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ORIGINAL RESEARCH ARTICLE

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Calculating the 30-day survival rate in acute myocardial infarction: should we use the treatment chain or the hospital catchment model?

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ABSTRACT

Introduction: Acute myocardial infarction (AMI) is a potentially deadly disease and significant efforts have been concentrated on improving hospital performance. A 30-day survival rate has become a key quality of care indicator. In Northern Norway, some patients undergoing AMI are directly transferred to the Regional Cardiac Intervention Center at the University Hospital of North Norway in Tromsø. Here, coronary angiography and percutaneous coronary intervention is performed. Consequently, local hospitals may be bypassed in the treatment chain, generating differences in case mix, and making the treatment chain model difficult to interpret. We aimed to compare the treatment chain model with an alternative based on patients' place of living.

Methods: Between 2013 and 2015, a total of 3,155 patients were registered in the Norwegian Patient Registry database. All patients were categorized according to their local hospital's catchment area. The method of Guo-Romano, with an indifference interval of 0.02, was used to test whether a hospital was an outlier or not. We adjusted for age, sex, comorbidity, and number of prior hospitalizations.

Conclusions: We revealed the 30-day AMI survival figure ranging between 88.0% and 93.5% (absolute difference 5.5%) using the hospital catchment method. The treatment chain rate ranged between 86.0% and 94.0% (absolute difference 8.0%). The latter figure is the one published as the National Quality of Care Measure in Norway. Local hospitals may get negative attention even though their catchment area is well served. We recommend the hospital catchment method as the first choice when measuring equality of care.

Keywords: Myocardial infarction, Norway, Quality, Survival

Introduction

Hospital performance is compared based on quality of care measures (1-3). This is also the case in the treatment of acute myocardial infarction (AMI), where 30-day survival is the main outcome measure (1-3). In Norway, the National Institute for Public Health (NIPH) publishes this indicator annually. As "mortality" is perceived as a negative framing, the 30-day survival probability has been the routinely reported quality indicator (3). This is in contrast to the majority of other quality indicator systems (4).

It is difficult to make reliable quality measures on a hospital level as many patients are transferred between hospitals during treatment. Different treatments are provided at various hospitals, and case-mix varies between hospitals (5). Similarly, interhospital transfer or lack of such transfers may alter the results (1-2, 6-8). Consequently, benchmarking approaches may not provide full insight into the real quality of care.

Patient organizations, healthcare owners, patients, relatives, clinicians, politicians, and media have raised concerns about equal outcome expectations for AMI patients, independent of their place of living. In this situation, robust quality of care measures are mandatory. In our region, it has been debated whether the treatment chain model is

