

Small area statistics as markers for personal social status in the Scottish heart health study

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Abstract

Objective - To evaluate a deprivation index, calculated from small area statistics for postcode sectors, as a measure of individual social status in an epidemiological study of coronary heart disease (CHD).

Design - A baseline, cross sectional survey.

Setting - Twenty two local authority districts of Scotland surveyed between 1984 and 1986.

Subjects - A total of 10 359 men and women aged 40-59 years randomly selected to the Scottish heart health study.

Main results - The Scottish deprivation categorisation, derived from small area statistics, exhibits a strong linear trend ($p=0.001$ or below) for individual prevalent CHD for men and women, unadjusted, and adjusted for major cardiovascular risk factors. The degree of association with CHD is similar to that for measures of social class based upon occupation.

Conclusions - The Scottish deprivation categorisation is an effective measure of individual social status in the current study, broadly comparable in its effect with the more traditional classification derived from occupations. The latter has important problems in definition, especially for women. Small area statistics may provide a useful marker of individual social status in a more general epidemiological setting.

(*J Epidemiol Community Health* 1996;50:570-576)

Small area statistics, that is summary measures for local geographical areas measured from routine data, have been widely used as markers of social status. The individual statistics on particular aspects of social status, such as the percentage unemployed or the percentage of single parent families, are usually combined to form a univariate score, or index, for each area. Such scores were originally used by market researchers to define target populations for advertising campaigns,¹ but the methodology has become increasingly used in health services research and planning to develop markers of deprivation for areas.^{2,3} The best known index is due to Jarman;^{4,5} this has been used in the allocation of health resources by government.⁶

When assessing the social status of individuals, as opposed to areas, in epidemiological investigations, a sensible approach is to use some suitable measure which is specific to that individual, such as income,

education level or housing tenure (owner occupied/rented).⁷ The measure most commonly used in the UK is the categorisation based on occupations developed by the Office of Population Censuses and Surveys (OPCS).^{8,9} This is widely used in studies of both morbidity and mortality.

This article considers whether a particular index which was derived from postcode sector statistics, and is thus an area-level measure, is a useful measure of social status for individuals within that area in the context of a large epidemiological investigation of coronary heart disease (CHD) in Scotland. Since the data are Scottish, the index chosen for evaluation is the Scottish deprivation score developed by Carstairs and Morris.¹⁰ This is already used in health research and planning at area level, for example in reporting national cancer statistics.¹¹ It has previously been shown to have a very high correlation with other deprivation indices, including the Jarman index,¹² and to have a graded relationship to Scottish mortality and hospital discharge rate data.^{10,13,14} In particular, the Carstairs and Morris (C&M) deprivation categorisation (derived from the score) is compared here with the OPCS occupational classification as a measure of individual social status in relation to CHD.

Methods

THE DATA

The data analysed here come from the baseline survey of the Scottish heart health study (SHHS) and were collected during 1984-86 from 22 of the 56 mainland local authority districts in Scotland. An age/sex stratified random population sample of 10 359 men and women aged 40-59 years were asked, by letter, to complete a questionnaire and attend at a medical clinic. The questionnaire included sociodemographic items (including employment), details of medical history, the Rose chest pain questionnaire,¹⁵ and a food frequency questionnaire.¹⁶ At the clinic a 12 lead electrocardiogram was recorded; height, weight and blood pressure were measured; and a blood sample was taken. Details are given elsewhere.^{17,18} Complete postcode information was not recorded as part of any participant's address; incomplete postcode information was only recorded for residents of Glasgow and Edinburgh.

