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NHS resources: scales of variation

DAVID R. JONES AND SHEILA MASTERMAN

Medical Information Unit, Wessex Regional Health Authority, Highcroft, Romsey Road, Winchester, Hampshire

Jones, D. R. and Masterman, S. (1976). *British Journal of Preventive and Social Medicine*, **30**, 244-250. **NHS resources: scales of variation.** The dangers inherent in comparing measures of health service provision and usage at high levels of aggregation and of ignoring variations at lower levels are illustrated with particular reference to regional and subregional levels in the NHS. Analysis of variance indicates that, for a wide range of variables, there is more variation at the subregional level than regional level.

The report by the DHSS Working Party on Resource Allocation (Department of Health and Social Security, 1975; *British Medical Journal*, 1975) has recently highlighted the variations in levels of provision of health care services between regional health authorities and their suggested reallocation. Other examples of substantive regional comparisons may be found (Griffiths, 1971; Noyce, Snaith, and Trickey, 1974). Statements such as 'the rate at which abortions are performed in the Newcastle region is three times that at which they are carried out in the Birmingham region' are familiar following the publication of the official statistics from which they are culled (*New Society*, 1974). However, it may be questioned whether or not the regional level is appropriate for such comparisons, and, perhaps more importantly, whether or not regional comparisons should play essential roles in resource allocation procedures.

Some confirmation of the suspicion that variations at the area level (and, of course, at levels below this) are greater than those at regional level (*Which?*, 1975) is afforded by studies of distribution of expenditure (Klein and Buxton, 1974; Rickard, 1976) and of provision of hospital beds (Buxton and Klein, 1975). Although the DHSS working party has been confined to date to reporting on the regional level, the intention of considering area and district levels is registered (Department of Health and Social Security, 1975), and in an interview (*Sunday Times*, 1975) Dr David Owen (Minister of State for Health) indicated that the DHSS is preparing to make comparisons of health provision district by district: 'We have always made regional comparisons before and that is no use at all'. That interest in such matters should be especially keen is natural at a time of financial stringency when competition for limited funds is greatest.

Choice of Level of Aggregation

Comparisons have largely been made at regional level because of the limited availability of data at lower levels of aggregation. However, in general, the method adopted for dividing a study area into smaller areas for the purpose of data collection may be expected to affect the results of the analysis of the data subsequently performed. The problem of choosing the most important scale for study (that is, the most appropriate level of aggregation) is a familiar one to geographers (Moellering and Tobler, 1972) and ecologists (Greig-Smith, 1964). In this paper we have applied one of the techniques suggested (Moellering and Tobler, 1972) for resolution of problems of this nature to levels of aggregation corresponding to the hierarchy of administrative levels (regional, area, and district) in the NHS. Rates of provision and use of health service facilities are known to vary from district to district, the lowest level of aggregation at which

it is aimed to provide a comprehensive service, but to what extent these variations are due to effects associated with

the region in which the district lies,
the area in which the district lies, and
the particular district

is not clear before the analysis is undertaken.

Method of Analysis

A measure is calculated of the diversity of rates of provision and use corresponding to each level of aggregation (region, area, and in some cases, district) in the hierarchy, taking account of the number of degrees of freedom available at each level. The particular measure of variation used is probably not critical; here conventional variance was chosen since the results obtained are robust to use of several similar alternatives. The basis of the method is a nested (or hierarchical) analysis of variance (Scheffe, 1959); essentially this provides a means of attributing portions of the total variation of some variable of interest to regional, area, and district levels.

More precisely, if the value of the variable of interest in the kth district of the jth area of the ith region is X_{ijk} we set

$$X_{ijk} = \mu + \alpha_i + \beta_{ij} + \gamma_{ijk}$$

where μ is an overall national mean value of the variable, α_i represents the effect of the ith region, β_{ij} that of the jth area in the ith region, and γ_{ijk} that of the kth district in the jth area of the ith region. We then make the Model II (random effects) analysis of variance hypothesis that the three effects represented by the α, β, and γ parameters are uncorrelated random variables with zero means and variances σ^2_α, σ^2_β, and σ^2_γ respectively. These variances may be estimated (Moellering and Tobler, 1972; Scheffe, 1959), so providing estimates of the magnitude of the effects attributable to each level or scale in the hierarchy.

