Health inequalities across UK regions: A Multilevel Modelling Approach

Author

Carlos Utrilla Guerrero, MSc Manchester University, SRMS.

Supervisor assignment

Prof. Dr Tarani Chandola
Cathie Marsh Institute for Social Research
Manchester University
E-mail: tarani.chandola@manchester.ac.uk

Course

Multilevel Modelling

Abstract

This essay investigates the different sources of variation between UK regions in self-rated health using two different approaches of multilevel statistical procedures.

Firstly, we found that health was not significantly associated with the Townsend score after adjusting for composition. However, the non- significant linkages between Townsend and unemployment status was decided to further analysis and the effect was strongest for retired participants. In addition, more contextual effect was added in the model but proved non-significant variability in the slopes of the relation between health and low social class. Secondly, the different source of variation considered, was based on individual and area level factors in a binary multilevel modelling. Results show that individual level factors are strongly associated with self-rated poor health. However, significant variation remains between areas after allowing for compositional factors. At the final model, the analysis demonstrated a differential impact of area deprivation level on top-quintile income group although it was not significant.

Our result suggest that place may affect the health on people but this hypothesis should be interpreted with caution since most of the contextual variables and cross-interaction in our analysis, remains non-significant.

- **Introduction**

Socioeconomic variation in the prevalence of health inequalities has been observed for many years ago in UK (i.e. by Townsend, Davidson and Whitehead, Britton, Duncan). Those studies have demonstrated the ample evidence of linking health outcome variation at individual level (i.e. differences in population characteristics) and area level (i.e. contextual places characteristics). (Ducan et al, 1993). Typically, health variation has been demonstrated to be influenced with socioeconomic status such as employment-status and income. (Townsend, 1988). These *compositional* effect, operate in the sense of classify types of people with similar characteristics and health experience, without taking in account where they live. However, *contextual* effects operate also at aggregate level where geographical characteristic also is source of health variation (Ducan, 1993). For instance, Subramanian (2001) adopted 'materialistic' approach to connect individual health to macro socioeconomic characteristic in USA where income distribution affects individual health. ('Absolute income' hypothesis: better health status leads with better health status).

In general, previous studies have showed some shortcomings on linkages deprivation area and self-rated health. (Ducan, 1993). Very often, the studies found some marked association between health outcomes and most deprived areas based on Carstairs Deprivation scores (i.e. mental health and fifth most deprived areas in Britain, see Weich et al, 2003) but not in the whole data set. Furthermore, Wainwright and Surtees (2004) proved that health outcome was significantly associated with Index of Multiple Deprivation but not with Townsend Deprivation Index. Giving clearly identified a nested hierarchical structure of the data set, by using multilevel analysis to examine the effect on health inequalities by compositional and contextual variables sounds to be technically correct method (Goldstein, 1995).

In view of the suggestion of previous studies of an association between health inequalities and area deprivation we aim to investigate whether individual health status is associated with area deprivation based in Townsend score in UK after adjusting for composition in two different approaches:

- Whether this association affect differently depend the social scale of the people and employment situation. (using Multilevel Regression)
- If this linkages varies between rich and poor people. (binary Multilevel)

- **Data, Multilevel Structure and Strategies Modelling.**

Data for the present analysis came from 8 waves of BHPS. Table 1A to 1B summarizes the variables that are used in this present analysis. The outcome variable is based on a single question that was asked to respondents in about general health status and was treated as: (a) from 1 to 8 wage polled in one continuous variable using a linear model and (b) using 8 wage dichotomous outcome (1=fair/poor; 0=excellent)was created as binary response using logistic regression analysis.

- Data structure

Table 1A. *Descriptive statistics*

	Continuous response SRH *area=372, ind=3775, occ=29668*	Total N	Mean H Score	SD
	Age (years)			
	44	3773	2.1	0.94
	45	3734	2.15	0.94
	46	3705	2.18	0.934
	47	3701	2.2	0.921
	48	3688	2.24	0.931
	49	3702	2.28	0.957
	50	3699	2.28	1
	51	3666	2.33	0.99
	Sex			
	Male	1675	2.02	0.931
	Female	2097	2.16	0.946
	Social Marital status			
	marriedcohabit	2611	2.08	0.928
	widow/divorce/separate	560	2.28	1.03
	never married	600	2.02	0.896
	Educational qualification			
	degree	292	1.8	0.833
	A level	643	1.9	0.856
	O level	1107	1.98	0.869
	no quals	1688	2.29	0.99
	Labour force status			
	employed/student	2503	2.02	0.918
	unemployed	195	2.09	0.895
	retired	616	2.27	0.963

	family care	456	2.32	1
	Social Class			
	high	837	1.87	0.87
	Middle	1417	2.01	0.894
	low	1362	2.27	0.966
	smoker behaviour			
	no	2580	2.04	0.923
	current smoker	1193	2.21	0.973
	Househouse income			
	lowest income	886	2.31	1
	quintile2nd	910	2.14	0.962
	lowest incomemiddle	758	1.99	0.889
	income quintile4th	732	1.99	0.878
	highest income quintile	487	1.97	0.893
	Disability			
	no reported	3271	1.92	0.78
	yes reported	502	3.28	1.04

Table 1b. Response: SHR 8 wages (%)		
Fair/poor Health	0=excellent(64.1%)	1=fair/poor (35.9)
Level 1: Individuals		
Age (in years)	Mean = 51 years	Range=22-97
Gender	Base Male (55.6)	Contrast (44.4)
Health Behaviour	Base smoke (31.6)	Contrast Non smoke (68.4)
Widow/divorce/separated	Base Married (69.2)	Contrast W/D/S (14.9) and NM (15.9)
Disabled	Base Disabled (13.3)	Contrast non disabled(86.7)
Income quintiles	Base lowest (23.5)	Contrast:
		Q2-low (24.1)
		Middle income quintile (20.1)
		4th income quintile (19.4)
		Highest income quintile (12.9)
Level 2: Contextual factors		
Townsend Score	Base Low (38.3)	Contrast:
		Middle Deprivation (27.4)
		High Deprivation (34.3)

- Multilevel structure and strategic.

    - *MULTILEVEL MULTIPLE REGRESION for Continuous Self rated health*

The dataset comprises three-levels of observations. Multilevel modelling allows us for the interdependence of health outcomes observations at different levels, portioning the total variance into different components of variability due to hierarchical structure in the data. (Snijders and Bosker, 2012). The sample was comprised 3775 individual, nested in 372 district areas and each individual with repeated measures of 8 wages. Our strategy started in fitting:

Model 1: A three-level model of simple variance component models with no inclusion of explanatory variables for three nested levels: area, individual, and occasion. In this model, the *random* effect terms and *errors* are assumed to be uncorrelated. The variance in self-rated health is portioned into occasion, individual and area level since the error term at different levels is assumed to be independence. (Snijders and Bosker, 2012). (The ‘’null’’ multilevel model)

Model 2: As Model 1, but we entered compositional variables estimated as fixed main effects at level 1 (occasion) and level 2 (individual), on the basis that those predictor affect in the equal way across level. We adjusted differences in covariates as age and age squared (centred around the GM), and the following categorical variables: gender, social class, unemployment, and smoker behaviour.

