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Natural history of acute coronary heart attacks
A community study

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Over a one-year period, 1858 episodes of suspected acute heart attack occurring in the Edinburgh population under the age of 70 were documented from a notification survey conducted by a special team in liaison with general practitioners, hospitals, and police surgeons.

The overall annual incidence of episodes of acute heart attack in the population aged 40 to 69 years was 1·5 per cent for men and 0·5 per cent for women: for first attacks it was 0·7 per cent for men and 0·2 per cent for women.

The high early death rate outside hospital is emphasized. Of all deaths occurring within the first 4 weeks, 73 per cent took place outside hospital and 45 per cent occurred within one hour of the onset of the acute attack. In men 23 per cent and in women 28 per cent of first attacks presented as medically unattended deaths.

Data are presented comparing mortality at home and in hospital, and the difficulties of making valid comparisons are stressed. General practitioners selected with a high level of accuracy the group with the largest proportion of myocardial infarction for hospital care.

For patients referred to hospital, the median time from the onset of the acute attack to sending for medical aid was 1 hour 30 minutes and to arrival in hospital was 5 hours 23 minutes. A detailed account of these delays is given.

While epidemiological studies have made a major contribution to knowledge about some of the causes of coronary heart disease, the natural history of acute heart attacks is still obscure. Though it is now known that efficient intensive care can prevent some early deaths in those surviving long enough to reach hospital (Lawrie *et al.*, 1967), further advances must depend upon a better understanding of this natural history. In order to obtain information about the sequence of events immediately after such attacks, an attempt was made to record data about every acute coronary heart attack in the city of Edinburgh over a period of one year. The preliminary findings have already been reported (Fulton, Julian, and Oliver, 1969) and this definitive report sets out 'to complete the clinical picture' (Morris, 1964) of acute heart attacks and thus to provide a factual basis for considering improvements in the service provided; in addition, the study is seen as a pilot investigation of how to set up a Register in this important condition.

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Background to study

The setting of the study is a city with a total population of approximately 500,000 persons, in a country with a very high death rate from ischaemic heart disease (World Health Organization, 1967). The medical services are organized in a comprehensive National Health Service; virtually all the inhabitants are registered with a general practitioner and, even in an emergency, most patients will contact their general practitioner rather than the hospital. There are two major hospitals, both teaching hospitals with coronary care units, and nine other hospitals which admit acute medical emergencies. Simple routine information is available about every patient discharged from hospital through the Scottish Hospital In-Patient Enquiry. All death certificates pass through the hands of

the City's Medical Officer of Health and all deaths of persons not being attended by a doctor are reported to the police surgeon.

Method

Notification system The study was based on notification by general practitioners of every patient in whom an acute coronary heart attack was suspected. Notification was made by telephone to the Study Office at any time of the day or night, calls being recorded by Robophone out of office hours. At the time of notification the general practitioner completed a short and simple questionnaire recording the findings of his clinical examination. If the patient was to be admitted to hospital the general practitioner's responsibility ended then (except for providing follow-up information six months later). The study team obtained further clinical details from the hospital doctor and the case notes, and basic demographic and social data from the patient; information about the times at which events occurred was also recorded. If the patient was kept at home a doctor from the team visited the patient, usually within 12 hours, recorded an electrocardiogram, withdrew blood for serum enzyme measurement, and obtained demographic, social, and timing information. The general practitioner was informed by telephone of the interpretation of the electrocardiogram and the results of serum enzyme tests. He was asked to record further brief clinical details of the patient's progress between the 2nd and 4th days. No attempt was made to influence the practitioner's decision about the management of the case.

General practitioners also notified cases of medically unattended deaths in their practices; further notification of all such deaths in the city believed to be due to a coronary heart attack came from the police surgeon.

Two modifications were made to the concept of registering *all* cases. First, registration was restricted to patients under the age of 70. Second, available medical staff resources were not thought to be sufficient to cover the necessary home visits to the patients of all general practitioners in Edinburgh. Accordingly, a sampling scheme was devised in which the sampling unit was the practice. Practices were divided into four groups; group I consisted of those who had previously taken part in co-operative studies or in the pilot study which preceded this investigation, irrespective of the size of practice; group II comprised all other single-handed practices, group III all other two-doctor practices, and group IV all other three-or more-doctor practices. All practitioners in groups I and IV and a 50 per cent random sample of the practices in each of the remaining groups were invited to join the study. One of the study team visited the practices of the 180 selected doctors and secured the co-operation of 171 (65% of the 263 general practitioners in Edinburgh). Each general practitioner took part for one year; for practical reasons their entry into the study was spread over a period so that the field work of the study lasted for 14 months.

All hospital patients who suffered an acute heart attack were registered, not just those who were patients of participating general practitioners. For this purpose, every acute medical unit in Edinburgh was visited regularly.

All patients were reviewed four weeks after the onset of the acute episode or on hospital discharge, if earlier. A final review by questionnaires addressed to the general practitioner and to the patient was conducted at six months. In this paper only deaths occurring within four weeks are considered.

To maintain interest among the general practitioners, a monthly newsletter about the progress of the study was sent to each of them. A system was devised to check the completeness of notification; the method and results are described in the Appendix.

Thus, all suspected acute heart attacks among the patients under 70 years of age in the practices of 65 per cent of the general practitioners in Edinburgh should have been notified. These notifications were requested for unattended deaths in the practice and for all patients seen alive, whether sent to hospital or kept at home. In addition, any patients from the practices not in the study who suffered an acute heart attack and either died unattended or were admitted to any hospital were documented. The only group of cases not notified were those managed solely at home by the non-participating general practitioners, i.e. by a random half of group II and group III practices. On the assumption that the behaviour of these doctors was similar to the random half recruited to the study in these groups, calculations of the number and characteristics of their presumed home cases were made. The addition of these expected numbers allows estimated numbers and rates for the whole City of Edinburgh to be given in Part I of the results.

