Health Selection and Health Inequalities

Myung Ki

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Department of Epidemiology and Public Health

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Abstract

Social inequalities in health remain a major social issue globally. One possible explanation of health inequality is health selection: in other words people with poor health move down the social hierarchy. This study started with the conceptual distinction between two types of health selection studies. Type I health selection study (the presence of health selection) examines the impact of poor health on the subsequent social mobility. On the contrary, type II study (the contribution of health selection to social inequalities in health) examines whether health selection changes social inequalities in health.

The first 13 waves (1991-2003) of the British Household Panel Survey with 63599 observations from 8819 individuals were used. In accordance with the typology, two different approaches were applied to empirical and theoretical investigation. For type I study, a multilevel multinomial model to fit all possible transition from multiple origins was used to assess social mobility with regard to health status. For type II study, both empirical and hypothetical analyses are applied in order to address the relationship between social mobility, health selection, and social inequalities in health on the population-level framework.

Findings from the type I study presented that health selection was negligible in mobility within employment indicated by class and income measures, although it was highly significant in the transition between employment and non-employment. In type II study, changes in social inequalities in health were associated with a set of elements extracted from a social mobility process. Varying levels of health selection and scales of social mobility result in different extents of change in social inequalities in health.

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Abbreviations

AD – Absolute difference

BHPS – British Household Panel Survey

CI – Confidence Interval

df – degree of freedom

ECHP – European Community Household Panel

IV – Instrumental variable

LLTI – Limiting long-term illness

ONS-LS – Office for National Statistics Longitudinal Study

OR – Odds Ratio

PSID – Panel study of Income Dynamics

RD – Relative difference

RGSC – Registrar General's Social Class

SD – Standard deviation

SE – Standard error

SEM – Structural equation modelling

SEP – Socioeconomic position

SMR – Standardized mortality rate

UK – United Kingdom

US – United States of America

Chapter 1: Introduction and literature review

1.1 Introduction

1.1.1 Background

The existence of social inequalities in health is well established. The Black report described three causal pathways for social inequalities in health: (1) materialist or structuralist explanations (social causation), (2) cultural-behavioural explanations, and (3) theories of natural and social selection (health selection) [Black *et al*, 1982]. There has been considerable debate on the validity of each model in explaining social inequalities in health. We now have a more profound understanding of the relationship between social context and health than ever before [Bartley, 2004a, pp1-21; Davey Smith, 2003, pp xii-xlvii; Lynch and Kaplan, 2000; Marmot and Wilkinson, 1999, pp1-12]. In explaining the causes of health inequality, much evidence has been accumulated that establishes social causation as a primary explanation for health inequalities.

Over the last 50 years, much work has focused on understanding health selection, which is a concept that, to some extent, health may exert influence on subsequent changes in social position. However, the direction of causation between health and social position is highly contested and is still not clearly understood. Some researchers have argued that health selection affects social position, whereas others have suggested a marginal role for health selection and have placed more importance on the role of social causation. Support for the importance of health selection in explaining social inequalities in health has also come from other fields of research. In economics, poor health has been the most commonly cited reason for retirement [Little, 2007; Disney *et al*, 2006; Haardt, 2006; Smith, 2004; Faggio and Nickel, 2003] and in occupational epidemiology, the 'healthy worker effect' that refers to the selection process for employment due to health status has long been supported as an established theory [Siebert *et al*, 2001; Arrighi and Hertz-Picciotto, 1994; Arrighi and Hertz-Picciotto, 1993; Östlin, 1989].

Moreover, two major limitations in the study of health selection have contributed to a position of stalemate. First, although the term 'health selection' has not been used uniformly, little has been done to map out the different types of approaches. Second, limited methodological approaches have been used, which have restricted longitudinal analysis to just two or three stages rather than making full use of such data [Twisk, 2003, pp55-60]. Conceptually, this study sets out to address some of the complexity in the health selection debate with particular attention to social consequences after illness. Methodologically, an attempt will be made to develop the application of new approaches to the analysis of longitudinal data.

1.1.2 The Structure of the thesis

The first two chapters provide a contextual and methodological review pertaining to the study of health selection. In Chapter 1, a typology of health selection studies is made, in order to distinguish between type I studies (the presence of health selection) and type II studies (the contribution of health selection to social inequalities in health). A brief overview of the health selection debate is presented based on the typology. Chapter 2 provides a review of the methodological limitations that might be involved in statistical design, analysis, and inference relying on types of health selection studies. In Chapter 3, research hypotheses are addressed. The methodological aspect of the current thesis is described in Chapter 4, with a particular focus on the application of the multilevel multinomial models in a longitudinal study.

