Attempt at deriving a formula for setting general practitioner fundholding budgets

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Abstract

***Objective*—To explore the possibility of using routine Hospital Episode Statistics, census data, and vital statistics to derive weights for an equitable capitation formula for setting general practitioner fundholding budgets for buying acute hospital services.**

***Design*—Analysis of a routine dataset of 9 million hospital episodes in 1991-2, extracting elective general practitioner fundholding procedures, combined with 1991 census variables, vital statistics, and data on supply of health care at ward level. Costs were attached to each procedure according to the average cost of the relevant "Mersey" band category.**

***Main outcome measures*—Variation in age and sex adjusted expenditure per head on fundholding procedures across wards modelled for the impact of health and social needs variables after adjusting for variations in supply.**

***Results*—No sensible simple model including determinants of use other than age and sex could be derived. The most parsimonious but statistically acceptable model showed that though standardised mortality ratio and self reported illness and several social class variables were associated with utilisation, the signs and the size of the coefficients were contradictory. The most important explanation of variation was provided by age and sex differences between wards.**

***Conclusions*—An equitable system of setting general practitioner fundholders' budgets is needed. In the short term age and sex weighted capitation should form the principal basis of fundholder budgets. Utilisation data at ward level are inadequate for developing a formula which adequately adjusts for the differences in the health care needs of populations. A capitation formula based on information derived from individual cohort data may be the only means of promoting equity and efficiency and of avoiding discriminating against patients with known high cost health problems.**

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BMJ 1994;309:1059-64

Introduction

The introduction of general practitioner fundholding means that some of the funds which were allocated to health authorities for secondary care of residents are now distributed to fundholders for buying a specified set of elective acute inpatient and day case procedures (fundholding procedures) and community services.[1]

The growing importance of fundholding raises important questions concerning equitable and efficient distribution of resources.[1-4] In particular, there is considerable interest in the way in which general practitioner fundholder budgets are determined. Ideally, allocations to fundholders for buying secondary care would be based on a formula which takes into account the number of patients in a practice weighted for the likelihood of those patients needing to use NHS acute care and the associated costs of that care. Such a weighted capitation formula would have two important properties: it would be consistent with the principles and manner in which hospital and community health resources are allocated to health authorities,[5 6] and it would promote the equitable allocation of resources between fundholding practices and between populations registered with fundholders and non-fundholders.[4]

The white paper *Working for Patients* made it clear that a capitation formula was to be the basis for funding the hospital and community health services element of the general practitioner fundholder's budget: "each practice's share should be based on the number of patients on its list, weighted for the same population characteristics as . . . for allocations to districts. There are social and other local features which affect the use of hospital services, and these too will be reflected in the budget."[7] In the initial years of the general practitioner fundholding scheme, however, budgets were based on previous activity. This has perpetuated a wide variation in the amount per patient allocated for purchasing care, with little understanding about how much of this may be justified by a corresponding variation in health care needs.[8] As a result of recent guidance from the Department of Health[9] new allocations represent a compromise between historical activity levels, capitation "benchmarks" derived from regional or national age and sex averages, and some discretion to take account of local factors.

This paper reports a study which explores the possibility of using routine data to derive a capitation formula for informing the allocation of hospital and community health service resources to general practitioner fundholders. The work was commissioned by the NHS Management Executive in 1993 as part of a larger study at the University of York to develop a national weighted capitation formula for allocating all hospital and community health service funds to health authorities in England.[6 10] The work was guided throughout by a technical group and steering group appointed by the Department of Health.

Materials and methods

The assumption underlying this study was that variation in the rate at which health services are used reflects variation in the need for health care and variation in the supply of (or access to) health care facilities. The intention was to attempt to isolate indicators of the need for elective fundholding procedures in small areas (after adjusting for supply variations). Age and sex adjusted expenditures per head on elective fundholding procedures were therefore calculated for each small area and were modelled as a function of indicators of supply and indicators of need,

