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Social Deprivation and Rates of Treated Mental Disorder
Developing Statistical Models to Predict Psychiatric Service Utilisation

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A review of the literature shows that there are strong associations of treated prevalence rates of psychiatric disorder with social class, sex, marital status, ethnic group and living alone; and moderate associations with living in inner-city areas and a high degree of residential mobility. The Jarman-8 index of social deprivation correlates with psychiatric admission rates for patients aged less than 65 years (R^2=0.38). Individual census variables can themselves account for up to 0.71 of the variance in the admission rates, while combined in a stepwise multiple regression the census variables will account for over 0.95 of this variation. Multiple regression models using individual census variables and derived indices should be applied next on a wider geographical basis, and to narrower age, sex and diagnosis-specific psychiatric morbidity rates.

This paper has three aims: firstly, to identify from the literature which sociodemographic factors have clearly identified associations with psychiatric morbidity rates; secondly, to replicate for the South East Thames Region (SETRHA) the North West Thames study (Hirsch, 1988), which found high correlations between the district Jarman-8 scores and the total adult admission rates, and the under 65 admission rates ($r=0.76$ and $r=0.80$ respectively); and thirdly, to test a series of multiple regression models for their ability to statistically account for the variation between health districts in psychiatric admission rates.

Five hypotheses will be examined in this study: (a) that the correlation between district psychiatric admission rates (adults under 65 years) for the SETRHA will correlate significantly with the district Jarman-8 indices; (b) that the Jarman-8 index will better predict district admission rates than do Standardised Mortality Ratios (SMRs), the ACORN index (1986), the Unit9 and the Department of the Environment (DoE) Social Indices (see below); (c) that the Jarman-8 index will better predict district admission rates than do single sociodemographic variables; (d) that single census variables combined in a multiple-regression model will account for a greater proportion of the variance in SETRHA district admission rates than do any single census variable or derived index; and (e) that a principal components analysis will identify meaningful components which will predict admission rates better than single census variables, single derived indices, or combined census variables.

Sociodemographic variables and psychiatric disorders

In 1939 Faris & Dunham described a clear gradient of psychiatric admission rates for psychosis in Chicago, with higher rates in the inner-city areas. More recent work at the ecological level has focused on treated prevalence in relation to four issues: intra-urban patterns, urban–rural differences, the effect of geographical distance from services, and the association with population density.

With regard to intra-urban patterns Hare (1956) reported a strong association in electoral wards between admission rates for schizophrenia and the proportion of people living alone. He concluded that the data supported two possible explanations: that social isolation is a causal factor for schizophrenic episodes or that schizophrenic people segregate in these areas. Such patterns may be very stable: they were found to persist in Bristol 20 years later but were then in areas with high proportions of first- and second-generation Afro-Caribbeans (Harrison *et al*, 1984; Ineichen *et al*, 1984). Similar patterns have been demonstrated in Nottingham (Giggs & Cooper, 1987) and in Mannheim where between 1965 and 1980, despite marked local sociodemographic changes, the spatial distribution of incident cases of mental disorders showed a correlation of $r=0.73$ over the 15-year study (Weyerer & Haefner, 1989).

While rates of treated mental disorder have been shown to be higher in urban than in rural areas (Eaton, 1974; Goodman *et al*, 1983), these data have not adequately accounted for the effects of migration, for the presumed stresses of urban life and for service availability (Eaton, 1974). Reviewing this literature, Dohrenwend (1975) showed that overall prevalence rates of psychosis showed little rural–urban difference, but that schizophrenic rates appeared higher in cities and rates of manic–depressive psychosis lower. There was also evidence in favour of higher urban rates of neurosis and personality disorder.

In addition, the effects of age and social class may differ between urban and rural areas. Using the Maryland Psychiatric Case Register, Eaton (1974) found that hospital admissions for schizophrenia occurred later in rural areas, a result later confirmed in Ireland by Keatinge (1989), although again limited by reliance on treated rather than true prevalence rates (Cagle & Banks, 1986).