In addition to the theoretical and methodological distinction of two types of health selection studies, the empirical chapters exhibit how both ideas are used in different contexts. Chapters 5 to 7 focus on the individual risk of social mobility following a health event. All applications are based on multilevel multinomial modelling. A series of different socioeconomic measures is introduced for each chapter. Chapter 8 deals with type II study and assesses the contribution of health selection to social inequalities in health based on simulation analysis. Chapter 9 discusses major issues arising from the thesis.

1.2 A review of the study of health selection

Over the last few decades, there have been a number of debates on the health selection pathway outlined in the Black Report to explain social inequalities in health. However, there has not yet been a clear resolution on the role of health selection. To review this research tradition, a typology has been developed to classify studies. Broadly, two categories of health selection studies are identified to describe a number of studies and to indicate a few drawbacks pertaining to each approach.

1.2.1 Early stage of the debate: Illsley to Black

When Illsley [1955] showed that more intelligent, healthy, and well educated women tended to marry into a higher class, his paper led to a lively debate on health selection. He opened the way for health selection to become a rival explanation to social causation, suggesting that selective marriage is partly responsible for the continuing class inequalities in mortality rates. As his interpretation included descriptions such as 'superior characteristic' and 'poor ability (to attain future gain)', the implication was that health selection could be approximated to natural selection, thereby attracting interest from proponents of natural selection [Himsworth, 1984].

Much of the early work in defending a social causation approach was attributed to the Black Report [Black *et al*, 1982]. However, its recognition of health selection provided a marked contrast to social causation, because health selection was positioned as the same concept as natural selection. Health selection was believed to justify class inequalities in mortality; for example, health selection was understood in the sense that 'the Registrar General's class I has the lowest rate of premature mortality rate because it is made up of the strongest and most robust men and women' [Black *et al*, 1982, p105]. Therefore, the Black Report dismissed health selection as an improbable hypothesis to account for social inequalities in health.

Stern [1983] was critical about the conclusion of the Black Report. He attempted to explain social class differences in health as being due to social mobility. His critique of the Black Report started with an assumption that when there is considerable social mobility, social causation is insufficient to explain the class differences in mortality.

Without using empirical data, he presented a hypothetical situation that no mortality differential was attributed to social origin and instead suggested that every differential was generated by social mobility. These assertions cast a shadow over the succeeding chapters of the debate. Many studies identified health selection as being a competitive explanation to social causation, because health selection initially appeared as having an intention to deny mortality differentials in class, and because health selection has been conceptually attributed to social drift by ‘innate physical characteristics’ [Black *et al*, 1982, p105].

After these early works, the study of health selection was diversified in many ways, becoming more variegated in approach. Therefore, a sensible distinction between study designs is necessary, because the debate is to some extent caused by vagueness in the health selection concept [Chandola *et al*, 2003a]. The next section describes how the study of health selection is categorized in this thesis.

1.2.2 Typology of health selection studies

In order to gain deeper insights into this debate and to raise a number of related methodological issues, a typology has been developed. Since health selection studies have varied in the type of study settings and measures, some researchers have tried to clarify them. Lundberg [1991] tried to classify the studies into three categories; i) social mobility to illness, ii) illness to social mobility, and iii) common background factor to social mobility and illness. Similarly, being aware of the design issue, Blane *et al* [1999a] distinguished ‘two separate propositions’; the first is the relations between health status and the direction of social mobility, and the second is the relations between health-related social mobility and class differences in health. Confirming the design issue, Chandola *et al* [2003a] also identified two different approaches. One approach focuses on health and subsequent social mobility (health-related social mobility) and the other focuses on the contribution of health selection in explaining social inequalities in health (the health selection hypothesis) [Chandola *et al*, 2003a, p2059].

Since numerous studies are in accord with the distinction defined by Blane *et al*

[1999a] and Chandola *et al* [2003a], this has also been employed here. This typology is expected to aid in structuring the debate. Now, in this thesis, health selection studies are summarized into two categories: the presence of health selection, or the presence of health-related social mobility (type I study), and the contribution of health selection to social inequalities in health (type II study).

