group of hospitals in mortality (0.04, 95% CI −2.40 to 2.47), CV readmission rates (−4.93, 95% CI −11.10 to 1.24), or the combined mortality/readmission indicator (−6.25, 95% CI −15.39 to 2.89). Concerning bleeding complications, the control hospitals actually demonstrated a negative outcome with a higher occurrence of bleeding complications (0.92, 95% CI 0.41 to 1.43). At the same time, the incidence of bleeding complications in the QUICC hospitals remained unchanged (0.07, 95% CI −0.44 to 0.58).

The differences between the control and QUICC hospitals with regard to their respective changes from baseline to postintervention are shown in Figure 2. For unadjusted mortality, CV readmissions and the combination of the two, there were numerically larger improvements in the QUICC hospitals, although they did not reach formal statistical significance (mortality: −2.86, 95% CI −6.42 to 0.70, P=0.11; CV readmissions: −4.38, 95% CI −13.40 to 4.64, P=0.33; the combination of mortality and CV readmissions: −5.55, 95% CI −18.92 to 7.82, P=0.40). However, the change in incidence of bleeding complications was significantly lower in the QUICC group (−0.84, 95% CI −1.59 to −0.10, P=0.03). These findings were consistent also when the effects of the intervention were analyzed according to the augmented model adjusting for patient characteristics presented in Table 1 (mortality: −2.70, 95% CI −6.37 to 0.97,
Discussion
Today, the healthcare sector is struggling to meet the increasing demands for improvements in the quality of care. At the same time, there is a strong international trend toward public presentations of the clinical performance data from individual care providers.17 However, it has been shown that mere publication of data are insufficient to alter care processes.18,19 These have been well-handled multicenter studies, but the lack of control groups has made it difficult to distinguish between the impact of the QI intervention and concurrent secular trends in AMI care.

With these limitations in earlier studies in mind, the QUICC study was designed to include a concurrent control group of hospitals, and in a previous report of the QUICC study it was demonstrated that hospitals participating in the QI initiative increased their adherence to the AMI guidelines significantly more than the control hospitals.13 However, the ultimate goal of any QI program is to improve clinical outcome. Therefore, the design of the QUICC study also included a follow-up of all patients, making possible an evaluation of whether participation in the QI program also resulted in improved clinical outcome. The results in the present report demonstrate that the QUICC hospitals, in contrast to the control hospitals, achieved significant improvements from baseline to postintervention in the mortality, CV readmission, and combined mortality/readmission end points. In the QUICC hospitals 2.8 lives per 100 patient years (14.2 to 11.4) and 9.3 readmissions for cardiac diagnoses per 100 patient years (49.5 to 40.2) were saved after compared to before the QI intervention, corresponding to a 20% and 19% relative decrease in incidence, respectively. The magnitude of improvement in clinical outcome was in the same order as in the study of Lappe et al,23 in which the 21% decrease in 1-year mortality was seen and in the Guidelines Applied in Practice project in which a 22% decrease in 1-year mortality8 and a 21% decrease in 6-months rehospitalization rates24 were shown. It is most probable that the improvement in clinical outcome in the QUICC hospitals was a result of the increase in the use of evidence-based treatments, and that the lack of significant improvement in the control hospitals was attributable to the much smaller increase in use of these

Table 2. Proportion of All Patients With a Discharge Diagnosis of AMI Receiving Different Treatments During the Baseline and Postintervention Periods at the Control and QUICC Hospitals, Respectively