THE OPCS OCCUPATIONAL CLASSIFICATION

The OPCS classifies occupations into six graded social categories: I non-manual, pro-

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Accepted for publication
April 1996

Table 1 Scottish heart health study (SHHS) sample in relation to the Carstairs and Morris deprivation category and selected features of the OPCS occupational classifications

Occupational class	Deprivation category							Missing	Total (%)
	1	2	3	4	5	6	7		
Men									
% Agree	19	50	39	54	63	26	11		
Classified no	517	808	1103	1189	746	405	211	87	5066 (99)
Missing no	6	7	10	12	10	7	4	1	57 (1)
Women: head occupation									
% Agree	17	48	38	49	56	29	12		
Classified no	481	793	1065	1263	705	343	221	69	4940 (94)
Housewives no	10	13	34	27	23	14	14	4	139 (3)
Missing no	14	23	33	38	25	14	7	3	157 (3)
Women: personal occupation									
% Agree	2	29	47	37	28	40	20		
Classified no	377	646	871	1056	589	297	184	54	4074 (78)
Housewives no	124	173	255	257	152	72	57	20	1110 (21)
Missing no	4	10	6	15	12	2	1	2	52 (1)
Persons									
Total no	1028	1644	2245	2529	1509	783	457	164	10359
Sample %	10	16	22	25	15	8	4		
Census %	6	14	22	25	15	11	7		

% Agree = % of individuals in any deprivation category who are also in the OPCS class of the same or next lowest rank.

Sample % = % of SHHS participants who have been classified to a deprivation class (denominator excludes missing values).

Census % = % in the 1981 Scottish Census.

Note: "housewife" is the occupation self-declared by the respondent herself (including single women).

fessional; II non-manual, intermediate; III non-manual, skilled; III m manual, skilled; IV manual, partly skilled; V manual, unskilled. The traditional approach is to classify men and single women according to their current occupation if currently employed, and to their last occupation if currently unemployed. Married women are classified according to their husband's occupation. This method is considered here, as well as an alternative approach wherein all women are classified by their own occupation. To distinguish between the two, the traditional approach will be termed the "head occupation" classification, since it implicitly characterises the husband as head of household. The alternative approach leads to the "personal occupation" definition. There will, of course, only be a difference for women. Anyone who has never held a job will be unclassified.

THE C AND M DEPRIVATION CATEGORISATION

Carstairs and Morris define their deprivation score as an unweighted sum of four standardised small area statistics. These statistics are: the proportion of all persons living in private households with a density of more than one person per room; the proportion of economically active males seeking or waiting to start work; the proportion of all persons in private households with an economically active head with head of household in OPCS occupational class IV or V; the proportion of all persons in private households which do not own a car. Standardisation is achieved by subtracting the all-Scotland mean and dividing by the all-Scotland SD for each of the four statistics for each area. This is done so as to prevent a statistic with wide variation from having a large influence on the overall score. The statistics themselves were derived from the 1981 census, and the areas to which they refer are postcode sectors: complete postcodes except for the final letters (eg, G1 5 or FK21 8). These have been split when they cross local authority district boundaries. Altogether there are 1155

Scottish postcode sectors, although C&M scores are not available for 145 sectors with very small populations due to suppression of Census data.¹⁰ The populations covered by the sectors range from 0 to 19 887. Carstairs and Morris¹⁰ define, arbitrarily, seven "deprivation categories" by grouping their deprivation score. These range from category 1, the most advantaged, to 7, the least advantaged. Both populations and postcode sectors are distributed unequally across categories¹³ – see table 1.

For the SHHS sample, each individual's postcode sector, and thus the C&M deprivation category, was determined from his or her address, by utilising the services of a commercial agency supplemented by study of maps and telephone directories. Postcodes were ascertained for 10 251 of the 10 359 subjects. In all, 495 postcode sectors are represented in the SHHS.

PREVALENT CHD

Each individual in the SHHS was classified as a CHD case if they had one or more of the following: a self reported previous doctor diagnosis of angina pectoris or myocardial infarction (MI); indications of angina or possible MI from the Rose chest pain questionnaire; indications of ischaemia (ST or T wave changes) or MI (Q/QS patterns) from their electrocardiogram.¹⁹ Everyone else was classified as free of CHD, except that remaining individuals with a history of drug treatment for cardiovascular disease or hypertension were excluded. This classification has been used in several publications describing the baseline SHHS; a detailed analysis by social status and components of the classification appears elsewhere.²⁰

STATISTICAL ANALYSIS

A variable will be considered to be an effective epidemiological measure of personal social status if:

1. It measures (directly or indirectly) items widely recognised as representing deprivation, lack of access to amenities, material disadvantage or other aspects of social class,
2. It exhibits a regular, graded, response for the health outcome variable (here, prevalence of CHD).