TABLE I—*Proportion of hospital activity which was fundholding*

Specialty group	% Of episodes with fundholding first procedure	% Of procedures that were fundholding: Elective only	% Of procedures that were fundholding: Elective and emergency	Total procedures
(1) All surgery (except (2))	65·6	38·7	42·7	4 654 381
(2) Neurosurgery, plastic surgery, cardiothoracic surgery, paediatric surgery	32·2	24·0	27·3	430 068
(3) All medical (except (4) and (5))	9·1	34·0	44·3	762 223
(4) Geriatric medicine	1·1	9·4	35·7	62 997
(5) Cardiology, medical oncology, neurology	3·2	6·2	8·9	131 414
(6) Psychiatric	0	0·5	3·4	6 047
(7) Mental handicap	0	0	14·0	43
(8) All maternity	1·8	2·3	2·9	1 021 546
(9) Gynaecology	40·2	50·1	53·8	1 082 144
(10) Radiotherapy and radiology	2·6	6·7	8·0	40 347
(11) All other valid episodes	2·0	10·8	12·2	29 345
(12) Invalid episodes	15·1	44·4	48·6	2 390
Total No	9 042 169			8 222 945

Source of data: 1991-2 national Hospital Episode Statistics.

TABLE II—*Average fundholding procedure costs by Mersey band*

Mersey band cost group	Inpatient case (£)	Day case (£)
AA	580	357
A	641	378
B	919	372
C	1715	405

as follows: age and sex adjusted expenditure on fundholding procedures=function of (health variables, socioeconomic conditions, supply of health services).

Data on the use of fundholding procedures were obtained from the 1991-2 Hospital Episode Statistics, which record all inpatient and day case episodes in England. Each episode and the procedures within each episode were linked by means of the postcode to one of 4985 small areas. The small areas cover the whole of England and are known as synthetic wards. They comprise aggregations of contiguous local authority wards such that none had a population of less than 5000. The average population was 9643 and the maximum 33 073.

Though concern has been expressed about the quality of the Hospital Episode Statistics, it is generally accepted that the 1991-2 dataset is more accurate and complete than that for previous years. The extract provided to us contained details of the patient's age, sex, and address; the broad specialty grouping; the source and destination of the episode; and a list of up to four procedures. None of the procedures had an invalid procedure code, and of the 3·8 million elective episodes, only 1978 (containing 1061 fundholding procedures) were classified as invalid in the specialty coding. A total of 9 042 169 completed inpatient and day case episodes were recorded across England. These episodes were associated with 8 222 945 procedures, of which 2 748 878 (33·4%) were elective fundholding procedures. The breakdown of episodes and procedures by specialty group is shown in table I.

The Hospital Episode Statistics extract did not contain detailed procedure codes. Instead, the Office of Population Censuses and Surveys assigned each procedure to one of four categories of fundholding procedures or to the non-fundholding category. The fundholding classification was ranked in increasing order of resource use, taking account of average lengths of stay, the proportion of cases treated without an overnight stay, and the BUPA (British United Provident Association) classification of the complexity of procedures (the "Mersey" bands). Up to four procedures were so coded for each episode. A cost was assigned to each of these procedures based on the average cost per inpatient and per day case procedure for each of the four Mersey bands (see table II). This was derived from detailed costs estimated for each fundholding procedure by East Cheshire Statistical Consultancy. A weighted average cost for each of the four bands used in this study was calculated by creating an average of these detailed costs, weighted according to national activity rates as supplied by the Department of Health. We emphasise that in order to avoid any bias due to the particular characteristics of first wave fundholders and their patients all elective fundholding procedures were included in the analysis irrespective of whether or not patients were registered with a fundholding practice.

Because of the possibility that the dataset overrecorded or underrecorded activity each episode was weighted by the ratio of the total number of episodes reported on form KP70 (a manual return) to the total number of episodes recorded in the Hospital Episode Statistics in the district of treatment. The KP70 was considered to yield the more reliable total number of episodes within a district. However, there was rarely substantial deviation from the Hospital Episode Statistics total. Wards with postcodes having more than 500 episodes were excluded because they may have been used as "dump" postcodes by providers in cases where no postcodes had been recorded.

The total observed expenditure per head of population on elective fundholding procedures for each ward could now be calculated. National rates of procedures and associated costs per head of population, disaggregated by age and sex, are shown in table III. This allowed us to calculate an expected expenditure per head for each ward, given the age and sex composition of the ward. The ratio of observed to expected expenditure per head represents the age and sex adjusted rate of expenditure in the ward. The aim of the modelling was to explain variations in this ratio by using health and socioeconomic variables, after taking into account any effect of variations in the access to health services within wards.

