AUDIT

Measuring outcomes: one month survival after acute myocardial infarction in Scotland

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Abstract

Objective—To examine 30 day survival after acute myocardial infarction as an outcome indicator, and explore the effects of adjusting for available prognostic factors such as age, sex, co-morbidity, deprivation, and deaths outside hospital.

Design—Cohort study.

Setting—The Scottish Record Linkage System was analysed. This national database links inpatient data to death certificate information for a population of 5·1 million.

Subjects—All 40 371 admissions to hospital with a principal diagnosis of acute myocardial infarction, plus all 18 452 deaths outside hospital with a principal cause of death registered as acute myocardial infarction (ICD9 code 410) during 1988–1991.

Main outcome measures—The outcome event was death from any cause, within hospital or elsewhere, within 30 days of admission.

Results—During 1988–1991, 30 day survival after acute myocardial infarction was 77% in 40 371 hospital admissions, but only 53% when 18 452 acute myocardial infarction deaths in the community were included (a population-based outcome indicator with many advantages). Using logistic regression at an individual patient level, the odds of dying within 30 days effectively doubled for each decade of age (odds ratio compared with patients aged under 55: 2·3 aged 55–64, 4·4 aged 65–74, 8·2 aged 75–84, 12·0 aged 85 plus); were marginally higher in females than in males (odds ratio 1·07); were almost doubled in patients with a history of previous infarction, coronary heart disease, or other heart disease, and were also significantly increased in patients with circulatory disease, respiratory disease, neoplasm, or diabetes. Socioeconomic deprivation had no significant effect. Marked variations in survival between different hospitals and health board areas persisted, even after adjusting for the above prognostic factors.

Conclusion—One month survival after acute myocardial infarction could be a useful means of measuring outcome of hospital care. There was important geographical variation in one month survival. These differences could be accounted for by variations in referral, admission, diagnosis, definition, and coding. These variables merit further research and local clinical audit before one month survival after acute myocardial infarction can be reliably used for detecting differences in quality of care. In addition, it would be essential to take account of infarct severity.

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Each year coronary heart disease kills 17 000 Scots, representing 30% of all male deaths and 25% of all female deaths.[1] Half of these deaths are premature, occurring before the age of 75; three quarters are due to acute myocardial infarction.[1] Epidemiological studies have confirmed the high prevalence of coronary heart disease in England[2] and in Scotland.[3 4] Other studies using routine information sources have been less satisfactory for measuring coronary heart disease morbidity. More recently, systematic analysis of hospital data, including deaths after discharge, has become possible with the creation of the Scottish Record Linkage System.[5]

The Clinical Outcomes Working Group of the Clinical Resource and Audit Group has recently published mortality within 30 days of hospital admission for acute myocardial infarction at the level of individual hospital trusts and health board area.[6] The primary aim was to improve the outcome of clinical care by stimulating discussion about variations between centres. Although geographical variations in survival after acute myocardial infarction were immediately apparent, the report emphasised that crude measures could not be used to make direct inferences about the quality of care.[6]

Survival statistics after acute myocardial infarction are critically dependent on the pre-

cise definitions used, the completeness of case ascertainment, and patient selection (whether all community cases or all hospital admissions or selected admissions).[7] In population based studies, 50–70% survive to one month.[8–10] In contrast, most hospital based studies report a higher one month survival of between 70% and 90%.[11–13] This is because about a quarter of all patients die within one hour of onset of symptoms (sudden deaths) and thus barely 75% survive long enough to reach hospital.[7 14] Following admission, key prognostic factors affecting survival include age, infarct severity, and co-morbidity,[9 13 15 16] and, possibly, socio-economic deprivation.[17 18]

Factors relevant to survival such as age, sex, prior morbidity, co-morbidity, and aspects of deprivation can be derived from the Scottish national linked data set.[5] In this study we describe their effect on 30 day mortality.

This paper contributes to the process of refinement and validation of an outcome indicator which is necessary before outcomes monitoring becomes an accurate instrument in assessing the quality of care.