Model 3: As model 2, but we added (1) an individual level interactions between gender and age. Also we modelled interaction between (2) social class and age, and (3) age and employment status. (‘random-intercept’ model)

Model 4: As model 3 but, we modelled area level deprivation as fixed effect by using Townsend score (Townsend et al., 1988). In addition, cross-level interaction between area characteristic (i.e. Townsend score) and different social class, and employment status was assessed to ascertain if association between self-rated health and area deprivation varied with social class and employment status of individual. (‘Cross-level’ contextual model)

Model 5: As model 4 but, by allowing random slopes for social class and unemployment compositional variables across.

- *MULTILEVEL MODELS FOR: Binary Self rated health.*

Since the response variable in the second analysis has two possibilities of outcomes, logistic binary multilevel models based on logit function was used (Goldstein, 1995). A two-level model was adopted with a four-step sequential modelling strategy with complexity being increased in each model:

Model 1: Same structure as ‘’null multilevel model’’ adopted previously.

Model 2: As Model 1, but considers individual predictors in the fixed part.(‘random-intercept’ model)

Model 3: As Model 2, but allowing effect of income varying between areas. (‘’random-slopes model)

Model 4: As Model 3, but adding cross-level interaction to ascertain the amount of variation between areas for the top two incomes quintile. (‘’cross-level’’ contextual model).

- **Results and interpretations:**

- *MULTILEVEL MULTIPLE REGRESION for Continuous Self rated health*

Model 1: Null model random intercepts

This model evaluates the variance between areas, individuals and occasions as described in Table 4:

Table 4. Variance Component Estimates for SRH

	Estimated Variance (Standard Error)	Intraclass correlation x 100	
Three Level Model:			
Area	0.026 (0.06)	2.8	
Individual	0.484 (0.013)	52.3	
Occasion	0.405 (0.04)	44.26	

As we can see in the second column of Table 4, the majority of random variation appeared at individual level-2 and occasion level-1. Of the total variance (0.915), only 56% was situated at area and individual level, but only 3% was contributed by intra area correlation. Additionally, 5 % of level two-intraclass correlation suggesting that individual level contributes more to variability than the area level (Snijders and Bosker, 2012).

Model 2 and 3: compositional effects (occasion and individual level)

Table 3 gives the results of two models of estimated fixed effects of a number of socioeconomic, and health-related individual covariates. By comparing these values with model 1, the intraclass correlation at both level were reduced after adjusting for this variables in model 2. In particular, the largest decline appears at area level variation (54%).

It is interesting to note that according with these model, the relation between self-health scores and age was best modelled by the linear function (the quadratic function was not statistically significant). The quadratic relation ‘’failed’’ between model predicted health score and age grouped by gender is displayed in *Fig. 1a*, which shows that the marked difference between gender in health (around 20 years old), tend to reduce over the years. Lower self-health scores were associated with male gender and retired. (Both statistically significant). Also, the following variables resulted significant main effect on self-health score: middle and low social class, unemployment and family care and current smoker. Adding interactions between age and gender, age and employment, and age with social class proved a significantly improvement of the model 3. Nonetheless, this model did not provided further reductions in random

intercept variances. The significant individual interaction between age and retired is illustrated in *fig. 2*.

