Is it feasible to plan secondary care services for coronary heart disease rationally? A quantified modelling approach for a UK Health Authority

S J Cornell, J B Chilcott, A Brennan

Abstract

Background—**Coronary heart disease (CHD) is the major cause of mortality in the UK. This paper explores the difficulties facing health authorities in applying a rational and needs based approach to the planning of hospital based services and describes a simple model used to bring available information to bear on this problem.**

Method—**Published estimates of CHD incidence were identified and methodologies were critically appraised. Estimates were extrapolated to a district population. A three month cohort study of patients with suspected CHD was undertaken within a district general hospital and a model of these clinical pathways was used to examine the volumes of patients and services required to meet the estimated levels of need.**

Results—**From published studies, estimates of CHD incidence ranged from 83 to 3600 per 100 000. From the cohort study, of patients referred with possible CHD 62% received a definitive diagnosis of CHD, 56% underwent an exercise ECG, 16% received an angiogram, 4% received a CABG and 2% a PTCA. Using these figures together with the cohort study, estimated activity ranges from 247 to 6475 surgical interventions per million population compared with the National Service Framework for Coronary Heart Disease recommendations of 1500 procedures per million.**

Conclusions—**Current research on CHD incidence gives a very wide variation in estimated need. This makes its value for service planning questionable and the model highlights a need for further high quality research. The model provides a link between epidemiological research and secondary care service planning and supports the implementation of recommendations within the National Service Framework for Coronary Heart Disease.**

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Doncaster Health Authority, White Rose House, Ten Pound Walk, Doncaster DN4 5DJ, UK
S J Cornell

School of Health and Health Related Research, Sheffield, UK
J B Chilcot
A Brennan

Correspondence to:
Dr Cornell (john.cornell@doncaster-ha.trent.nhs.uk)

In England and Wales, coronary heart disease (CHD) is the main cause of death for both men and women, generating around 135 000 deaths per year.[1] Despite this, there is little quantified understanding of the relation between the burden of CHD within a community and the need for hospital based services. Government Commissioning Guidelines advocate a planned approach to services based on needs assessment.[2] However, such an approach requires knowledge of: the level of need within the community, the relation between CHD incidence, prevalence and service use and the differences between current and "ideal" clinical practice, defined by an agreed set of clinical guidelines. Routine NHS monitoring statistics do not fully address these issues.

The National Service Framework (NSF)[3] for the management of CHD, in line with strategies for CHD produced by many health authorities, is intended to improve care and reduce variations in clinical management and access to services. It includes suggestions for early referral for hospital assessment and the development of criteria for investigation and surgical intervention.[4–6] Implementation of the strategy will increase referrals for cardiology assessment and could reveal a large amount of un-met need. The concern is that the increase will be beyond the current capacity of local health authorities and trusts in terms of personnel and facilities and in financial resources.

Previous attempts to estimate the need for CHD services have chiefly focused on determining the number of revascularisation procedures per head of population. Methods include both consensus opinion[7 8] and modelling approaches.[9–11] Many estimates[9–11] use a combination of information on current service use and routinely available statistics or proxies for need such as mortality, numbers of admissions for myocardial infarction or the prevalence of CHD risk factors. Other attempts, including the British Cardiac Society guidelines,[7 8] and the NSF[3] do not make explicit the methodology used for devising the estimate. None of these make a direct attempt to define or measure the incident level of CHD in the population or relate this to a need for hospital based services.

This paper describes a model devised to link estimates of population CHD incidence to service need. Indeed, it is only through such a quantified understanding of the relation between incidence and the demand for services that the future impact of a declining incidence on hospital based services can be estimated. Thus, declining incidence related to national trends and health promotion activities can be allowed for by re-calculating the model as changes in the incidence of disease become apparent. It should be noted in this respect that the guidelines for increasing revascularisation rates in both the NSF and by the BCS do not

seem to correspond directly to reducing incidence.