Subjects and methods

DATA SOURCES
In Scotland, all non-maternity, non-psychiatric hospital inpatient and day case discharges are recorded and aggregated nationally as the SMR1 scheme. The application of record linkage techniques permits analysis of the data at the level of the individual patient rather than the episode of care. Linkage of hospital discharge data to Registrar General's death records enables routine follow up in terms of mortality.[5]

METHODS
The outcome indicator adopted was 30 day mortality after admission to hospital with a principal diagnosis of acute myocardial infarction (ICD9 code 410). For each patient, only the first admission in the three year period was included (October 1988–September 1991). The outcome event was death from any cause, within hospital or elsewhere within 30 days of admission. A three year period was chosen to allow a valid statistical comparison between hospitals.

The SMR1 record allows the coding of the principal diagnosis and up to five other diagnoses.[5 19] This presented the opportunity for controlling for the presence of co-morbidity at the time of admission. The linked data set also made it possible to search for any conditions involving admission to hospital in the previous five years. Secondary diagnoses on the index admission and previous conditions were then classified into a limited number of mutually exclusive prior and co-morbidity categories.

In order to examine the effect of socioeconomic deprivation, all cases were assigned to one of five categories based on the deprivation score developed by Carstairs and Morris.[20]

POPULATION-BASED INDICATORS
In addition to hospital admissions as defined in the individual and hospital level analyses, a case can be made for the adoption of "survival after *recognised* acute myocardial infarction". This represents an outcome indicator complementary to post-admission survival. The broadening of the analysis beyond those cases of acute myocardial infarction admitted to hospital, required the estimation of a further denominator (referred to as recognised acute myocardial infarction in this paper). This denominator included all deaths outside hospital registered with a principal cause of death of acute myocardial infarction (AMI). This definition excluded those patients who had been admitted for any other condition but who subsequently died of AMI in hospital.
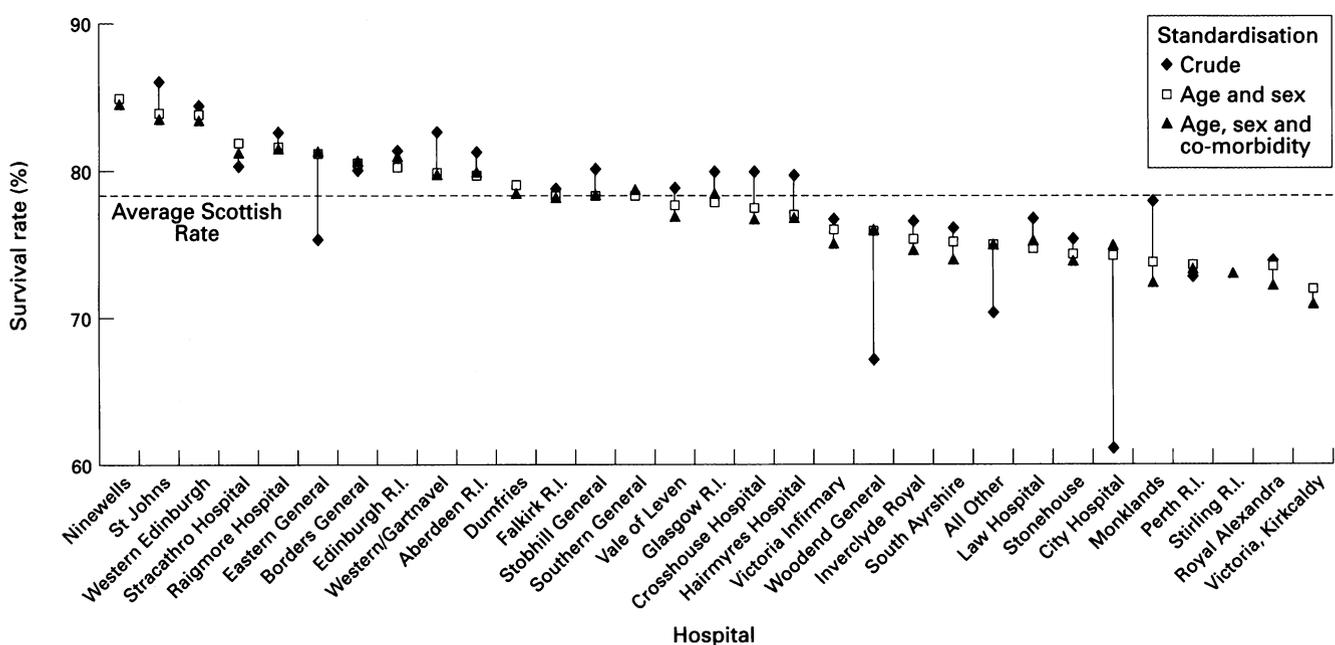

Figure 1   30 day survival after admission with a principal diagnosis of acute myocardial infarction between October 1988 and September 1991. Effects of standardisation for (a) age and sex and (b) age, sex, and prior and co-morbidity.