Therefore, for each synthetic ward data were assembled relating to supply of health services, mortality experience, and self reported health status and socioeconomic factors derived from the 1991 census. Four measures of the supply of health care services at the ward level were derived. These were the physical proximity to NHS acute hospital beds (assessed by using a database of 1478 hospitals in

TABLE III—*Average activity and expenditure per head on elective fundholding procedures*

	Age (years): 0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	≥85	All
Procedures per 1000 population																			
Male	49·3	56·8	17·9	16·0	20·8	25·5	32·9	35·9	34·8	40·5	50·1	64·3	80·9	102·3	121·0	137·1	137·8	116·0	48·9
Female	24·0	42·1	17·0	20·7	36·1	54·9	72·5	79·3	81·5	87·9	83·8	76·2	75·5	80·9	88·6	96·4	92·5	71·5	62·7
All	37·0	49·7	17·5	18·3	28·3	40·0	52·6	57·6	58·1	64·1	67·0	70·2	78·1	90·8	102·7	112·4	107·7	82·1	56·0
Costs per head (£)																			
Male	34·4	47·2	13·9	11·8	14·5	16·2	19·5	21·0	21·2	25·9	33·1	44·1	56·8	71·6	85·2	97·9	98·4	83·7	33·8
Female	18·9	39·3	17·1	17·5	23·5	35·0	48·9	56·6	61·5	67·5	61·2	55·4	57·5	64·1	72·2	79·6	75·4	57·4	47·5
All	26·9	43·3	15·4	14·6	18·9	25·4	34·1	38·8	41·4	46·7	47·1	49·8	57·1	67·6	77·8	86·8	83·1	63·7	40·8
Population (thousands)																			
Male	1661	1560	1481	1578	1909	2027	1776	1584	1740	1475	1278	1205	1159	1076	823	614	361	183	23 489
Female	1575	1473	1397	1490	1832	1968	1754	1579	1738	1470	1277	1217	1240	1243	1080	954	716	580	24 581
All	3236	3033	2878	3068	3741	3994	3530	3163	3478	2945	2554	2421	2399	2319	1903	1569	1077	762	48 071

Source of data: 1991-2 national Hospital Episode Statistics weighted by costs derived from East Cheshire Statistical Consultancy.

England, excluding special health authorities, which gave the number of doctors and the address of the principal surgery of all practices in England); access to private hospital beds (assessed by using the 1991 census figure for the number of visitors present in private hospitals on census night by ward); and the provision of nursing home services (measured as the proportion of the population aged 75 or over in nursing or residential homes).[6 11]

The three access measures were calculated by methods of spatial interaction modelling, which seek to reconcile simultaneously the supply of facilities, their proximity to the small area of interest, and the impact of competing populations and competing supply (see appendix).[12] Thus access to NHS inpatient facilities increases with the number of beds in the vicinity or as distance to the facility or population in nearby wards decreases. In effect the access measures yield estimates for each ward of (distance adjusted) acute NHS beds per head, general practitioners per head, and private acute beds per head.

Standardised mortality ratios for all causes of death were available for both sexes and for three age bands: 0-64, 65-74, and 75 and over and combinations of these. Self reported health status was measured by using a question which appeared for the first time in the 1991 census about long term limiting illness: "Does the person have any long-term illness, health problem or handicap which limits his/her daily activities or the work he/she can do?" Respondents were asked to include problems which were due to old age. The prevalence of limiting longstanding illness in a ward was standardised for age and sex in the same way as the standardised mortality ratio.

Many socioeconomic variables used to explore demand for health care may be considered as proxies for the underlying social causes of need, such as poverty. With this in mind, researchers and policy makers have developed several indices which seek to provide a deprivation score for geographical areas. Examples include the Jarman and Townsend indices of deprivation. These indices have been criticised for their lack of theoretical basis and the combination of highly correlated variables. It was thought unnecessary to use them in this study, as all the components of a deprivation index were available separately, without constraining the way in which they were combined.

Many socioeconomic variables from the census were created for use in this study (some are shown in the box). In summary the variables covered the following aspects of social and economic circumstances: housing tenure, housing amenities, car ownership, overcrowding, ethnic origin, elderly living alone, lone parents, students, migrants, unemployment, educational qualifications, social class, and non-earning households.