The model was constructed by combining information from a number of sources, including a literature search for estimates of CHD incidence, a cohort study of suspected CHD patients and routine statistics on the current activity levels for a health authority population. The outputs from the model link the service requirements, in terms of number of: outpatient appointments, exercise ECGs, angiograms and revascularisations, to meet either a predetermined level of need (based on actual or estimated incidence levels of CHD in the population) or a predetermined revascularisation rate.

This model was designed to assist trusts, primary care groups and health authorities to plan balanced increases in cardiac services and thereby relate such developments to local Health Improvement Plans (HImPs) and Service and Financial Frameworks (SaFFs). It is being used by local health authorities in North Trent to assist their service planning.

Method

LITERATURE REVIEW OF CHD INCIDENCE STUDIES

A systematic literature search for CHD incidence in the UK was undertaken in 1995 and updated in June 1998, using the Medline, Cochrane and Embase databases from 1966 onwards, identifying three review documents,[9 12 13] and five studies of CHD incidence.[14–18] The primary search terms used were: coronary, angina, prevalence and incidence. The results of these were focused using coronary disease and epidemiology, angina pectoris, and also using prevalence and incidence as text words. The results of these searches were combined. A more detailed methodology of the literature search is given elsewhere.[19]

ESTIMATION OF CHD INCIDENCE IN THE ROTHERHAM HEALTH AUTHORITY POPULATION

The incidence estimates were extrapolated to the full health authority resident population as follows:

- The age/sex specific incidence was applied to the appropriate group of the Rotherham population.
- Studies based only on men were pro rata extrapolated by a factor of 0.5 for women, based on the Framingham study[20] (that is, 2/3 male, 1/3 female).
- The Gandhi (1994)[14] paper gave estimates for age groups between 30 and 70 years. Where studies included only limited age ranges, these were extrapolated to include 30–70 years. The multiplying factor used for this extrapolation was the overall incidence in the particular study divided by the age specific incidence from the Gandhi (1994)[14] paper.
- The figures were uplifted by the ratio of the CHD standardised mortality ratio (SMR) for Rotherham and that of the study population (for example, 133/100 where 133 is the SMR for CHD in Rotherham and 100 is that for England and Wales).

This review of the evidence leads to a wide range of estimates for the incidence of CHD in the health authority population. The extrapolation method has a number of strengths and weaknesses, but the necessity for these adjustments is an indication of the paucity of evidence available in this area.

THE OUTPATIENT COHORT STUDY

All new referrals to a general medical outpatient department of Rotherham District General Hospital (RDGH) were examined during a three month period from April to June 1995. The patient group included only the first referrals for possible CHD, either from the GP or after a first acute admission. Any patients previously referred or investigated were specifically excluded. Patients' conditions were classified as possible angina, heart failure, atrial fibrillation, myocardial infarction or uncertain. The pathways of care for these patients were followed up until the diagnosis of CHD was confirmed or rejected.

The vast majority of patients from Rotherham are referred to the local general hospital and would therefore feature in the study. The small number that do not would still receive their angiogram or surgery at the Northern General Hospital in Sheffield, as this is the referral centre for tertiary local hospitals. This activity would be captured in the total activity data for Rotherham patients.

The diagnosis of CHD was made by the cardiologist by a combination of clinical and simple ECG evidence initially and on further investigation by exercise ECG and or angiography where there was clinical doubt. Those in whom a diagnosis of CHD was made (the "final diagnostic group") were followed up until they were either, discharged to their GP, referred for surgery or died. The use of exercise ECGs, scans, angiograms, CABGs and PTCAs for this cohort was recorded. The data were quadrupled to provide an estimate of annual activity associated with "met-incident need" that is; demands made on the hospital based services, by patients not previously known to have CHD. The assumptions underlying this estimate are further discussed below.

CURRENT CHD ACTIVITY

Routine hospital data on the total volume of investigations and surgical interventions for CHD were examined for 1995/6. The difference between the total activity for the health authority and the annual activity implied by the incident cohort is assumed to provide an estimate of the activity associated with current "met-prevalent need for hospital based services" (that is, demands made on the hospital based services by patients previously diagnosed with CHD).