This enabled the calculation of the following indicators: 30 day survival of all recognised cases of AMI, not just those admitted to hospital; and proportion of recognised AMI cases admitted to hospital. Because of the inclusion of data from death certification these indicators can only be calculated at an area level; Health Board of residence was chosen for our analysis.

STATISTICAL ANALYSIS

Indirect standardisation was used to adjust hospital-specific 30 day survival rates, first for age and sex differences in the admissions populations and secondly for differences in prior morbidity and co-morbidities and deprivation scores. The outcome measures at hospital level are presented with 95% confidence intervals as an aid to interpretation, calculated using the square root transform method.[21]

To provide information at an individual patient level a multiple logistic regression model with 30 day mortality as the outcome was used to assess the effect of age, sex, prior morbidity and co-morbidity, and deprivation category.[21]

Results

Between October 1988 and September 1991, 40 371 patients were admitted to Scottish hospitals with a principal diagnosis of acute myocardial infarction. Of these 9097 died within 30 days of admission, giving a one month survival rate after admission of 77·5%.

Crude 30 day survival rates varied across hospitals from 61·2% to 85·8% (fig 1). Standardisation for age and sex had a marked effect on the survival rates of several hospitals, with standardised survival rates ranging from 71·9% to 84·6%. Figure 1 also shows the effect of adding prior and co-morbidity categories to the standardisation for age and sex. The effects on hospital survival rates were relatively modest. The largest absolute change was 1·29 percentage points; indeed only five out of the 30 effects were larger than 1%. The effect of standardisation for Carstairs deprivation category has not been tabulated; the largest change between the age/sex standardised survival rate and the age/sex/deprivation standardised survival rate involved a shift of only 0·24 percentage points.

At an individual patient level, logistic regression was used with 30 day mortality after hospital admission with AMI as the outcome, to investigate the effect of age, sex, prior and co-morbidity, and deprivation (table 1). All main effects presented are adjusted for all other covariates in the model. Age was a strong influence on the odds of dying within 30 days of hospital admission with AMI. The odds of dying effectively doubled for each decade of age compared with patients aged under 55 (odds ratio: 2·3 aged 55–64; 4·4 aged 65–74; 8·2 aged 75–84; 12·0 aged 85 plus). The odds of dying within 30 days were marginally higher in females than in males (odds ratio 1·066; 95% confidence interval 1·012 to 1·124.

Compared with patients with no coded prior and co-morbidity, the estimated odds of dying within 30 days were almost doubled in patients with a history of previous infarction (odds ratio 1·74; 95% confidence interval 1·57 to 1·92), previous coronary heart disease (odds ratio 2·03; 95% confidence interval 1·86
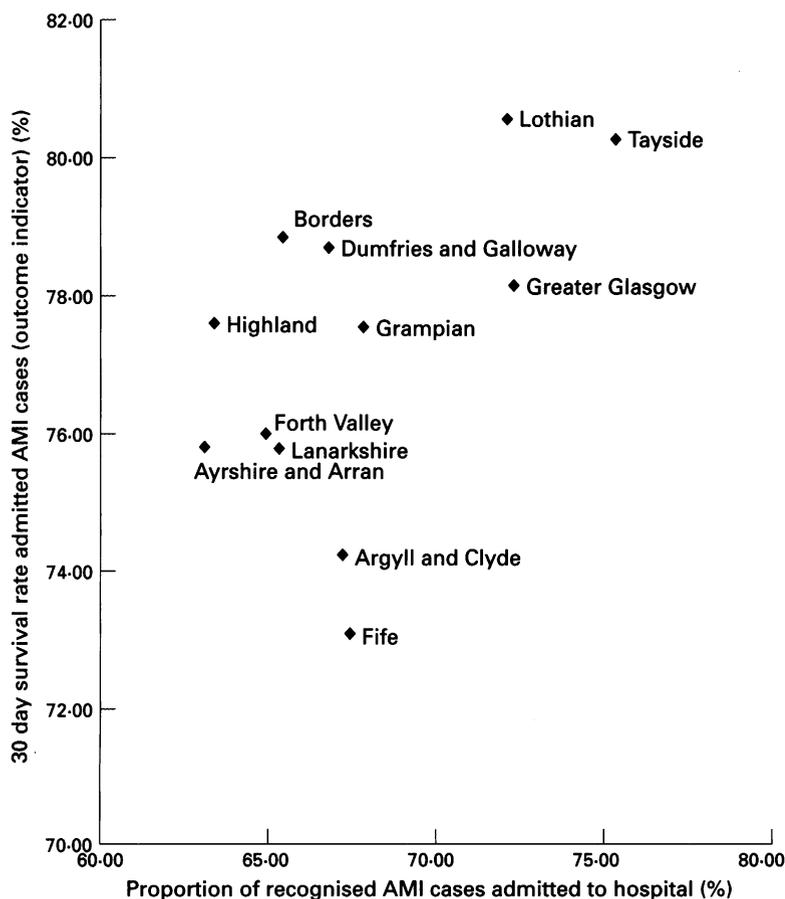