Definition of criteria for acute coronary heart attacks The intention of this study was to document the occurrence of every acute coronary heart attack. The criteria for inclusion in any one of the diagnostic categories to be registered were as follows:

A: Patients seen alive

1) *Myocardial infarction* The presence, on the initial electrocardiogram, of pathological Q waves, or inversion of T waves or bundle-branch block pattern or ST depression of more than 1 mm accompanied by abnormally high level(s) of the appropriate serum enzyme(s); *or* the observed development of pathological Q waves, or the evolution of an injury current on serial 12-lead electrocardiograms; *or* the occurrence of a typical history of prolonged chest pain without diagnostic electrocardiographic evidence of recent infarction but with abnormal serum enzyme level(s); *or* postmortem evidence of recent cardiac inafrction or recent coronary occlusion.

2) *Myocardial ischaemia* (ischaemia) A typical history of prolonged chest pain with normal serum

enzyme levels and a normal electrocardiogram, or electrocardiographic signs of myocardial ischaemia or of a previous myocardial infarction.

3) *Insufficient data* A typical history of prolonged chest pain where for various reasons, most often death of the patient shortly after notification, data were not available to permit allocation into one of the other categories.

Categories 2 and 3 are both indefinite but had to be included if the study was to be comprehensive. The category of 'ischaemia' was unsatisfactory since it relied almost entirely on the history. It is likely that a number of episodes classified as myocardial ischaemia were due either to myocardial infarction with insufficient cell death to change the electrocardiographic pattern or raise the serum enzyme levels, or were other conditions wrongly diagnosed because of a previous history of acute coronary disease. The 'insufficient data' group was particularly important because it included a high proportion of early deaths.

B: Medically unattended deaths

(Those who died, usually suddenly and unexpectedly, before or immediately on the arrival of a doctor)

1) *Acute coronary disease* Postmortem evidence of recent myocardial infarction or recent coronary occlusion.

2) *Probable acute coronary disease* No postmortem evidence but a previous history of coronary heart disease; *or* the occurrence of chest pain immediately preceding death.

3) *Doubtful acute coronary disease* No postmortem evidence, no other cause apparent.

Unfortunately, the very small proportion (6·4%) of these deaths that were followed by necropsy meant that most could only be allocated to categories 2 or 3.

Results using estimated numbers and rates

Episodes During the year of study, 1858 episodes of suspected acute heart attack occurring in the resident population of Edinburgh aged under 70 years were documented and studied. Medically unattended deaths registered as due to heart attacks accounted for 342 of these episodes; 1516 occurred among patients who survived long enough to come under medical care. Among these 1516 episodes, 212 were found to have other diagnoses and did not fulfil the criteria of an acute heart attack. The remaining 1304 were the observed episodes and do not, by definition, include the cases treated at home by those general practitioners not participating in the study. Using the methods described earlier, it was calculated that 63 episodes would have occurred in those practices, giving an estimated total of 1367 episodes in which the patient was seen alive by a doctor.

Appendix Table A presents details of all episodes accepted as heart attacks during the year, classified by sex, age, and diagnosis. The Table includes episode rates calculated by using the mid-1967 estimated population of Edinburgh.

Diagnosis The distribution by diagnosis of the estimated total of 1367 episodes among live patients and the 342 unattended deaths are shown in Tables 1A and 1B. Overall, 20 per cent of attacks in men and 19 per cent in women presented as medically unattended deaths.

The small proportion (4·4%) of definite diagnoses of acute coronary heart disease shown in Table 1B reflects the very low necropsy rate among medically unattended deaths. The category of 'doubtful acute coronary disease' consists of cases with neither a necropsy nor a history of previous coronary disease and must contain an unknown number of cases of other disease. While this category must be included in the various analyses, it should be treated with particular caution.

There is a difference between the sexes in the 'live' episodes classified in Table 1A, with women showing a lower proportion of myocardial infarction and a higher proportion of ischaemia. Table 1B shows that about half of all medically unattended deaths in women were classified as 'doubtful' compared with one-third among men. Thus, both in patients

TABLE 1 *Distribution of diagnostic categories by sex: estimated numbers*

	Men		*Women*		*Both sexes*	
	No.	%	*No.*	%	*No.*	%
A: Episodes among patients coming under medical care						
Myocardial infarction	638	65·8	224	56·4	862	63·0
Ischaemia	268	27·6	143	36·0	411	30·1
Insufficient data	64	6·6	30	7·6	94	6·9
Total	970	100·0	397	100·0	1367	100·0
B: Medically unattended deaths						
Acute coronary disease	11	4·4	4	4·3	15	4·4
Probable acute coronary disease	156	62·9	44	46·8	200	58·5
Doubtful acute coronary disease	81	32·7	46	48·9	127	37·1
Total	248	100·0	94	100·0	342	100·0

TABLE 2 *First (incidence) and subsequent attack rates for all acute heart attacks among men and women aged 40–69 years: rates per thousand based on estimated numbers*

	Men	*Women*	*Both sexes*
First attack (incidence)	7·0	2·2	4·4
Subsequent attacks (previous history of coronary heart disease)	8·4	2·9	5·4
All attacks	15·5	5·1	9·8

TABLE 3 *Proportion of first attacks presenting as unattended death: based on estimated numbers*

	Percentages in age groups			
	20–49 yr	*50–59 yr*	*60–69 yr*	*20–69 yr*
Men	23·7	18·8	27·1	23·1
Women	10·7	21·1	36·5	28·0
Both sexes	21·1	19·4	30·4	24·5

registered alive and in unattended deaths, the diagnostic category of heart attack appears to be less definite among women.

Incidence and attack rates Using information about previous history, subjects can be identified whose acute heart attack was the first manifestation of coronary heart disease; the numbers and rates are presented in Appendix Table B. The overall annual incidence rate among Edinburgh residents aged 40 to 69 years, illustrated in Table 2, is estimated to be 15·5 per 1000 for men and 5·1 per 1000 for women. (Table 2 summarizes data from Appendix Tables B and C to show incidence and attack rates by sex in the age group 40 to 69 years.)

The proportion of first heart attacks presenting as 'medically unattended death' is given by sex and age in Table 3. The overall proportion is slightly higher among women than men and the behaviour with age differs in the two sexes. In both sexes, a slightly higher proportion of first heart attacks presents as a medically unattended death than occurs among subsequent attacks (men 23% compared to 18%, $P<0.05$; women 25% compared to 12%, $P<0.01$).[1]

Deaths within four weeks An observed total of 548 deaths occurred within four weeks of the onset of acute symptoms; 342 of those were medically unattended deaths and 206 were among patients who had come under medical care. Allowing for deaths at home in the patients of practices not included in the study, an estimated total of 217 deaths occurred among patients seen by a doctor. Appendix Table C records these deaths by sex, age, and diagnostic category and includes episode fatality ratios. Fatality ratios are similar in the two sexes and in both sexes they show a sharp rise with age. The addition of medically unattended deaths allows the calculation of overall fatality ratios for acute heart attacks in Edinburgh. These ratios are, of course, much higher than the usual figures presented for hospital admissions only.

