Prediction of general practice workload from census based social deprivation scores

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Abstract

Study objective—The aim was to compare the ability of census based social deprivation scores devised by Jarman, Carstairs, and Townsend to predict workload in general practice.

Design—This was a prospective study of 140 050 patients registered with general practices over one year from 1 July 1981 (Third National Morbidity Survey). Main outcome measures were workload score for each patient, defined as a weighted sum of consultations at the surgery and consultations elsewhere, excluding preventive procedures.

Setting—25 general practices in England and Wales.

Main results—In multivariate analyses the Jarman, Carstairs, and Townsend indices all predicted workload, but the Townsend index was the best predictor, with both housing tenure and car ownership being strong predictors of workload. The overcrowding and geographical mobility variables used in the Jarman index did not predict increased workload. The weighting assigned to children under five by the Jarman index underestimated the additional workload this group generated.

Conclusions—For identifying social pressures on general practice workload the Jarman index is less valid than other census based scores because it fails to include car ownership and housing tenure. A more rational scheme for compensating general practitioners would directly weight the capitation fee for children aged under five years and allocate current deprivation payments according to the Townsend index or a similar score. This would redistribute resources from London to deprived areas in northern England.

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Reports in the early 1980s on the problems of primary health care in inner cities emphasised the need for some means of identifying deprived areas where general practitioners faced greater difficulties.^{1,2} A census based score was devised for this purpose by Jarman.³ Initial selection of variables was based on the opinions of general practitioners in London and weightings for a final score based on eight census variables were derived from a subsequent national survey of general practitioners. To validate the index, area scores were compared with the opinions of family practitioner committees and general practitioners.⁴

Associations were demonstrated with adverse health outcomes,⁵ admission rates,^{6,7} permanent sickness,⁶ and self reported ill health.⁸

It was subsequently "thought desirable to give extra support" to areas with high Jarman scores³ and on this basis some £25 million of capitation fees were redistributed in 1990-91.⁹ The use of this index has however also generated criticism.¹⁰⁻¹² Other census based deprivation scores have been developed by Townsend¹³ and Carstairs.¹⁴ All three scores correlate with each other¹⁵ and with indicators of ill health,^{6,16} but the Townsend and Carstairs indices identify more deprived areas in the north of the United Kingdom than the Jarman index.¹⁷ We have used data from the 1981 third national morbidity survey¹⁸ in an attempt to validate the Jarman index for its initial purpose, that of identifying practices with greater pressure of workload. We also compared the Jarman, Townsend, and Carstairs indices to determine which of the currently existing indices is the best to use if general practitioners are to be remunerated for extra workload associated with social factors.

Methods

MORBIDITY SURVEY

In the third national survey, 48 practices around the country recorded all consultations for one year from 1 July 1981 using a standardised episode book (for detailed description of methods see ¹⁸), and 140 050 individuals registered with 25 practices were matched to their 1981 census records. Each consultation was classified as a surgery visit, home visit, or visit elsewhere. Consultations for morbidity were classified separately from consultations for preventive care such as vaccinations or family planning.

DEFINITION OF OUTCOME AND EXPLANATORY VARIABLES

Workload score for each individual was defined as the number of surgery visits plus 2.5 times the number of consultations at home or elsewhere, excluding consultations for preventive procedures. This takes into account that home visits are more time consuming than surgery consultations and is based on an estimate of general practice workload.¹⁹ Some analyses were repeated using a weight of 3 to check the sensitivity of the assumption. As most preventive procedures are remunerated directly anyway, these were excluded from the workload score.