The first criteria will be assumed to be satisfied by both the C&M and OPCS variables; the second may be tested by statistical analysis. Here logistic regression was used to calculate CHD prevalence odds ratios for the C&M deprivation categories of individuals. A linear trend was then fitted to the log odds; this is equivalent to assuming a constant multiplicative increase on the raw scale, ie, the odds of prevalent CHD increases by a constant multiple as the deprivation category rank increases by a constant amount. A similar analysis was performed for the OPCS variable, although less detail is presented here, both because the properties of the occupational social classification are well known and because some results from the SHHS have already been published.²⁰ The C&M and OPCS ("head" and "personal" occupation) variables were compared in absolute terms by examining their agreement. In relation to CHD, their sets of log odds, goodness of fit to a linear trend, and the magnitude of that trend were compared. The marginal significance of each variable in the presence of the other was also evaluated, as was the possibility of interactions, through further logistic regression modelling. Analyses were carried out using the multilevel modelling package *MLn*,²¹ which takes account of the clustering of individuals to postcodes. Penalised quasi-likelihood estimation was used, taking Taylor series approximations to the second order.²²

Whatever measure of social class is adopted, it is of interest whether its effect as a predictor of prevalent CHD remains after adjustment for known coronary risk factors. The analyses described above were thus repeated with age, serum total cholesterol, diastolic blood pressure, body mass index, serum cotinine and antioxidant vitamin consumption as covariates. Cotinine is an objective measure of tobacco smoke inhalation.²³ Antioxidant vitamin consumption was measured by the first principal component of β carotene, vitamin C, and vitamin E consumption calculated from self reported food consumption.²⁴ As in the unadjusted case, an earlier publication²⁰ has already shown that the traditional OPCS occupational social class variable is a significant ($p < 0.05$) predictor of prevalent CHD after adjustment for a very wide range of established coronary risk factors, for the current data.

Results

The Spearman rank correlations between the C&M variable and the OPCS variable in the SHSS are 0.35 for men and 0.34 ("head") and 0.28 ("personal") for women. Table 1 shows the distribution of C&M outcomes and a further summary measure of agreement with the OPCS variables. Since C&M have seven, but

OPCS only six, categories, exact one-to-one agreement is not possible. If they did both measure exactly the same thing then no-one would be in a higher C&M category than their OPCS category. In table 1 an "agreement" is where someone in a particular C&M category is also in the OPCS category of either the same or next lowest rank. This inevitably means that percentages are likely to be lowest in the extreme categories (C&M classes 1 and 7). Table 1 suggests that there is considerable disagreement between the C&M and OPCS variables because the percentage agreements rarely exceed 50%. Although the C&M definition includes use of the OPCS classification, there is no reason why the two should have close agreement at the individual level since C&M only use area-level statistics. In fact, when complete cross tabulations of C&M against OPCS category are examined, there is only one case in which a C&M class does not contain men and women from every OPCS class.

Table 1 gives a basis for comparing unclassifiable subjects between the variables. A "housewife" is a woman (single women only for the "head occupation" definition) who has declared this as her current occupation and who has not declared any previous employment. These women are not classified on the graded OPCS scale. Missing values are where there is insufficient detail, either in the job description or the address, to classify an individual. Overall a few more men, but considerably fewer women, are uncoded for the C&M variable compared with the OPCS variable(s). Although the "personal" occupation definition has produced fewer missing values than the "head" occupation definition, this is far outweighed by the enormous increase in the number of uncoded "housewives".

Table 1 also includes the distribution of the C&M variable for the Scottish population, calculated from the 1981 census.¹³ Since the SHHS used a stratified sample with a restricted age range, there is no reason to expect very close agreement between the SHHS and population distributions.