For this study the range of issues covered was likely to be enough to capture the important social causes of the need for health care. Indeed, because there is high correlation between many socioeconomic variables, the exclusion of a variable from any particular model did not necessarily mean that the phenomena it was measuring were not being captured. We emphasise that most of the variables were acting as proxies for unmeasured characteristics of the ward. Thus, for example, lack of car ownership or unemployment may be reflecting aspects of poverty rather than simply measuring narrow economic status.

We found it necessary to use two least squares regression methods to estimate the equation shown in the appendix because of the problem of the simultaneous relation (endogeneity) between use and supply.[13] The method entails, firstly, regressing each of the supply variables on the set of social and health variables (instruments), then using the predicted values of the supply variables as explanatory variables in the regression in place of their actual values. This approach should yield consistent estimates of all coefficients in the regression of utilisation on needs and supply. Standard errors are adjusted to take account of the endogeneity. Using this method means that the usual measures of the goodness of fit of a regression, such as the R^2, do not have the same meaning as in ordinary least squares regression.

Regional dummy variables (relating to the former 14 regional health authorities) were included in the model to take into account shifts between regions which might reflect historical differences in, for example, funding, policy, or data collection procedures that should not be incorporated into a national formula. For this reason they are not reported here. Throughout, the models performed better when natural logarithms of all variables were used. The relation assumed between variables is therefore assumed to be multiplicative rather than additive. More details on the data collected and methods used to estimate the equations have been reported.[6 11]

Key to variables used in modelling utilisation

Supply variables	
ACCNHSA	Access to NHS acute beds
ACCGPS	Access to general practitioners
HOMES	Proportion of population aged ≥75 not in nursing or residential homes
ACCPRI	Access to private hospital beds
Health variables	
SMR074	Standardised mortality ratio, ages 0-74
SMR75	Standardised mortality ratio, ages ≥75
SIRI074	Standardised illness ratio, ages 0-74
SIRI75	Standardised illness ratio, ages ≥75
LONGILL	Proportion of total population with limiting long term illness
PERMSICK	Proportion of residents of working age permanently sick
Socioeconomic variables	
UNEMP	Proportion of economically active unemployed subjects
SCARER	Proportion of dependants in single carer households
CHNEARN	Proportion of children in non-earning families
NCENHEAT	Proportion of residents in households lacking central heating
NOCAR	Proportion of residents in households with no car
OVERCROWD	Proportion of residents in households with more than one person per room
HNEWCOMM	Proportion of residents in households with head born in new Commonwealth
NEWCOMM	Proportion of residents born in new Commonwealth
BLACK	Proportion of residents not in black ethnic groups
ASIAN	Proportion of residents not in Indian, Pakistani, and Bangladeshi groups
STUDENT	Proportion of working age population who are students
QUAL	Proportion of subjects aged ≥18 with some qualification
CLASSI/II	Proportion of subjects in households with head in class I or II
MANUAL	Proportion of economically active residents in manual social classes
NONMAN	Proportion of economically active residents in non-manual social classes
HMAN	Proportion of subjects in households with head in manual class
PCTURBAN	Proportion of population living in urban enumeration districts
DENSITY	Subjects divided by hectares
OWNOCC	Proportion of residents in owner occupied accommodation
PRIVRENT	Proportion of residents in privately rented accommodation
AMENITY	Proportion of residents not in households lacking or sharing the use of a bath or shower or inside lavatory, or both
OLDALONE	Proportion of subjects aged ≥75 living alone
MOVED	Proportion of residents with a different address from that of a year before
PENSALONE	Proportion of subjects of pensionable age living alone

Results

The simplest model of use of general practitioner fundholding procedures which remained statistically acceptable is shown in table IV. B is the size of the coefficient (elasticity) of the variable, β the standardised effect size (coefficient B divided by the standard deviation of the associated variable). The larger the β value the greater is likely to be the actual impact of the variable in any formula for resource allocation. A key to the variables listed is given in the box. The results suggest that access to general practitioners (ACCGPS) was positively related to utilisation of fundholding procedures and that the provision of nursing home places was negatively associated with utilisation. (Note that the variable HOMES was the proportion of the population aged ≥75 not in nursing or residential homes.) Access to NHS acute beds (ACCNHSA) and private hospital provision (ACCPRI) were not statistically significant at the 1% level.