Illness ⟶ Social consequence (type I)

Health selection ⟶ Social inequalities in health (type II)

Figure 1-1 Displaying two health selection studies: the presence of health selection (type I study), and the contribution of health selection to social inequalities in health (type II study)

As shown above, the type I study (the presence of health selection, or the presence of health-related social mobility) questions whether poor health can influence social outcomes. To be consistent with terminology, the words ‘health selection’ and ‘health-related social mobility’ are used interchangeably throughout this thesis. On the other hand, a type II study (the contribution of health selection to social inequalities in health) denotes the situation where health selection is related to social inequalities in health.

In a later section, the health selection debate is reviewed using this typology. In this review, social mobility indicated by social class classification schemes is described in detail. Some examples of the two types of study are illustrated in table 1-1 and 1-2. The included studies are not intended to form an entire list for a thorough review, but are instead provided to illustrate the difference between two basic designs. The clearest distinction may be found in their outcome measure. Regarding the effect of health on income and employment status, studies dealing with this type of health selection are reviewed in individual chapters for income (Chapter 6) and employment status (Chapter 7).

1.2.3 Findings from type I studies (the presence of health selection)

Although some studies started to investigate the role of previous illness in the subsequent risk of social mobility, this form of study was not fully recognized, except in some rare cases, until the mid 1980s. Some researchers were uncomfortable with the formulation of this type of study, which saw social class as the dependent variable [Black *et al*, 1982, p105; Wilkinson, 1986a, p5, 14]. Although basic designs were similar with a connection between previous health and later social mobility, there were various methods which have been used to define health and to characterize social mobility.

Wadsworth [1986a] tested whether childhood illnesses are associated with adulthood social class and other achievements in education using data from the 1946 British Cohort study. Childhood serious illnesses at age 0-10 years were significantly associated with long-term educational attainment in men and women, although this effect disappeared after taking into account the cohort member's height and level of parental education. Social mobility for those with serious childhood illness was compared with healthy members. Subsequent downward mobility in adult life was indicated among men with childhood illness even after controlling for social class of origin [Wadsworth, 1986, p64-69].

Power *et al* revisited this issue [Manor *et al*, 2003; Power *et al*, 1996; Power *et al*, 1986] using data from the National Child Development Study (NCDS). They investigated the relationship between height and social mobility between birth and age 23, with four categories of Registrar General's Social Class (RGSC). Expressed in ratios of observed to expected shortness, fewer short men and women were in social classes I/II, implying that social mobility was selective as to height. They also found the existence of health-related social mobility over a range of other health measures, including malaise scores, evidence of psychiatric problems, and general health. Those measures presented similar patterns and the pattern was more marked among women than among men [Power *et al*, 1986]. Using logistic regression, Power *et al* [1996] examined the relationship between self-rated health and social mobility between ages 23 and 33. This was addressed by assessing the odds ratio (OR) by mobile groups compared to a stable group as a reference category. The ORs for the downwardly mobile group were consistently higher than the stable group and the ORs for the upwardly mobile group appeared to be lower, supporting the possibility of health-related social mobility. A more recent study from this research team confirmed the same result [Manor *et al*, 2003]. The previous health predicted the direction of social change, and the relationships between health at age 16 (school absence due to ill health) and intergenerational social mobility (ages 16-23), and between self-rated health status at 23 and intra-generational social mobility (ages 23-33) were significant in both logistic regression and log-linear models.

Using the Whitehall II study, a survey of London civil servants, Chandola *et al* [2003a] questioned whether health-related social mobility contributes to the association between two health measures (GHQ mental health and SF-36) and two SEP measures (employment grade and financial deprivation). They attempted to compare two routes, health on changes in SEP and *vice versa* – over three successive periods. By using cross-lagged structural equation modelling (SEM), they resolved the troublesome problem of endogeneity which arises from multiple causal relationships [Rothman and Greenland, 1998, pp424-425]. Both paths from employment grade and financial deprivation to mental and physical health were significant, while paths from health to social indices were not. Accordingly, they concluded that there is little evidence that poor health is working on social mobility in the cohort of civil servants.

Outside the UK, some other European studies offered another blend of logic and design. Lundberg [1991] examined the association of health status with both subsequent inter- and intra-generational mobility with a log-linear model, using the Swedish Level of Living studies. No sign of the presence of health selection over intergenerational mobility was observed, though there was a minimum effect of health on intra-generational mobility. On the other hand, the presence of health selection was clear when leaving paid employment. By analyzing retrospective data in the Netherlands, van de Mheen *et al* [1998] evaluated the effect of poor health in childhood on educational attainment in early adulthood. Respondents who reported severe disease or hospital admission in childhood experienced a higher risk of a lower educational level. Using the Italian Turin Longitudinal Study, Cardano *et al* [2004] investigated the connection between hospitalization and later social mobility via a multinomial logistic regression. Taking the stable group as a reference, the effect of health based on the hospitalization records on upward and downward mobility was not statistically significant in either sex.