Each deprivation score uses different variables, though some variables are common to several indices (table I). Rates are based on households in the Townsend index but on all residents in the

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Table I Variables used in the Jarman, Carstairs, and Townsend models

Variables	Jarman Index	Carstairs model	Townsend model
Unemployed	X	X (males)	X
No car	-	X	X
Overcrowding (> 1 person per room)	X	X (all residents)	X
Social class IV and V	-	X	-
Housing tenure (not owner-occupier)	-	-	X
Socioeconomic group 11	X	-	-
Lone pensioner	X	-	-
Age under five	X	-	-
Lone parent	X	-	-
Geographic mobility	X	-	-
Ethnic minority (New Commonwealth and Pakistan)	X	-	-

Carstairs and Jarman indices. In this analysis the definition of each variable refers to individuals or their household coded as a dichotomous variable (yes/no), rather than to the proportion in an area as in the original deprivation scores. For example for a child, the car ownership variable is coded "yes" if that child lives in a household with access to a car. The "lone parent" variable applies to both parent and children. Social class was defined according to the Registrar General's criteria. The "unskilled" variable used in the Jarman index is defined by households headed by a person in socioeconomic group II; this was not available in the national morbidity survey so social class V was used as a close equivalent.²⁰ Married or cohabiting women were coded according to their partners' social class and employment status, while other women were classified by own social class. The "unemployment" variable has three levels: employed, unemployed, and inapplicable (permanently sick, out of working age, housewife, or student). This was represented in the model by two indicator variables for the unemployed and inapplicable categories, with the employed category as baseline; coefficients presented are for unemployed relative to employed.

STATISTICAL ANALYSIS

Odds ratios

Associations between census variables were examined by calculating odds ratios for 2 × 2 tables except for combinations which were mutually exclusive. These odds ratios are shown in table II; ratios greater than 1 indicate positive associations.

Model form

Prediction of workload score from census variables was examined by least squares regression analyses. Before analysing such a highly skewed variable it is more usual to transform it or allow for heterogeneity of variance. For our analysis a transformation was undesirable since we wanted to produce a linear predictor for individuals which would also be valid for predicting the mean workload generated by groups. Allowance for heterogeneity of variance would weight frequent consulters less than occasional consulters, whereas it is more meaningful to weight all consultations equally. When least squares regression is used with highly skewed data in small or medium sized datasets the standard errors may be inaccurate but this is not likely to be a serious problem in a dataset of this size. As a safeguard, we adopted a validation sample approach (see below).

Model analyses

Practice, "age over 65", and "age over 75" were included as categoric variables in all regression models. We controlled for practice in order to examine differences between individuals within practices rather than differences between practices. Age over 65 and age over 75 are already remunerated by additional capitation fees and our objective was to predict effects additional to these factors. The "over 65" variable was dropped from the Jarman index for the same reason.³ We did not stratify further by age bands as we did not intend to determine the workload associated with each age group but rather to validate the currently existing indices.

Prediction of workload by each variable was first examined in a univariate model. To compare the deprivation scores proposed by Jarman, Townsend, and Carstairs, a model was constructed for each index containing the appropriate choice of variables and the multivariate regression coefficients were estimated. For the set of variables used in the Jarman index, prediction of workload based on the weightings chosen by multivariate regression was compared with prediction based on the weightings derived by Jarman from a survey of general practitioners. For this purpose a score was calculated for each individual as a weighted sum of the variables using the weightings chosen by Jarman; this score

Table II Odds ratios for associations between variables used in Jarman, Townsend, and Carstairs models (95% confidence interval)

	Lone pensioner	Under 5	Lone parent	Unskilled	Unemployed	Crowded	Changed address	Ethnic minority	No car	Tenure	Class 4 and 5
Lone pensioner	-										
Under 5	me	-									
Lone parent	me	2.03 (1.82-2.26)	-								
Unskilled	0.91 (0.80-1.03)	1.07 (0.96-1.19)	1.15 (0.96-1.37)	-							
Unemployed	me	me	2.83 (2.52-3.18)	me	-						
Crowded	me	2.19 (2.05-2.33)	0.55 (0.45-0.67)	2.23 (2.05-2.43)	2.07 (1.95-2.19)	-					
Changed address	0.34 (0.30-0.38)	2.05 (1.92-2.20)	1.90 (1.73-2.10)	0.85 (0.77-0.94)	1.35 (1.29-1.41)	1.11 (1.03-1.19)	-				
Ethnic minority	0.10 (0.08-0.13)	2.09 (1.94-2.25)	2.68 (2.40-3.00)	1.18 (1.04-1.33)	1.75 (1.64-1.86)	7.42 (7.05-7.81)	1.60 (1.49-1.72)	-			
No car	15.9 (15.1-16.7)	0.98 (0.94-1.03)	6.67 (6.21-7.16)	3.46 (3.27-3.65)	1.82 (1.76-1.88)	1.70 (1.62-1.78)	1.17 (1.13-1.22)	1.73 (1.64-1.81)	-		
Tenure	2.12 (2.02-2.22)	1.12 (1.07-1.16)	3.94 (3.65-4.22)	3.29 (3.11-3.48)	1.47 (1.43-1.52)	2.54 (2.43-2.65)	1.90 (1.83-1.97)	0.78 (0.74-0.83)	4.63 (4.52-4.74)	-	
Class 4 and 5	0.70 (0.65-0.75)	0.93 (0.88-0.98)	1.00 (0.90-1.10)	∞	me	1.89 (1.80-1.99)	0.88 (0.84-0.93)	1.41 (1.33-1.50)	2.45 (2.38-2.53)	2.65 (2.57-2.72)	-