Goldberg & Huxley (1980) have demonstrated that selection and referral filters modulate and direct recognised psychiatric morbidity from the primary to the secondary and tertiary care sectors. The extent to which service utilisation is related to service availability is much less well documented. Considering here only geographical availability, a model developed in Auckland showed that distance from health centres was a significant predictor for utilisation rates in three psychiatric intervention services (Hall, 1988). Even so, the reduction in demand with distance appears to be non-linear (Srole, 1975), as a study in western Australia has illustrated (Stampfer *et al*, 1984).

Data examining the contribution of population density to psychiatric morbidity is sparse. In his Bristol study Hare (1956) found a correlation of 0.37 with admission rates for schizophrenia, and −0.39 for the neurotic disorders. A larger study of 13 parliamentary constituencies in London and six electoral wards in Sheffield (Lomas *et al*, 1973) found a range in population density from less than eight to over 60 persons per acre, and a highly significant correlation with the schizophrenia discharge rate of 0.83.

Associations with derived sociodemographic variables

Social class and social security benefits are two derived variables whose association with psychiatric morbidity has been examined. The association between social class and mental disorder is best documented and established for schizophrenia (Hollingshead & Redlich, 1958; Goldberg & Morrison, 1963; Dunham, 1965; Eaton, 1974; Kohn, 1976; Eaton, 1985; Jablensky, 1986, 1988; Shur, 1988; Wyatt, 1988). Reviews of both true prevalence (Dohrenwend & Dohrenwend, 1969) and of treated incidence (Eaton, 1974) have shown that low social class confers a relative risk of 2–3 for schizophrenia. Social status has most often been defined in the USA by using education or income (Kessler, 1982; Liberatos *et al*, 1988) and in Britain by the Registrar General's classification (Goldberg & Morrison, 1963).

For schizophrenia, lower social class is associated with longer duration of episode (Cooper, 1961), greater risk of relapse (Myers & Bean, 1968), poorer quality of care (Mollica & Milic, 1986*a*,*b*), lower per capita treatment expenditure (Hollingshead & Redlich, 1958) and poorer treatment response and clinical outcome (Cooper, 1961; Weyerer *et al*, 1982). It is also associated with disproportionate utilisation of psychiatric services (Lavik, 1983) and with differing perceptions of mental illness (Heller *et al*, 1979). Further, a study in Bavaria has suggested that the effect of social class on prognosis may diminish with increasing length of stay (Weyerer *et al*, 1982).

Explanations of these findings use two models: social causation and social selection/drift. The social causation model suggests that exposure to social, especially urban, stressors induces onset or relapse of schizophrenia (Link *et al*, 1986). The selection/drift model proposes two processes which jointly produce downward social mobility. Firstly, there is intergenerational mobility which involves a reduction in social status in relation to the parental generation. Secondly, intragenerational 'drift' occurs, which is a progressive deterioration in the patient's own relative socioeconomic standing (Turner & Wagenfield, 1967; Eaton, 1980, 1985; Wiersma *et al*, 1983).

With regard to social security benefits, British data on the receipt of severe disability allowance, invalidity benefit, sickness benefit and attendance allowance, although classified by ICD category for cause of disability, are not available for any smaller unit than the 11 standard statistical areas of Great Britain, and so are of little use in predictive models. Their potential, however, has been demonstrated in the USA. Goldman *et al* (1981) attempted to formulate an operational definition of severe mental disorder along the three axes of diagnosis, disability and duration. The uptake levels of Supplemental Security Income (SSI) was used as a proxy for combined severity of disability and duration (greater than 12 months), and allowed an estimate of between 1.7 and 2.4 million people who suffer from severe mental disorders in the USA. This estimation method, used in Oslo, indicated that patients receiving disability pensions were relatively more frequent and more intensive users of the local psychiatric services (Lavik, 1983).

A variation employed by Shapiro *et al* (1985) using Epidemiologic Catchment Area (ECA) data is to define poverty by the proportion of the population registered for the state health insurance, Medicaid. Using such a scheme, they describe a strong gradient of greater psychiatric needs, and lower levels of met need among Medicaid recipients.