Private patients are not included in this study. There are no routine data available for private patients receiving appointments, investigations or treatment for CHD related illness. Neither do the rates of revascularisation per million population suggested by the BCS or the NSF specify the contribution of the private sector to this activity. This is consistent with

Table 1   Summary of studies identified in the literature review

Study/year	Group studied	Age group (y)	Diagnostic criteria	Number in study	Incidence in the study (%)	SMR of study group	Incidence extrapolated ito the Rotherham population (SMR 133)
Gandhi (1994)[13]	Men and women	31–70	Clinical assessment by cardiologist	467	0.083 in 31–70 age group	90	153
NHSME (1994)[11]	Men and women	>30	Hospital clinically proven MI used as proxy for incidence	100 000 hypothetical population	0.255	100	430
Fry (1976)[16]	Men and women	>40	Clinical diagnosis	2755	0.39	85	650
Grieg (1980)[18]	Men	45–54	Hospital physician diagnosis	1202	1.7	assume 100	2006
Marmot (1997)[14]	Men and women civil servants	35–55	Doctor diagnosed ischaemia—reported by person	7372 completed full three year programme	2.4 men 1.9 women	assume 100	4193
Rose (1968)[17]	Men civil servants	35–59	Self reported validated questionnaire	1136	1–3.6	assume 100	1937–6973

current planning practice but implies that the outputs of the model may overestimate the demand on NHS services.

DEVELOPMENT OF THE MODEL

The spreadsheet model was populated using the cohort study data and routine activity data. The baseline model calculates the annual activity for hospital based services, firstly for the "met- incident CHD " group and secondly, for the "met-prevalent CHD".

The "what if" analyses examine how many extra referrals might be expected given each of the incidence estimates derived from the published literature. These extra referrals would represent the currently "unmet incident need for hospital based services". The model then calculates the activity consequences of these extra referrals, given evidence based guidance that all patients with suspected CHD should be referred for investigation, diagnosis and appropriate management, as per NSF requirements.

The key assumptions are:
(1) The data from the cohort study are representative of annual activity. There is evidence of seasonal variation in deaths from CHD in the UK.[6] However, local emergency admissions for myocardial infarction and angina during April to June were equal to the annual average. Furthermore, the number of referrals during the study period was also close to the average for the year.
(2) The difference between the cohort study data, and the current workload represents activity from patients in the previously diagnosed group—that is, "met-prevalent need for hospital based services" related activity. Therefore, errors in the estimate of the cohort study data could have an opposite effect on the estimate of prevalent need. That is, overestimates in the cohort study would lead to an underestimate in met prevalent need and vice versa.

(3) The number of emergency admissions would not change under different primary care referral policies. These may be expected to reduce with the introduction of an earlier referral policy. This implies that the outputs of the model may become an overestimate of demand with time.
(4) Additional referrals would follow the same treatment pathway as the GP referred element of the cohort study group.

Results

LITERATURE SEARCH FOR CHD INCIDENCE DATA

Table 1 lists the incidence studies identified by the literature search, their characteristics and the resulting annual number of new patients with CHD for Rotherham, after extrapolation. The published studies demonstrate a wide range of estimates for the incidence of CHD. The reasons for this are the varied methodologies of the studies, the criteria used for determining the presence of CHD and the different age, sex and social groupings studied. The different criteria used by the studies make a formal meta-analysis of incidence invalid. However, it is possible to make a judgement as to the likely direction of bias within individual studies.

Adjustments for resident versus registered population and even for the local SMR for CHD have relatively little effect on the overall predictions of the model, compared with the scale of the variation resulting from differences in study design and estimates of incidence .

Extrapolating from Gandhi (1994)[14] for Rotherham gives a figure of 152 new cases per annum. This is less than the number of new patients referred in the quarter of the year covered by the outpatient study. This suggests that the Gandhi(1994)[14] data are below the real level of incidence. The Gandhi study requested GPs to refer all suspected CHD cases, within the paper it is not clear what validation process was in place.

Similarly, the NHSME (1994)[12] figure is likely to be an underestimate of the true incidence of CHD in the community as it excludes those with angina that do not present with myocardial infarction. Such patients are clearly an important group.

The Fry (1976)[16] study was undertaken in a single GP practice and involved relatively small numbers.