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Control Hospitals (n=19)</th>
<th>QUICC Hospitals (n=19)</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline, %</td>
<td>Postintervention, %</td>
<td></td>
</tr>
<tr>
<td>ACE-I/ARB</td>
<td>48.6 (43.2–52.8)</td>
<td>48.0 (43.3–53.7)</td>
<td></td>
</tr>
<tr>
<td>Statins</td>
<td>67.8 (60.6–73.7)</td>
<td>72.9 (66.0–79.3)</td>
<td></td>
</tr>
<tr>
<td>Clopidogrel</td>
<td>18.8 (12.1–31.9)</td>
<td>50.2 (36.1–61.4)</td>
<td></td>
</tr>
<tr>
<td>LMWH</td>
<td>67.3 (53.8–76.5)</td>
<td>72.8 (63.5–79.5)</td>
<td></td>
</tr>
<tr>
<td>Coronary angiography</td>
<td>44.1 (30.9–57.1)</td>
<td>66.0 (51.1–71.8)</td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td>82.9 (76.3–87.1)</td>
<td>83.5 (81.6–87.4)</td>
<td></td>
</tr>
<tr>
<td>Beta blockers</td>
<td>86.2 (80.8–89.1)</td>
<td>85.4 (81.5–90.1)</td>
<td></td>
</tr>
<tr>
<td>Reperfusion treatment</td>
<td>32.5 (25.7–36.8)</td>
<td>27.9 (26.6–41.3)</td>
<td></td>
</tr>
<tr>
<td>CABG</td>
<td>5.9 (3.0–7.4)</td>
<td>10.0 (4.4–13.0)</td>
<td></td>
</tr>
<tr>
<td>PCI</td>
<td>16.7 (10.8–28.4)</td>
<td>33.1 (24.2–41.6)</td>
<td></td>
</tr>
</tbody>
</table>

The values represent the median hospital in each group. The intervals in parenthesis correspond to the span between the 25th and the 75th percentile hospitals. ACE-I indicates angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; LMWH, low-molecular-weight heparin; CABG, coronary artery bypass graft; and PCI, percutaneous coronary intervention.

*The P value relates to the difference between QUICC and control hospitals in increase between baseline and postintervention.

Table 3. Clinical Outcomes Expressed as Events per 100 Patient-Years

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Control Hospitals (n=19)</th>
<th>QUICC Hospitals (n=19)</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline Events (SD)</td>
<td>Postintervention Events (SD)</td>
<td></td>
</tr>
<tr>
<td>Death, all causes</td>
<td>14.2 (4.2)</td>
<td>14.2 (4.5)</td>
<td>NS</td>
</tr>
<tr>
<td>CV readmissions</td>
<td>54.5 (15.8)</td>
<td>49.6 (12.2)</td>
<td>NS</td>
</tr>
<tr>
<td>Death/readmissions</td>
<td>73.6 (23.0)</td>
<td>67.4 (17.0)</td>
<td>NS</td>
</tr>
<tr>
<td>Bleeding complications</td>
<td>1.0 (0.9)</td>
<td>1.9 (1.4)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Morbidity comprises hospital care under the diagnoses of AMI, angina pectoris, congestive heart failure, and cardiac arrest. Bleeding complications indicates hospital care with a diagnosis of a bleeding complication.
Because this study, in contrast to the before-mentioned studies, included a control group, it was possible to compare the differences in change of outcome between QUICC and control hospitals. The QUICC hospitals showed a numerically larger decrease in clinical events, 2.9 fewer deaths and 4.4 fewer cardiac readmissions per 100 patient years, compared to the control hospitals. However, these differences did not reach formal statistical significance. Nevertheless, summarizing all the analyses discussed above, our interpretation of the result is that the QI intervention in the present study led to a clinically relevant decrease in cardiac events beyond what could be simply explained by concurrent secular trends in cardiac care.

The increased use of aggressive treatments in AMI might lead to an increase in serious side effects. A particular worry is bleeding complications, because it has been shown that increased occurrence of bleedings is associated with an increased mortality. Therefore, it was important to evaluate the effect of the increased use of treatments, especially of long-term clopidogrel treatment known to increase the prevalence of bleedings. The results demonstrated, for the control group, a baseline to postintervention increase in occurrence of hospitalizations because of bleeding complications. However, much to our surprise the incidence of bleeding complications at the QUICC hospitals remained unchanged, despite the larger increase in use of treatments, including clopidogrel. Also, when the evaluations were based on the difference between QUICC and control hospitals in the changes in bleeding complications, the difference was significant and in favor for the QUICC hospitals.