Associations with individual sociodemographic variables

Treated prevalence rates of the neurotic disorders are higher among women, and personality disorders more prevalent among men (Dohrenwend, 1975). Data from the ECA multisite survey in the USA demonstrated that, for all diagnoses, a higher proportion of women made mental health visits, but that men in contact with services were more likely to be seen by a mental health specialist (Shapiro *et al*, 1984). For schizophrenia, treated prevalence rates for men are higher (Eaton, 1985; Sartorius & Jablensky, 1986; Jablensky, 1988), onset is earlier, and course, outcome and treatment response are poorer (Wyatt *et al*, 1988). Furthermore, men's pre-morbid social functioning is poorer (Eaton, 1985), and they make greater demands upon services for the long-term mentally ill (Hughes, 1973; Lavik, 1983; Liberatos *et al*, 1988).

In his review, Warr (1987) indicates that unemployment may impair physical and mental health (especially anxiety and non-psychotic depression), and increase smoking, suicide and deliberate self-harm. Analyses of aggregate data are as yet less conclusive, although divorce rates appear to increase. Further substantiating these links, analyses carried out in Sheffield and Hackney found a correlation between admission rates for schizophrenia and unemployment levels of 0.87 (Lomas *et al*, 1973).

Drawing on eight previous studies, Eaton (1985) calculated a mean relative risk of schizophrenia of 3.0–4.7 for non-married compared with married individuals. The widowed have a lesser risk than the divorced, separated and never-married (Eaton, 1975), while heavy service users are more likely to be unmarried (Lavik, 1983). Indeed, in one Connecticut study the association between marital status and relative risk had remained relatively unchanged over 25 years (Mollica & Milic, 1986*b*).

Living alone, living in overcrowded accommodation and living in council housing are all related to higher psychiatric prevalence rates. In the ECA study, people living alone had very high rates of need, of which a high proportion was unmet (Shapiro *et al*, 1985). Overcrowding was used in the predictive model of Lomas *et al* (1973) who found a correlation of 0.90 between the percentage of the population living at more than 1.5 persons per room and schizophrenia discharge rates.

From the early work of Faris & Dunham in Chicago (1939) emerged the suggestion that residential mobility is associated with rates of mental disorder. That schizophrenia rates are higher in the inner-city 'zones of transition', characterised by a highly itinerant population, has been reinforced more recently by work in Los Angeles (Dear & Wolch, 1987).

There is now substantial evidence that patients' ethnic group may have a profound influence upon psychiatric morbidity rates (London, 1986). Most large studies report treated morbidity and suggest that both schizophrenia and all-diagnosis rates for West Indian and Irish patients, for example, are at least twice those of white English patients (Hemsi, 1967; Cochrane, 1977; Rweglera, 1977; Carpenter & Brockington, 1980; Littlewood & Lipsedge, 1981; Dean, 1981; Cochrane & Bal, 1989; Glover, 1989). Indeed, a more recent study in Nottingham, using standardised instruments, found that utilisation rates may be even higher among second-generation Afro-Caribbeans (Harrison, 1987).

Mediators between census variables and service use

The sociodemographic factors referred to above have most often been directly correlated with various psychiatric morbidity indices, most often in-patient admission rates. Several authors, however, have attempted to go beyond this descriptive level and interpret the results in terms of three constructs presumed to mediate the relationships: poverty, social isolation and social disorganisation (Department of Health and Social Security, 1980).

Using health indicators, a study in Bristol concluded that poor health is significantly correlated with material deprivation (Townsend *et al*, 1985). In relation to psychiatric morbidity, an analysis of electoral ward data in Edinburgh and Glasgow found correlation coefficients of 0.45 to 0.53 between a combined index of deprivation and psychiatric admission rates (Carstairs, 1981). Total household income would arguably be the best index of material deprivation, but, like social security benefit data, is not available for small-area comparisons.

Social isolation as a mediator between sociodemographic characteristics and psychiatric morbidity was proposed by Hare (1956). From his findings in Bristol, that schizophrenia admission rates correlated with districts with a high proportion of the population living alone, he concluded that this was consistent either with social isolation acting as causal factor in incident cases, or with the segregation hypothesis that affected individuals clustered in poorer, isolated households. The finding was replicated in a community mental health survey of New Haven, Connecticut (Tischler *et al*, 1975). Patients who were unmarried, unemployed, living alone or without religious affiliations were disproportionately heavy users of the mental health services.