Rose (1968)[17] noted that, because angina is variable in its presentation and persistence, repeat examination of a group of patients at
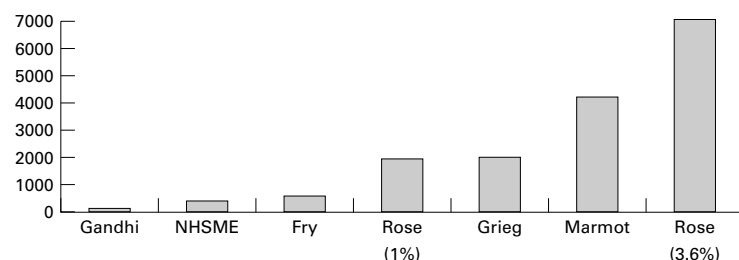

Figure 1   Published study estimates of annual incidence of CHD extrapolated to the Rotherham population (SMR 133).
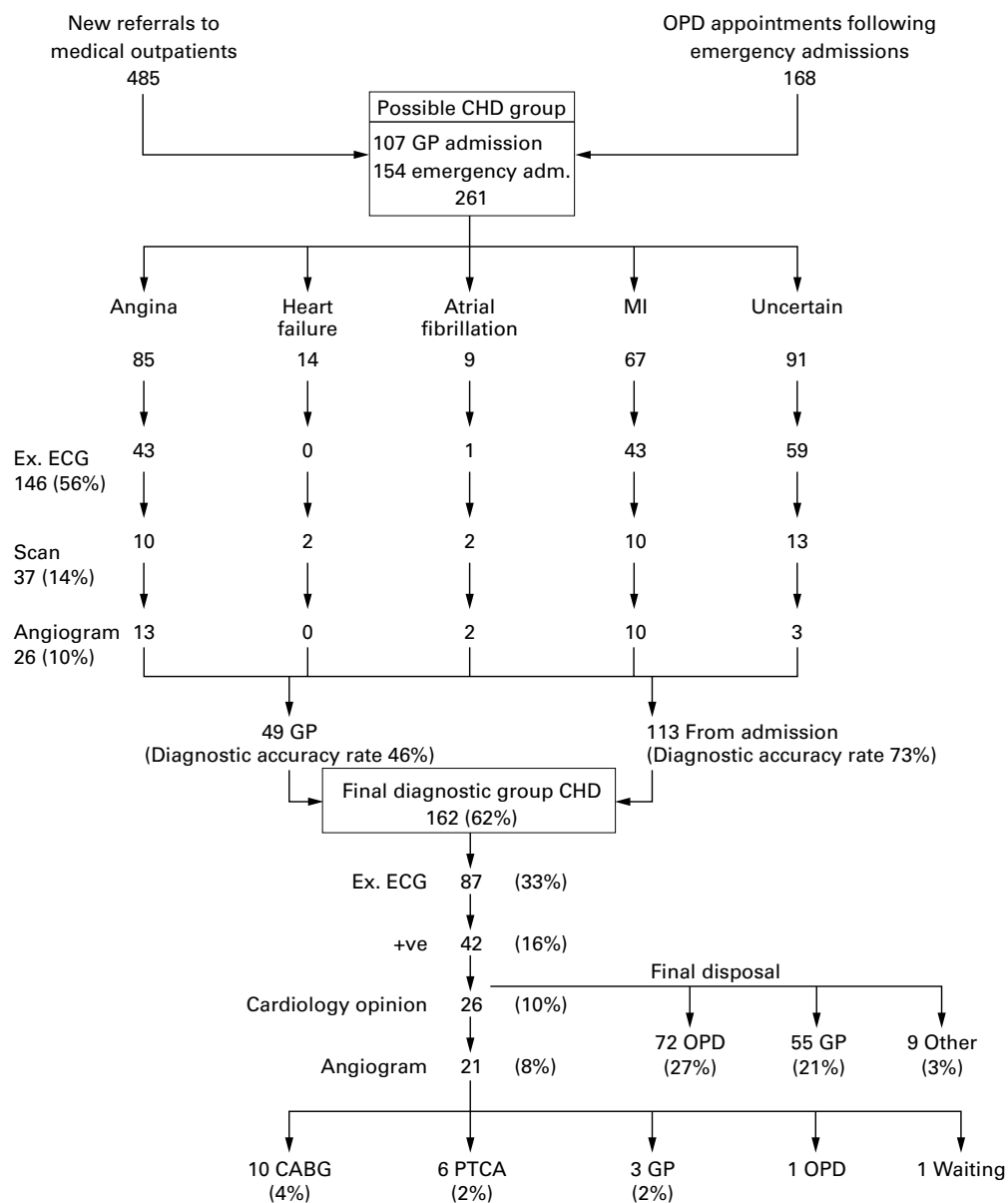
Figure 2   Progress of patients with possible CHD through the hospital system.