TABLE IV—*Two stage least squares regression of per capita expenditure on fundholding procedures (best model). (Regional dummies not shown)*

Variable*	B (95% confidence interval)†	β (95% confidence interval)†
	Supply variables	
ACCNHSA	−0·170 (−0·307 to −0·033)	−0·266 (−0·481 to −0·051)
ACCGPS	0·545 (0·368 to 0·722)	0·326 (0·220 to 0·432)
HOMES‡	1·337 (1·047 to 1·626)	0·449 (0·352 to 0·546)
ACCPRI	−0·052 (−0·156 to 0·051)	−0·148 (−0·440 to 0·145)
	Health and social variables	
SMR074	0·070 (0·025 to 0·115)	0·076 (0·027 to 0·125)
SMR75	0·158 (0·107 to 0·208)	0·135 (0·091 to 0·178)
SIRI074	0·069 (0·009 to 0·129)	0·096 (0·013 to 0·180)
SIRI75	0·351 (0·237 to 0·465)	0·179 (0·121 to 0·237)
CHNEARN	−0·047 (−0·073 to −0·021)	−0·156 (−0·243 to −0·069)
NCENHEAT	−0·019 (−0·030 to −0·008)	−0·069 (−0·108 to −0·030)
NOCAR	−0·050 (−0·085 to −0·013)	−0·145 (−0·249 to −0·040)
OVERCROWD	0·045 (0·023 to 0·066)	0·157 (0·081 to 0·232)
HNEWCOMM	0·063 (0·031 to 0·096)	0·373 (0·182 to 0·565)
NEWCOMM	−0·049 (−0·085 to −0·012)	−0·260 (−0·467 to −0·071)
BLACK‡	0·978 (0·798 to 1·159)	0·233 (0·190 to 0·276)
SCARER	0·132 (0·080 to 0·184)	0·185 (0·112 to 0·259)
STUDENT	−0·048 (−0·073 to −0·023)	−0·082 (−0·125 to −0·040)
QUAL	−0·038 (−0·060 to −0·013)	−0·116 (−0·191 to −0·041)
CLASSI/II	0·054 (0·007 to 0·102)	0·120 (0·015 to 0·224)
MANUAL	0·252 (0·196 to 0·309)	0·351 (0·272 to 0·429)
NONMAN	0·289 (0·213 to 0·365)	0·377 (0·278 to 0·476)
Constant	−2·74 (−3·46 to 2·02)	

Analysis of variance—Regression: df=34, sum of squares=87·85, mean square=2·58. Residual: df=4905, sum of squares=154·34, mean square=0·03; F=82·11, P=0·0000.
χ^2 test for specification=41; critical value 0·1% level=48.
*Key to variables is presented in a separate box.
†95% Confidence intervals are approximate, as they assume normality.
‡Variables which are one minus proportion in ward with this characteristic.

TABLE V—*Ordinary least squares regression of per capita expenditure against health and social variables*

Variable*	B (95% confidence interval)†	β (95% confidence interval)†
SMR074	0·054 (0·014 to 0·095)	0·059 (0·015 to 0·103)
SMR75	−0·016 (−0·048 to 0·016)	−0·014 (−0·041 to 0·014)
SIRI074	0·133 (0·081 to 0·185)	0·185 (0·113 to 0·257)
SIRI75	−0·038 (−0·107 to 0·032)	−0·019 (−0·055 to 0·016)
CHNEARN	−0·039 (−0·063 to −0·015)	−0·130 (−0·208 to −0·051)
NCENHEAT	−0·032 (−0·040 to −0·023)	−0·114 (−0·145 to −0·083)
NOCAR	0·006 (−0·017 to 0·029)	0·018 (−0·051 to 0·086)
OVERCROWD	0·018 (0·001 to 0·035)	0·063 (0·005 to 0·122)
HNEWCOMM	0·056 (0·029 to 0·083)	0·328 (0·168 to 0·488)
NEWCOMM	−0·036 (−0·066 to −0·005)	−0·196 (−0·365 to −0·027)
BLACK‡	0·897 (0·758 to 1·037)	0·213 (0·180 to 0·247)
SCARER	0·082 (0·035 to 0·128)	0·114 (0·049 to 0·180)
STUDENT	−0·075 (−0·096 to −0·053)	−0·128 (−0·165 to −0·092)
QUAL	0·027 (−0·049 to −0·005)	−0·084 (−0·151 to −0·017)
CLASSI/II	−0·011 (−0·049 to 0·026)	−0·025 (−0·107 to 0·057)
MANUAL	0·346 (0·308 to 0·384)	0·481 (0·428 to 0·534)
NONMAN	0·306 (0·246 to 0·365)	−0·398 (0·321 to 0·476)
Constant	−0·27 (−0·43 to −0·11)	

R^2=0·39, SE=0·16.
Analysis of variance—Regression: df=30, sum of squares=85·38, mean square=2·85. Residual: df=4922, sum of squares=129·97, mean square=0·026; F=107·78, P=0·0000.
*Key to variables is presented in a separate box.
†95% Confidence intervals are approximate, as they assume normality.
‡Variables which are one minus proportion in ward with this characteristic.