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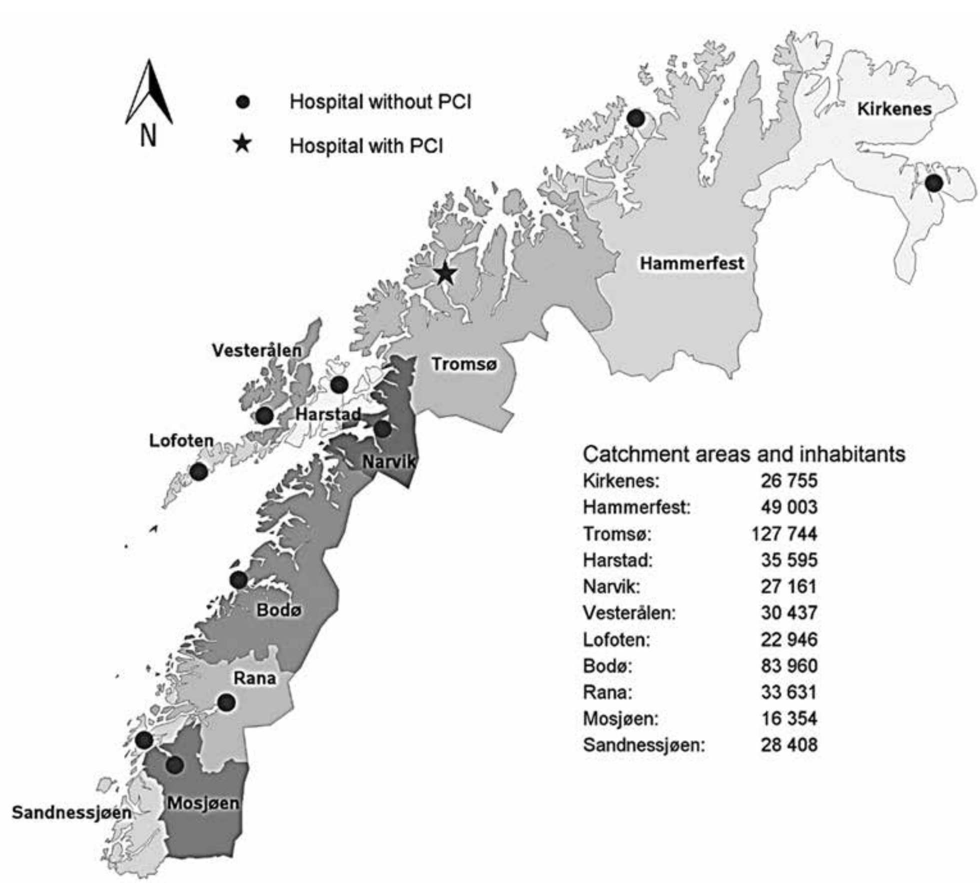

Fig. 1 - The map shows northern Norway, the catchment areas for the 11 somatic hospitals, and the location of the 11 somatic hospitals in the region.

reliable. An alternative way of calculation is according to hospital catchment area. In this study, we examined the two alternatives.

Methods

Institutions and patients

Northern Norway has 9.4% (0.5 million) of the total Norwegian population (5.2 million), and people are scattered within an area of 112,946 km^2. To serve the population, the Northern Norway Regional Health Authority (NNRHA) Trust runs 11 somatic hospitals on the mainland. They are organized in four hospital trusts. Their names, locations, and catchment areas are shown in Figure 1 and Table I. The Regional Coronary Angiography (CAG) and Percutaneous Coronary Intervention (PCI) Centre is located in Tromsø.

The Norwegian Patient Registry (NPR) enables patients to be tracked from one stay to another, thus allowing identification of transfer between hospitals. All hospitals must submit data to the NPR for registry and reimbursement purposes. In this study, all patients admitted to any of the somatic hospitals in northern Norway between January 1, 2013 and December 31, 2015 with AMI (ICD-10 I21/I22) for the first time (defined as no prior AMI during the previous 7 years) were included in the study. Patients transferred between hospitals were registered at each hospital, and consequently, the total treatment chain could be monitored.

We conducted a retrospective cohort study calculating the 30-day survival, employing both the hospital catchment area model and the treatment chain method. In the NPR database 3,155 patients were detected; the mean age was 69 years; one-third were female; and the mean hospital stay was 7.2 days. The PCI center had the shortest mean hospital stay (6.1 days), and Rana and Hammerfest the longest ones (8.1 days). Except for the PCI center, Hammerfest Hospital had the lowest percentage treated at more than 1 hospital (55.7%) and the lowest percentage (80.3%) of patients with Charlson comorbidity index of 0 points. Vesterålen Hospital had the oldest patients (mean age 72.4 years) and Kirkenes Hospital the youngest ones (mean age 67.9 years). Details are shown in Table I.