Figure 2   Proportion of recognised AMI cases admitted to hospital plotted against the 30 day survival rate for cases admitted to hospital.

Table 1   Logistic regression analysis: odds of dying within 30 days of admission for AMI

Coding	Odds ratio	95% Confidence intervals
Age:		
Under 55	1·00	
55–64	2·27	2·00 to 2·58
65–74	4·41	3·91 to 4·98
75–84	8·19	7·25 to 9·26
85 plus	11·99	10·42 to 13·80
Sex:		
Male	1·00	
Female	1·07	1·01 to 1·12
Prior and co-morbidity:		
No other condition	1·00	
Previous AMI	1·74	1·58 to 1·92
Other CHD	2·03	1·86 to 2·22
Other heart disease	1·83	1·69 to 1·98
Other circulatory disease	1·53	1·38 to 1·69
Respiratory disease	1·65	1·46 to 1·87
Neoplasm	1·60	1·37 to 1·87
Diabetes	1·49	1·23 to 1·81
Any other disease	1·24	1·14 to 1·34
Deprivation:		
Least deprived	1·00	
	1·07	0·99 to 1·17
	1·05	0·96 to 1·14
	1·10	1·01 to 1·19
Most deprived	1·06	0·98 to 1·15

Odds ratios are adjusted for the remainder of the potential confounders given above. Logistic regression was performed on 39 876 AMI admissions.

Table 2   Recognised AMI attacks and deaths at Health Board level: October 1988 to September 1991

Health Board	Hospital admission for AMI (A)	AMI deaths without hospital admission (B)	Proportion of recognised AMIs hospitalised (A/(A+B))	Died within 30 days of admission (C)	Survival rates	
					All recognised AMIs (A−C)/(A+B)	AMIs admitted C/A
Ayrshire & Arran	2933	1724	62·95	675	48·09%	75·84%
Borders	803	448	65·24	194	51·18%	78·89%
Argyll & Clyde	3590	1750	67·13	917	49·89%	74·17%
Fife	2504	1233	67·34	679	49·17%	73·12%
Greater Glasgow	7398	2790	72·11	1581	56·38%	78·18%
Highland	1298	779	63·21	286	49·77%	77·64%
Lanarkshire	4149	2151	65·15	916	49·59%	75·79%
Grampian	3416	1674	67·61	810	52·35%	77·58%
Orkney	130	117	53·19	44	34·82%	66·15%
Lothian	5929	2307	71·86	1171	57·71%	80·59%
Tayside	4006	1354	75·09	851	59·76%	80·32%
Forth Valley	2038	1133	64·75	504	49·15%	76·00%
Western Isles	183	182	51·39	58	38·85%	71·73%
Dumfries & Galloway	1385	715	66·58	309	52·31%	78·73%
Shetland	114	95	55·53	31	57·62%	74·73%
Scotland	**39 876**	**18 462**	**68·65**	**9026**	**53·19%**	**77·48%**

AMI, acute myocardial infarction.

to 2·22), or other heart disease (odds ratio 1·83; 95% confidence interval 1·69 to 1·98) and were also significantly increased in patients with circulatory disease, respiratory disease, neoplasm, or diabetes. There was little or no indication that socioeconomic deprivation had a statistically significant effect on the odds of dying within 30 days of admission within this patient population; this finding reinforces the results obtained by the method of standardisation (table 1).