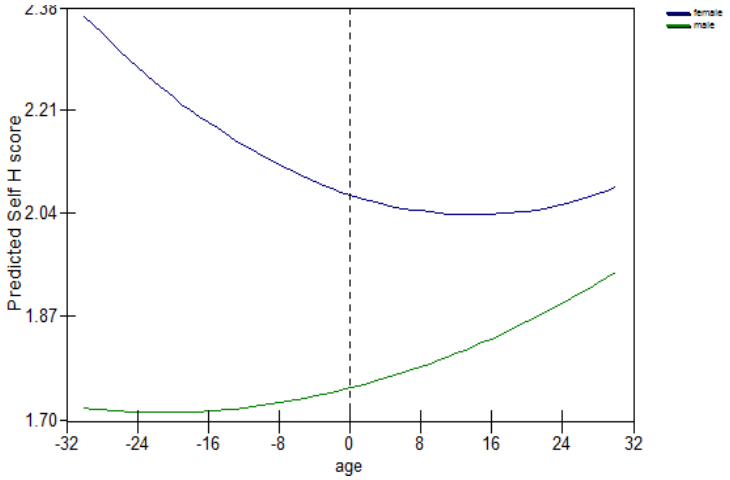

Fig 1a. Interaction term age and gender

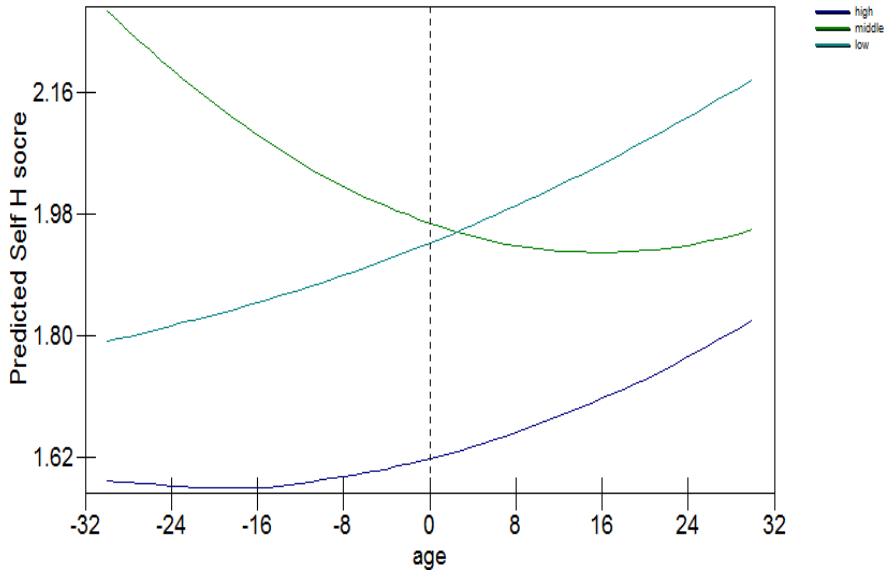

Fig 1b. Linear quadratic age and social class

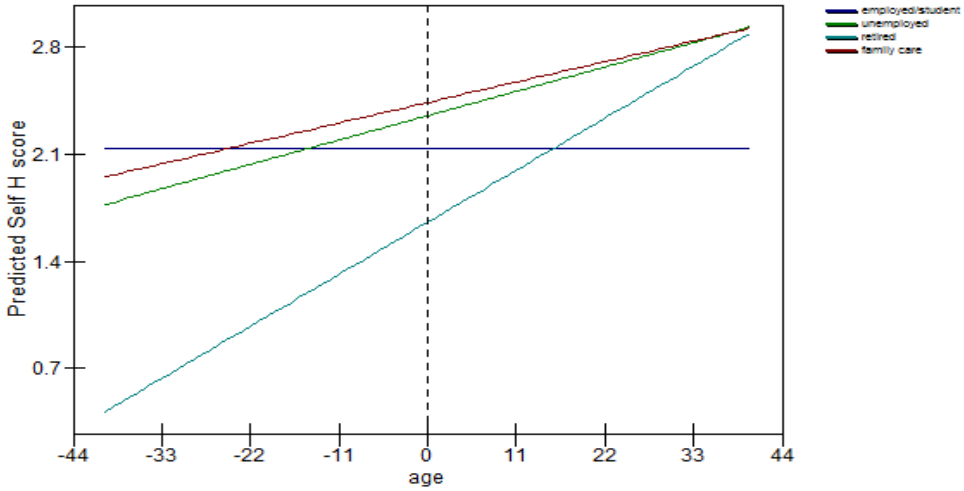

Fig. 2 linear quadratic age and employment

Table 3. Model 2 and Model 3 results

		Model 2: add compositional fixed parameters		Model 3: add compositional interaction	
		Parameters	S.E.	Parameters	S.E.
Variable					
	Fixed Parameters				
	Constant	**2.025**	**(0.031)**	**2.023**	**(0.036)**
	Composition				
Age					
	Age centred	**0.015**	**(0.001)**	**0.017**	**(0.002)**
	Age centred square	0	(0.000)	0	(0.000)
Gender					
	male	**-0.097**	**(0.025)**	**-0.074**	**(0.031)**
Social class					
	middle	**0.07**	**(0.031)**	0.048	(0.038)
	low	**0.259**	**(0.032)**	**0.267**	**(0.040)**
Unemployment status					
	unemployed	0.06	(0.055)	**0.147**	**(0.070)**
	retired	**-0.259**	**(0.046)**	0.009	(0.148)
	family care	0.077	(0.041)	**0.123**	**(0.051)**
Health behaviour					
	current smoker	**0.233**	**(0.026)**	**0.232**	**(0.026)**
	Interactions				
	Age*male			0	(0.001)
	Age square*male			0	(0.000)
	age*unemployment			-0.002	(0.004)
	age square*unemployment			0	(0.000)
	age*retired			**-0.03**	**(0.011)**
	age square*retired			0.001	(0.000)
	age*family care			-0.002	(0.003)
	age square*family care			0	(0.000)
	age*middle SC			-0.003	(0.002)
	age square*middle SC			0	(0.000)
	age*low SC			-0.002	(0.002)
	age square*low SC			0	(0.000)

Random Parameters		Variance red.		
Level 3 variance:area		(dif M2-M1)		
Intercept	0.012	**54%**	0.012	
Level 2 variance: individual				
Intercept	0.432	**11%**	0.433	
Level 1 variance: occasion				
Intercept	0.398	**2%**	0.398	
-2*loglikelihood:	62741.4		62711	
Reduction from previous model	3593.31		30.362	
	0.000		**0.002**	

Model 4: contextual effects

In model 4, the parameter estimate for the area deprivation Townsend score resulted not significant (estimates shows table 4). However, it is interesting to note how this cross interaction (particularly, middle deprivation) becomes to statistically significant when we modelled cross-level interaction with employment status (retired) and with social class (low group). This is illustrated in *Fig 2a* and *Fig 2b*, which shows how varies health scores by social class and employment status across the type of area deprivation, and how the slopes do vary with different social class and employment status. The most of the variables that had a significant positive or negative impact on self-health rated in model 3, also have similar impacts

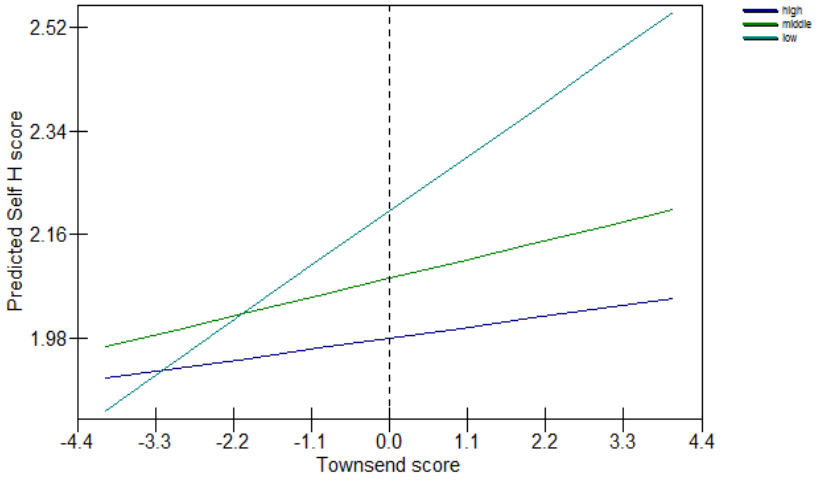

Fig 2a. Townsend score and social class

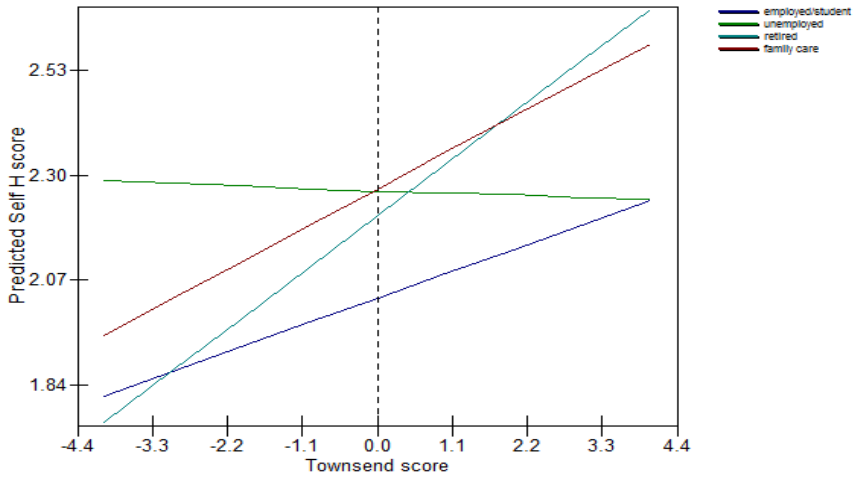

Fig.2b. Townsend score and unemployment

Table 4. Contextual model 4	Parameter	SE
Area Level:		
Townsend score-middle	-0.01	0.063
Townsend score-high	0.051	0.062
Townsend score middle*unemployment	0.037	0.141
Townsend score-high*unemployment	-0.154	0.13
Townsend score-middle*retired	**0.211**	**0.084**
Townsend score-high*retired	0.126	0.077
Townsend score-middle*family care	-0.03	0.094
Townsend score-high*family care	-0.031	0.093
Townsend score-middle*middle SC	0.031	0.076
Townsend score-high*middle SC	-0.009	0.073
Townsend score-middle*low SC	**0.166**	**0.079**
Townsend score-high*low SC	0.107	0.076

Turning to the variance components estimates, we can see reduction of total variance from 0.843 to 0.838 where the most of the variability (98%) was situated between level-2 and level-3. The intraclass correlation at area level and individual level drops slightly from the previous model.