A disintegration of social functioning has been associated with high psychiatric morbidity rates since the earliest Chicago studies. Disorganisation has been characterised by excessive residential mobility, ethnic conflict, communication breakdown, and a lack of consensus (Dunham, 1965). Although conceptually interesting, there is little empirical evidence for this view (Bebbington & Davies, 1980; Weyerer & Haefner, 1989).

Psychiatric morbidity and service use

Psychiatric morbidity data based upon service-contact rates show a highly biased picture that may grossly underestimate true incidence and prevalence rates, and which may distort or even reverse aetiological associations.

Reviewing 13 epidemiological studies, Link & Dohrenwend (1980) estimated that for all psychiatric diagnoses the median proportion of (true) cases in treatment was 27%, with considerable variations between diagnostic groups. Overall, more serious conditions are more likely to have been in treatment. For all psychoses the proportion treated is 60%, and for schizophrenia 83%. Consistent with this, the ECA study determined that a majority of psychiatric cases ascertained by the Diagnostic Interview Schedule had not seen a mental health provider during the previous six months, and that the proportions were especially low among those with cognitive disorders, and alcohol and drug abuse (Shapiro *et al*, 1984).

Sociodemographic factors in turn mediate the referral process that brings true cases into service contact. There are higher proportions of treated cases among young adults, men, city dwellers, and in those who are divorced or separated. While true rates are inversely related to social class, treated rates are directly associated with this variable (Link & Dohrenwend, 1980). In the ECA study, psychiatric needs were less often met for those who were elderly, living alone, or receiving Medicaid (Tischler *et al*, 1975; Shapiro *et al*, 1985).

Statistical models to predict service use

The literature reviewed in the previous sections indicates that many social and demographic variables are individually and jointly associated with rates of psychiatric service usage. Firstly, there is strong evidence to relate such rates with social class, sex, marital status, ethnic group, and living situation. Reasonable evidence links utilisation rates with living in inner-city areas, and a high degree of residential mobility. The evidence is less firm in implicating geographical distance from services, population density and the levels of social security received as possible predictor variables. Secondly, it is clear that many of these sociodemographic variables are highly inter-related (the statistical problem of multicolinearity). Thirdly, there appear to be interactions between utilisation and age, sex, social class, marital status, and place of residence. We therefore developed statistical models to further explore the relationship between sociodemographic variables and service use in the South East Thames Region.

Method

The South East Thames Regional Health Authority (SETRHA) provides a service to the 3.6 million people living to the south and east of London as far as the Sussex and Kent coasts. The inner-city areas of London have experienced an outflow of population over the last ten years. The region has one of the highest proportions of elderly in England – a proportion that continues to increase. The overall social class distribution is similar to that of the whole nation. Regional psychiatric services, in line with national policy, are being decentralised (SETRHA, 1989; Thornicroft & Bebbington, 1989). Nevertheless, in 1986 84% of all psychiatric beds were still sited in the seven large institutions, while seven of the 15 districts have no in-patient psychiatric facilities on their district general hospital sites. In terms of treated psychiatric morbidity, it has higher than national average rates of admissions, patient turnover and residents in psychiatric hospitals (Department of Health and Social Security, 1984, 1985).

Procedure

The analyses use three types of variables: individual census variables (predictor variables), derived indices of social deprivation (also predictor variables), and psychiatric admission rates (outcome variables). The predictor variables used are from the 1981 census Small-Area Statistics (OPCS, 1981), from SETRHA (Rice *et al*, 1984), and from Professor Jarman.

Outcome data were derived from the SETRHA annual reports of the Mental Health Enquiry (MHE). Regional admission data were made available by the Department of Health as the national MHE tape for 1982, and Professor Jarman provided admission rates for the SETRHA districts standardised by age, sex and marital status. The analyses presented here concern the crude and standardised admission rates for adult patients aged less than 65 years for the district health authority of residence, not treatment.