different time intervals is likely to result in different estimates of incidence. This also causes problems in differentiating incidence from prevalence and leads to the difference between the low (1%) and high (3.6%) estimates.

Grieg (1980)[18] was a hospital based study and the diagnosis was based on an assessment from a cardiologist and ECG recording.

Marmot (1997)[15] was similar to the Rose study in that it was a GP diagnosis based on clinical examination alone, which one would expect to result in a high estimate.

The clinical diagnosis of CHD is known to be inaccurate.[21 22] Furthermore, as the death rate from CHD in under 65s has been falling over recent years, it is expected that the incidence of CHD is also falling. The true figure is likely to be between Gandhi (1994),[14] Fry (1976)[16] and the NHSME (1994)[12] at the lower end and Rose (1968),[17] Grieg (1980)[18] and Marmot (1997)[15] at the upper.

OUTPATIENT COHORT STUDY AND CURRENT CHD ACTIVITY

The results of the cohort study are shown in figure 2. Of 653 new patient referrals, 261 were identified as having possible CHD. Of these, 162 (62%, standard error 3.0%) were given a final diagnosis of CHD. The diagnostic accuracy was 46% of new GP referrals and 73% of those referred following emergency admission.

In the final diagnostic group, 87 people (33%, SE 2.9%) had had an exercise ECG and 42 were found to be positive according to the Bruce criteria, 21 people (8.1%, SE 1.7%) received an angiogram, 10 (3.8%, SE 1.2%) received a CABG and six (2.3%, SE 0.9%) had a PTCA. From reviewing the patient records we found that all the patients requiring CABGs had triple vessel disease and those undergoing PTCA had single vessel disease with intractable symptoms.

Table 2 compares the cohort study data (a) with the actual total activity levels (c). Eighty

six per cent of ECGs are estimated to be on incident need patients. Around half of the angiograms (44%) are estimated to be on incident need patients, the remainder taking place on previously investigated cases (though not necessarily with a previous angiogram). For revascularisation, around half (46%) of CABGs are estimated to be on incident need patients but 83% of PTCAs are estimated to be on incident need patients. There is no well understood reason to explain the difference between CABGs and PTCAs here but the numbers are small enough for it to be attributable to randomness during the study period (a cohort value of four rather than six PTCAs would have given 55% rather than 83%).

WHAT IF MODEL: IMPLICATIONS FOR SERVICES REQUIRED

Table 3 shows the numbers of investigations and procedures required to meet the estimated levels of currently unmet need implied by the different incidence studies. The estimates of activity clearly vary enormously. The Gandhi (1994)[14] study is not considered further as this implies a level of activity so far below the current levels as to make its validity questionable. The NHSME (1994)[12] estimate of incidence produces required activity that is 46% below the current actual levels. The Fry (1976)[16] study implies that required activity is almost exactly equal to the current level. The Rose (1968)[17] 1% study and the Grieg (1980)[18] study both imply almost a 300% increase in activity would be required to meet current unmet need. The Marmot (1997)[15] and the Rose (1968)[17] 3.6% studies imply phenomenal changes of 740% and 1320% respectively.

Table 4 shows the implied level of activity per million population and comparison of the British Cardiac Society Guidelines (BCS) with the current NSF. This shows that while the Fry and the current activity are almost equivalent; the NSF Guidelines would require more than a doubling of current activity levels. However, the Rose (1968) 1% or Grieg (1980) studies would imply activity levels broadly in line with the current NSF targets for areas of high CHD SMR.