We have no definite explanation to this finding; however, the emphasis during the QI program on the importance of treating only the eligible patients (ie, the patients with indication and without contra indications for the particular treatment) might be of importance. That the patient selection was more careful in the QUICC hospitals is evidenced by the relatively larger increase in usage of the 5 selected treatments when the comparison was restricted to the target populations for the respective treatment as shown in the original publication, compared to when the analysis was done in the total population of AMI patients as in Table 2 in the present report.

With the experience gained from this study, we feel that some of the key factors for the success were the following: First, the collaborative design. The different teams were willing to share experiences and fruitful ideas, some which were adopted by other teams. Second, the use of a strategic and proven QI model, with its emphasis on creating locally adjusted and working processes and involving all relevant staff on the local level. Third, the study was both initiated and managed by, on a national level, well-renowned experts in the fields of cardiology as well as healthcare QI. This was clearly advantageous in the initial phase, when it was crucial to get interest for the study, as well as acceptance for the obligations associated with participation. Last, the national quality reg-

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

**Figure 1.** Differences in incidence of clinical events pre–post intervention, comparison made between control and intervention hospitals. Vertical bars represent 95% CIs. Gray bars indicate control hospitals; black bars, QUICC intervention hospitals. Horizontal bars denote mean values. The y-axis gives events per 100 patient-years. Corresponding probability values are presented in Table 3.

![Figure 2](http://circoutcomes.ahajournals.org/)

**Figure 2.** Differences of changes in clinical outcome, control versus QUICC hospitals. Vertical bars denote adjusted and unadjusted 95% CIs for the difference of changes between control and QUICC hospitals. Horizontal bars denote mean values. The y-axis denotes events per 100 patient-years. Note different scale on the y-axis for bleedings. Gray line indicates unadjusted values; black lines, adjusted values. Probability values are presented above the graphs.
istry RIKS-HIA which made it possible to generate real-time feedback on the performance, which is a prerequisite when local incremental improvements are to be tested and implemented.

This study has some inherent limitations. As the nature of this study made it difficult to have a fully randomized design, the intervention was made in volunteering hospitals. These hospitals might, therefore, because of selection bias, be more eager to improve. However, as the baseline performance levels were no different from the control hospitals, that eagerness is unlikely to alone explain the improved quality of care at the QUICC hospitals. We feel that we can agree with the conclusion from the Guidelines Applied in Practice study by Eagle et al8 that “wanting to improve” is not sufficient to reach substantial improvement levels. Furthermore, as in all nonrandomized studies, differences in unregistered variables between the 2 groups of hospitals might influence the results and are impossible to adjust for in the statistical analyses.

Even with the attempt to optimize the coverage by excluding the very eldest that commonly are cared for outside a critical care unit, a minor proportion of eligible AMI patients are also cared for outside the critical care units and hence not registered in RIKS-HIA nor included in the study.

Our conclusions are limited to the care of patients with acute AMI. However, given that the general methods used in the QI program10 has already been successfully used in different medical areas, it is probable that the minor modifications in our study are generalizable to other patient groups as well.

The evaluation of the occurrence of bleeding complications was made only on bleedings severe enough to necessitate rehospitalization. The total number of bleeding events was therefore rather low. The design of the study and the current version of the quality registry RIKS-HIA made it impossible to register less severe bleedings. The important findings, however, were that there was no increase in bleeding rate between the baseline and postintervention phases at the QUICC hospitals despite a large increase in use of antithrombotic treatments, and that in the postintervention phase there were no more frequent bleedings requiring hospitalizations at the QUICC hospitals compared to at the control hospitals despite a much higher use of antithrombotic treatments.

In summary, our results strongly suggest that participation in a QI program, in which the whole care process is revised and optimized in a way that durable improvements are achieved, might not only increase the adherence to guidelines but also lead to an improved clinical outcome.

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Disclosures
Dr Lindahl has received fees for speaking on satellite symposia and other educational meetings from Roche Diagnostica, Dade-Behring, Beckman-Coulter, and Merck Sharp & Dohme. The other authors report no conflicts.

References


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