Table 4 presents the proportions of all deaths, whether in a first or subsequent attack, which were medically unattended. In both sexes, 61 per cent of all deaths were unattended; there is a suggestion that the proportion is highest in the youngest age group, though this is not statistically significant.

Calculated from Appendix Tables B and C.

TABLE 4 *Proportion of all deaths within 4 weeks which were medically unattended: by sex and age, based on estimated numbers*

Age group (yr)	*Men (%)*	*Women (%)*	*Both sexes (%)*
20–49	71·2	60·0	69·4
50–59	63·8	62·9	63·6
60–69	59·3	56·4	58·3
20–69	62·5	58·0	61·2

TABLE 5 *Acute heart attacks coming under medical care: place of initial care, based on estimated numbers*

	*Home**	*Hospital*		*Died† en route*	*Total*
		Conventional	*Coronary care*		
Myocardial infarction					
Numbers	133 (63)	342	380	7	862
Percentages	15·4 (7·3)	39·7	44·1	0·8	100·0
Insufficient data					
Numbers	48 (1)	23	7	16	94
Percentages	51·1 (1·1)	24·5	7·4	17·0	100·0
Ischaemia					
Numbers	166 (27)	130	115	—	411
Percentages	40·4 (6·6)	31·6	28·0	—	100·0
Total					
Numbers	347 (91)	495	502	23	1367
Percentages	25·4 (6·7)	36·2	36·7	1·7	100·0

* Numbers and percentages in brackets refer to those subsequently sent to hospital
† These patients died after being seen by a doctor but before being admitted to hospital.

Place of care During the period of study there were two fully operational coronary care units in Edinburgh – one a six-roomed unit in the Royal Infirmary admitting male and female patients under the age of 70 years, if the onset of acute symptoms is within the previous 48 hours; the other a four-bedded ward at the Western General Hospital equipped for continuous monitoring, admission being limited almost exclusively to male patients under 70 years.

Using estimated numbers for episodes treated at home, the overall numbers of episodes among patients registered alive are set out in Table 5 according to place of care and diagnosis. General practitioners undertook the domiciliary care of one-quarter of all episodes but later sent just over a quarter of these patients (episodes) to hospital (91 out of 347). Thus four-fifths of all episodes were finally treated in hospital, with almost equal numbers in conventional and in coronary care. In the two main diagnostic groups, 91 per cent of episodes with a final diagnosis of myocardial infarction and 66 per cent of those diagnosed as myocardial ischaemia were admitted to hospital.

Considering all episodes, including medically unattended deaths, 64 per cent of all episodes of acute heart attacks were treated in hospital. However, only 27 per cent (153) of the 559 persons who died within four weeks were treated in hospital. The hospital picture of this condition is therefore a very incomplete one; the rapidly fatal episodes are not usually seen there.

Findings based on observed cases

This section is concerned only with observed episodes, and estimates of the total numbers occurring in Edinburgh will not be used.

Diagnosis and place of care of episodes among patients seen by participating general practitioners In one year, 1073 episodes of suspected acute heart attack were seen by participating general practitioners. Though 182 of these did not fulfil the diagnostic criteria for inclusion in the study, they are included in the analysis set out in Table 6. This Table relates the place of care to the general practitioner's provisional diagnosis and to the final diagnosis arrived at after investigation.

In Table 6, the provisional diagnosis headed 'other' refers to episodes which the general practitioner thought were probably not acute heart attacks but in which this was a possibility; the 'no diagnosis recorded' group consists either of those episodes notified as an acute heart attack with no further diagnostic detail or of those picked up by the checking system. A final diagnosis of 'other' refers to episodes that were finally diagnosed as a condition other than an acute heart attack. No final diagnosis was made in a small proportion of episodes.

The practitioner's diagnosis of suspected acute heart attack was confirmed (final diagnosis myocardial infarction or ischaemia) in 891 episodes (83%). In 779 episodes the practitioner specifically diagnosed myocardial infarction or ischaemia and this was confirmed in 662 episodes (85%).

Just over two-thirds (68·9%) of all episodes were immediately referred to hospital; the remainder were kept at home in the first instance, but nearly a quarter of these (23·6%) were subsequently admitted to hospital. Positive results from the domiciliary electrocardiographic and serum enzyme service were responsible for a considerable proportion of these later admissions. The highest proportion of hospital referrals occurs in the 'no

TABLE 6 *Place of initial care in relation to general practitioner's provisional diagnosis and to final diagnosis, for episodes in patients seen by participating general practitioners*

	General practitioner's provisional diagnosis				
	Myocardial infarction	*Ischaemia*	*'Other'*	*No diagnosis recorded*	*Total*
No. of episodes referred to hospital	473	69	29	168	739
Per cent of hospital episodes with final diagnosis:					
1) Myocardial infarction (or insufficient data)	65·8	47·8	62·1	61·3	62·9
2) Ischaemia	19·7	36·2	3·4	24·4	21·7
3) 'Other'	13·7	14·5	34·5	13·7	14·6
4) No diagnosis	0·8	1·5	—	0·6	0·8
Number of episodes retained at home	129	108	54	43	334
Per cent of home episodes with final diagnosis:					
1) Myocardial infarction (or insufficient data)	45·0	32·4	29·6	65·1	41·0
2) Ischaemia	34·9	57·4	29·6	14·0	38·6
3) 'Other'	17·0	6·5	37·0	14·0	16·5
4) No diagnosis	3·1	3·7	3·7	7·0	3·9

diagnosis recorded' group; within the three groups given a diagnostic label, the proportion falls steadily from 'myocardial infarction' to 'other'. These findings suggest that the practitioner's policy of referral is strongly influenced by his initial diagnosis.