When prevalent CHD is classified, there are 2122 positives, 7618 negatives, and 619 exclusions. Virtually half of each group are female. Table 2 shows odds ratios for the C&M categories (omitting missing values) both before and after adjustment for coronary risk factors. For men the differences between CHD prevalence by C&M category are extremely significant ($p < 0.0001$) before and after adjustment. For women the corresponding p values are 0.0002 and 0.04, so that adjustment makes a considerable difference in this case. Adjustment reduces the magnitude of the extreme effects.

For each sex there are clear gradients, even if contiguous categories are sometimes similar. The "multiplicative constant" model (model for linear trend on the log scale) predicts between 8%–16% increase in odds as the category rank increases by one. Adjustment reduces the rate of increase.

Table 2 Odds ratios (OR) (95% confidence intervals) for prevalent coronary heart disease according to the Carstairs and Morris deprivation category. Adjustments are for age, serum total cholesterol, diastolic blood pressure, body mass index, serum cotinine, and antioxidant vitamin consumption. The "multiplicative constant" is the estimated OR for comparing each deprivation category with the previous one

Deprivation category	Men			Women		
	Cases (%)	Unadjusted OR	Adjusted OR	Cases (%)	Unadjusted OR	Adjusted OR
1	83 (17)	1	1	83 (18)	1	1
2	143 (18)	1.02 (0.72, 1.45)	0.99 (0.70, 1.41)	147 (19)	1.10 (0.81, 1.51)	1.04 (0.75, 1.42)
3	195 (18)	1.08 (0.77, 1.50)	1.02 (0.73, 1.43)	207 (20)	1.15 (0.86, 1.55)	1.08 (0.80, 1.46)
4	261 (23)	1.37 (1.00, 1.89)	1.24 (0.89, 1.71)	291 (24)	1.47 (1.10, 1.96)	1.32 (0.98, 1.76)
5	204 (28)	1.89 (1.35, 2.65)	1.76 (1.25, 2.48)	158 (23)	1.41 (1.03, 1.93)	1.25 (0.91, 1.72)
6	109 (28)	1.74 (1.20, 2.54)	1.63 (1.11, 2.39)	85 (25)	1.57 (1.09, 2.24)	1.34 (0.93, 1.94)
7	59 (29)	2.03 (1.32, 3.12)	1.66 (1.06, 2.59)	69 (31)	2.06 (1.40, 3.04)	1.69 (1.14, 2.53)
Multiplicative constant		1.16 (1.10, 1.22)	1.14 (1.08, 1.20)		1.11 (1.06, 1.17)	1.08 (1.03, 1.14)

The OPCS variables give broadly similar results to the C&M variable. For men the comparison of CHD prevalences is significant without adjustment ($p=0.01$), but not significant ($p=0.11$) after adjustment for the risk factors used in table 2. For women, "head occupation" gives much more extreme results ($p<0.0001$ before adjustment, $p=0.004$ after adjustment) than "personal occupation" ($p=0.003$ and $p=0.20$ respectively), although "head" has around 20% more observations and so the comparison must be made with caution.

Figure 1 shows the estimated log odds and the fitted linear model for all three classifications for each sex, without adjustment. The two occupational definitions for women may be compared directly; the "head" definition gives a slightly better fit for the linear model, and has a slightly higher gradient. The differences are only important at the most advantaged end of the social scale; broadly the "personal" definition gives a relatively low estimate of prevalent odds in occupational social

class I. For social class III in the two odds concur. The linear term for OPCS categories is extremely significant before adjustment in each case ($p<0.0001$ for "head" and $p=0.004$ for "personal") but is not quite significant after adjustment at the 5% level for "personal" ($p=0.07$). Both before and after adjustment, there is no significant non-linear component for any OPCS classification ($p>0.10$).