Data

As noted above, considerable problems arise when complete data sets appropriate for the description of provision and usage of health services at levels of aggregation below the regional level are sought. Rickard (1976) presents per caput expenditures on each of the three subsets of the health services for 1972-73, attributing these expenditures to each post-1974 area health authority. The method of analysis described above (for regional/area levels only) has been applied to these data and the results are shown in Table I.

Table I

RATIO OF AREA AND REGIONAL SCALE VARIANCES

Sector	Area Scale Variance / Region Scale Variance
Community health	2·60
General hospital	1·96
All services	1·69

(Data from Rickard, 1976)

Variations of several more variables, mainly direct (as opposed to financial) indicators of the rates of provision and use of health care services, are examined. The data used to construct these variables relate to England and Wales in 1971; definitions of the variables and sources of the data are given on page 248. It has not proved possible to recast the data to yield reliable values for each of the post-reorganization regions and areas. This exemplifies the problems of data handling which may result from collection of various subsets of data bases in incompatible geographical units. Some of the other problems of deriving appropriate indicators of provision and usage from routine data sources are discussed elsewhere (Jones and Bourne, 1976). The basic unit of analysis in this paper is the county; regions are represented as aggregations of counties. In most cases the correspondence between the regions defined here and NHS administrative regions is close; the county level is also broadly that of the area in the NHS administrative hierarchy, although, especially in metropolitan areas, a county sometimes embodies more than one area health authority.

The basic data are set out in Tables II and III. In Table IV the scale variances associated with county/area and regional levels obtained when the total variation is analysed into county/area and regional components only are displayed. For variables 1 to 4 we have assumed that counties (and for variables 5 and 6 that areas) form catchment areas for the services and facilities concerned so that, for example, each value of the first variable in Table II is obtained simply as the quotient of the number of residents of the homes for the aged and infirm located in the county and the population of the county over the age of 65 years. This assumption is probably weakest in the hospital sector and a second set of measures is presented (variables 7 to 12 in Table II) in which beds used by the population of a county regardless of the location of the beds, and corresponding bed availability figures obtained by allocating beds in proportion to the usage, are represented.