However, the data as presented in Table 6 illustrate that factors other than the provisional diagnosis must influence the practitioner's decision as to management. This is most clearly seen in episodes with a provisional diagnosis of 'ischaemia' and 'other'. In the 'ischaemia' group 47·8 per cent of episodes referred to hospital had a final diagnosis of myocardial infarction or insufficient data compared to 32·4 per cent in those retained at home, and this difference is even more striking where the provisional diagnosis was 'other' – 62·1 per cent of hospital episodes having a final diagnosis of myocardial infarction (or insufficient data) compared to 29·6 per cent of domiciliary episodes. In fact general practitioners were accurately selecting from those episodes which they considered to be 'ischaemia' or to have some other diagnosis, a group for hospital care, which contained a higher proportion of myocardial infarction than those whom they retained at home.

Fatality and place of care among patients of survey general practitioners During the year, 999 episodes which fulfilled the criteria of acute heart attacks occurred in the practices of general practitioners in the study. Fatality ratios according to place of care are now presented for these episodes.

Table 7 presents fatality ratios among patients treated wholly at home, those initially treated at home and then sent to hospital, and those sent to hospital at once either by a general practitioner or directly without seeing the general practitioner. These comparisons must be treated with great caution. For example, the apparently much better outcome among patients with a diagnosis of myocardial infarction treated at home (1·9% compared to 15·4% among those referred to hospital) is influenced by three major factors: (1) The home treated patient in this category had already survived the most dangerous period by the time the visiting team had established the diagnosis. (2) This group has had 51 patients removed from it who were later transferred to hospital – these 51 had a comparatively high fatality ratio (17·6%) considering the time that must have elapsed since their infarction. (3) A higher proportion of patients kept at home (79·5%) showed no physical disturbance from their infarction compared to those admitted to hospital (67·1%).

If episodes characterized as 'insufficient data' are now added, the comparative fatality ratios are reversed, with home-treated patients showing a higher ratio than hospital-treated patients. But this comparison is now biased in the opposite direction, by including those patients who were seen by their general practitioners but died quickly before a full diagnostic assessment could be made. Some of these patients might easily have been unattended deaths but for the speed of the practitioners in reaching them.

A further comparison of fatality ratios can be made between patients initially admitted to coronary care units and those treated throughout in conventional hospital beds. Fatality ratios are almost identical (Table 8) in the two groups, but it must be remembered

TABLE 7 *Number of episodes, deaths, and episode fatality ratios in first four weeks by place of care, for episodes occurring in practices of participating general practitioners (number of deaths in brackets)*

	Home	*Home to hospital*	*Hospital**		*Total*
			Direct	*Referred*	
Myocardial infarction	54 (1)	51 (9)	87 (12)	441 (68)	633 (90)
Episode fatality ratio (%)	1·9	17·6	13·8	15·4	14·2
Insufficient data	32 (27)	1 (1)	6 (6)	12 (7)	51 (41)
Episode fatality ratio (%)	84·4	100·0	100·0	58·3	80·4
Myocardial infarction and insufficient data	86 (28)	52 (10)	93 (18)	453 (75)	684 (131)
Combined episode fatality ratio (%)	32·6	19·2	19·4	16·6	19·2
Ischaemia	107	22	27 (1)	159 (1)	315 (2)
Episode fatality ratio (%)	—	—	3·7	0·6	0·6

* Hospital cases exclude those who died en route.

that patients were not allocated at random to the different methods of care.

Deaths from acute heart attacks during survey year

Further details about deaths recorded in this survey are now presented.

Interval between onset and death During the year, all deaths due to acute coronary heart disease in the city were registered, with the exception of those occurring at home among patients of general practitioners not taking part in the survey. An observed total of 541 deaths occurred within four weeks of the onset of acute symptoms. This excludes the 7 deaths which occurred in the diagnostic category of ischaemia. Time intervals between onset and death are available for 422 of these deaths, and Table 9 sets out these intervals. Nearly half (45·5%) the deaths occurred within the first hour, but this percentage is probably an underestimate as most of the 119 deaths for which the interval was not known were unwitnessed and many were likely to have occurred suddenly or very early in the acute attack. As expected, 99% of medically unattended deaths occurred within 24 hours, compared to 43% of attended deaths.

TABLE 8 *Number of episodes, deaths, and episode fatality ratios in first four weeks in coronary care and conventional care, for episodes occurring in practices of participating general practitioners (number of deaths in brackets)*

	Conventional care	*Coronary care*	*Total*
Myocardial infarction	257 (41)	271 (39)	528 (80)
Episode fatality ratio (%)	16·0	14·4	15·2
Insufficient data	12 (7)	6 (6)	18 (13)
Episode fatality ratio (%)	58·3	100·0	72·2
Myocardial infarction and insufficient data	269 (48)	277 (45)	546 (93)
Episode fatality ratio (%)	17·8	16·2	17·0
Ischaemia	107 (1)	79 (1)	186 (2)
Episode fatality ratio (%)	0·9	1·3	1·1

The median[1] time interval from the onset of the acute attack to death was very similar in the two sexes for both unattended and attended deaths. However, the median for all male deaths was 1 hour 26 minutes and for female deaths 4 hours 41 minutes. This difference of over 3 hours in median times is simply due to the fact that a much higher proportion

[1] The median was considered to be the best single measurement of the intervals as the mean is not representative due to the skewed distributions.

TABLE 9 *Distribution of observed deaths within four weeks by time interval from onset of the acute attack*

	Men			*Women*			
	Cumulative % of unattended deaths	*Cumulative % of attended deaths*	*Cumulative % of all deaths in men*	*Cumulative % of unattended deaths*	*Cumulative % of attended deaths*	*Cumulative % of all deaths in women*	*Cumulative % of all deaths in both sexes*
<1 hr	78·5	6·0	47·8	80·9	6·6	38·9	45·5
<2 hr	84·6	9·8	52·9	87·3	9·9	43·5	50·5
<3 hr	89·6	10·6	56·1	91·6	13·2	47·2	53·8
<4 hr	94·0	12·9	59·6	91·6	14·8	48·1	56·6
<6 hr	96·2	18·9	63·4	95·9	21·4	53·7	60·9
<12 hr	99·0	31·7	70·4	98·0	31·2	60·2	67·8
<24 hr	99·5	43·7	75·8	98·0	42·7	66·7	73·5
<48 hr	99·5	58·0	81·9	100	55·8	75·0	80·1
<3 dy	100	62·5	84·1	100	60·7	77·8	82·5
<5 dy	100	67·8	86·3	100	68·9	82·4	85·3
<7 dy	100	70·8	87·6	100	72·2	84·3	86·7
<4 wk	100	100	100	100	100	100	100
Total known	181	133	314	47	61	108	422
Median interval for known cases	38 min	34 hr 34 min	1 hr 26 min	37 min	37 hr 22 min	4 hr 41 min	1 hr 54 min
Numbers not known	67	2	69	47	3	50	119