Comparison of the C&M category and occupational social class is, again, complicated by the difference in the number of categories, although figure 1 uses the same range on each horizontal axis to aid the visual comparison of slopes and fits. The linear term for C&M categories is extremely significant before and after adjustment ($p<0.0001$ in both situations for men; $0<0.0001$ unadjusted and $p=0.001$ adjusted for women). Once again, there is not a significant non-linear component ($p>0.10$) in any of the circumstances. Thus, each of the three social variables exhibits a clear gradient for CHD prevalence; there is little to choose

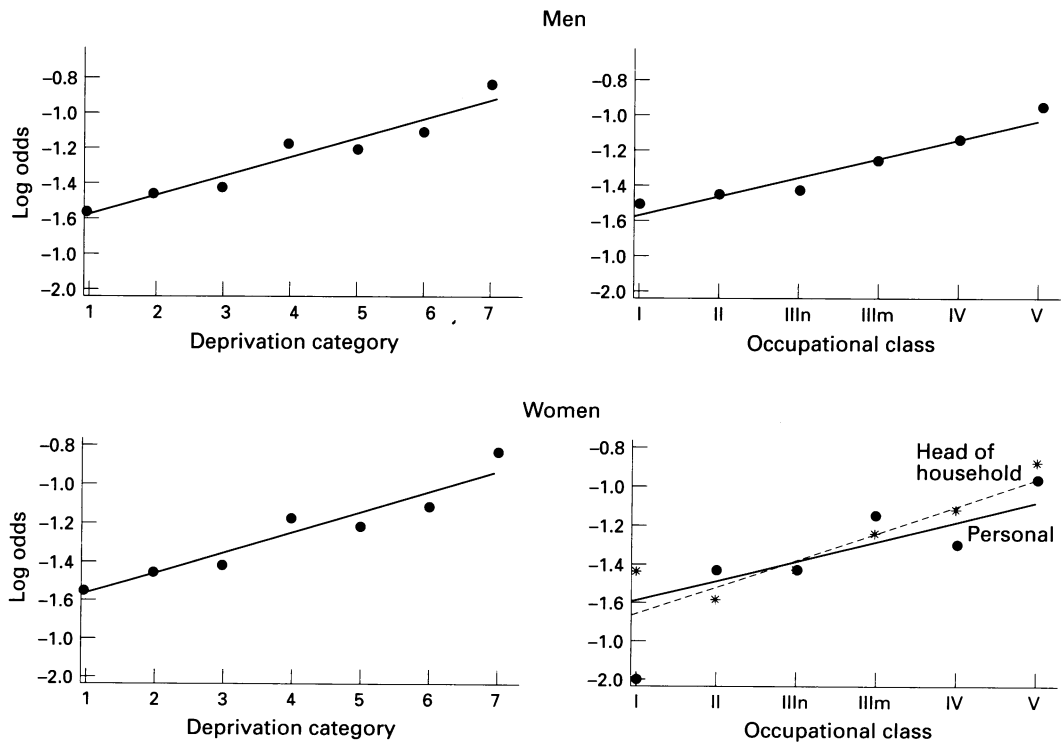


Figure 1 Estimated log odds of prevalent coronary heart disease and fitted linear model according to the Carstairs and Morris deprivation category and the OPCS occupational classifications. In the bottom, right hand plot, the closed circles and solid line refer to the OPCS "personal occupation" classification and the asterisks and dashed line refer to the "head of household" classification.

between the C&M and "head" OPCS variables as linear predictors of CHD, but the "personal" OPCS variable is slightly less effective.

When cross adjustments are made between the linear C&M and OPCS variables, similar results are found for the two sex groups and the two female OPCS classifications. Adjustment for the C&M variable does not remove the effect of the OPCS variable and vice versa ($p=0.02$ or below). There is no evidence of any interaction ($p=0.17$ or above) between the C&M and OPCS variables.

Discussion

The statistical analysis from the SHHS suggests that, at least in the context of epidemiological studies of CHD for middle-aged people, an index based on small area statistics is an effective marker of personal social status. The categorical C&M variable exhibits a strong linear trend for prevalent CHD, and its effect is broadly comparable with the OPCS occupational variable. The two variables seem to act independently, but not synergistically, upon CHD. Similar conclusions are drawn for the two sexes.