TABLE VI—*Ordinary least squares regression of per capita expenditure against three key variables*

Variable*	B (95% confidence interval)†	β (95% confidence interval)†
MANUAL	0·273 (0·249 to 0·297)	0·379 (0·346 to 0·412)
SMR074	0·026 (−0·014 to 0·066)	0·028 (−0·015 to 0·071)
SIRI074	0·064 (0·029 to 0·099)	0·090 (0·041 to 0·138)
Constant	−0·15 (−0·22 to −0·08)	

R^2=0·21.
Analysis of variance—Regression: df=3, sum of squares=45·87, mean square=15·29. Residual: df=4949, sum of squares=169·48, mean square=0·03; *F*=446·53, P=0·0000.
†95% Confidence intervals are approximate, as they assume normality.
*Key to variables is presented in a separate box.

The results for the health status and socioeconomic variables were more problematical. Though the direct measures of health status—the standardised mortality ratio (SMR) and standardised illness ratio (SIR) based on the self reported longstanding limiting illness census question for the under and over 75s—were positively associated with expenditure, the relation between the socioeconomic variables and expenditure was hard to interpret (table IV). In general, wards with a higher proportion of students and people with qualifications had lower utilisation rates, whereas apparently more deprived wards, with a higher proportion of residents in overcrowded accommodation, had higher utilisation rates. However, indicators of poverty such as the proportion of residents in households with no car (NOCAR) and the proportion of children in non-earning families (CHNEARN) were negatively associated with utilisation.

In addition, there were contradictory signs on the coefficients of two other groups of social variables. For example, all three social class variables (CLASSI/II, MANUAL, NONMAN) were positively correlated with relative expenditure. This implied that utilisation increased as the proportion of a ward's population which was in the manual social classes increased as well as with an increase in the proportion of social classes I and II. Similarly, the three ethnic variables (HNEWCOMM, NEWCOMM, BLACK) also opposed each other. Reducing the number of social class or ethnic variables to one each significantly reduced the adequacy of the model, which then failed the statistical tests of model specification.[14] The introduction of interaction terms in the equation did not resolve the problem.

These results were not the product of the statistical methods used. For example, when the analysis was repeated with the more usual (ordinary least squares) regression method being used on the subset of health and social needs variables which were significant in table IV (excluding the supply variables) the same problems occurred (table V). Though there was a positive expenditure gradient with health variables, some social variables (children in non-earning families and non-manual) had a negative sign. This contradicted the more intuitively sensible results for similar variables such as households with head in manual class, which were positively correlated with expenditure.

The practice of using simple regression of age and sex adjusted per capita expenditure on elective fundholding procedures against a small subset of variables (such as standardised mortality ratio and unemployment) may therefore result in the relation between needs variables and utilisation being wrongly estimated. For example, a regression on standardised mortality ratio, standardised illness ratio, and manual social class showed no contadictory signs (though standardised mortality ratio was no longer statistically significant, the confidence interval included zero; table VI). However, unemployment entered the model with a significant negative coefficient (table VII). This showed that though it is fairly easy to derive an apparently plausible equation by using simple regression techniques on a very limited set of variables, the coefficients may be misleading and the model possibly seriously misspecified.

Regressing observed expenditure per head on fundholding procedures unadjusted for age and sex against dummy variables for each age and sex band showed that 26% of the total variation across wards over England was statistically explained by age and sex differences between the wards. A further 20% was explained by our preferred statistical model in table V.