Treatment chain model

In the “treatment chain method,” data were accessed from the NPR database and combined with data from the Cause of Death Registry. Only first time AMI was included and day 1 was the first day of hospitalization (for AMI) at the first hospital in the treatment chain. The individual AMI patients’ stays at the various units and hospitals were aggregated into a treatment chain. A new chain was initiated when the time from discharge and rehospitalization was more than 8 hours. Each hospital was given their “weight” based on the number of days (of the total treatment chain) the patients stayed at the hospital. The 30-day survival result of each hospital (treatment chain model) was analyzed according to the national

TABLE I - Patient characteristics according to hospitals and hospital trusts

	Northern Norway	Helgeland Hospital Trust			Nordland Hospital Trust			University Hospital of North-Norway Trust			Finnmark Hospital Trust	
Variables	Total	Rana	Sandnessjøen	Mosjøen	Bodø	Lofoten	Vesterålen	Tromsø	Harstad	Narvik	Kirkenes	Hammerfest
No. of pts.	3155	217	207	117	585	167	216	638	231	173	182	422
Deaths ≤30 days(%)	259 (8.2%)	32 (14.7%)	15 (7.2%)	9 (7.7%)	46 (7.9%)	17 (10.2%)	35 (16.2%)	30 (4.7%)	14 (6.1%)	19 (11.0%)	14 (7.7%)	28 (6.6%)
Mean hospital stay(days)	7.2	8.1	7.1	7.7	7.9	6.8	6.8	6.1	7.4	6.5	7.3	8.1
Treated at >1 hospital	1738 (55.1%)	155 (71.4%)	166 (80.2%)	91 (77.8%)	422 (72.1%)	106 (63.5%)	133 (61.6%)	25 (3.9%)	175 (75.8%)	117 (67.6%)	113 (62.1%)	235 (55.7%)
Females	1045 (33.1%)	62 (28.6%)	58 (28.0%)	39 (33.3%)	225 (38.5%)	68 (40.7%)	86 (39.8%)	189 (29.6%)	70 (30.3%)	64 (37.0%)	49 (26.9%)	135 (32.0%)
Mean age(yrs)	69.3	69.1	70.2	69.1	69.4	71.9	72.4	67.7	68.8	71.1	67.9	69.1
18-49 yrs	266 (8.4%)	24 (11.1%)	12 (5.8%)	10 (8.5%)	49 (8.4%)	13 (7.8%)	18 (8.3%)	53 (8.3%)	15 (6.5%)	10 (5.8%)	20 (11.0%)	42 (10%)
50-75 yrs	1761 (55.8%)	114 (52.5%)	116 (56.0%)	65 (55.6%)	333 (56.9%)	74 (44.3%)	104 (48.1%)	397 (62.2%)	139 (60.2%)	94 (54.3%)	97 (53.3%)	228 (54.0%)
>75 yrs	1126 (35.7%)	79 (36.4%)	79 (38.2%)	42 (35.9%)	202 (34.5%)	79 (47.3%)	94 (43.5%)	188 (29.5%)	77 (33.3%)	69 (39.9%)	65 (35.7%)	152 (36.0%)
Mean no. of prior hosp.	1.6	1.2	1.4	1.3	2.2	1.7	3.5	1.1	1.1	1.2	2	1.5
0	1743 (55.2%)	129 (59.4%)	123 (59.4%)	69 (59.0%)	324 (55.4%)	77 (46.1%)	110 (50.9%)	364 (57.1%)	132 (57.1%)	99 (57.2%)	105 (57.7%)	211 (50.0%)
1	607 (19.2%)	43 (19.8%)	31 (15.0%)	21 (17.9%)	117 (20.0%)	37 (22.2%)	46 (21.3%)	128 (20.1%)	44 (19.0%)	31 (17.9%)	31 (17.0%)	78 (18.5%)
2	323 (10.2%)	19 (8.8%)	19 (9.2%)	9 (7.7%)	53 (9.1%)	17 (10.2%)	29 (13.4%)	63 (9.9%)	28 (12.1%)	16 (9.2%)	16 (8.8%)	54 (12.8%)
3-5	320 (10.1%)	13 (6.0%)	22 (10.6%)	12 (10.3%)	60 (10.3%)	23 (13.8%)	16 (7.4%)	64 (10.0%)	18 (7.8%)	19 (11.0%)	20 (11.0%)	53 (12.6%)
6+	162 (5.1%)	13 (6.0%)	12 (5.8%)	6 (5.1%)	31 (5.3%)	13 (7.8%)	15 (6.9%)	19 (3.0%)	9 (3.9%)	8 (4.6%)	10 (5.5%)	26 (6.2%)
Charlson index, mean	0.4	0.5	0.4	0.3	0.4	0.5	0.5	0.3	0.4	0.4	0.4	0.5
0 point	2628 (83.3%)	181 (83.4%)	173 (83.6%)	102 (87.2%)	482 (82.4%)	135 (80.8%)	175 (81.0%)	556 (87.1%)	193 (83.5%)	142 (82.1%)	150 (82.4%)	339 (80.3%)
1 point	178 (5.6%)	10 (4.6%)	12 (5.8%)	5 (4.3%)	35 (6.0%)	13 (7.8%)	14 (6.5%)	29 (4.5%)	14 (6.1%)	9 (5.2%)	12 (6.6%)	25 (5.9%)
2 points	196 (6.2%)	10 (4.6%)	13 (6.3%)	6 (5.1%)	41 (7.0%)	9 (5.4%)	14 (6,5%)	35 (5.5%)	11 (4.8%)	13 (7.5%)	10 (5.5%)	34 (8.1%)
3+ points	153 (4.8%)	16 (7.4%)	9 (4.3%)	4 (3.4%)	27 (4.6%)	10 (6.0%)	13 (6.0%)	18 (2.8%)	13 (5.6%)	9 (5.2%)	10 (5.5%)	24 (5.7%)