Both the C&M and OPCS variable have the advantage that they are easy to obtain in epidemiological investigations, since they require knowledge only of the address or occupation respectively. Both are commonly recorded on official records, including the death certificate, or may be found, without major difficulties, from the subject or his/her relatives, neighbours or friends. Furthermore, both have a multi-point graded scale which enables dose-response effects to be studied.

Social measures based on employment have been widely used and well researched, and are readily comparable with the extensive literature on occupational health. Notwithstanding possible "prestige" error, the "healthy worker" effect and other well known biases in occupational data, employment details have provided a workable definition of social status in the past, when unemployment was rare and men were the major family bread winners. However, unemployment rates are now very high in many parts of the West. Furthermore, much of the unemployment is long term, so that previous employment, used in the OPCS classification, may not be relevant to current social status.

The occupational social classification of married women is problematical for two reasons. Firstly, the movement towards sexual equality in occupation and income clearly invalidates the blanket assumption that the husband is the economic head of the household. In areas of social decline the wife may well be employed while her husband is not. Other modern social developments, including increases in divorce and co-habitation cause more general problems for the OPCS classification. Secondly, for understandable reasons, it can be difficult to have results accepted when married women are classified by the occupation of their spouse. In the current investigation there is evidence that the "head" definition gives slightly better results,

both in terms of fewer unclassified subjects and the strength of the linear relationship for log odds of CHD. This agrees with other evidence, both specific to CHD²⁵ and more general.²⁶ Such evidence may not be readily acceptable by a sceptical audience and, indeed, may not be reproducible in the future. Measures of occupational social class based on "average" or "highest rank" family employment are possible to construct but more complex to collect, and not necessarily comparable with single persons' occupational social class.

Social measures based on small area statistics have the advantage that a person's address is very easy to obtain, even in situations where employment (particularly spouse's or former employment) details are not normally recorded. Although the postcode may not always be given, this can usually be found from Post Office records. In the SHHS, where the postcode was not recorded for anyone at the outset, it was possible to discover the majority of postcodes by subsequent investigation. Unlike the OPCS variable, there is no problem of sex differentiation. However, there are three major disadvantages with postcode based indices.

Firstly, the times at which the small area statistics and the data, which will later use them for social classification, are collected may differ by a number of years. Thus, in the present study, 1981 census statistics were used to group SHHS data from 1984–86. It may then be that the social characteristics of a particular area have altered, so that there is some misclassification. Comparison of 1981 and 1991 census based C&M postcode classifications shows a small number of major disagreements.^{13,14} On the other hand, the OPCS classification of occupation is also periodically reviewed. Secondly, small area statistics do not give values which are specific to any particular subject, and standard epidemiological and statistical wisdom will therefore go against their use when individuals are studied. The results here suggest that this may not be such a problem. Third, the way in which the particular index chosen is constructed may affect the results. The C&M categorisation used here is an extremely subjective measure; the original authors used their own selection of four small area statistics from many, decided not to weight them according to any measure of importance and used totally arbitrary groupings. Despite this, they have found good agreement with other indices, and their variable seems to perform well in the current analysis.

Looked at in another way the flexibility of small area statistics might be considered an advantage. Statistical techniques, such as principal component analysis, may be used to derive indices from raw statistics which have some optimum property. Categorisation of the derived index may be chosen in some sensible way, perhaps to produce groups of equal size so as to maximise power when making comparisons. Within this article only the previously defined deprivation categories of the raw C&M deprivation score have been used. In a study of deprivation and mortality, McCarron *et al*²⁷ used cluster analysis to define "neighbourhood

type", using a set of small area statistics that included those used by Carstairs and Morris. Revised groupings may be derived in order to give "better" results within the current context, but at the expense of giving biased comparisons with the OPCS variables. Alternatively, the score might be left as a continuous variable,²⁸ or even a multi-dimensional variable,²⁹ which would be preferable in some statistical analyses. In the current context the actual deprivation scores could be used to further investigate linearity with CHD prevalence, either by leaving the scores in their continuous state or by using them to define more meaningful scores for the categories (eg, medians). Again, the comparison with the OPCS variables would then be compromised.