TABLE 10 *Place of death and time interval from onset of acute attack among medically attended and unattended deaths*

Place of death	*Attended deaths*			*Medically unattended deaths*				
	Time interval			*Time interval*				
	< 24 hr	*24 hr to < 4 wk*	*Not known*	*< 24 hr*	*24 hr to < 4 wk*	*Not known*	*All deaths*	*% of total*
Home	20	10	5	122	2	89	248	45·8
Work	—	—	—	23	—	4	27	5·0
Street	—	—	—	43	—	9	52	9·6
Ambulance	3	—	—	4	—	2	9	1·7
Arrival at hospital	14	1	—	1	—	—	16	2·8
Hospital	47	99	—	2	—	—	148	27·4
Other (hotel, friend's house, etc.)	—	—	—	31	—	10	41	7·8
Totals	84	110	5	226	2	114	541	100

of unattended deaths among men had a known time interval than among women.

Place and circumstance of death Table 10 records the place of death in relation to medical attendance and to occurrence within 24 hours of onset or longer. Nearly half of all deaths occurred at home, and just over a quarter in hospital. Even considering only the medically attended deaths, the high early death toll outside hospital is clear. Of 84 attended deaths occurring within 24 hours, 37 occurred among patients not yet admitted to hospital (44%). The majority of these deaths – 31 – were classified in the insufficient data category and neither survived for long enough to allow diagnostic assessment nor were brought to necropsy to confirm the diagnosis. In contrast, only 11 of the 110 attended deaths occurring after the first day took place outside hospital. Thus, most of the deaths (68%) which occurred in those who survived for long enough to reach a hospital bed took place after the first day of illness.

Most deaths occurred at home, at work, or in the street. Nine deaths were recorded as taking place in ambulances but it is uncertain how many of these patients were dead before being put in the ambulance. It is the custom in Edinburgh that if the patient is found to be dead when the ambulance arrives, the body is transported to hospital for confirmation of death unless the relatives wish to call the family doctor. The 16 deaths on arrival at hospital occurred at some time between reaching the reception area and being admitted to the ward or coronary care unit.

Thirty-five attended deaths occurred at home. Six occurred after being seen by a doctor but before the ambulance arrived. Twenty-eight occurred among patients for whom the general practitioner had not sought hospital admission: of these only 1 patient had received diagnostic assessment by the community study domiciliary service: the remaining 27 deaths occurred mainly within the first 24 hours, the clinical picture was often poorly established, and the diagnoses were for the most part retrospective. One death occurred after discharge from hospital.

The cause of death could not be established with certainty in the attended deaths occurring outside hospital except in the presence of severe cardiac failure or shock. However, in the 16 deaths which occurred on arrival at hospital the cause was ascertained in 14, all of whom died within 12 hours of the onset of acute symptoms – 6 suffered ventricular fibrillation, 4 asystole, 3 unspecified cardiac arrest, and 1 cardiogenic shock.

Time intervals after onset of symptoms At the beginning of the study only the intervals from the onset to the major events in the patient's progress to hospital were recorded. The advantages of recording the actual time of each event quickly became apparent, and this was done during the second six months of the study – from October 1967 to March 1968. This has permitted the intervals between events to be analysed and these have been reported in a preliminary way (Fulton *et al.*, 1969).

In Edinburgh the progress to hospital usually follows the steps indicated in Fig. 1 which illustrates the median intervals between events for episodes of acute heart attack referred to hospital by the general practitioner. Because these data were collected for only six months of the study, the numbers involved

are relatively small. Moreover, there were some gaps in the data so that numbers in the following sections are not consistent.

Onset of attack to sending for medical aid This interval was from the time of onset of the acute symptoms to the time the patient, or someone else, sent for the doctor. For patients subsequently referred to hospital, the median time for the 199 episodes for whom this time interval was known was 1 hour 30 minutes. In one case the call to the general practitioner was made after 48 hours and this has been excluded. This median value during the 24-hour day ranged from 2 hours 15 minutes when the onset occurred between midnight and 6 a.m., to 1 hour 17 minutes when the onset occurred between 6 a.m. and 12 noon. For 65 episodes treated at home this median interval was 2 hours 30 minutes and again 4 calls made after 48 hours have been excluded from the analysis.

Time interval between sending for medical aid and arrival of general practitioner For 194 episodes referred to hospital the median of this interval was 44 minutes. During the 24-hour day this value ranged from 31 minutes when the onset occurred between 6 p.m. and 12 midnight to 59 minutes when the onset was between 6 a.m. and 12 noon. For the 69 episodes treated at home the median interval was 1 hour 35 minutes.

Many factors must influence the speed at which the general practitioner visits: these include his availability, density of traffic, his knowledge of the patient's personality and previous history, and the urgency of the content of the message.

Time interval between arrival of general practitioner and contacting Emergency Bed Bureau A time interval with a median of 30 minutes occurred while the general practitioner made a clinical examination and contacted the Emergency Bed Bureau, which is responsible for arranging the admission of the patient and for summoning the ambulance.

Times of ambulance journeys The city of Edinburgh has an area of 54·4 square miles and can be described very approximately as a circle with a radius of 4 miles. The time taken by the ambulance to reach the patient after being summoned by the Emergency Bed Bureau was known for 211 patients and the median time was 20 minutes. For 279 patients for whom the time of the ambulance journey was known, 50% of journeys were achieved within 21 minutes and 91% within 30 minutes. No information was available about ambulance times where the patient or his relatives were responsible for calling the emergency ambulance service.