Overall, the findings of the type I study (the presence of health selection, or the presence of health-related social mobility) remain contested for both inter-and intra-generational mobility. Some studies reported no impact of illness on intergenerational social mobility [Chandola *et al*, 2003a; Lundberg, 1991], whereas others found a negative role of illness [Manor *et al*, 2003; Power *et al*, 1986; Wadsworth, 1986; Illsley, 1955]. As to intra-generational mobility, one study showed a limited impact of health [Cardano *et al*, 2004]. On the other hand, other studies found a considerable contribution [Manor *et al*, 2003; Power *et al*, 1996; Lundberg, 1991; Power *et al*, 1986]. However, Cardano *et al* discussed the possibility of underestimation of health effect on mobility due to a less specific characteristic of health measure (i.e., admission history).

Several methodological limitations are found in most studies. One limitation is related to the capability of a multivariate logistic model to capture the strength of a multi-way social mobility table between origins and destinations. Mobility tables with a third variable as a predictor (e.g., health variable) are statistically translated into either log-linear [Manor *et al*, 2003; Lundberg, 1991] or logistic regression model [Cardano *et al*, 2004; Manor *et al*, 2003; Power *et al*, 1996] assuming that they are equivalent models. The comparability of these models is discussed in section 2.2 throughout. Another limitation, which pertained to many health selection studies, concerns the collapsibility of the social mobility table, usually into three directions (upward, stable, and downward) [Cardano *et al*, 2004; Manor *et al*, 2003, Blane, 1999a] or two directions (stable and mobile) [Classsen, 2005; Cardano *et al*, 2004]. This simplification of social mobility might allow evaluation of only the net effect of health on simplified mobility, rather than the detailed effects on each transition between classes. This issue is further elaborated in section 2.2.2. A third limitation is related to the fact that a comprehensive understanding of the pattern of health selection might be compromised by the characteristics of a study sample. The study samples adopted in previous studies consisted predominately of the employed, excluding the non-employed[1]. However, the processes, exit from and entry into employment, may assist in altering the shape of the class structure. A few studies [Elstad and Krokstad, 2003; Cardano *et al*, 2004; Lundberg, 1991] included the non-employed along with the employed and they commonly reported that the effect of health on exiting employment is much greater than that for movement between classes. Since the formation of social classes is associated, not only with movements across class boundaries, but also with transitions into/out of employment, it is likely that transition into/out of employment has an impact on class inequalities in health. This connection has not been fully investigated.

[1] The term 'non-employed' is used to denote not only the unemployed but also the economically inactive throughout this thesis.

Table 1-1 Studies handling the presence of health selection (type I study)

References	Population	Main outcome measure	Variable for interest	Covariates	Operational concept of health selection	Analysis	Results
Cardano *et al*, 2004	Turin longitudinal study / Italy	Class mobility, exit from employment	Poor health (hospital admission more than one night)	Education, sex, birth region	-	ANOVA, Polytomous logistic regression	Weak relationship between health status and occupational mobility chances
Manor *et al*., 2003	1958 British cohort/UK	Class mobility (upward, stable, downward)	School absence	Social class of origin	2 way interaction term (prior health×class of destination) controlling for class of origin	Polytomous logistic regression / Log linear model	Health selection due to ill health was operating.
Chandola *et al*., 2003	Whitehall II/UK	Employment grade /Financial deprivation	Health status (GHQ-30, SF-36)	-	-	Structural equation modelling.	Limited evidence for an effect of initial health on subsequent social position.
Elstad & Krokstad, 2003	HUNT study/Norway	16 mobility groups (class trajectories)	Perceived health	-	The effect of perceived health on subsequent social mobility	Cross-tabulation with OR	Mobility between occupational classes was not selective for health, but transitions into and out of employment were strongly health selective
Power *et al*, 1996	1958 British Birth Cohort / UK	Social mobility between class at 23 and class at 33	Self rated health at 23	Social class at birth, 16, and 23	The relation between social mobility between 23 and 33 and health at 23	Cross tabulation with OR	Those reporting poor health at 23 have higher risk of downward mobility