TABLE VII—*Ordinary least squares regression of per capita expenditure against four key variables*

Variable*	B (95% confidence interval)†	β (95% confidence interval)†
UNEMP	−0·154 (−0·174 to −0·135)	−0·373 (−0·420 to −0·327)
MANUAL	0·245 (0·222 to 0·268)	0·341 (0·308 to 0·373)
SMR074	0·086 (0·046 to 0·126)	0·093 (0·050 to 0·136)
SIRI074	0·272 (0·229 to 0·315)	0·378 (0·318 to 0·438)
Constant	−1·78 (−1·90 to −1·66)	

R^2=0·25.
Analysis of variance—Regression: df=4, sum of squares=53·90, mean square=13·48. Residual: df=4948, sum of squares=161·45, mean square=0·03; F=413·000, P=0·0000.
†95% Confidence intervals are approximate, as they assume normality.
*Key to variables is presented in a separate box.

However, the extent to which all these latter variables reflected legitimate underlying need and therefore should be incorporated in a formula was unclear.

Discussion

Despite having developed a statistically robust, theoretically sound, and intuitively appealing model for the whole of acute sector activity,[10 11] we have derived no sensible model for the impact of health and socioeconomic indicators on the use of elective fundholding procedures. There are several possible hypotheses which could be put forward to explain these results, though it is impossible to test them by using these data.

Firstly, though the average social gradient for all fundholding procedures is likely to have a positive slope (as indicated by tables IV and V-VII) it is probably "flatter" than for all acute health care procedures. This is because there is no obvious role of socioeconomic factors in the epidemiology of many of the conditions corresponding to the fundholding procedures.

Secondly, all patients receiving these elective procedures must first be referred by a general practitioner. Therefore, general practitioners' referral behaviour will have an influence on the extent to which variations in the need presented to general practitioners will be translated into corresponding variation in utilisation. There is much published work documenting the wide variations in general practitioner referral behaviour independent of patient need.[15] Of particular interest is the possibility (supported by some empirical evidence) that there might be an inverse gradient between social class and referral rates by general practitioners or treatment rates by hospital consultants.[16] In other words, the higher social classes may be better at getting what they want. If this is true for fundholding procedures the observed overall utilisation rate may represent the net effect of a slightly positive needs social gradient and a countervailing negative referral and treatment social gradient.

Lastly, the relation between needs for elective fundholding procedures and health and socioeconomic variables may not accurately be reflected in hospital utilisation because of social class differences in patient thresholds for consultation. In addition, some groups may make more use of private care, while others may be more likely to use emergency services for the same level of need. These, combined with a large amount of statistical "noise" due to random variations,[17] may help to explain the inconclusive results.

Conclusion

Though it is likely that there is some social gradient in the need for elective fundholding procedures, using the data available we could not identify a set of health or socioeconomic needs variables which we feel confident captures variations in underlying need. Ideally, any formula will incorporate only the relevant social and health factors, excluding other, non-needs related variables. However, there seems to be no direct way of disentangling the various sources of variation using these routine cross sectional data.

We have shown that age and sex distribution is a very important determinant of the ward variation in expenditure on fundholding procedures. This has also been shown to be important in explaining variation at the individual level.[18] Therefore, it is important that at least an age and sex adjusted capitation formula should be used to inform the budget setting process for general practitioner fundholders. Table II presents the average national age and sex weights in 1991-2 which could be used as the basis for such a formula, though we emphasise that the cost data refer to the relative use made by different demographic groups and should not be used as absolute benchmarks. Clearly many will wish to modify these data locally to take account of variations in social factors or morbidity between practices. However, as this study has shown, it is not clear how these factors may indicate relative need.

The principle of using an age and sex capitation formula can also be used to determine the size of the overall budget allocated for fundholding procedures, which ensures that the populations registered with both fundholders and other general practitioners receive a fair share of the resources.[3-4] This can be done either by setting a national fixed capitation per head (adjusted for age and sex), independent of the location of the fundholding practice, or by identifying a proportion of the total local hospital and community health service budget as relevant for fundholding elective activity for the local population, and then allocating this between practices on the basis of age and sex relativities. If the second course is adopted and the national formula for district allocations takes account of mortality, morbidity, and social factors as recommended by the York team's work on a national formula for allocation to health authorities,[6 10 11] then fundholding budgets will to an extent reflect district variations in need.