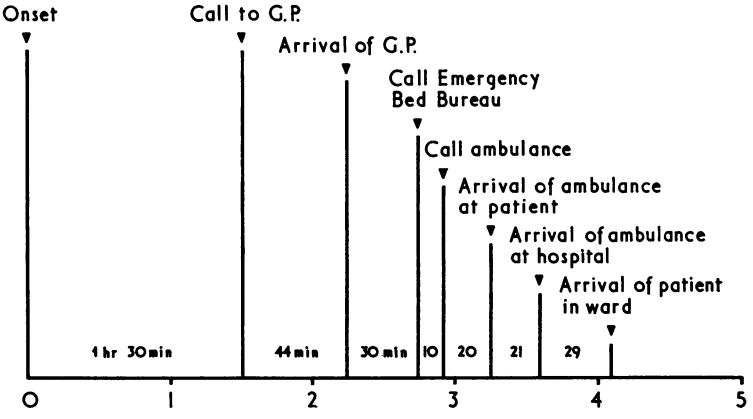
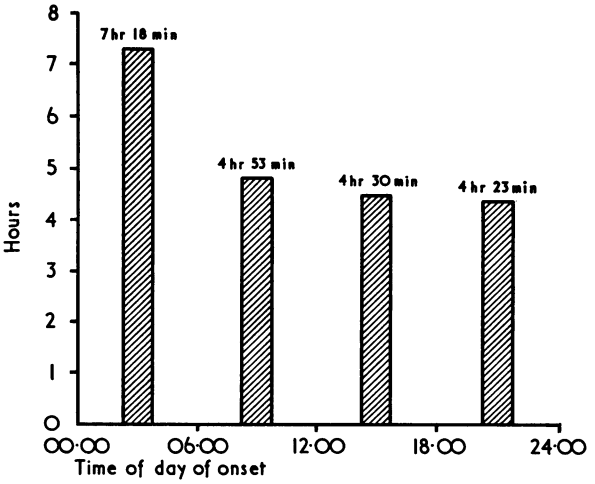


FIG. 1 *Median time intervals between events for episodes of acute heart attack referred to hospital by general practitioners.*

Interval between arrival at reception area of hospital and admission to ward or coronary care unit This time interval was known for 278 patients. Fifty per cent had been fully admitted by 29 minutes, 70 per cent by 45 minutes, and 99 per cent by 2 hours.

Direct admissions Not all patients admitted to hospital had been referred by the general practitioner. The time interval from the onset of the acute symptoms to hospital admission for those who came directly to hospital, omitting general practitioner con-

FIG. 2 *Comparative median time intervals between onset of the acute attack and hospital admission according to the time of day of onset.*[1]



[1] Time taken between midnight and 6 a.m. differs significantly from the other three intervals ($P < 0.01$).

tact, was known for 60 patients. The median of this interval was 2 hours 21 minutes, very much less than the 5 hours 23 minutes for the referred cases; the difference was significant ($P < 0.01$). Only one patient was admitted after 48 hours and has been excluded from the analysis. Seventy-seven per cent had been admitted within 4 hours and 83 per cent within 6 hours.

Time of day of onset of acute symptoms

The mode of admission, direct or referred, exerted the greatest influence on the interval from onset to hospital admission. There were also significant differences[1] in this interval when it was analysed according to the time of day at which the attack occurred, and these are illustrated in Fig. 2. By far the longest median interval of 7 hours 18 minutes occurred in the 73 episodes with an onset time between midnight and 6 a.m., and the shortest median interval of 4 hours 23 minutes was recorded for the 78 episodes with an onset between 6 p.m. and midnight. It is likely that those patients who become ill during the night are reluctant to disturb the doctor, and the finding that the median interval from the onset to calling the general practitioner was 2 hours 15 minutes when the onset occurred between midnight and 6 a.m. compared to that of 1 hour 23 minutes during the remaining 18 hours supports this contention.

Discussion

This study has shown that, in Edinburgh, only a comparatively small proportion of patients who suffer an acute heart attack, and survive long enough to be seen by a doctor, is treated at home by a general practitioner. However, when information about medically unattended deaths is included, it becomes apparent that the view of acute coronary heart attacks in hospital can be highly misleading. Thus the hospital episode fatality ratio for men and women aged 20 to 69 years was 13 per cent, whereas the overall fatality ratio, including unattended deaths, was 33 per cent. The major contribution to the high four-week mortality after an acute heart attack was made, in fact, by medically unattended deaths (62%). Sudden death, defined as death occurring within an hour of the onset of symptoms, whether medically attended or not, was responsible for at least 45 per cent of all deaths within the first four weeks. This figure is lower than that found in other studies (Fry, 1968), but it was pointed out earlier that it is almost certainly an underestimate.

[1] See footnote to Fig. 2.

The findings with regard to the high early mortality and the high proportion of deaths that occur outside hospital corroborate those of several other studies (Pell and D'Alonzo, 1964; McNeilly and Pemberton, 1968; Kuller, Lilienfeld, and Fisher, 1966). The consequence of these findings is important. Only 27 per cent (153) of the 559 persons who died within four weeks were treated in hospital. While hospital treatment, particularly where there are coronary care units, has probably already reduced the mortality among those who survive long enough to reach hospital, no expansion of resources within the hospital can do anything for those who die outside. If any further impact is to be made on overall mortality, then hospital personnel must direct their efforts to the community and work in close partnership with general practitioners and the ambulance service.

This study has also illustrated the difficulties of general practitioners. They are faced with the task of making the initial diagnosis, usually with no technical aids, and deciding at once whether or not to admit the patient to hospital. The accuracy of their diagnosis and the skill with which they have decided on appropriate care has been emphasized in this paper.

Comparisons of fatality ratios among patients treated at home and in hospital are fraught with difficulties. The overriding importance of the high mortality within the first few minutes of an attack, slowly falling over the next few hours, vitiates simple comparisons. Any doctor or institution seeing patients in the earliest stages will inevitably show a higher fatality ratio than one seeing patients who have already survived longer. The data presented in Table 7 are the product of a complicated process and cannot be used to imply that hospital admission makes no difference to outcome.

The attack rate (Table 2), for ages 40 to 69 years, among those with no previous history of coronary heart disease was 0·7 per cent in men and 0·2 per cent in women. It is difficult to compare these rates with those found in other studies because of different designs (incidence rates are usually obtained from cohort studies in which first occurrence is related to a population at risk known to have no evidence of coronary heart disease at the beginning of the study), different criteria for acute heart attacks, and different age groups. The 'incidence' rates reported here are lower than those reported from, for example, Framingham, and higher than those found among London busmen (Epstein, 1965).