MHE data are only available for health districts after the 1982 reorganisation, and for this reason 1981 census data are correlated with 1982 MHE data, and there may be a minor degree of slippage over the elapsed year. The reliability of the census data was tested by cross-reference between the three data sources. The outcome variables were taken from standard regional MHE tables whose validity is checked by the Department of Health in comparison with daily ward returns.

Table 1 summarises the components of four of the derived indices of social deprivation used in the analysis. Jarman has produced a composite index of social deprivation (Jarman, 1983, 1984), aiming to identify areas in Britain which are relatively underprivileged (Department of Health and Social Security, 1976; Bebbington & Davies, 1980; Townsend *et al*,1985). There are two versions based upon eight and ten census variables (Jarman-8 and Jarman-10) which are weighted in accordance with the judgments of a national survey of general practitioners on the factors which increase workload, standardised and transformed. The Jarman-8 score has become the more widely used.

Despite criticism of this approach (Scott-Samuel, 1984; Wilkin *et al*, 1984; Bickler, 1988; Carr-Hill, 1988), it has gained external criterion validity (Charlton & Lakhani, 1985) and has become widely recognised as a useful summary measure of social deprivation (Leavey & Wood, 1985).

The Unit9 index (Department of the Environment, 1983) is calculated from nine census variables which are given equal weighting. The variables are those used in the Jarman-8 without the change of address item and adding scores for lack of amenities and the population aged over 65 years. The DoE Social Index also uses eight census variables, with weights of 1 or 2 (Department of the Environment, 1983; Irving & Rice, 1984). In addition, the standardised mortality ratio (SMR) (OPCS, 1986) for all age groups and for those aged less than 65 (SMR65) were used as predictor variables.

A further index of social deprivation used, the ACORN index (A Classification of Residential Neighbourhoods), also draws on variables from the 1981 census. Enumeration districts are categorised using cluster analysis into 38 different types on the basis of 40 census variables measuring age, housing conditions, and socioeconomic status (ACORN, 1986). Individuals may be linked via their enumeration district to an ACORN type by using the address postcode.

Table 1
Calculation of derived sociodemographic measures by weighting census scores: weights used

Census variable[1]	Jarman-8	Jarman-10	Unit9	Social index
Over 56	0	6.19	1	0
Elderly alone	6.62	6.62	1	2
Children under 5	4.64	4.64	1	2
One parent	3.01	3.01	1	2
Unskilled	3.74	3.74	1	0
Unemployed	3.34	3.34	1	2
Lacks amenity	0	3.60	1	1
Overcrowded	2.88	2.88	1	1
Changed address	2.68	2.68	0	0
Ethnic minority	2.50	2.50	1	1

1. See Appendix for full definition of variables.

Account can be taken of the influence of supply of services on utilisation, and the analysis here will employ ACORN ratings both with (ACORNS) and without (ACORNN) this supply correction.

Results

Model 1: correlations of admission rates with individual census predictor variables

The correlations between individual census variables and the outcome variables are given set out in Table 2, and definitions of the census variables used are shown in the Appendix. Table 2 demonstrates that, with the exception of the age-specific predictor variables, all the census variables are strongly or very strongly correlated with the outcome variables.

Table 2 also shows the R^2 value, that is the proportion of variance (R^2) of each outcome variable which is explained by each individual predictor variable. The census variables which account for the highest proportion of the variance in the crude admission rate are, in rank order, overcrowding (over 1.5 people per room), lack of household amenities, living in one room, change of address in last year, overcrowding (over one person per room), population density, ethnic composition, no access to a car, and being a single parent.