There were 18 452 AMI deaths without hospital admission and 39 876 with hospital admission for AMI, producing a total of 58 328 recognised cases of acute myocardial infarction (table 2).

Figure 2 presents the relation between the post-admission 30 day survival rate standardised for age and sex, and the proportion of recognised cases of acute myocardial infarction admitted to hospital.

There seems to be no tendency for health boards that admit a high proportion of recognised cases of AMI to have a lower post-admission survival rate. In particular the three boards which admitted the highest proportions of AMIs to hospital, all had relatively high post admission survival rates. The three, namely Lothian, Greater Glasgow, and Tayside, which seemed to admit a higher proportion of cases to hospital, clearly have the highest 30 day survival in terms of recognised AMI compared with the remaining health boards (fig 3).

QUALITY OF DATA
An ISD Quality Assurance Study in 1992 examined a 1% sample of all SMR1 forms for accuracy of ICD9 coding (Houston, personal communication). Of 199 records with a principal diagnosis of AMI (ICD9 code 410), 190 were correct, nine were incorrect (false positive rate 4·4%), and a further 13 "true" acute myocardial infarctions were concealed under other codes (false negative rate 6·4%). The overall accuracy was therefore 89·2% $(1 - [((9 + 13)/203) \times 100\%])$ (table 3).

Discussion
QUALITY OF DATA
The quality of the administrative data used is crucial to the validity of a study such as this. Completeness and accuracy of death certificates for coronary heart disease are generally
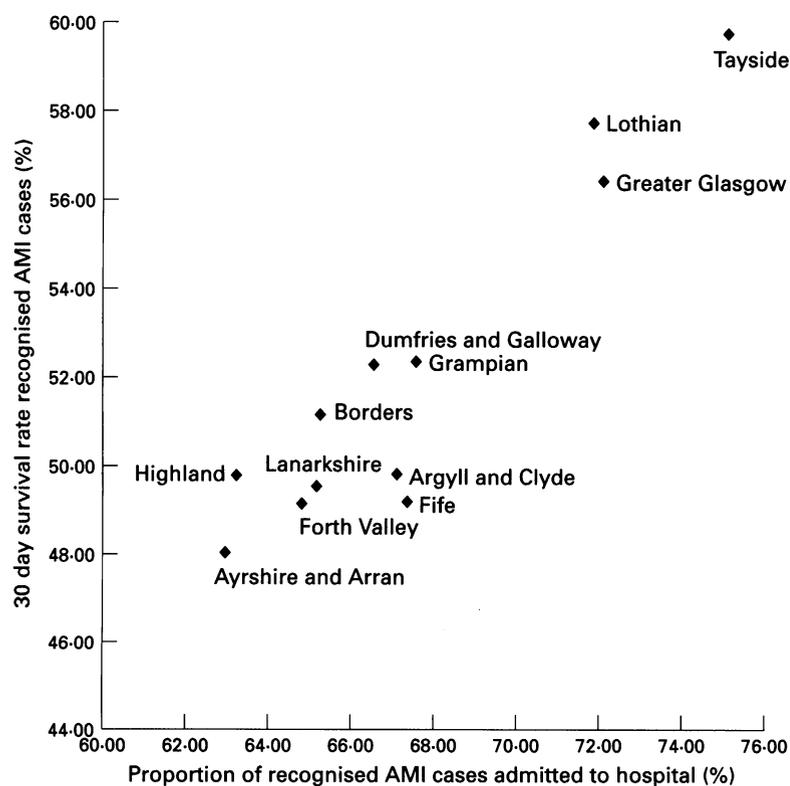

Figure 3   Proportion of recognised AMI cases admitted to hospital plotted against the 30 day survival rate for all recognised cases.