hosp. = hospitalization; no. = numbers; pts. = patients; yrs = years.

standard method (9, 10). This method adjusted for patient composition and transferring between hospitals. Patient composition was adjusted for age, sex, comorbidity (Charlson comorbidity index) and prior hospitalizations (during the last 7 years) employing the false discovery rate (FDR). The patients were followed for 30 days.

Hospital catchment area model

The 30-day survival was also calculated for each hospital's catchment area, based on patients' place of living and independently of where the patients had been treated. The catchment area was defined as the geographically defined region from which patients attending a hospital were drawn. The defined catchment area was given by the NNRHA Trust (Fig. 1). Data were accessed from the NPR database and were combined with data from the Cause of Death Registry. We adjusted for differences in age, sex, comorbidity and prior hospitalizations, employing the FDR.

Statistics and authorizations

Each record in the NPR database contained information from a single ward admission, and the same patient could have several records during transferals between wards and hospitals. The NPR data comprised an encrypted PIN for NIPH, admission category, diagnosis codes, codes for medical procedures, age, gender, date and time for ward admission/discharge, and postal codes. The encrypted PIN enabled the possibility to track patients between hospitals and link hospitalizations throughout the data collection period. NPR performed the quality assurance of the data, including linking to the National Registry. Except for Tonya Moen Hansen, none of the researchers had access to the identifiable patient database.

For both alternatives, adjusted mortalities were estimated by logistic regression. The analyses included age, sex, comorbidity (11, 12), and the number of prior hospitalizations (3). The method of Guo-Romano with an indifference interval of 0.02 was used to test whether a hospital was an outlier or not (13). Details are shown in Table I.

In the hospital chain model, the treatment chains of all patients were aggregated for each year, plus the 2013-2015 period, and the corresponding weight of each hospital was calculated.

The study was performed as a quality of care analysis. Consequently, no ethical committee, data inspectorate, nor Norwegian Social Science Data Services (NSD) approval was required.

Results

The analysis employing the treatment chain model revealed significant variations in 30-day survival between hospitals (86.0%-94.0%). Whereas 3 hospitals (Narvik, Vesterålen, Rana) had a significantly inferior 30-day survival, Tromsø (with the PCI center) experienced a superior survival (Tab. II).