me = mutually exclusive

Table III Univariate coefficients for variables in the Jarman, Townsend, and Carstairs models^a

	No of observations	Extra workload (standard error)	p value
<i>Variables used in Jarman index</i>			
Lone pensioner	139 049	0.728 (0.091)	0.0001
Under 5	140 049	1.004 (0.070)	0.0001
Social class V (unskilled)	136 979	0.583 (0.095)	0.0001
Unemployed	138 232	0.545 (0.049)	0.0001
Lone parent	140 049	0.288 (0.123)	0.020
Overcrowding	138 232	-0.234 (0.074)	0.0015
Change of address	136 412	0.000 (0.062)	NS
Ethnic minorities	140 049	0.248 (0.089)	0.0054
<i>Additional variables used in Townsend model</i>			
No car	140 049	0.848 (0.042)	0.0001
Not owner-occupier	138 300	0.574 (0.038)	0.0001
<i>Additional variables used in Carstairs model</i>			
Social Class 4 and 5	140 049	0.427 (0.049)	0.0001

^aEach analysis includes age over 65/75, practice, and the variable of interest.

was included in a regression model as a single continuous variable. This is referred to as the Jarman "score" index. A "derived" index, containing the best possible subset of all variables suggested by Jarman, Townsend, and Carstairs, was selected by minimising Mallows' C_p coefficient on the first half of the dataset.²¹

Validation

To test the predictive power of each index, the sample was randomly divided into two halves. All coefficients were derived from the first half of the dataset and then applied to the second half (the validation sample) to assess the prediction error for each individual. Individuals with missing data on any variable were excluded, so that all models had the same number of observations.

To test whether differences in predictive ability between two models might be due to chance, a "competing models" approach was used. In this it is assumed that workload score is best predicted by a weighted average of the two predictors:

$$\text{Workload score} = \tau \times \text{predictor 1} + (1 - \tau) \times \text{predictor 2} + \text{error.}$$

A linear regression of (workload score minus predictor 2) on (predictor 1 minus predictor 2), with no intercept, is performed to estimate the weighting parameter τ and its standard error. If the weighting parameter is significantly greater than 0.5, predictor 1 is considered to be significantly superior to predictor 2; this test is equivalent to a test of equality of the mean squared prediction errors.

The percent variance explained by each index as well as the relative additional variance was calculated. The latter was derived by calculating the additional variance explained by each index over a model controlling for over 65, over 75, and practice. This additional variance was expressed as a proportion relative to the additional variance explained by the basic Jarman index over the model with age over 65, over 75, and practice.

Results

Age was the strongest single predictor of workload and there was a J shaped relationship. Mean workload score (weighted sum of illness consultations during the year) by age group were: 0-4 years, 4.2 (95% CI 4.1-4.5); 5-64 years, 3.2 (3.2-3.3); 65-74 years, 5.9 (5.7-6.0); 75+ years, 9.5 (9.4-9.7). Table III shows the β coefficients for univariate predictions of workload by each variable, controlling for practice, age over 65, and age over 75. All variables except geographical mobility were significantly associated with workload; for overcrowding there was an inverse relationship. The multivariate analyses resulted in the coefficients for most variables being slightly reduced except for the "age under 5" variable, where the coefficient was increased (data not shown). Repeat analyses using a weighting score of 3 rather than 2.5 for non-surgery consultations yielded similar results, but the coefficients for car ownership and lone parent were slightly increased.