Limitations of data The methods adopted permit the calculation of estimated attack rates in the population of Edinburgh, but certain limitations in the data should be mentioned.

1) Complete registration of *medically unattended deaths* attributed to acute coronary disease was achieved. However, the difficulties of obtaining accurate information about the previous medical history and about symptoms immediately before death for persons dying suddenly mean that these data were often incomplete. More important, the accuracy of diagnosis in this group is subject to considerable error. In a high proportion of cases (one-third) no supporting evidence for the diagnosis was available apart from the suddenness of death and the apparent absence of another cause. Though there are limits to the contribution of necropsy examination towards the accurate cause of death, especially in deaths occurring within the first few hours of the onset of symptoms (World Health Organization, 1970a), the very low necropsy rate in those cases referred to the procurator-fiscal has undoubtedly reduced the accuracy of classification of medically unattended deaths. This is a feature of Scotland's medico-legal system which is not at present amenable to change.

2) The data for *patients treated in hospital* are the 'hardest' in the study. A complete return of known episodes was achieved and the final diagnosis was based on full investigation. However, there were patients who died before diagnostic tests could be carried out and who were necessarily placed in the 'insufficient data' category.

3) Information about *patients treated at home* by the general practitioner was dependent upon notification of the case by the practitioner, and there was no direct way of ensuring that every relevant episode was notified. There must, therefore, remain some reservation about the completeness of the figures given for home-treated episodes. The standard of notification was fairly good among participating doctors with regard to referred hospital cases (75%), and it is reasonable to conclude that it was at least as good for those treated at home. The provision of domiciliary diagnostic services by the study personnel did provide an incentive to notify domiciliary episodes. Nevertheless, the diagnostic information was in general more limited, and diagnostic classification less precise, since, in the majority of such cases, only one electrocardiogram and one serum enzyme level were obtained.

Within these various limitations, the data obtained for attack rates, incidence, and mortality are probably a fair reflection of the pattern of clinical acute coronary disease in Edinburgh.

Prevention of early deaths in acute heart attacks An, as yet, unknown proportion of patients with acute heart attacks die instantaneously or after experiencing symptoms for such a short time that specialized medical aid could not be made available in time. Deaths of this kind can only be prevented if those at risk can be identified in advance and effective preventive treatment becomes available. Much research is now being devoted to the identification of such patients (Sidel, Acton, and Lown, 1969), but our concern here is with those who survive long enough to make help possible and the ways that might be employed to reduce the long interval between onset and admission to intensive care.

The most important delay is the interval between the onset of the attack and the patient calling for medical assistance. The reasons for this delay have not yet been fully investigated, but it appears that in some patients it is occasioned by the mildness of the symptoms, in others by the denial of symptoms, and in yet others by the reluctance to call for medical aid on a variety of grounds. It is possible that this delay could be reduced by public education, but there are obvious dangers of swamping the medical services by unnecessary calls and of inducing cardiac neurosis. However, it is clear that those with a known history of angina pectoris or myocardial infarction should be instructed to contact medical aid without delay if they experience severe and prolonged chest pain.

Once the patient has decided to obtain medical aid, it is usual for him or his relations to telephone for help from a nonspecialized source. In this city, as in the rest of Britain, the call normally goes to a general practitioner who must leave his other duties to attend to the patient. In our experience, the median interval between the patient's call and the arrival of the practitioner is approximately 45 minutes, and it is usual for the doctor to take about 30 minutes to achieve the diagnosis and to initiate the call for an ambulance. There are several ways in which these time intervals could be reduced. It would be possible for certain selected patients to call the hospital or coronary care unit directly if they had previously been advised to do so. There are clearly risks involved in this in terms of abuse of the services by the overanxious. Next, the general practitioner could make a

decision on the telephone rather than visit the patient. This is, in fact, practised in Belfast where it is frequently the case that the general practitioner calls the mobile coronary care unit without himself having seen the patient. There is the possibility here of an error in diagnosis resulting in the unnecessary call of the mobile coronary care unit, but experience reported by Pantridge suggests that this is not very common (Pantridge and Geddes, 1967).

In some countries, it is usual for the call for medical help to go to a special emergency service, sometimes linked with the ambulance service. This results in the very rapid arrival of an ambulance, sometimes staffed by a doctor as in the U.S.S.R. While this rapid service has much to recommend it, it may be that certain patients are more reluctant to call for such an ambulance service than for the services of their own general practitioner, and it cannot therefore be assumed that this would necessarily accelerate overall admission rate.

Delay in an ambulance reaching the patient necessarily varies with the environment. Delays are long in rural areas and in congested cities, but in a medium-sized city, such as Edinburgh, the median time for the ambulance to reach the patient was 20 minutes. This time probably could not be appreciably reduced. Likewise, the time taken for the ambulance to travel from the patient's home to hospital is of the same order and could hardly be accelerated.

In many hospitals there is a substantial interval between the arrival of the patient in the accident and emergency department and subsequent admission to the coronary care unit. Much of this delay is of an administrative nature, depending upon the availability of medical staff to make decisions about admission, but it is also due to the recording of cardiograms and the taking of chest *x*-rays. This interval could certainly be reduced by better organization and by the postponement of procedures for those patients clearly requiring admission.

An additional way of ensuring early intensive care is by the provision of a mobile coronary care unit. With increasing experience of a mobile coronary care unit in Belfast, it has been shown that the proportion of patients admitted within the first hour has increased from 13·4 per cent in 1966 to 27·5 per cent in 1969 (J. F. Pantridge, 1971, personal communication). However, the contribution to long-term survival resulting from correction of ventricular fibrillation outside hospital was only 14 of 447 (3%) patients managed by the mobile unit (World Health Organization, 1970b). There are valid doubts also about the use of mobile coronary care units in areas with less well-developed cardiological services than exist in Belfast, particularly where there are shortages of medical or nursing personnel or where coronary care units do not yet exist in receiving hospitals and in cities that are large and congested.