This article describes a prevalence study. The cross sectional nature of the data could have an influence on the results. It might be expected that a person is more likely to change job as a consequence of being diagnosed for CHD than they are to move home. Further, a woman is more likely to change her own job than her husband is to change his, should she be found to have CHD. Hence an incidence study might find personal occupation a relatively better predictor of CHD. There is also the problem that the current study must inevitably omit the more extreme cases of CHD: those that have already led to death. This factor might have diluted the overall social effect, but is unlikely to bias the comparison between deprivation index and employment classification.

The degree of clustering of individuals to postcode sectors in the SHHS is quite low: the median number of individuals per postcode is 14, while 57 postcodes have only one representative. Consequently the estimated confidence intervals from the two level (postcode-individual) model presented in table 2 are only very slightly wider than those produced when clustering is ignored. With more concentrated data the benefit of a multilevel approach to statistical modelling will be more apparent. A good example, in a context similar to that considered here, is the paper by Ecob,²⁸ which shows how variability may be modelled and interpreted in a multilevel model.

Occupational social class is, of course, only one of several measures of social status that can be compared with the C&M variable. In an earlier publication concerning the SHHS,²⁰ housing tenure (owner-occupied/rented) was found the most effective of four possible dichotomous measures of social class in relation to prevalent CHD. The other three measures considered were the OPCS "head" definition as used here, but split into manual/non-manual occupations, level of education achieved (professional or degree/school) and years of education (less than or equal to 10/greater than 10). Housing tenure has the great disadvantage that it does not allow for dose-response investigations since it has only two levels (rentals are sometimes split by private and local authority, but the first is very rare in Scotland). The C&M variable has a strong relationship to housing tenure: the percentage of renters in C&M groups 1-7 respectively is 7%, 24%,

40%, 53%, 67%, 81%, and 91%, with virtually no difference by sex group. After allowing for housing tenure, the C&M variable is a significant predictor of prevalent CHD in the SHHS for men ($p < 0.0001$), but not women ($p = 0.09$). After allowing for the C&M variable, housing tenure is always still significant with $p < 0.0001$ for both sexes. There are no significant interactions between the two variables ($p > 0.4$). Hence housing tenure provides important information additional to the C&M variable, and it may be sensible to use the two together to provide both grading and extra explanatory power.

Social gradients have been discovered for many conditions. Since CHD is a major disease in the West, analyses of social factors using this end point provide important evidence for determining a social classification. The SHHS also collected information on five other medical conditions, and the C&M variable was evaluated for each of these. The C&M variable produced very strong gradients for the log odds of chronic cough and chronic phlegm (stronger than for CHD), before and after adjustment for age and serum cotinine. Hypertension, stroke and diabetes showed some evidence of gradient for men, but little for women. With these three diseases there were few cases, and thus considerable error associated with some of the odds ratios. In broad terms the OPCS variables and C&M variable were comparable for all five additional conditions considered. As already discussed, the C&M classifications are not, in any way, an optimal use of small area statistics. Hence there is evidence that small area statistics may have a more general use in measuring personal social status in epidemiology.

Provided the user is convinced that the small area statistics themselves measure the key elements of social status, then they are certainly acceptable as area level measurements. Whether they can then also be used at an individual level clearly depends upon the amount of homogeneity within the areas. In this national study, which is sure to include postcode sector areas with a wide range of characteristics, individual level measurement seems to be reasonably accurate, to a degree that is comparable with the more widely-used occupational measure of social class. This paper lends support to the contention³⁰ that area level measurements of deprivation may be effective indicators of personal health.

The Scottish heart health study was funded by the Scottish Home and Health Department. The author wishes to thank Richard A'Brook, Caroline Morrison and Hugh Tunstall-Pedoe for providing data and references for this article. Thanks also to the referee who made several useful suggestions to improve the article. The views expressed are those of the author and should not be attributed to any of the above.

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