Table IV compares the weights given to each variable in the Jarman index by the multivariate analysis with the weights used by Jarman which were based on the opinions of general practitioners. The smallest positively associated variable (ethnic origin) was taken as the baseline. The ranking of variables in the multivariate analysis was similar to that derived from the Jarman index but the multivariate analysis assigned more weight to the effect of age under five years.

The derived index contained eight variables: car ownership, age under five years, unemployment, housing tenure, social class IV or V, overcrowding, lone pensioner, and ethnic minority. Table V shows the percent variance explained by each index and the proportion of variance explained by the Jarman "score" index, Townsend index, and Carstairs index relative to the basic Jarman index. Compared with the basic Jarman index, the Townsend, Carstairs, and derived indices were better predictors and the Jarman score index was worse. When the "age under five years" variable was included in the analysis with the Townsend and Carstairs indices, both these models predicted better than the Jarman index ($p < 0.001$).

Table IV Ranking and relative weighting of Jarman variables according to Jarman index and multivariate model

<i>Jarman index</i>			<i>Multivariate model</i>	
	Ranking	Relative weights	Ranking	Relative weights
Lone pensioner	1	2.6	2	2.3
Under fives	2	1.9	1	5.3
Social class V	3	1.5	4	2.2
Unemployed	4	1.3	3	2.3
Lone parent	5	1.2	5	1.8
Overcrowding	6	1.2	8 ^a	—
Change of address	7	1.1	7 ^a	—
Ethnic minority	8	1.0	6	1.0

^aAssociated with fewer consultations rather than more

Table V Predictive ability of models based on coefficients generated from a random half of the sample ($n = 65\,492$) and applied to the validation half ($n = 65\,541$)

Models	Percent variance explained	Ratio of additional variance relative to model (2) ^a	p value
(1) Over 65/over 75 and practice	8.65	0	—
<i>Basic model:</i>			
(2) Jarman model (data weighted)	9.02	1.00	—
<i>Comparison models:</i>			
(3) Jarman model (score)	8.81	0.44	<0.001
(4) Carstairs model	9.08	1.11	0.09
(5) Townsend model	9.14	1.28	0.008
(6) Derived model ^b	9.31	1.72	<0.001

^aThis column is derived by dividing the additional variance for models 3-6 over model 1 by the additional variance for model 2 over model 1.

^bThe derived model contains the following variables: car ownership, age under five, unemployment, housing tenure, social class IV or V, overcrowding, lone pensioner, and ethnic minority.

Discussion

Although the Jarman index was intended to identify practices with greater workload it has not been validated directly against consultation rates except in one study based on self reported consultations in a two week period.⁸ Jarman argued that to validate the score against general practice consultation rates would be inappropriate, since hospital services in deprived areas may compensate for inadequate primary health care so that consultation rates for each practice may not reflect "potential workload".³ This argument is valid when consultation rates are compared between areas or practices. However within a practice each individual has the same potential access to available services and the effects of social factors upon workload can be examined by comparing the consultation rates of individuals. Although dealing with consultations takes up two thirds of practitioners' time,¹⁹ reliance on the consultation rate as an indicator of workload has limitations since workload is also affected by the complexity of the consultations. It is not possible to examine this in the national morbidity study dataset.

There are difficulties in extrapolating from associations at individual level to associations at area level. There may be a relationship between poor areas and health independent of the attributes of individuals in that area.^{22 23} Analysis based on comparison between practices would not help this issue for the reasons discussed above. This problem is common to both our method and that used by Jarman in constructing his index. Jarman asked general practitioners to weight each of the listed attributes "according to the degree to which it increases workload or contributes to the pressure of work when it is present": this is likely to have been interpreted by respondents as a comparison between individuals in the same practice. The weightings were then extrapolated to produce an area based score.