Lundberg, 1991	Level of living studies / Sweden	-	Three way health selection term defined by 'health×class origin×class of destination'	Sex	Interaction between health and social mobility	Log linear model	Ill-health is shown to have no direct effect on social mobility between classes
Power *et al*, 1986	1958 British Birth Cohort / UK	Social mobility between classes at birth and 16	Height at 23 as a measure of health potential	Social mobility	The relationship between height and social mobility	Cross tabulation	Social mobility was selective with respect to height
Illseley, 1955	Aberdeen married primiparae study / UK	Class mobility between classes of women's father and husband's	Height/self assed health when women were hospitalized for delivery	-	Comparison groups classified by interclass movement at marriage	Cross tabulation	Health selective movement between classes occur as the healthy women would marry to higher social classes.

1.2.4 Findings from type II studies (the contribution of health selection to social inequalities in health)

As mentioned above, the first impression endowed on health selection was that it explained social inequalities in health in a different way to social causation, and therefore most studies tried to apply an analysis of health selection to social inequalities in health. The type II study dealing with the contribution of health selection to social inequalities in health is reviewed below.

At the beginning, this type of study used cross-tabulation to compare the ratio from each transition [Dahl and Kjaersgaard, 1993b; Power *et al*, 1986]. For instance, using the ratio between the numbers of observed and expected shorter people to reach a class destination, Power *et al* [1986] looked at the relationship between health and social mobility. Class gradient in this ratio was maintained even after controlling for earlier social class and, from this result, they rejected the idea that social mobility could account for social inequalities in height.

Since social mobility is presumed to predict mortality, Dahl and Kjaersgaard [1993b] compared each standardized mortality ratio (SMR) in regards to every mobility process. Social mobility between 1970 and 1980 was followed by 5-year mortality during the period of 1980-1985. Among men, those without mobility experience had lower mortality than those who drifted down and had inversely higher mortality than those who were upwardly mobile, though among women such a trend was not observed. This result, which implied that health selection was present among men, guided his conclusion of widening inequality in SMR, although this was not applied to women.

Power *et al* [1996] repeated their early conclusion that health selection occurs but does not explain social inequalities in health. They carried out analysis using logistic regression where health status was a dependent variable and class status served as an independent variable. The social mobility variable, which was defined by the interaction term between class of origin and class of destination, was introduced to the model as an independent variable. It was then explored whether the introduction of the social mobility term reduces the OR of the class variable. It was argued that social mobility does not seem to be a major determinant of social inequalities in health, because there was little reduction in the effect (OR) of class on health after adjustment for social mobility. Manor *et al* [2003] used a similar approach, but focused specifically on the health selection variable defined by using an interaction term between prior health and class of destination, instead of using the broad social mobility term. They reached the conclusion that intra-generational health selection played a role in widening social inequalities in health, but only to a modest degree.

One feature of this approach [Manor *et al*, 2003; Power *et al*, 1996] is distinctive. In explaining the contribution of health selection to social inequalities in health, they directly incorporated a health selection term as an independent variable. Changes in ORs by the class variable before and after adjustment for health selection were suggested as evidence to decide whether health selection works to widen or narrow social inequalities in health. In the current thesis, it is questioned whether this approach to take account of adjustment for health selection is appropriate. It is pointed out that two social inequalities in health (before and after adjustment) used for a comparison does not correspond to the concept of pre- and post-mobility inequalities in health. This issue is discussed in the section of 'health selection adjustment approach' (section 2.3.2).

Another tradition of type II studies is found in the framework which identifies individual social movement and combines the inflow and outflow to evaluate changes in social inequalities in health. Bartley and Plewis pioneered this issue using data from the England and Wales Office for National Statistics Longitudinal Study (ONS-LS) [Bartley and Plewis, 2007; Bartley and Plewis, 1997]. Limiting long-term illness (LLTI) at 1991 as a binary outcome was examined with respect to class mobility between 1971 and 1981, whilst controlling for class of origin and class of destination using logistic regression. They found that there are health differences over the three mobility groups; the highest prevalence of LLTI among the downward group, the lowest among the upward group, and the middle among the stable group. Therefore, the upwardly mobile group is less likely to have LLTI than the class of origin from which they moved, but more likely to have LLTI than the class of destination into which they relocated. This explanation provided a theoretical account of the relationship between the mobility process and social inequalities in health; social mobility may improve the health status of the lower class and aggravate that of the higher class. From this interpretation, Bartley and Plewis [1997] reached the conclusion that social mobility constrains social inequalities in health rather than widening it. Later using the latest ONS-LS data, they reaffirmed their previous finding [Bartley and Plewis, 2007].