Random Parameters	*Estimations(Standard Error)*	*Intraclass x 100*
Level 3 variance: ward		
Intercept	0.009(0.004)	1.07
low SC		
Slope		
covariance		
Unemployment		
Intercept		
slope		
covariance		
Level 2 variance: individual		
Intercept	0.431(0.012)	51.4
low SC		
Slope		
covariance		
Unemployment		
Intercept		
slope		
covariance		
Level 1 variance: occasion		46.8
Intercept	0.398(0.004)	
-2*loglikelihood:	62683.515	
Reduction from previous model	27.526	
	0.006	

Model 5: Random effects

The final model investigated random slopes for the relation between health and low social class. This model retained the significant compositional and contextual effect from the previous model including the interaction term. Additionally, age was also allowed to be random in all level since further models demonstrated to fit better our model to the data. The low parameter showed no significant slopes at area level. The Wald test for this extra parameters for allowing low social class to vary across area was non-significant. (Wald test, x2 = 0, df 2, p=0). In the final model, we see that the intra class correlation at area-, individual-, and occasion level are similar to the previous model. The deviance is still reducing from the previous model and statistically significant. (X2=133, df 10, p<0.005).

Model 5		S.E.
Response	Self-rated health	
Random Part		
Level 3: awardidn		
Intercept	**0.00988**	**0.00417**
low/consn	0.00000	0.00000
low/low	**0.00000**	**0.00000**
(age-gm)^1/consn	0.00035	0.00017
(age-gm)^1/(age-gm)^1	**0.00002**	**0.00001**
low/(age-gm)^1	0.00000	0.00000
Level: pidn		
consn/consn	**0.42790**	**0.01512**
(age-gm)^1/consn	0.00322	0.00038
(age-gm)^1/(age-gm)^1	**0.00005**	**0.00004**
Level: occ		
consn/consn	**0.37510**	**0.00481**
(age-gm)^1/consn	-0.00054	0.00012
(age-gm)^1/(age-gm)^1	0.00007	0.00001
-2*loglikelihood:	62550.07974	
Reduction from previous model	133.43	
pD:		
Units: awardidn	372	
Units: pidn	3614	
Units: occ	28446	

- *Multilevel Models for Binary Response: wage at 8.*

Context and composition

Table 2 displays the results of Model 1 and model 2. Converting the fixed part Logit estimates to proportion, 35% people are likely to report fair/poor health. We can see that the level-2 variation in that is significant (X2(1df) = 7.2, p>0.05), suggesting differences in self-rated health score between areas may be due of not adding key compositional variables.

In the next model 1 showed in Table 2, the level-2 variation is estimated after allowing for particular individuals, compositional characteristics seen in the fixed part. We can see that there is a strong patterning in self-health scores on the basis of whole individual characteristics. Then, the probability of self-reporting poor/fair health for a women with around 52 years old who does not smoke, married, no disabled with lowest incomes is, 31% (constant). Note that the probability of self-reporting poor/fair health increase by: 10% for smokers, 38% for disables and 35% for non-married group. It is interesting the marked influence of individual income on health score. The probability self-report poor health decrease for the top three highest income categories where middle income has the stronger impact in self-health reporting with 15% decreasing the probabilities of poor self-reporting. However, the addition of these compositional variables have not reduced substantially the variance between areas (5.7% from Model 1 to Model 2 and Wald test no significance) suggesting that the distribution and variability of income do not varies across areas. In other words, variations in self-rated health may be is accounted only by individual factors and ergo, area-context no matter.

Table 2: Result Model 1 and Model 2

	null model	S.E.	model 2 add explanat	S.E.
Response				
Fixed Part				
cons	-0.586	0.04	-1.04	0.1
(hage-gm)^1			0.023	0.003
(hage-gm)^2			0	0
male			-0.203	0.079
unemployed			0.614	0.164
retired			0.025	0.157

family care			0.269	0.124
middle			0.139	0.101
low			0.48	0.103
current smoker			0.439	0.08
Random Part				
Level: AWARDID				
cons/cons	0.098	0.037	0.068	0.037
Level pind:	1	0	1	0

Contextual heterogeneity: How between areas variance depend of group income.

It is reasonable to conjecture that different income groups will have different map of self-health scores. (i.e. low income more likely to report greater scores of self-rated health). However, further investigations (table 4, random part of Model 3) showed a relative different variation of self-health scores depending on the area of residence. For instance, the community of residence has strongest effect on the probability of poor/fair self-health in the richest area of income distribution (0.194 amount of variance, see table 4). Nonetheless, Wald test of adding these three new parameters (random coefficient/slopes of top income quintiles) resulted no statistically significant($X2(5df) = 1.362$, $p > 0.05$), suggesting that this different between incomes, do not vary across areas.

Table Random part multilevel logit estimates for Model 3a

Level2-Between Areas	Constant	4th Income quintile	Highest income quintile
Constant	0.031(.048)		
4th Income quintile	0.029(.084)	0.071 (.203)	
Highest income quintile	0.046(.105)	-0.008(.277)	0.205(.277)

- Only level-2 random part results are reported, as other estimates have not changed significantly as compared to Model 2.

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Contextual relationship

After disaggregated the contextual variation by two top highest income groups, we evaluated key control variable of Townsend score, to examining the effects of deprivation in the variation of self-rated scores. We can see in table 5 that including such area level variable into the model, did not explain substantively the variation in poor self-reporting in each income quintile. On the top two quintiles of income remaining more variability than previous model.

Table 5. Estimates of between-area variance

Income quintile	Model 3: Model without Townsend	Model 4: Model with Townsend
Income quintile 1^{th} -2^{th} - 3^{th}	0.031	0.026
Income quintile 4^{th}	0.153	0.157
Income quintile 5^{th}	0.194	0.197

The final model allows that, the effect (or chance) of different areas deprivation on poor self-health rated varies depending on people economic status. The results of our final model are presented in Table 7:

As we noted, the cross-level effects were not found significant, due of not individual significance of each variable into the model.

Table 6: Multilevel logit estimates for Model 4a

Fixed parameters	Estimates	SE	*t*
Individual factors			
Constant	-0.984	0.178	-5.53
Age (centered)	0.015	0.003	5.00
Age square (centered)	0.000	0.000	
Male	-0.226	0.079	-2.86
Smoker	0.466	0.083	5.61
Widow/divorce/separated	0.130	0.122	1.07
Never married	0.023	0.125	0.18
Disabled	1.622	0.119	13.63
2nd lowest income	-0.011	0.199	-0.06
Middle income quintile	-0.307	0.217	-1.41

4th income quintile	0.105	0.210	0.50
Highest income quintile	-0.178	0.239	-0.74
Contextual factors			
Middle deprivation	0.274	0.206	1.33
High deprivation	0.297	0.185	1.61
2ndlowest income*middle deprivation	-0.023	0.276	-0.08
middle income quintile* middle deprivation	-0.384	0.304	-1.26
4th income quintile* middle deprivation	-0.512	0.306	-1.67
Highest income quintile* middle deprivation	-0.027	0.353	-0.08
2nd lowest income* high deprivation	0.107	0.256	0.42
Middle income quintile* high deprivation	-0.281	0.285	-0.99
4th income quintile* high deprivation	-0.448	0.282	-1.59
highest income quintile* high deprivation	-0.125	0.329	-0.38
Random Part			
Level-2 AWARDID	Constant	4th income quintile	5th income quintile
Constant	0.032 (0.048)		
4th income quintile	0.021(0.084)	0.080(0.204)	
5th income quintile	-0.063(0.107)	0.039(0.219)	0.250(0.284)

Coefficients for middle-income groups and high-income groups are seen as contrasts to the constant, low-income groups.