Model 2: correlations with derived predictor variables

The derived census variables were separately inserted into the linear regression procedure, and the results are displayed in Table 3. The three derived variables most successfully predicting the unstandardised admission rate are, in rank

Table 2
Correlations between outcome variables and individual census variables

Census variable[1]	Correlation with:			
	Crude admission rate		Standardised admission rate	
	R	R^2	R	R^2
Elderly alone	0.12	0.01	−0.03	0.0009
Children under 5	0.12	0.01	−0.03	0.0001
Single parent	0.65	0.42	0.59	0.34
Social class V	0.50	0.25	0.52	0.27
Unemployed	0.57	0.33	0.52	0.27
Lack of amenities	0.83	0.69	0.75	0.56
Overcrowded 1	0.71	0.50	0.68	0.46
Overcrowded 2	0.84	0.71	0.79	0.62
Changed residence	0.71	0.51	0.59	0.35
Ethnic minority	0.67	0.45	0.63	0.40
No car	0.66	0.40	0.59	0.35
Living in one room	0.77	0.59	0.66	0.43
Population density	0.68	0.46	0.66	0.43
General beds	0.65	0.42	0.60	0.36
Psychiatric beds	0.30	0.09	0.29	0.08
Nursing home beds	−0.18	0.03	−0.26	0.07

1. See Appendix for full definition of variables.

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Table 3
Regression of derived variables by outcome variables

Derived variable	Correlation with:			
	Crude admission rate		Standardised admission rate	
	R	R^2	R	R^2
Jarman-8	0.62	0.38	0.54	0.30
Jarman-10	0.56	0.31	0.45	0.20
SMR	0.32	0.11	0.37	0.14
SMR65	0.52	0.27	0.46	0.21
ACORNN[1]	0.52	0.28	0.52	0.27
ACORNS[1]	0.53	0.28	0.53	0.28
Unit9	0.63	0.40	0.55	0.31
Social index	0.65	0.42	0.56	0.32

1. Ratings with (ACORNN) and without (ACORNS) correction for the influence of supply of services on utilisation.

order, social index, Unit9, and Jarman-8. It is notable that they each account for just over a third of the outcome variance, compared with just over two-thirds by the better individual census variables.

For the standardised outcome rate, the same derived variables in the same rank order, best predict admissions. Again, the extent of the prediction is slightly less for the standardised than the unstandardised rates. This was expected as the variability of the admission rates due to age, sex and marital status has been removed by standardisation.

Model 3: stepwise multiple regression with individual census variables

The forwards-stepwise form of multiple regression analysis first adds the single predictor with the highest contribution to the variance of the outcome variable, and then in turn adds further predictor variables one at a time as long as each new addition produces a significant improvement in the R^2 value. It should be noted that the order and relative contributions of the predictor variables in this approach are relatively unstable, and the output cannot be considered as the 'best' model.

For the crude admission rates, the two predictors which added significantly to the model (with the cumulative R^2 values) were overcrowded 2 (0.71) and ethnic minority (0.83). Seven other factors, which brought the combined R^2 to 0.95, were population density, overcrowded 1, social class V, availability of general beds, living in one room, nursing home places available, and availability of psychiatric beds. For the standardised rates, the significant predictors were overcrowded 2 (0.62) and single parent (0.74), while another seven variables brought the R^2 to 0.93: general bed availability, unemployment, living in one room, population density, overcrowded 1, children under aged five years, and changed accommodation (see Appendix for explanation of variables).

Model 4: principal components analysis

The principal components analysis (PCA; Armitage & Berry, 1989) was performed for all census variables and produced three interpretable components (Prin1, Prin2, Prin3; Table 4). The advantage of PCA is that it allows census variables to be identified from within each component which are both relatively independent, and which together contribute towards a high R^2 value in a multiple regression model.

The first three components together account for 92% of the variance within predictor variables entered into the model. The first component has only moderate loadings from a wide range of census and population factors, and represents a general deprivation factor ($R^2=0.59$). The second component has highest loadings for the variables elderly living alone, living alone, and those registered as permanently sick, and represents the socially isolated who are physically infirm and who use psychiatric services ($R^2=0.26$). The third component is primarily loaded by the availability of psychiatric services, the lesser loadings suggesting that this element of psychiatric bed usage is particularly taken up by those young adults who are unemployed, in social class V, and socially isolated ($R^2=0.07$).

Model 5: multiple regression model of components 1–3 by crude admission rate

The components identified in the PCA were inserted serially into a multiple regression model for both the crude and standardised admission rates. The three principal components together account for about two-thirds of the variance of the outcome variables. For the crude admission rates, the cumulative R^2 values from adding the three principal components were 0.50, 0.54 and 0.68, while the corresponding values for the standardised admission rates were 0.44, 0.45 and 0.58.