In the hospital catchment area model, the variation in survival rate ranged from 88.0% to 93.5%. In this model, only 2 catchment areas had statistically significant inferior results (Vesterålen, Rana), and no catchment area experienced a significantly better survival. Consequently, the differences between hospitals were reduced when the hospital catchment care method was employed. Details are given in Table II.

Both hospitals (Rana and Vesterålen), having inferior results in both models, also had the worst absolute death rates (14.7% and 16.2%). Details are shown in Table I.

TABLE II - The 30-day survival rate (2013-2015) following hospitalization for first time acute myocardial infarction according to the treatment chain model and the hospital catchment area model

	30-day survival* – treatment chain model		**30-day survival* – hospital catchment model**	
Local hospital	**30-day survival**	**FDR**	**30-day survival**	**FDR**
Reference	91.8	NA	91.7	NA
Hammerfest	92.6	0.301	92.7	0.315
Kirkenes	90.9	0.307	91.7	0.465
Tromsø	94.0	0.008#	93.5	0.058
Harstad	91.4	0.472	92.8	0.315
Narvik	89.9	0.147#	91.0	0.427
Vesterålen	87.0	0.003#	88.6	0.010#
Lofoten	90.5	0.231	91.7	0.465
Bodø	91.5	0.496	92.2	0.427
Rana	86.0	0.002#	88.0	0.006#
Mosjøen	90.9	0.307	91.8	0.465
Sandnessjøen	91.4	0.472	92.3	0.431

Data were adjusted for differences in age, sex, comorbidity, prior hospitalizations, and FDR.
FDR = false discovery rate.
* Adjusted for age, sex, comorbidity, and number of prior hospitalizations.
# FDR. Method Guo-Romano with a 0.02 indifference interval.

Discussion

We have shown a wider variation in 30-day survival between hospitals (treatment chain model) than between catchments areas (hospital catchment area model). However, is an absolute 2.5% difference (8.0% vs. 5.5%) between the 2 models statistically or clinically significant? Also, why do they give different results?

The different results were due to methodology. In the treatment chain model, the data of each patient were divided between the places of treatment, making it possible to calculate the probability of 30-day survival figure for each hospital. Consequently, delays in transfer (in extreme weather conditions, delay of air ambulance resources, prolonged in-hospital stay, etc.) deteriorated the hospital's results when the patient died. Similarly, when the patient was directly transported to the regional PCI center, the local hospital was not "rewarded" when the patient survived. However, in the hospital catchment model, the patient's place of living and their outcome was focused, and the number of hospitals in the treatment chain was irrelevant.

From a clinical view, the 2 methods just offer 2 ways of presenting data. However, the hospital's reputation may be affected. Today, the publicly available nationwide quality of care measure exposes healthcare workers and administrators to significant and unwarranted pressure. Despite a quality indicator, this only gives an indication of quality of care and not a direct measure of quality. However, this knowledge is often not present when media and politicians are "hunting for interesting front page news." In such a setting, an absolute 2.5% difference may be crucial to the individual hospital. Especially when significant differences are revealed or not (Tab. II). Consequently, it is important to continuously upgrade and improve the quality measures employed and explain their limitations. Despite adjusting for the participation of each hospital in the treatment chain model, it is difficult to avoid "unfair" results when comparing hospitals that mostly receive patients in the most acute and critical stage with those that receive far more patients who are fit to be transferred (3). Different subgroups of patients have different risk patterns, and the selection of patients may influence a hospital's treatment measure (14). There have been concerns that PCI hospitals, which accept a greater volume of high-risk ST-elevated AMI (STEMI) patients, may have their reported mortality rates adversely affected (15). However, it also can be argued that patients presenting to non-PCI hospitals may have an equally worst outcome due to the lack of facilities, treatment delays, delayed access to air ambulances, or simply a delay in specialist input.

In northern Norway, most patients were offered primary thrombolysis and secondary CAG and PCI when indicated (5). The goal was thrombolytic therapy within 30 minutes from the first medical contact. Similarly, patients with 90 minutes or less to revascularization were treated with primary PCI. Prior studies have indicated significant variations in quality of care, but the variations have improved (3, 10).