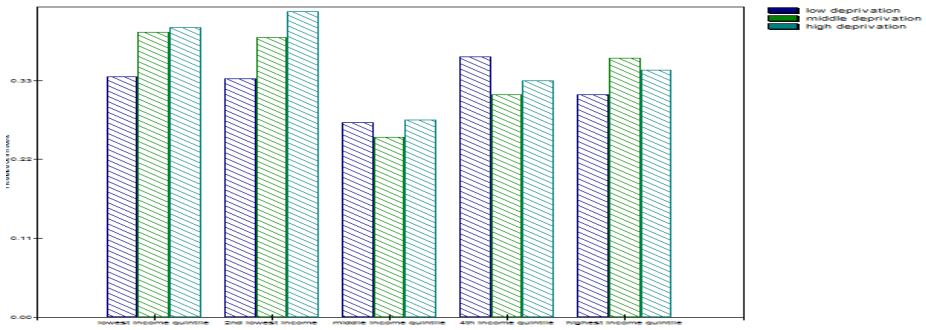
Based on results, high and middle deprivation areas increase the probability of poor self-health reporting but not significantly different comparing with low deprivation areas. It is interesting to note that those people in 4th income quintile located in high deprivation areas have more strong decreasing effect on probability of poor health than people in the richest quintile. However, in view of these results, there is evidence that even being in the richest economic status, people with less income has less probability to reporting poor health.

The level-2 random part results, proved not significantly decreased from the previous model displayed in Table 4. This finding suggests that differences in self-rated

health between areas may not be accounted by area characteristic associated with level of area deprivation.

We can observe from the predictors plot (fig.3) that the contextual effect of area deprivation is weaker among people in the middle income quintiles. In addition, those who are living in high deprivation areas have more variability in poor self-reporting, particularly between middle income and rest, although this different were not statically significant.

Fig.3. Residual Plots



- **Validity of the models:**

Continuous self-rated health:

Standard diagnostic plots found that the occasion and individual level residual were normality distributed. However, at level 3-area inspection, there were not enough data to predict residuals. We have reconsidered again this model because the plots did not support the approximate normality of the level-three residuals. Even then, we could not check the random part at level 3 and their influence and the heteroscedasticity. (see appendix A)

Binary self-rated health (wage 8):

Models were fitting with Marginal Quasilikelihood (MQL) first order estimation for starting values and then, extent to the best available quasi-likelihood method (PQL2). Finally, we considered MCMC methods to estimate and assess convergence of the model parameters. The criteria to check was to use Trace Plot to see the convergence reached (in the case of the constant we did not mix as we expected), kernel Density plot (all variables appears normally smoothed on the histogram). Then, we used Autocorrelation Function (ACF) and partical Function (PACF). Finally our last criteria used was Effective Sample Size: in this case, we noted a small independent interactions with 5000.(particularly in the coefficient/slope parameters and variances). (See appendix A)

- **Conclusion:**

  Regarding the first aim of the study, we have shown a non-significant association between health status and the contextual Townsend deprivation scores, after adjusting for social class, unemployment and other characteristics. Only in the case of retired was achieved significant effect**.** Significant contextual variation of low social class was not achieved by the random variability in slope at area level. However, this interpretation is limited to the validity of our last model; we couldn't check three-level residual and heteroscedasticity. The second analysis we have demonstrated that there is not strong evidence that health variability was explained by area the level.

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APPENDIX

Fig. 4 Variation between areas Low-, Middle- and High-income groups.

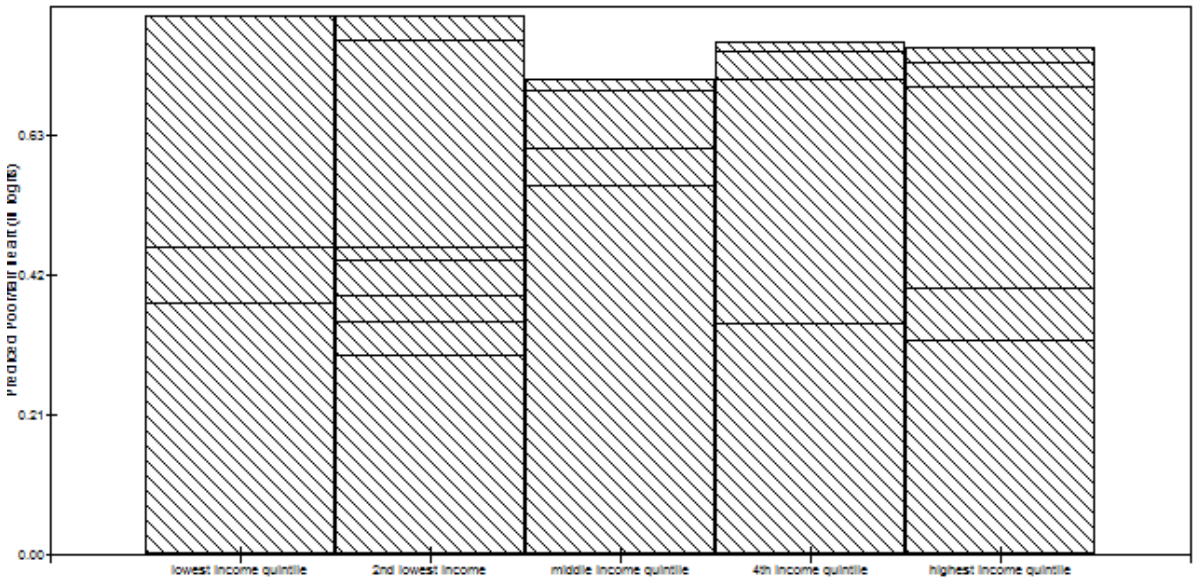


Fig. 2. Variation between US states for Low-, Middle- and High-income groups after including state-level variables