Conclusion

Data from this study provide a basis for the improvement of the services for the treatment of acute heart attacks in an urban population. They serve as a further stimulus to divert more attention to prevention, in particular to studying the significance of prodromal symptoms and the management of patients with such symptoms. The findings from this study cannot necessarily be applied in other parts of the country but they may indicate sensitive areas in the working of health services which would repay detailed study. The World Health Organization is encouraging the development of registration schemes for acute heart attack in order to make further progress in the control of this condition. It is hoped that this study will assist that aim.

We are most grateful to the 171 general practitioners in Edinburgh whose willing help and co-operation made the study possible. We also record our gratitude to many colleagues in the Edinburgh hospitals and to Dr. F. S. Fiddes and Miss Isabel Chirnside of the Police Department. And, finally, we thank Mrs. Sandra Brown, Mrs. Lyn Chalmers, Miss Thea Kincaid, Mrs. Susan Paul, and Miss Helen Potts, who were responsible for much of the background work of the study. The study was financed by the Department of Health and Social Security and the Scottish Home and Health Department; we are grateful to both these organizations.

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Appendix

Checking system In order to ensure that all unattended deaths and all hospital admissions due to acute heart attacks were registered, death certificates were regularly scrutinized in the Public Health Department of the City and the Hospital In-Patient Enquiry discharge data for the Edinburgh hospitals were inspected. Both disclosed a few omitted cases.

There was no direct way of checking that survey general practitioners were notifying all those patients whom they were treating at home. However, their performance could be measured indirectly in three ways: (1) by comparing their notifications of unattended deaths with those registered from other sources; (2) by comparing their notifications of patients who died at home with those found in the regular scrutiny of death certificates; (3) by comparing their notification of patients sent to hospital with those found in the regular visitations of all hospitals. The results of these three methods are set out in Table D.

APPENDIX TABLE A *Acute heart attacks in Edinburgh; estimated numbers and episode rates per thousand population in one year*

	Men					*Women*					*Both sexes*
	20–39 yr	*40–49 yr*	*50–59 yr*	*60–69 yr*	*20–69 yr*	*20–39 yr*	*40–49 yr*	*50–59 yr*	*60–69 yr*	*20–69 yr*	*20–69 yr*
Myocardial infarction	20	91	251	276	638	4	15	81	124	224	862
Episode rate per 1000	0·37	3·45	8·84	12·96	4·88	—	0·51	2·36	4·22	1·48	3·06
Insufficient data	2	5	25	32	64	—	2	4	24	30	94
Episode rate per 1000	—	—	0·88	1·50	0·49	—	—	—	0·82	0·20	0·33
Ischaemia	5	45	103	115	268	2	21	40	80	143	411
Episode rate per 1000	—	1·70	3·63	5·40	2·05	—	0·71	1·17	2·72	0·95	1·46
Unattended death	5	32	90	121	248	2	4	22	66	94	342
Rate per 1000	—	1·21	3·17	5·68	1·90	—	—	0·64	2·24	0·62	1·21
Total number	32	173	469	544	1218	8	42	147	294	491	1709
Episode rate per 1000	0·59	6·55	16·51	25·54	9·31	0·14	1·41	4·29	10·0	3·25	6·07
Population at risk (thousands)	54·7	26·4	28·4	21·3	130·8	57·4	29·7	34·3	29·4	150·9	281·7

APPENDIX TABLE B *Acute heart attacks as first manifestation of coronary heart disease; estimated numbers and incidence rates per thousand in one year*

	Men				*Women*				
	20–49 yr	*50–59 yr*	*60–69 yr*	*20–69 yr*	*20–49 yr*	*50–59 yr*	*60–69 yr*	*20–69 yr*	*Both sexes 20–69 yr*
Myocardial infarction	65	122	120	307	14	39	44	97	404
Incidence: rate per 1000	0·80	4·30	5·63	2·35	0·16	1·14	1·50	0·64	1·43
Insufficient data	3	8	14	25	2	2	2	6	31
Incidence: rate per 1000	—	—	0·66	0·19	—	—	—	—	0·11
Ischaemia	19	47	27	93	9	15	27	51	144
Incidence: rate per 1000	0·23	1·7	1·27	0·71	—	0·44	0·92	0·34	0·51
Unattended death	27	41	60	128	3	15	42	60	188
Incidence: rate per 1000	0·33	1·44	2·82	0·98	—	0·44	1·43	0·40	0·67
Total	114	218	221	553	28	71	115	214	767
Incidence: rate per 1000	1·41	7·68	10·37	4·23	0·32	2·07	3·91	1·42	2·72

Note: Previous cardiac history not known in 9 men and 5 women.

APPENDIX TABLE C *Estimated number of deaths within 4 weeks in each diagnostic category and episode fatality ratios among patients presenting alive; overall fatality ratios including unattended deaths*

	Men				*Women*				
	20–49 yr	*50–59 yr*	*60–69 yr*	*20–69 yr*	*20–49 yr*	*50–59 yr*	*60–69 yr*	*20–69 yr*	*Both sexes 20–69 yr*
Myocardial infarction	9	30	54	93	2	10	26	38	131
Insufficient data	5	20	26	51	2	3	23	28	79
Ischaemia	1	1	3	5	—	—	2	2	7
Total deaths among patients presenting alive	15	51	83	149	4	13	51	68	217
Episode fatality ratio among patients presenting alive (%)	8·9	13·5	19·6	15·4	9·1	10·4	22·4	17·1	15·9
Unattended deaths	37	90	121	248	6	22	66	94	342
Overall episode fatality ratios (%)	25·4	30·1	37·5	32·6	20·0	23·8	39·8	33·0	32·7

The first check, on the notification of unattended deaths, includes cases where the practitioner, naturally enough, was quite unaware that one of his patients had died. The second check appears to give very poor results with less than half the deaths at home being notified. However, the 14 deaths not notified included doubtful cases where the practitioners did not suspect a heart attack until the patient died. The third method may represent the closest approximation to the overall notification performance, and it can therefore be assumed that at least three-quarters of all home episodes were in fact notified.

APPENDIX TABLE D *Comparison of numbers of cases actually notified with numbers that should have been notified*

	Notified		*Not notified*		*Total*	
	No.	%	*No.*	%	*No.*	%
Unattended deaths	63	63·0	37	37·0	100	100·0
Deaths among patients treated at home	12	46·2	14	53·8	26	100·0
Referred hospital episodes	553	74·8	186	25·2	739	100·0