Table 3   Accuracy of ICD9 3–digit coding of principal diagnosis: ISD Quality Assurance Study of 1% sample Scottish SMR₁ patients during 1992

	True number	False positive	False negative	Overall accuracy
Acute myocardial infarction (ICD9 code 410)	203	4·4%	6·4%	89·2%
Fractured neck of femur (ICD9 code 820)	74	1·4%	6·8%	92%
Stroke (ICD9 codes 430–434, 436–438)	139	4·3%	10·8%	85%

good.[7 14 22] SMR1 hospital inpatient records are essentially complete and about 94% accurate for the diagnosis and coding of principal diagnosis in general, and 89% accurate specifically for acute myocardial infarction (table 3; Harley personal communication and Pears *et al*[23]). Recording of secondary diagnoses on the SMR1 form is relatively poor,[19] therefore the main source for establishing prior morbidity in our study was the presence of principal diagnosis in both previous SMR1 episodes and prior cancer registrations. The odds ratios (relative risk) associated with prior and co-morbidities in the individual analysis were very similar to other studies.[9 12 13]

EFFECTS AT THE HOSPITAL LEVEL

Standardisation for age and sex produced marked changes in outcome for some hospitals. Further standardisation for prior and co-morbidities and deprivation respectively had little effect on survival at hospital level (fig 1).

INDIVIDUAL CORRELATES OF SURVIVAL

Although over 50 prognostic factors are described in AMI, multivariate analyses reveal that four are dominant: infarct severity, age, pre-existing disease,[12 13 15] and patient selection.[7 9]

Only the latter three can be derived from the available administrative data. In Scots patients, the main determinants of the odds of dying within 30 days of admission for AMI were age, prior and co-morbidity, and sex. These findings accord closely with previous hospital based[9 13 15] and population-based studies.[10] There was little or no evidence that socioeconomic deprivation had any effect. Larger effects have been reported in other studies using a longer follow up period.[17 18]

POPULATION-BASED SURVIVAL

A quarter of all infarct patients die within the first hour and more within the next 24 hours.[7 14 24] In our series, 67% of deaths occurred without hospital admission, similar to Belfast, Glasgow, and elsewhere.[14 22] The 77% survival in hospital patients and 53% population-based survival accord closely with other studies.[8-13 25] The latter population-based measure is less vulnerable to selection bias and may represent a useful "global" measure of value to purchasers.

It had been suggested that those health boards that were quickest at getting heart attack cases to hospital might be penalised in terms of worse post-admission survival rates. In fact, our data suggest the opposite—survival was highest in the three health boards admitting the highest proportion of recognised acute myocardial infarctions (figs 2 and 3). All three, Greater Glasgow, Lothian, and Tayside are teaching health boards with largely urban populations. The definition of acute myocardial infarction may vary substantially between hospitals and health boards, as seen in the USA and Scandinavia.[26 27]

As diagnostic tests become more sensitive and more frequently performed on larger numbers of patients, so the increasing proportion of milder AMI cases diagnosed may "dilute" patient groups and expand the denominator, with apparent improvements in survival.[26 27] Any such variation between hospitals in admission and diagnostic thresholds would lead to variation in the mean severity of disease in the patients admitted. Infarct severity has a 20 to 50 fold effect on mortality.[12 13 15] In contrast, treatment effects are relatively modest, reducing mortality by 20 to 30 %.[28] The potential impact of revascularisation after infarction seems similarly limited.[29 30]

This study has been able to address the effects on survival of aspects of case mix which can be derived from routine administrative data such as age, coded co-morbidity and prior morbidity, and deprivation. Prospective disease registers offer one option to facilitate valid outcome comparisons.[7] Conversely, differences in quality of care between hospitals may be better detected by process measures.[31] However, estimates such as Mant and Hicks'[32] rely heavily on assumptions that all treatment interventions have been identified and that in each case their precise effects in routine clinical practice are known. In reality, process and outcome measures will probably remain complementary audit tools for a long time.[6]

One month survival after acute myocardial infarction could be a useful means of measuring outcome of hospital care. We have found important geographical variation in one month survival. However, these differences could be accounted for by variations in referral, admission, diagnosis, definition, infarct severity and coding. These variables merit further research and local clinical audit[6 7] before one month survival after acute myocardial infarction can be reliably used for detecting differences in quality of care.

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