Table 4
Principal components analysis: loadings of census variables to components Prin1–3

Variable[1]	Prin1	Prin2	Prin3
Elderly alone	0.02	0.43	−0.17
Single parent	0.29	−0.01	−0.07
Social class V	0.26	−0.13	−0.21
Unemployed	0.26	0.02	−0.31
Changed residence	0.25	0.20	−0.02
Ethnic minority	0.28	−0.07	0.07
Lack of amenities 1	0.24	0.12	0.30
Overcrowded 1	0.28	−0.09	−0.01
Living alone	0.19	0.32	−0.02
No car	0.28	0.07	−0.17
Permanently sick	−0.13	0.37	−0.19
Living in one room	0.23	0.21	0.16
Population density	0.27	−0.09	0.07
General beds	0.25	0.08	0.06
Psychiatric beds	0.02	−0.18	0.77
Nursing home beds	−0.11	0.37	0.10

1. See Appendix for full definition of variables.

Table 5
Summary chart of complexity and predictive power of models used

Model	Model type	Number of variables	R^2 crude	R^2 standardised
1	Regression with census variables	1	0.71	0.62
2	Regression with derived variables	1		
		Jarman-8	0.38	0.30
		Unit9	0.40	0.31
3	Stepwise multiple regression	3	0.86	0.77
		5	0.90	0.82
		9	0.95	0.93
5	Principal components analysis	1	0.50	0.44
		2	0.54	0.45
		3	0.68	0.58
6	Multiple regression with variables identified in model 5	3	0.80	0.69
		4	0.84	0.74

Model 6: multiple regression model using variables identified by principal components analysis

Model 6 uses three census variables, one taken from each of the principal components. It is argued that this gives model 6 more stability across districts, although accounting for a lower R^2 than does model 3. A very good level of predictive power can be achieved from a combination of three predictor variables (psychiatric bed availability, overcrowding 2, and proportion of unskilled workers). To test the appropriateness of the model, residual (observed minus expected) and standardised residual values were calculated and plotted against the outcome variables. The results showed no systematic deviation from a linear model and confirmed that this was a suitable statistical approach to the data.

To summarise the results, Table 5 displays the relationship between the complexity and the predictive power of each model. The results show that each of the derived variables account for less of the variation in the outcome variables (R^2) than do the best individual census variables, the principal components, or the individual census variables combined. Furthermore, these combinations of census variables can effectively account for virtually all the variations in admission rates. Models of increasing complexity, therefore, do indeed better predict admission rates. Clinical, research and planning applications can therefore balance the degree of predictive accuracy desired against the complexity of the analysis required.

Discussion

The major advantage of the small-area analyses performed here is that they employ relatively accessible data, and so can be completed without large-scale data collection. However, they do run the risk of the 'ecological fallacy' – that each individual person is assigned the characteristics of the district of residence. An area-based approach assumes homogeneity within a given geographical area, and this assumption may be misleading or incorrect. Only relatively stable predictor variables therefore should be used, and model performance may improve if multiple rather than single indicators are included (Cagle & Banks, 1986; Liberatos *et al*, 1988). The more widespread use of computerised postcodes may allow such analyses at the electoral ward and enumeration district levels in future (Coopers & Lybrand, 1988).

Hypothesis 1, which stated that psychiatric admission rates for SETRHA will correlate significantly with the Jarman-8 indices, is supported by the results (Table 3). The correlation coefficient values are of the same order of magnitude as those reported by Hirsch (1988) for the North East Thames Region.

Hypothesis 2, which postulated that the Jarman-8 index will better predict SETRHA admission rates than do SMRs, ACORN, Unit9 and Social Index indicators, is not confirmed (Table 3). Both the Unit9 and Social Index variables account for a slightly greater proportion of the variance in admission rates than does the Jarman-8.