The use of a capitation formula introduces a theoretical incentive to discriminate against the few patients with known high cost health problems ("cream skimming") and generate surpluses.[18-22] In addition, fundholders have an incentive to attract patients more likely to use private health care for elective fundholding procedures. An age and sex based capitation formula would not eliminate these problems because it does not take into account other important factors which explain variations in expenditure between population groups such as disability, functional health status, and indicators of chronic

Policy implications

- General practitioner fundholder budgets are based on a mixture of historical activity and capitation
- Concerns that allocations to fundholders may be inequitable have led to calls for the budget to be determined by a national formula
- Age and sex are the most important determinants of variation in utilisation of fundholding procedures at ward level
- A valid capitation formula which takes into account variations in need for fundholding procedures between practices cannot easily be derived from analysis of routine available data
- Research following up individuals' health care needs and use is needed in order to derive a more accurate capitation formula based on the characteristics of registered patients

medical conditions nor use of private acute services.[23-26] A formula which could adjust for these factors would need to be derived from epidemiological cohort studies following up individuals' health care experiences.[18 27] However, because doctors will always have more relevant information on the likely cost of individual patients than any budget setter, some incentive to discriminate against patients whose expected costs exceed their capitations may always be present.

This work was funded by the Department of Health. We acknowledge the helpful comments of Anita Bird, Professor Alan Maynard, and two anonymous referees. We also thank the members of the technical and steering groups appointed by the Department of Health for their invaluable advice and support.

Appendix

METHOD OF CONSTRUCTING SUPPLY VARIABLES

For NHS inpatient facilities the relative accessibility A_1 of zone i to acute hospital beds is given by:

$$A_i = \sum_d \left[\frac{Sd\, f(C_{id})}{\sum_r P_r\, f(C_{rd})} \right]$$

where P_i is the population of zone i, S_d is the number of available beds at hospital d, c_{id} is the straight line distance between zone i and hospital d (inferred from the zone's centroid and the postcode of the hospital), and f(.) is an inverse square distance decay function.

Though superficially opaque, the equation can be interpreted simply as the ratio of hospital size (weighted by distance) to population (also weighted by distance). It is directly analogous to the "beds per head" ratio but takes account of distance and competition from other wards.

Similar methods were used for private inpatient beds, except that details of individual hospitals D_d were replaced by numbers of filled inpatient beds within wards. The location of these beds was taken to be the ward centroid. For general practitioners S_d was the number of general practitioners employed within the practice and the location was the address of the main surgery.

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(Accepted 19 August 1994)

THE NOBEL PRIZES

The fringe festival

Like vicars and haemorrhoids, Nobel prizes are not themselves funny but have inspired a wealth of humour and anecdote. Just a few months ago, for example, the quixotic *Journal of Irreproducible Results* held its annual ceremony to bestow on hapless recipients the latest round of Ig Nobel prizes.

Given in recognition of research that "cannot or should not be reproduced," the most recent batch went to an appropriately international mixture of workers. Kenneth Newall of the Liverpool School of Tropical Medicine and Paul Williams of the Oregon State Health Division received the biology prize for their study entitled "*Salmonella* excretion in joy-riding pigs," while James Nolan and colleagues at the Guthrie Clinic in Sayre, Pennsylvania, were given the medicine award for their paper "Acute management of the zipper-trapped penis" in the *Journal of Emergency Medicine.*

Particularly innovative was the award of the Ig Nobel prize for literature to the 972 authors whose paper on thrombolytic therapy in the *New England Journal of Medicine* some months ago resulted from collaboration between 972 research workers in 15 different countries. In a rare feat of international collaboration each of the writers was responsible for penning exactly two words of the paper.

It was just two authors, A J P Martin and R L M Synge, who wrote the paper describing the invention of paper chromatography, for which they received the real 1952 Nobel prize for chemistry. Shortly afterwards, Martin was recruited by Boots the Chemist, in the expectation that such an intellectual heavyweight would enhance the firm's economic prosperity and prospects. He was given a laboratory and a desk and encouraged to discover something.

What happened next is recorded by Magnus Pyke in *The Six Lives of Pyke* (Dent, 1981):

"At the end of a month, a polite administrator called to ask for his monthly report. After some delay, this was delivered. It consisted of one word: 'Thinking.'

"'I am sure you will understand, Dr Martin, that we require a longer report than this.'

"'I'll do my best next month.'

"The month went by, the report was submitted and was, as had been requested, twice as long: 'Still thinking.'

"It came as no surprise to philosophical observers, familiar with the normal calibre of industrial scientists, when Martin quite soon left the employment of Boots the Chemist."—BERNARD DIXON *is a freelance science writer*