TABLE II

BASIC DATA BY COUNTY IN ENGLAND AND WALES, 1971

County	Variable No. 1	2	3	4	7	8	9	10	11	12
Northern Region										
Cumberland	16·4	1018·3	57·9	76·7	3·20	10·51	8·02	5·34	84·9	210·2
Durham	17·7	582·4	95·3	35·6	3·86	11·26	8·55	3·18	91·1	264·0
Northumberland	15·7	885·9	91·8	58·0	4·24	7·97	8·27	2·66	90·8	221·1
Westmorland	20·0	704·9	28·7	100·0	2·81	9·59	7·25	1·33	80·4	27·4
Yorkshire region										
East Riding	17·6	596·3	85·6	56·3	3·79	10·34	8·35	4·76	103·1	242·9
North Riding	19·0	606·3	72·5	48·3	3·88	7·38	8·45	2·04	96·4	187·2
West Riding	17·2	544·2	102·5	45·8	3·53	11·98	7·81	3·25	92·4	263·4
Trent region										
Derbyshire	12·5	579·3	71·8	43·0	2·96	9·85	6·19	2·00	75·9	245·3
Leicestershire	18·6	572·1	90·9	44·6	2·29	8·27	5·83	1·17	60·9	276·9
Lincoln (Holland)	21·0	538·4	69·8	38·5	4·75	8·59	6·80	0·88	79·6	147·0
Lincoln (Kesteven)	20·7	437·5	67·1	63·0	2·89	8·37	6·77	2·35	74·8	212·9
Lincoln (Lindsey)	16·4	572·7	79·4	53·6	2·94	9·37	7·40	1·80	81·2	208·0
Nottinghamshire	14·0	477·3	85·6	36·7	2·78	8·51	6·31	2·23	73·9	233·9
Rutland	24·0	293·0	50·2	44·8	5·14	6·88	6·19	0·94	62·4	110·1
West Riding	17·2	544·2	102·5	45·8	3·53	11·98	7·81	3·25	92·4	263·4
East Anglia region										
Cambridge	16·1	409·3	71·1	65·7	2·00	11·48	6·02	2·64	56·9	259·9
Huntingdonshire and Peterborough	20·4	387·2	47·5	49·4	3·39	7·90	6·52	1·73	79·1	130·1
Norfolk	19·0	454·6	62·6	67·4	2·56	7·13	3·68	2·71	39·8	182·7
East Suffolk	13·2	569·7	70·0	58·3	3·38	9·88	5·68	2·92	74·1	265·5
West Suffolk	17·7	625·2	56·5	61·6	3·35	12·86	7·02	4·37	65·1	273·5
N.W. Thames region										
Bedfordshire	17·8	487·0	68·7	20·1	2·67	11·83	6·93	2·38	73·9	320·4
Hertfordshire	14·6	450·8	80·1	38·2	3·32	9·63	6·45	1·74	73·4	291·9
Greater London	15·0	518·7	96·3	55·1	4·58	7·90	8·88	1·96	119·4	205·6
N.E. Thames region										
Essex	16·1	514·9	93·2	41·8	3·14	8·90	8·35	2·25	87·3	245·7
Greater London	15·0	518·7	96·3	55·1	4·58	7·90	8·88	1·96	119·4	205·6
S.E. Thames region										
Kent	10·3	576·4	48·8	47·6	3·30	9·34	6·85	2·44	74·8	225·5
East Sussex	13·4	943·9	58·0	62·3	4·01	6·51	7·17	1·52	94·7	178·1
Greater London	15·0	518·7	96·3	55·1	4·58	7·90	8·88	1·96	119·4	205·6
S.W. Thames region										
Surrey	11·0	583·3	45·1	58·1	3·44	7·08	7·89	1·23	88·3	160·7
West Sussex	9·8	825·7	51·4	68·3	3·48	4·43	7·61	0·85	93·5	180·1
Greater London	15·0	518·7	96·3	55·1	4·58	7·90	8·88	1·96	119·4	205·6
Wessex region										
Dorset	13·6	651·1	53·9	73·0	2·95	7·66	6·84	1·88	84·7	211·5
Hampshire	13·9	445·3	56·9	62·6	2·78	8·42	7·61	1·71	86·8	226·2
Isle of Wight	12·8	353·8	68·8	82·0	3·12	17·40	5·77	2·16	60·7	477·9
Wiltshire	13·0	702·7	31·8	50·8	2·70	7·25	7·69	1·72	79·7	307·6