Hypothesis 3 stated that the Jarman-8 will better predict outcome than single sociodemographic variables. A comparison of Tables 2 and 3 reveals that many individual variables out-perform all the derived variables. It may be argued that the combined derived variables will prove more robust when applied to larger datasets of, for example, all health districts in England, and future research may test this specifically.

Hypothesis 4 stated that single census variables combined in a multiple regression model will account for a greater proportion of the variation in SETRHA district psychiatric admission rates than either individual or derived variables. This is the case and indeed nine individual census variables will account for more than 95% of such variation in outcome.

Hypothesis 5 proposed that a principal components analysis can identify meaningful components which will predict outcome better than single, derived or previously combined variables. Table 4 shows that three components are identified which account for 92% of the variation within the individual predictor variables, and that they contain census variables which can be entered separately into a further multiple regression equation. However, when the three components themselves are entered into a regression model, although they out-perform the derived variables, they predict less well than the better individual census variables.

Public health implications

The result that many individual census variables are highly correlated with outcome can be interpreted in a somewhat different light: that they indicate characteristics of groups at high risk of psychiatric admission. This approach has implications for health service planning. Patient groups most likely to make relatively heavy use of services can be described (Lavik, 1983), and may warrant specifically targeted services, both to meet their service needs and to free other services for separate patient groups (Richman & Barry, 1985; Tischler *et al*, 1984). Thirdly, these data allow estimates, at the aggregate level, of not only where greater levels of service need exist, but also about the patient groups having a higher proportion of their needs unmet (Shapiro *et al*, 1985; Brewin *et al*, 1987) and this can further guide service development. For this reason the Jarman-8 index is now being used to adjust general practice budgets for local social conditions.

Several specific areas of data collection and access remain inadequate. Firstly, standard data on psychiatric service utilisation should be made readily available by the Department of Health by district of residence. Secondly, data on the receipt of social security benefits would be usable for epidemiological purposes if it were available for health regions and districts. Thirdly, standard reports for utilisation rates should be categorised by diagnosis and by duration of stay. Fourthly, internationally standardised categories for sociodemographic data would allow meaningful comparisons (Kramer & Taube, 1973).

The results presented in this paper indicate that such multiple regression analyses may have the following uses. These models may be used for districts in other health regions, and indeed at more local levels of analysis: that is, electoral wards and enumeration districts. Furthermore, diagnosis-specific rates will allow more precise elaboration of the relationships between exposure and disease, and their possible aetiological implications. Finally, the use of such multiple regression models can be extended to other age and patient groups. Together, these may prove to be rich veins for research in psychiatric epidemiology in the coming years.

Appendix

Elderly alone	Pensioners (men aged over 65, women aged over 60) living alone as a percentage of all people resident in private households.
Over 65	People aged over 65 as a percentage of all residents in private households.
Permanently sick	People economically inactive and permanently sick as a percentage of all people aged over 16 (422/380)
Living alone	All people in a single-person private households as a percentage of all those in private households (1360/1351)
Children under 5	People with children aged under five years as a percentage of all residents in private households
Single parent	People in households consisting of one person over 16 and one or more children under 16 as a percentage of all residents in private households
Unskilled	People in households headed by person in socioeconomic group II as a percentage of all residents in private households
Unemployed	People aged 16 years or over seeking work or temporarily sick as a percentage of all residents in private households
Lacks amenity 1	People in households lacking exclusive use of a bath and inside WC as a percentage of all residents in private households
Lacks amenity 2	People in households sharing an inside WC as a percentage of all residents in private households (944/937)
Overcrowded 1	People in households with more than one person per room as a percentage of all residents in private households
Overcrowded 2	People in households with more than 1.5 persons per room as a percentage of all residents in private households (947/937)
Living in one room	People in private households with one room as a percentage of all persons living in private households (1191/1198)
Population density	Resident population in each district in 1983 divided by district area (hectares)
Changed residence	People aged 16 or over with a usual address one year before the census different from the present address as a percentage of total residents
Ethnic minority	People in households headed by a person born in the New Commonwealth or Pakistan as a percentage of all residents in private households
No car	People in households with no car as a percentage of persons in all households (950/937)

General beds	Number of psychiatric beds available in each district
Nursing home beds	Number of nursing home places available by district

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