Using ONS-LS, Blane *et al* [1999a] examined the effect of social mobility between 1971 and 1981 on the subsequent mortality risk between 1981 and 1992. Using a Cox regression model, mortality risk was compared with regard to three mobility directions (i.e., upward, stable, and downward) allowing adjustment for class of origin and class of destination. They found that the mobile group had a mortality risk somewhere between class of origin and destination. They advocated the concept of 'gradient constraint', because mobility moderated, rather than amplified, class inequalities in health. Afterwards, this concept of 'gradient constraint' was recognized by others [Claussen *et al*, 2005; Cardano *et al*, 2004; Elstad, 2001].

Unlike the previous studies where social mobility was grouped into three categories, Using data from 27 workplaces in the west of Scotland, Hart *et al* [1998] combined social class classification with social mobility, categorizing them into four groups [stable manual, upward, downward, and stable non-manual] over three time phases [birth to age 25, birth to age 50 (intergenerational), and age 25 to age 50 (intra-generational)]. They adopted both morbidity and mortality indices, which were measured twice: when participants were screened and 21 years after the screening. The result showed that the two social mobility groups had an intermediate risk of morbidity and mortality between the two stable groups [Hart *et al*, 1998] for several health screening results, such as diastolic blood pressure and body mass index (BMI), and for all causes of death with the exception of cancer mortality. Because the main health differentials were found between the stable non-manual and manual group, and the mobile groups were between the two stable groups, they came to the conclusion that there is little evidence that social mobility is associated with an increase in social inequalities in health.

In a series of logistic regression models, Claussen *et al* [2005] modelled mortality during 1990-1994 as a dependent variable while social mobility between 1960 and 1980 was introduced as an independent variable. Nine different models with different parameters, such as class of destination, mobile, stable, and the extent of resemblance of mortality rate to class of origin and to class of destination, were compared by the likelihood ratio test. Based on the result that the mortality risk of movers may be between the mortality risk of their class of origin and destination, they also provided an explanation supporting the 'gradient constraint hypothesis'. They explained that upwards-movers tend to increase the mortality in their class of destination, instead of reducing the total mortality. In the reverse pattern, downward-movers tend to reduce the mortality rates in the lower social classes.

These studies [Claussen *et al*, 2005; Blane *et al*, 1999a; Hart *et al*, 1998; Bartley and Plewis, 1997] share common characteristics. They tried to discover whether health selection explains social inequalities in health, by assessing the social mobility variable, and they all reached a similar conclusion that social mobility does not increase social inequalities in health. This hypothesis has been considered plausible in explaining the relationship between health selection and social inequalities in health. However, some questions are cast on whether this approach properly describes the relationship. This issue is dealt with in the section on gradient constraint hypothesis (section 2.3.1).

Elstad [2001; 2003] broadened the horizon of the health selection debate with an attempt to conceptualize the concrete operation of the process from social mobility to social inequalities in health, by adding some factors such as the scale of mobility. He tested the gradient constraint hypothesis, by examining changes in the health differentials in a Norwegian sample. Health indices such as general health were measured at the time of interviewing, while mobility was indicated by intergenerational changes between father's occupation and the respondent's own when they were 30-69 years old [Elstad, 2001]. A conclusion was derived that health-related social mobility is not sufficient to generate gradient constraint. Rather, he suggested that health-related social mobility worked together with other circumstances, such as considerable initial health differentials across the class spectrum, widespread mobility, and the weak association between health and mobility. This explanation depicts the reproduction of social inequalities in health as a process that involves several elements along with health-related social mobility. The current study details the process from social mobility to social inequalities in health, which will be presented in Chapter 8.

In summary, there was inconsistency in the outcomes of type II health selection studies. The majority of studies found that health selection decreases health differentials [Bartley and Plewis, 2007; Claussen *et al*, 2005; Blane *et al*, 1999a; Bartley and Plewis, 1997; Power *et al*, 1996], although some studies proposed health selection might increase health differentials [Manor *et al*, 2003; Dahl, 1993a]. A large portion of the disagreement in results may be attributable to differences in study design. The methodological review of type II studies is extensively carried out in section 2.3.