The model was also used to calculate an estimate of incidence, by working backwards from the activity targets per million suggested by the NSF.[3] The combined CABG and PTCA target of 1500 procedures per million corresponds to an estimated annual incidence for CHD in Rotherham of 1.08%. This will equate to the "Final diagnostic group" and the "met-incident need for hospital based services

> **KEY POINTS**
> - Uncertainty in the incidence of CHD and its impact on hospital based services leads to great problems in service planning.
> - Research is required on the incidence of CHD in different communities using agreed methodologies and definitions.
> - A model of hospital services, combined with routine and locally collected data provides a powerful planning tool for health authorities.
> - British Cardiac Society and National Service Framework revascularisation rates fall within the range of estimates generated by this study.
> - The rationale underlying these rates is unclear, a quantified model is required to keep planning in line with falling CHD incidence.

group", see figure 2, in the scenario where all patients presenting with newly symptomatic CHD are referred for hospital based care. Movement towards this scenario is consequent on following evidence based guidance for the management of patients with CHD. This value lies between the two groups of incidence estimates identified from the literature.

RATIO OF INVESTIGATION PROCEDURES TO REVASCULARISATIONS

The datasets also show differences in the ratios of ECG:angiogram:PTCA:CABG: (PTCAs + CABGs). The NSF guidelines indicate a ratio of 1:1 for PTCAs and CABGs. The ratios in the BCS Guidelines are 4:2:0.4:0.6:1. The ratios for the total current health authority activity are 5.8:2:0.25:0.75:1. These results show that the local balance between angiograms and revascularisation is 2:1, the same as in the BCS Guidelines. The local ratios of ECGs to angiograms and ECGs to revascularisations (5.8:1) are higher than in the BCS Guidelines. This could reflect that local ECG availability is less constrained than the access to revascularisation or that the local casemix presenting for ECG is less complex than that nationally. Equally however it could indicate that the BCS guidelines for ECGs are slightly out of balance. The ratios for the cohort study incident need group are 9.1:1.6:0.38:0.62:1, which shows again that there is higher use of ECGs on incident cases than on the prevalent group and could indicate that the BCS guidelines do not reflect the need for ECG testing of a large group of patients who are found not to have CHD.

Table 2 Data from study and actual activity at time of the study in 1995–6

Activity	Cohort study (a)	Cohort projection—that is, "met incident need" (b)=(a) × 4	Activity as % of OP referrals with possible CHD (÷by row 3)	Total actual activity 1995/6 (c)	"Met incident need" activity as % of 1995/6 total activity =(c)÷(b)	Implied "met prevalent need" activity =(c)−(b)
1 GP referrals to outpatients	107	428	41	—	—	—
2 Emergency admissions to outpatients	154	616	59	—	—	—
3 Total referrals to outpatients	261	1044	100	—	—	—
4 Exercise ECG	146	584	56	677	86	93
5 Angiograms	26	104	10	235	44	131
6 Final diagnostic CHD Group	162	648	62	—	—	—
7 CABG	10	40	4	87	46	47
8 PTCA	6	24	2	29	83	5

Table 3 *Estimate of incidence applied to Rotherham and corresponding effect on procedures, etc*

Activity required to meet the estimated unmet need of patients with CHD in Rotherham given different incidence studies ("extra" is the difference from current provision. A negative sign means the model predicts fewer investigations or procedures than currently provided)

Study	Implied Rotherham incidence	OPD referrals		Exercise ECG		Scans		Angiograms		PTCAs		CABGs		CABGs+PTCAs		% Difference from current
		estimate	extra	estimate	extra	estimate	extra	estimate	extra	estimate	extra	estimate	extra	estimate	extra	
Current activity	—	1 044		677		89		235		29		87		116		—
NHSME (1994)	430	568	−476	318	−309	48	−40	128	−107	16	−13	47	−40	63	−53	−46
Fry (1976)	650	1 048	4	680	3	149	1	236	1	29	0	87	0	116	0	0
Rose (1968) (1%)	1937	3 859	2 815	2502	1825	329	240	867	634	107	78	322	235	429	313	+270
Grieg (1980)	2006	4 009	2 965	2600	1923	342	253	902	667	111	82	334	247	445	329	+283
Marmot (1997)	4193	8 785	7 741	5697	5020	749	660	1977	1742	244	215	732	645	976	860	+740
Rose (1968) (3.6%)	6973	14 856	13 812	9633	8956	1266	1177	3344	3109	413	384	1238	1151	1651	1535	+1323