We do not know why the Rana and Vesterålen hospitals achieved inferior results, but several factors may be speculated. The city of Mo i Rana has been the most heavily industrialized city in northern Norway. During past decades, the Norwegian ironworks have caused significant pollution in the area and this may have resulted in more comorbidity among their cohort of AMI patients. However, this has not been confirmed, but Rana hospital had the highest percentage (7.4%) of patients with a Charlson comorbidity index of ≥3 in our study (16). Other causes also should be considered; for example, the use of prehospital thrombolysis, daily routines, the transmission of electrocardiograms, the competence among car ambulance personnel, and adherence to the European guideline program, which was approved for Norway by the Norwegian Cardiology Association (17, 18). A significantly inferior 30-day survival in hospitals that did not achieve an award for a high level of care has been documented (19). Smoking cessation has been another factor improving survival (20).

The quality of care measures for survival focus on short-term survival (30 days). Consequently, we do not know whether the inferior results may progress as times goes on. Bucholz and associates (21) concluded that patients admitted to high-performing hospitals had longer life expectancies than patients treated in low-performing hospitals. On average, patients treated at high-performing hospitals lived between 0.74 and 1.14 years longer. This survival benefit occurred during the first 30 days and persisted over the long term.

You et al (22) documented an inferior survival among indigenous people in the Northern Territory of Australia. We have a group of indigenous people in our region, known as the Sami. However, the 2 hospitals with inferior results (Rana and Vesterålen) do not have a higher concentration of Sami people than the other hospitals.

In northern Norway, the use of regular site visits at each hospital by a team of experienced cardiologists has been suggested as a tool to improve the quality of care and the survival rates. It may also broaden the local clinicians' experience. We argue that the discussion of regular reports on quality of care should be implemented as part of these visits. Similarly, the results of quality of care measures in cardiology, according to catchment areas, should be presented and discussed at meetings and conferences.

A proper diagnosis also may lead to a more customized treatment regime and, hopefully, improved results. Consequently, it is of importance that a common set of diagnostic tools is employed. Such an example is the definition of AMI given by the European Society of Cardiology task force (23). Harrison et al (24) disclosed that higher hospital AMI volumes was correlated with better adherence to the process of care measures, but not in-hospital mortality. Based on this study, we should focus on improved cooperation between hospitals.

Strengths and limitations

Our study has shown the benefit of a complete regional cohort study. The combination of data submission for registry and reimbursement assures complete registration.

When employing a retrospective study of observational data, the possibility of an unmeasured confounder cannot be ruled out. Furthermore, the hospital catchment model may be limited because patients may move. However, the trusts have to report data to the NPR every fourth month. The hospitals' electronic patient record system is connected to the

National Registry and is updated continuously. Finally, patients' addresses may also be updated during their hospital stay. Therefore, we argue that this is at least a minor limitation.

Patients staying abroad while having their first AMI will not be captured and adjusted for in this analysis. Unfortunately, we do not have any data that may elucidate this topic.

This study was based on data reported to the NPR. In this setting, the coding may be a "culprit." The quality of the diagnosing and coding of AMI at each hospital may obviously influence the results. Also, information of the severity of the disease was not available in the NPR data. Consequently, we could not consider the severity by making subanalyses of STEMI and non-STEMI.

Despite the uncertainties and weaknesses connected to the calculations, it is mandatory that quality of care measures are taken seriously by the hospital trusts and healthcare administrations. In Norway, a quality of care project (safety campaign) has been initiated (25).

Conclusions

We have indicated the hospital catchment area model a useful model when measuring 30-day survival. The treatment chain method has its advantages when the aim is to measure the performance of individual hospitals, but this is more difficult to interpret due to patient selection. We suggest the hospital catchment area method employed when equality of care is considered.

Disclosures

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