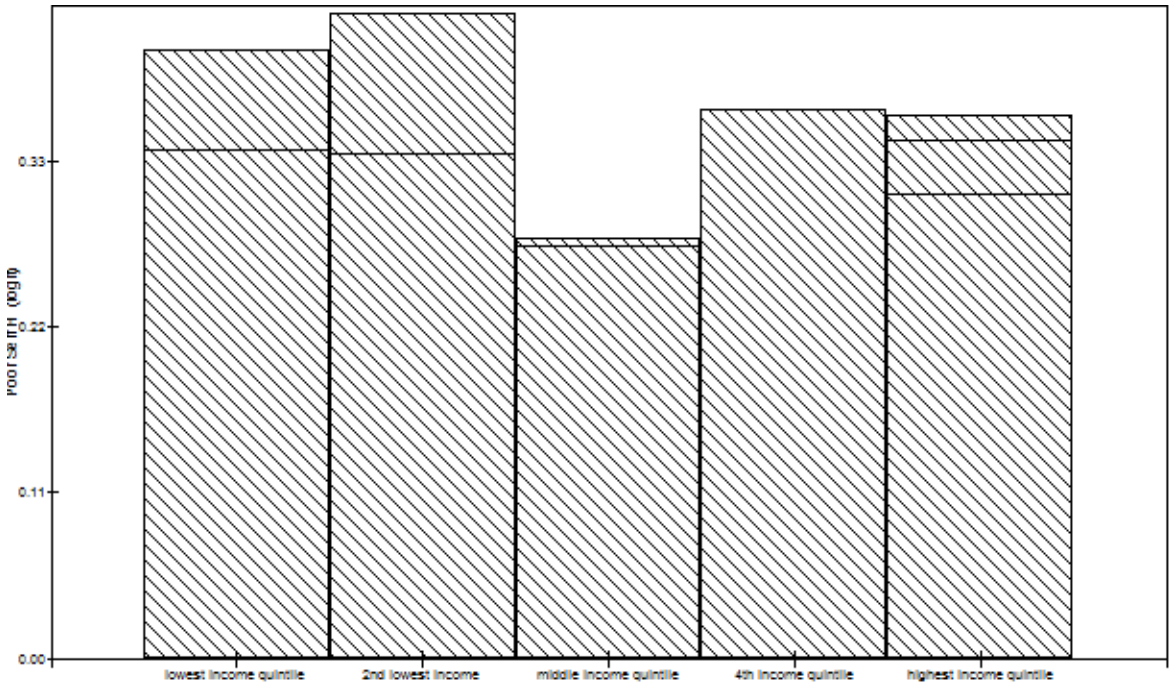
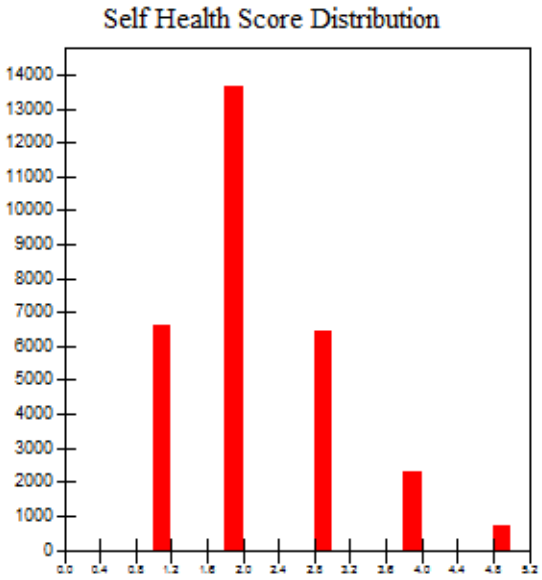
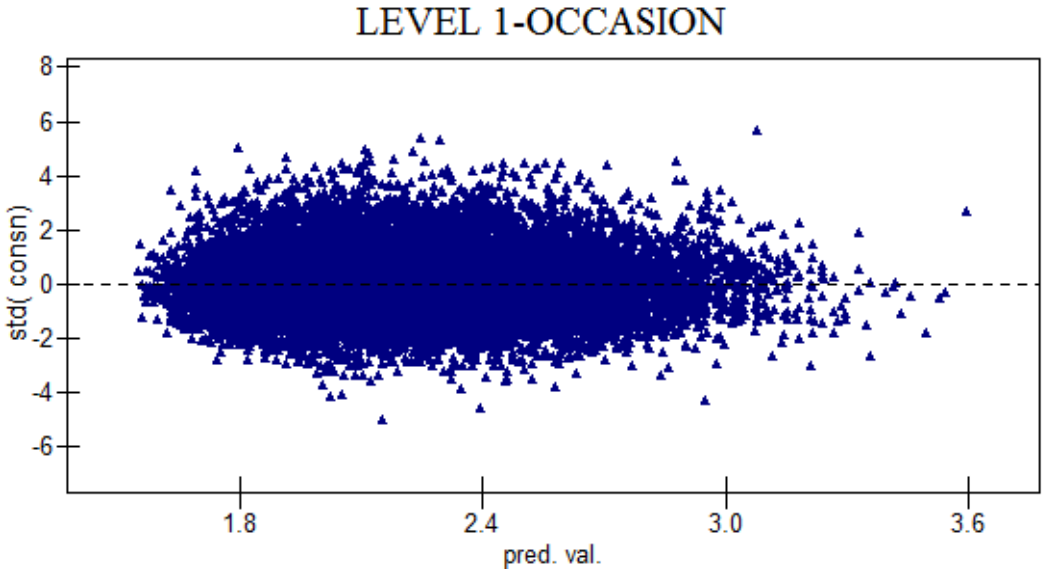


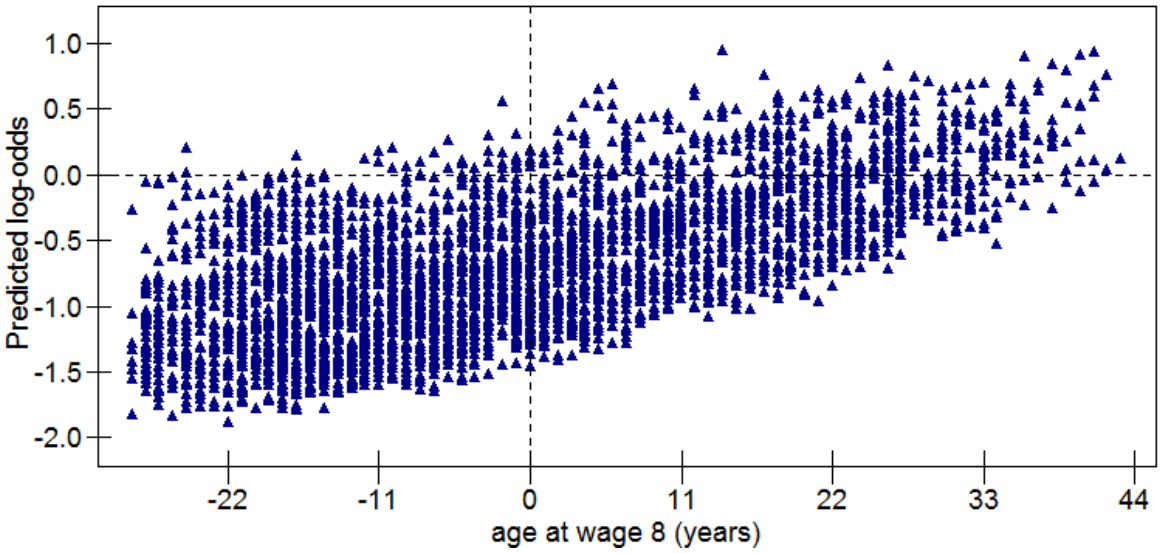
Fig.A Distribution outcome A: SHS Continouos


Self Health Score Distribution
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
5.2


LEVEL 1-OCCASION
8
6
4
2
0
-2
-4
-6
std(consn)
1.8
2.4
3.0
3.6
pred. val.