Table 4 *Implied required activity rates per million population given published incidence studies*

Study	Exercise ECG	Angiogram	PTCA	CABG	PTCAs + CABGs
Gandhi (1994)	NA	NA	NA	NA	
NHSME (1994)	1 247	502	63	184	247
Current activity	2 642	917	113	340	453
Fry (1976)	2 667	925	114	341	455
British Cardiac Society	4 000	1 600 to 2 000	400	600	1000
Rose (1968) (1%)	9 812	3 400	420	1263	1683
Grieg (1980)	10 196	3 537	435	1310	1745
Marmot (1997)	22 341	7 753	957	2871	3828
Rose (1968) (3.6%)	37 777	13 114	1620	4855	6475

Discussion

This study has implications for policy makers, health authorities, clinicians and researchers. Although health needs assessment is seen as the means by which health communities will plan the level of services for their communities,[2] together with the associated financial consequences, this paper demonstrates that assessing need for CHD is problematic. The different estimates of incidence derived from the literature give rise to a sixfold variation in the range of estimates of the need for services. This makes rational planning difficult. Local health communities are not adequately resourced to undertake primary research into "unmet" need for hospital based services and the literature review highlights the dearth of information to help them. Routine data sources only reveal the demand uncovered by current patient behaviour and clinical practice. Recommendations to urge patients to seek help for chest pain sooner and for GPs to refer all of these for investigation is likely to uncover a large amount of "unmet" need for hospital based services. An increase in the use of statins or an increase in the conversion of people to "more healthy lifestyles" may reduce the need for hospital based services.

However, it is necessary to plan services and to do so with what information is currently to hand. This model allows us to bring together available information for planning purposes and also provides a facility for making adjustments consequent on local circumstances.

Thus, if an estimate of local incidence can be made, this may be entered into the model to calculate the required levels of outpatients, exercise ECGs and angiograms. If not, a predetermined level of revascularisations can be entered into the model and the level and balance of services required can be calculated. Working backwards from this point will indicate a level of CHD incidence/need in the population being met by such a level of services. Changes in cardiology referrals can be monitored and adjusted accordingly, depending on the effect of changes in clinical referral patterns associated with changes in prescribing or in patient behaviour.

Recommendations

(1) Health authorities should consider the use of this cohort study and model (to be available through ScHARR's web site)[24] as a starting point for calculating the provision of outpatient appointments, exercise ECGs and angiograms

required to meet estimated levels of local need or national recommended levels of revascularisation.

(2) Health authorities should consider the use of quantified models such as the one described here as a framework for coordinating the definition, implementation and auditing of criteria for the referral, investigation and intervention for patients with CHD, as per the NSF.

(3) More research is required on the incidence of CHD in different communities using agreed methodologies and definitions for diagnosis and age, sex and ethnic groupings

(4) Further studies could be undertaken to test the robustness of this model and its use in health authorities as a planning tool. Data now to be collected from rapid access chest pain clinics will facilitate this.

Conclusions

The wide variation in estimates of incidence and the consequent wide variation in the service estimates brings into question the planning of services on the basis of needs assessment in CHD. The concept of rational planning may be flawed unless high quality needs assessment is undertaken at local level. However, such detailed research, even for CHD alone, may be beyond the capacity and scope of many health authorities. Extrapolating from different published incidence estimates gives very different results.

However, a simple planning model of hospital based investigations and interventions, when combined with routine data on activity and the outpatient cohort study provides a powerful tool, both locally and in a wider UK context, for answering a series of important questions on the strategic direction of CHD services.

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