Oxford region												
Berkshire	15·0	775·7	92·0	44·1	3·05	9·27	6·99	2·53	65·0	182·6		
Buckinghamshire	12·9	693·3	61·1	45·7	3·26	7·61	7·57	3·44	66·3	134·6		
Northampton	13·3	542·8	49·0	44·6	2·72	14·38	7·42	3·59	78·8	287·6		
Oxfordshire	20·7	591·8	75·1	68·3	3·04	5·89	7·85	1·83	63·5	118·9		
South Western region												
Cornwall	12·5	680·5	37·3	62·1	2·60	8·77	5·78	2·06	66·4	327·4		
Devon	17·4	810·3	46·8	72·5	3·37	8·68	6·87	2·00	84·9	265·7		
Gloucestershire	10·9	729·4	88·3	74·4	3·05	9·32	7·23	1·64	82·7	135·7		
Somerset	12·5	738·8	56·0	66·8	3·19	10·23	7·25	1·71	80·7	238·3		
West Midlands region												
Hereford	14·8	570·7	48·1	72·7	3·39	13·00	8·41	1·96	95·9	278·8		
Shropshire	22·0	520·8	53·9	54·4	3·20	14·52	6·29	3·11	72·4	348·7		
Staffordshire	14·6	453·6	80·4	30·9	2·66	10·07	5·79	1·70	70·6	241·6		
Warwickshire	17·1	646·6	72·5	42·9	3·07	10·89	7·81	2·67	86·6	309·3		
Worcestershire	13·7	705·1	72·6	52·9	4·04	9·71	6·94	2·32	89·8	220·3		
N. Western region												
Lancashire	16·9	778·8	87·9	42·5	3·79	9·24	7·85	2·22	95·6	213·2		
Mersey region												
Cheshire	14·1	512·8	53·0	54·0	3·84	10·71	6·59	2·88	85·9	215·8		
Wales												
Anglesey	14·6	691·7	61·5	85·2	3·50	13·34	9·08	4·41	98·7	221·2		
Brecon	20·0	1128·0	64·2	85·7	4·08	20·64	6·90	2·77	90·2	232·1		
Caernarvon	16·1	1283·9	36·8	88·2	3·36	12·18	9·75	3·65	100·8	219·9		
Cardigan	27·3	1066·1	36·6	80·0	3·94	15·21	9·39	3·50	117·3	110·7		
Carmarthen	15·7	895·9	41·4	96·4	3·20	9·42	6·20	2·58	77·1	216·3		
Denbigh	12·5	837·1	40·3	63·6	5·17	6·84	8·21	1·85	101·0	89·6		
Flint	15·0	869·2	59·8	63·6	4·88	10·52	8·60	4·46	108·7	143·0		
Glamorgan	16·3	715·4	86·5	66·1	4·43	9·12	8·79	3·18	99·2	161·1		
Merioneth	23·8	878·8	60·6	95·8	6·01	9·17	10·90	2·06	124·5	74·8		
Monmouth	15·4	833·8	115·8	60·6	4·21	7·10	8·04	1·47	101·4	92·1		
Montgomery	21·8	1010·9	49·0	100·0	5·35	3·45	8·26	0·72	102·4	119·1		
Pembroke	22·9	1151·8	44·7	85·4	3·18	8·77	6·12	2·93	65·3	110·8		
Radnor	19·8	1525·2	36·2	87·5	7·26	9·55	8·98	0·94	115·2	45·9		

Definition of the variables:

1. Residents of homes for the aged and infirm
2. Home nurse visits
3. Home help cases
4. General practitioner availability
5. Available beds (acute)
6. Available beds (acute) omitting teaching areas
7. Available beds (acute)—full catchment areas
8. Available beds (geriatric)—full catchment areas
9. Deaths and discharges (acute)—full catchment areas
10. Deaths and discharges (geriatric)—full catchment areas
11. Occupied bed days (acute)—full catchment areas
12. Occupied bed days (geriatric)—full catchment areas