1.2.4.1 Relative importance of health selection compared with social causation

As a way of evaluating the contribution of health selection to health inequalities (type II study), some researchers have attempted to compare the relative importance between health selection and social causation. Wilkinson, in his critique of Illsley, emphasized the importance of this approach. He recalculated the results from Wadsworth's work arithmetically to derive the observation that only 1.5% of serious illness experience is affected by downward mobility [Wilkinson, 1986a, pp5-6]. In an accompanying study, Wilkinson also showed that the arithmetic calculation of height difference between classes I/II and IV/V only indicated around 20% difference while the perinatal mortality differential between classes was 116% [Wilkinson, 1986b, p420]. From these findings, he repeatedly asserted that there is little doubt that social mobility is selective for health, but the size of its contribution to mortality differentials is likely to be small.

Power *et al* [1996] carried out an analysis using logistic regression to determine the relative importance of social mobility. In their model, social mobility was compared to cumulative social exposure by introducing both variables into the same model, dealing with health as the outcome variable. They reached the conclusion that cumulative lifetime exposure has a major role in social inequalities in health, in contrast to the minor role of social mobility.

With structural equation modelling (SEM), Chandola *et al* [2003] tested two routes, health to SEP and SEP to health, simultaneously. They compared two models with changes in chi-square after and before removing the specific routes. An F-test was performed on the health-related social mobility route and the results were not significant. In contrast, an F-test of the regression from SEP to health yielded high significance. They treated residual correlation between SEP and health as a marker for evaluation. They found that most of the correlation could be explained by the effect of SEP on subsequent health, which provided evidence against the role of health selection.

Almost all studies reached a common consensus, that health selection contributes only a small fraction to social inequalities in health [Wilkinson, 1986a; Wilkinson, 1986b; Power *et al*, 1996; Chandola *et al*, 2003a]. The comparison seemed to be made under the assumption that health selection and social causation work in opposite directions [Claussen *et al*, 2005]. This may be correct if an increase in one explanation of health inequalities results in a decrease in the other.

Table 1-2 Health selection studies handling the contribution of health selection to health inequalities (type II study)

References	Population	Main outcome measure	Variable for interest	Covariates	Operational concept of health selection	Analysis	Result
Bartley and Plewis, 2007	ONS Longitudinal Study / UK	Limiting long-term illness	Social mobility; upward mobility to more favourable, stable, downward mobility to less favourable	Age, social class (NS-SEC)	-	Logistic regression	Social mobility did not increase the extent of health inequality
Claussen *et al*, 2005	Oslo mortality registry with the 1960 and 1980 census /Norway	Mortality	Social mobility	Age, gender	Mobility groups; mobile, stable, upward, and downward	Logistic regression model	The effect of social mobility on mortality divide is small.
Manor *et al*, 2003	1958 British cohort / UK	School absence, self rated health	Health selection defined by interaction term (prior health×class of destination)	Social class of origin, school absence(prior)	2 way interaction term (prior health×class of destination)	Logistic regression	Health selection widens health inequality for women, narrows the inequality for men.
Chandola *et al*, 2003	Whitehall II / UK	Association between employment grade and health (GHQ-30, SF-36)	Employment grade, health (GHQ-30, SF-36)	-	-	Structural equation modelling.	Health selection does not explain social inequalities in health
Elstad, 2001	Norwegian Health Study / Norway	Five health measures; height, somatic symptom, self rated health, mental symptoms, medical diagnoses	Class mobility	Age	Class mobility; movers, stable members	Cross-tabulations Logistic regression	Health-related mobility may narrow social class health differential.

Blane *et al*, 1999	ONS Longitudinal Study / UK	Mortality	Social mobility	Age, class of destination	Social mobility ; fully expanded mobility (between all categories), and mobility with three categories (upward, stable, downward)	Cox regression	Result fits best with gradient constraint where social mobility moderates rather than widens the size of the social class differential.
Hart *et al*, 1998	Scottish cohort / UK	Health screening result (diastolic BP, BMI, current smoking etc) and mortality	4 mobility groups	Age, smoking etc	4 mobility groups ; upward, downward, stable manual, and stable non-manual	Cox regression	Little evidence that social mobility was associated with mortality or morbidity risk
Bartley and Plewis, 1997	ONS Longitudinal Study / UK	The existence of limiting long-term illness	Mobility	Age, social class	Mobility; stable, down, entered the labour force, out of the labour force, never in the labour force	Logistic regression	Social mobility constrain socioeconomic differences in health
Power *et al*, 1996	1958 British Birth Cohort / UK	Self rated health at 33	Social class at 33, inter(intra)generational mobility	Prior health, social class at birth, 16, and 23	Inter(intra)generational mobility	Logistic regression	Social mobility does not seem to be major factor in creating and maintaining social inequalities in health
Dahl *et al*, 1993b	Mortality registry with the 1970 and 1980 census / Norway	Mortality	Social class, intergenerational mobility	-	Mobility groups; staying, upward, downward	Standardized mortality ratio	Little support for health selection to contribute the occupational inequalities in mortality