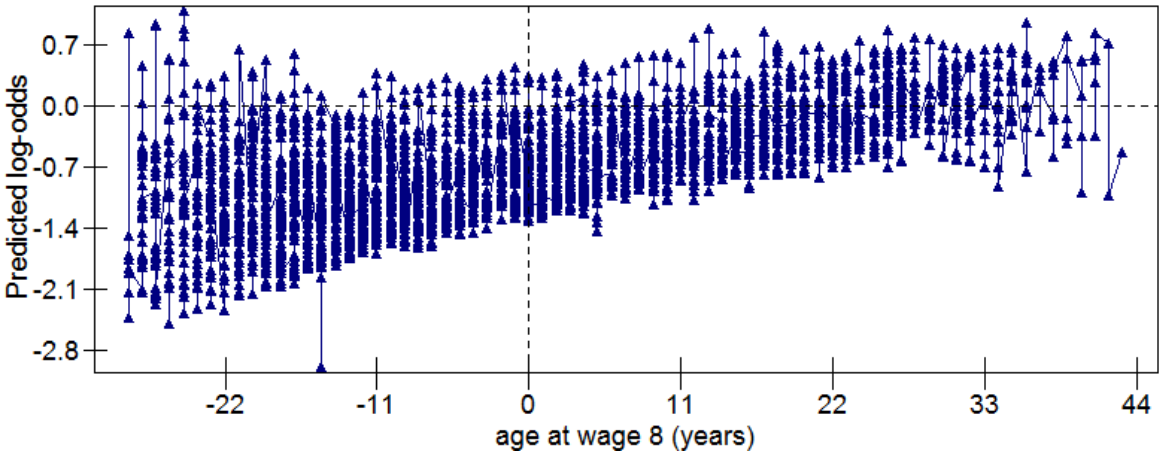
The fitted line for a given area will differ from the average line in its intercept.

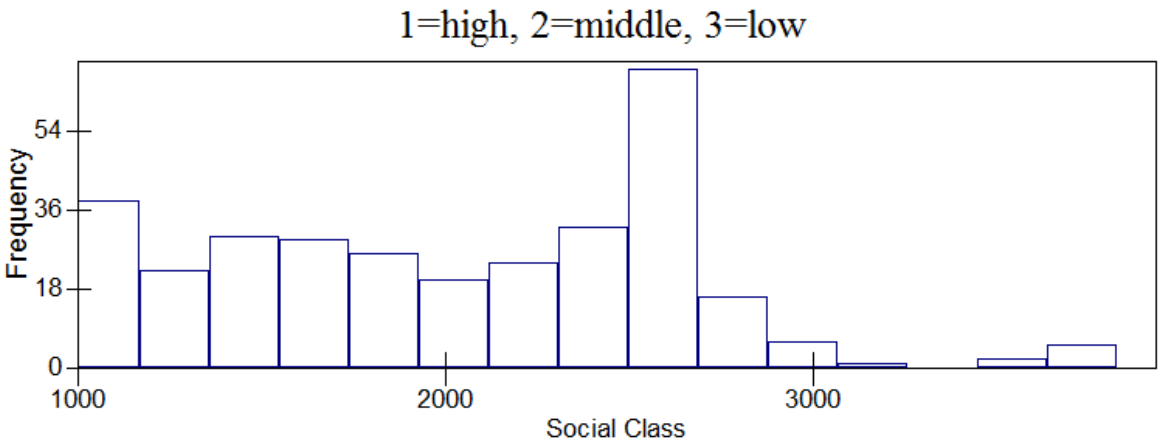
Plot predicted community lines Model 2



The fitted line for a given area will differ from the average line in its intercept.

Plot predicted community lines Model 3 interactions



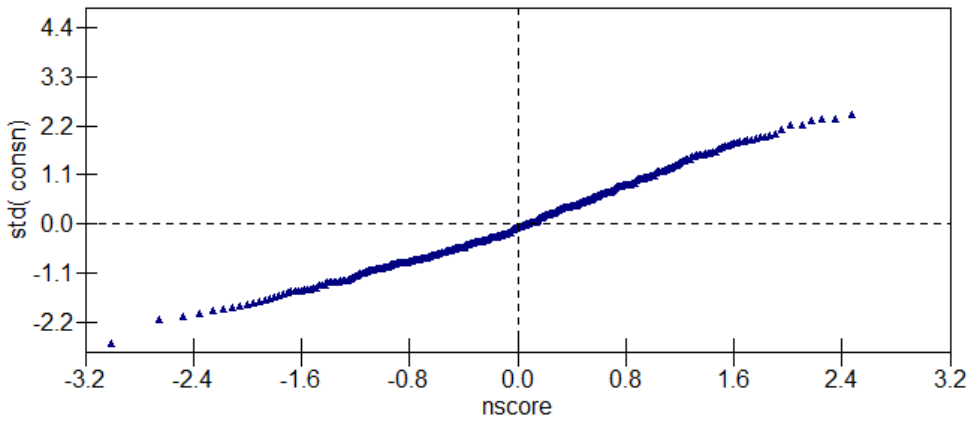


There is not variability between areas on social class

ASSUMPTIONS:

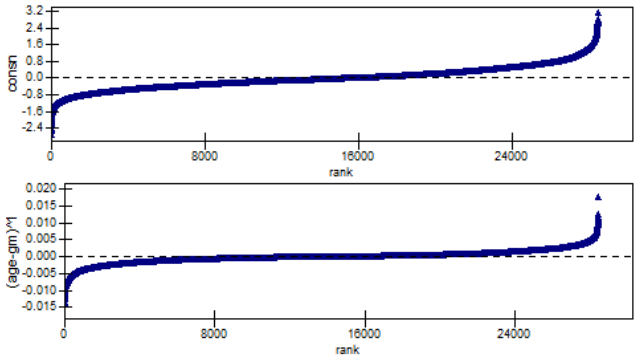
Normally distributed of random effect at:

Level 3-Area

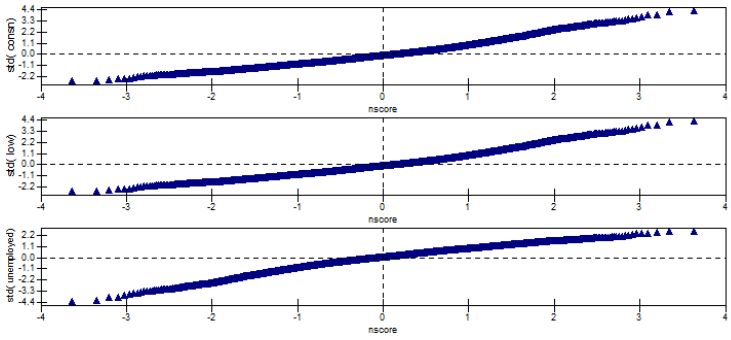


Normality residuals:

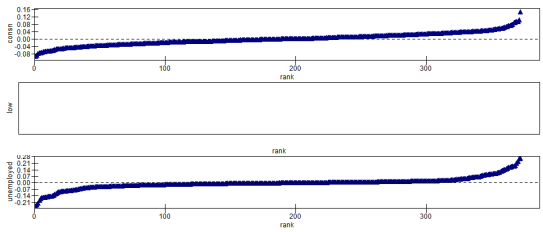
Level 1- Occasion



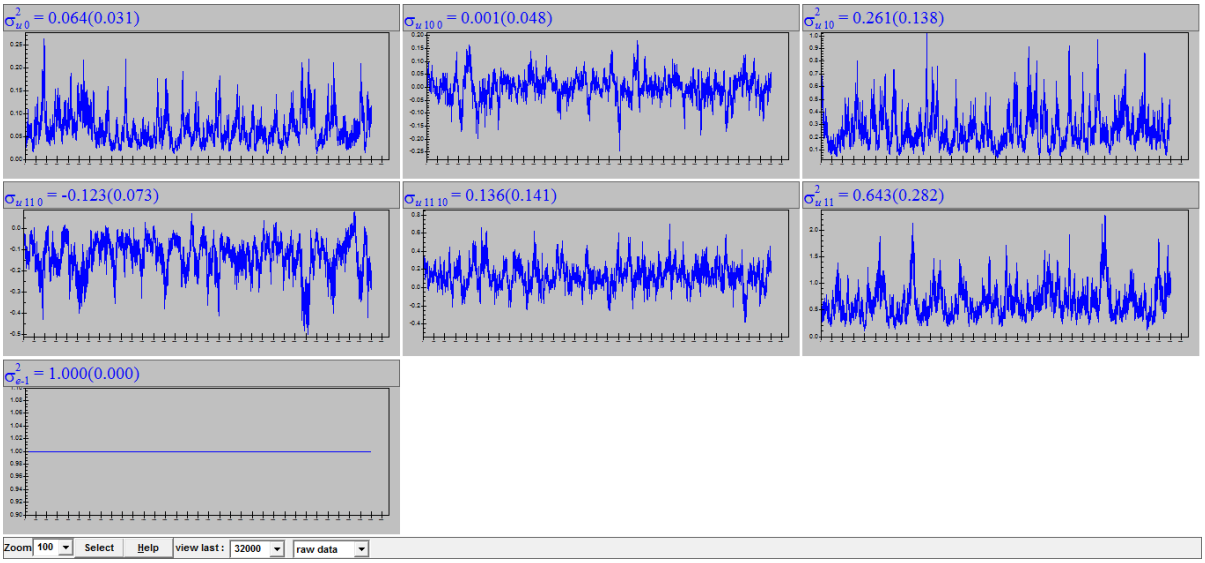
Level 2-Individuals

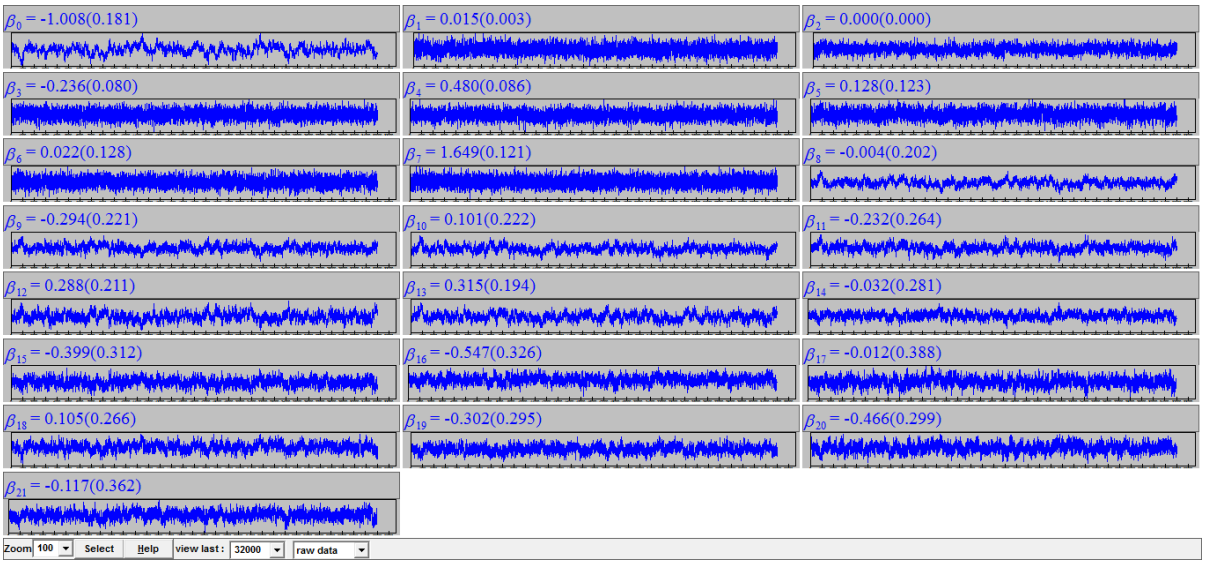


Level 3- Area Level



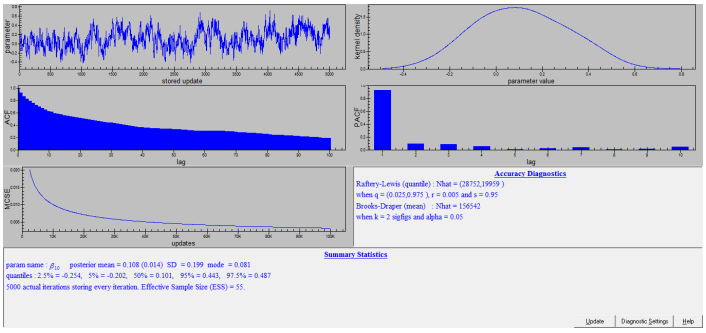
MCMC Diagnostic:





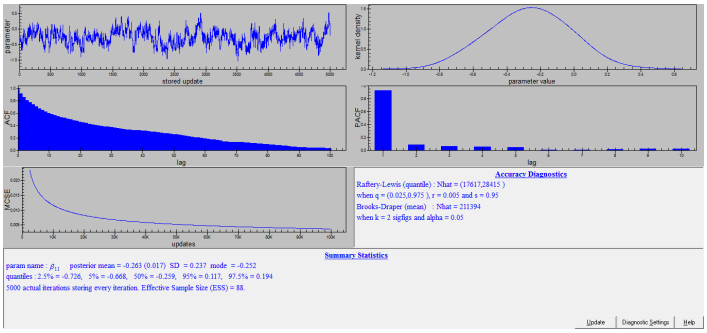
Slopes:

B10



ESS = 48 independent interaction with 10000 actual interaction

B11:



ESS = 55 independent interaction with 10000 actual interaction