Only a small additional proportion of the variation in consultation rates between individuals is explained by census variables, when age is taken into account. There are many reasons for large variations between practices in mean consultation rates which are unrelated to social deprivation: for example, some doctors may encourage patients to consult more frequently, and the availability of hospital services differs between practices. The effect of these factors on workload is interesting but irrelevant to the assessment of potential workload associated with deprivation. We consider the practice effects in our models to relate to supply factors rather than to demand or "potential workload". The proportion of variance of potential workload (ie, ignoring practice effects) explained by social factors will be far greater at an area level than at an individual level. This is because when the data are aggregated, individual differences in consultation rates will tend to average out while systematic effects of social factors will not. Similarly, the differences between indices in proportion of variance explained are likely to be substantial at an area level even though they are small at an individual level.

The national morbidity study is the largest dataset available to examine the possible relationship between attributes of individuals and general

practice workload. Although the age and sex structure of the practice populations is similar to that of England and Wales, the practices are not representative of all practices in the country.¹⁸ Practitioners in this highly motivated sample may give special attention to their socially deprived patients, biasing the estimates. Unless they favoured certain categories of deprived patients more than others, this would not alter the relative weightings of the variables on which our analyses depend.

Predictions of workload based on the Carstairs and Townsend indices were better than predictions based on the Jarman index. Although the differences were relatively small, this is likely to be far more important at an area level. This is surprising, as the Jarman index was devised specifically to predict general practice workload, whereas the Townsend and Carstairs indices were intended to measure social deprivation generally; because of this difference, the "age under five years" variable, which is not an indicator of social deprivation but a predictor of workload, was not included in the Townsend and Carstairs indices. The inclusion of this variable in a census based score, designed to compensate practitioners, is less rational than directly weighting the capitation fee for this group, as is already done for the elderly.⁶ When age under five years is controlled for, the superiority of the Carstairs and Townsend indices over the Jarman index increases further.

Overcrowding, which is included in all three deprivation scores, was inversely associated with general practice workload. This inverse relationship arises because overcrowding is less common among older age groups which generate greater workload. After controlling fully for age in a regression model, there was a weak positive relationship between overcrowding and workload. The Jarman index includes geographical mobility, which was not associated with increased rates of consultation for illness. Among patients who were geographically mobile, the unemployed were overrepresented, but so were skilled and non-manual workers. This heterogeneity may account for the lack of association between geographical mobility and workload. Jarman has also recently commented that this variable is unrelated to levels of mortality and morbidity.¹⁵ Our analyses emphasise car ownership and housing tenure, not included in the Jarman index, as among the strongest census based predictors of workload in general practice. Both variables were identified in an alternative score suggested by Scott-Samuel using chronic sickness as the outcome measure.²⁴ The list of 13 social factors originally identified by the Acheson Committee included "difficulties visiting" and "poor housing" but these were subsequently dropped from the Jarman index. Lack of access to a car is likely to increase the need for home visits and is also a powerful predictor of mortality.²⁵

Social meaning of variables such as car ownership and housing tenure may change over time. Therefore their validity as indicators of socioeconomic status may need reassessment. Unemployment has recently been suggested as a more stable alternative²⁶ but in our analysis was not as powerful a predictor of general practice workload as car ownership.

In conclusion, the Jarman index is weaker than the simpler indices of Townsend and Carstairs in predicting general practice workload because it fails to include car ownership or housing tenure. The validity of overcrowding and geographical mobility as indicators of greater workload is not empirically supported. The weightings used in the Jarman index underestimate the relative importance of children aged under five years in generating work. A more rational remuneration system for general practitioners would include a direct weighting of the capitation fee for children aged under five years. A score similar to the Townsend index would be most appropriate to identify aggregations of social deprivation which increase workload. It has recently been suggested that the choice of deprivation score for remunerating general practitioners is unimportant, as all three indices are highly inter-correlated.²⁷ However a high correlation coefficient between two variables does not mean that both measure the same thing.²⁸ Areas identified as being most deprived also differ depending which measure is used.^{17 29} Using the Townsend index instead of the Jarman index would redistribute resources from London to deprived areas in other parts of the country.¹⁷

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