Definition of the Variables and Sources of Data

1. *Residents of homes for the aged and infirm:* Number of residents in local authority homes for the aged and infirm, per 1000 county population over 65; Institute of Municipal Treasurers and Accountants and Society of County Treasurers, Local Health and Social Services Statistics (1971-72); 1971 Census of Population—County Reports.
2. *Home nurse visits:* Number of home nurse visits per 1000 county population; sources as 1.
3. *Home help cases:* Number of cases attended by local authority home helps per 1000 population over 65; sources as 1.
4. *General practitioner availability:* Percentage of principals with fewer than 2500 on list; *DHSS Annual Report (1971).*
5. *Available beds (acute):* Number of available beds in acute specialties (excluding psychiatric, obstetrics, GP maternity, geriatric, and chronic sick) in each area per 1000 area population; SH3 (1971); 1971 Census of Population—County Reports.
6. *Available beds (acute)—omitting teaching areas:* As 5, but omitting teaching areas.
7. *Available beds (acute)—full catchment areas:* Number of available beds in acute specialties (excluding psychiatric, obstetric, GP maternity, geriatric, and chronic sick) in each hospital group allocated to each county in proportion to deaths and discharges of residents of each county per 1000 county population; HIPE (1971) unpublished data; SH3 (1971); 1971 Census of Population—County Reports.
8. *Available beds (geriatric)—full catchment areas:* As 7 but geriatric and chronic sick specialties and county population over 65; source as 7.
9. *Deaths and discharges (acute)—full catchment area:* Deaths and discharges from acute specialties (excluding psychiatric, obstetric, GP maternity, geriatric, and chronic sick), per 1000 county population; HIPE (1971), special enquiry; 1971 Census of Population—County Reports.
10. *Deaths and discharges (geriatric)—full catchment areas:* Deaths and discharges from geriatric and chronic sick specialties per 1000 population over 65; sources as 9.
11. *Occupied bed days (acute)—full catchment areas:* Number of occupied bed days in acute specialties (excluding psychiatric, obstetric, GP maternity, geriatric, and chronic sick) per 1000 county population; sources as 9.
12. *Occupied bed days (geriatric)—full catchment areas:* Number of occupied bed days in geriatric and chronic sick specialties per 1000 population over 65; sources as 9.

TABLE III
BED AVAILABILITY DATA BY AREA (1971 DATA)

Region	Variable 5
Northern	
Cleveland	4·50
Cumbria	2·97
Durham	3·16
Northumberland	2·67
Gateshead ..	2·33
Newcastle (T)	12·06
North Tyneside	2·06
South Tyneside	2·74
Sunderland	4·41
Yorkshire	
Humberside	3·41
North Yorkshire	3·66
Bradford	3·42
Calderdale	2·88
Kirklees	2·09
Leeds (T)	4·28
Wakefield	4·75
Trent	
Derbyshire	2·12
Leicestershire (T)	2·02
Lincolnshire	2·45
Nottinghamshire (T)	3·07
Barnsley	2·07
Doncaster	2·26
Rotherham	2·73
Sheffield (T)	4·52
East Anglia	
Cambridge (T)	2·96
Norfolk	2·81
Suffolk	3·11
S.E. Thames	
East Sussex	4·21
Kent	4·03
Greenwich	4·55
Bromley	6·40
Lambeth (T)	7·14
S.W. Thames	
Surrey	3·28
West Sussex	2·72
Croydon	2·67
Kingston and Richmond	2·66
Merton, Sutton, and Wandsworth (T)	3·37
Wessex	
Dorset	2·51
Hampshire (T)	2·17
Isle of Wight	2·47
Wiltshire	3·58
Oxford	
Berkshire	3·03
Buckinghamshire	2·45
Northamptonshire	2·75
Oxfordshire (T)	3·40
S. Western	
Avon (T)	3·38
Cornwall and Scilly	1·98
Devon	3·56
Gloucestershire	2·61
Somerset	2·76
Mersey	
Cheshire	2·63
Liverpool (T)	7·93
St Helens and Knowsley	2·39
Sefton	5·09
Wirral	5·56
N. Western	
Lancashire	3·35
Bolton	3·37
Bury	2·82
Manchester (T)	5·64
Oldham	2·91
Rochdale	2·96
Salford	4·14
Stockport	3·80
Tameside	1·65
Trafford	5·40
Wigan	2·19

Teaching areas (denoted by (T)) are omitted from variable 6

RESULTS AND DISCUSSION

The results of the analysis of Rickard's expenditure data shown in Table I indicate clearly that more of the overall variance of per caput expenditure, both total and subdivided, between health authorities is associated with the area level rather than with the regional level. The psychiatric hospital sector expenditure is not analysed as the absence of such hospitals from many areas leads to artificially wide variations between areas. Some caution should be exercised in interpreting the results shown in Table I. First, they relate to the distribution of the expenditure rather than of the resources which the expenditure may produce, and secondly, greater variation at area rather than regional level may be a *consequence* of attempts to create centres of excellence. In other words, the implicit assumption that equality between areas is a desirable objective may not be appropriate.

The data presented in Tables II and III provide direct measures of the distribution of resources rather than expenditure. Some considerable individual variations between counties/areas are apparent and the analysis summarizes one aspect of the pattern of variation. The results of the analysis set out in Table IV exhibit remarkable uniformity; in all cases the variance associated with the county scale is larger than that associated with the regional scale. Since some counties embody more than one area health authority,

TABLE IV
RATIO OF COUNTY/AREA AND REGION SCALE VARIANCES

		County/Area Scale Variance / Region Scale Variance
1.	Residents of homes for the aged and infirm	2·19
2.	Home nurse visits	1·10
3.	Home help cases	2·16
4.	General practitioner availability	1·11
5.	Available beds (acute)*	3·16
6.	As 5 but omitting teaching areas*	1·74
7.	Available beds (acute)—full catchment areas	3·34
8.	Available beds (geriatric)—full catchment areas	7·83
9.	Deaths and discharges (acute)—full catchment areas	1·63
10.	Deaths and discharges (geriatric)—full catchment areas	2·71
11.	Occupied bed days (acute)—full catchment areas	1·32
12.	Occupied bed days (geriatric)—full catchment areas	2·42

*Data from eleven regions only, see Table III

the county/region analysis may tend to underestimate the subregional scale variance which would be found in a true area/region analysis. The variables examined comprise indicators of use and provision relating to several facets of the health care system, and, in particular, not just to the hospital sector. None the less, the dominance of the county (that is, subregional) level variation is most marked in the hospital sector variables, especially those of bed availability. The results for variables 5 and 7 may be interpreted as suggesting that cross-boundary flows of patients making use of the facilities of neighbouring areas make little difference to the overall picture of variations. Some measure of the contribution to the subregional scale variance arising from a teaching/non-teaching area dichotomy is provided by comparative entries 5 and 6 in Table IV. The general message implicit in these results will come as no surprise to many employed in the NHS: variations of provision and use attributable to the subregional level are in some sense greater than those attributable to the regional level. Comparisons performed at regional level may thus understate the magnitude of variation throughout the country. Hence regional comparisons should perhaps be regarded with some suspicion and comparisons at lower levels of aggregation considered to be more appropriate. Every effort should be made to obtain data allowing comparisons at area and district levels.

It is not generally possible to obtain reliable data at district level corresponding to those analysed at regional and county/area level in Table IV, so that the magnitude of variations attributable to the district level cannot in general be estimated. However, a preliminary analysis of bed availability data collected at hospital management committee level corresponding to variable 5 in Table IV and again pertaining to 11 of the English regional health authorities (that is, excluding NW Thames, NE Thames, and West Midlands) suggests that rather less variance is attributable to this lowest level than to the county level.

Evidence of substantial variations of resources at lower rather than higher levels of aggregation has been presented. As noted above some variation may merely reflect the existence of centres of excellence. None the less, it is of paramount importance that we should not remain content with analyses at high levels of aggregation and ignore characteristics which emerge only at lower levels. In particular, as acknowledged by the DHSS Working Party on Resource Allocation (Department of Health and Social Security, 1975) the distribution of resources at subregional levels must be monitored and modified if necessary. The knowledge that he or she lives in a relatively well provided region is of little consolation to the patient unable to enjoy satisfactory facilities in his or her locality. However, the inhomogeneities of each of the levels in the NHS hierarchy with regard to the functions they perform (Warren, 1975) unfortunately suggests that comparisons between authorities at any particular level in the administrative hierarchy may easily be misinterpreted.

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Requests for reprints: D. R. Jones, Institute of Cancer Research, Clifton Avenue, Sutton, Surrey SM2 5PX.

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