1.3 A glossary

Several of terms in the health selection debate have been used in varying ways – for example, natural or social selection was used in the Black report as being the same kinds of concept to denote the situation in which health appears as a predictor of socioeconomic position [Black *et al*, 1982, p105]. Afterwards, the term health selection acquired the same connotation. This thesis, however, distinguishes between three selection terms; health selection, natural selection, and social selection. Likewise, there are sources of uncertainty in the usage of terms. Therefore, some of the basic terms are considered below to provide the context of how they will be defined in this thesis.

Social selection: Social selection is when individual's attainment is a result of essentially social processes. The term 'social selection' is generally accepted as a way to describe the role of social mechanisms, such as the education system, although sometimes this term has been applied to a broader range of factors (e.g., sex selection and race selection) [Clark, 2007; Oomman and Ganatra *et al*, 2002; Closson, 1896]. An education system, for example, functions to select individuals by sorting and selecting pupils through academic differentiation, such as degree certification and vocational qualifications. This process has been revealed as operating in a way that reproduces a social hierarchy by legitimating the class structure [Bourdieu and Passeron, 1996, p141].

Natural selection: Natural selection refers to the concept that individual achievement is mainly attributed to hereditary factors. Natural selection emphasizes the innate part or genetic component of ability, which is assumed to decide future success in socioeconomic position. This concept has often been connected with the health selection hypothesis, where health is assumed to carry little social aetiology.

Social inequalities in health: Social inequalities in health denote the situation when poor health is distributed across socioeconomic groups unequally. Thus, in measuring social inequalities in health, meaningful social groupings, such as social class or ethnicity, are used as the basic premise that can reveal characteristics of unequal distribution of health [Kawachi *et al*, 2002; Regidor, 2004a]. Unlike social inequalities in health, health inequality can conceptually describe a dispersion and a variation with a univariate measure, and it does not necessarily carry moral implications [Kawachi *et al*, 2002, p647]. This thesis uses, however, health inequality in the same context to refer to social inequalities in health, if not otherwise specified.

Social causation: Social causation refers to the concept that socioeconomic conditions play an important role in setting future health distributions. Socioeconomic conditions have been used to describe the social environment of an individual, from external factors such as political or economical development to internal factors such as occupational social class [Regidor, 2004a]. Social causation has long been accepted as the dominant explanation for social inequalities in health.

Social mobility: Social mobility is indicated by the movements between different levels of the social hierarchy, typically as a change in social class [Turner *et al*, 2001]. In a more general sense, various types of mobility can be identified depending on types of socioeconomic position used [Schnore, 1961]. For example, income mobility is applied in economics as an indicator of income change [Dickens, 2000; Jarvis and Jenkins, 1998]. The well-established debate on the determinants of social mobility has been aware of two competing explanations: genetic and socioeconomic background. Studies of social mobility distinguish between intergenerational and intragenerational mobility. While intergenerational mobility looks across generations, for example, the SEP of a man compared to that of his father, intragenerational mobility compares two positions measured at different phases for the same individual. This thesis refers to intragenerational mobility based on social class, income, and employment status.

Health-related social mobility: Health-related social mobility is typically defined as a situation in which health exerts an effect on subsequent social mobility. Notably, health is a minor cause of social mobility compared with the entire causes. As health-related social mobility runs in the reverse direction to social causation (i.e. from health to SEP), it is sometimes known as 'reverse causation' [Hallqvist *et al*, 2004; Lynch *et al*, 1997; Jin *et al*, 1997].

Health selection: Health selection has been used as a term for explaining social inequalities in health without employing social factors. Many researchers are unwilling to accept this idea because it has been understood as accommodating little social meaning. In the current usage, health selection denotes the situation when health is associated with social and economic consequences (e.g., disability on labour supply), and broadly it is used as a synonym for health-related social mobility.
In this thesis, two different types of health selection study are discerned; those concerned with identifying the presence of health selection (type I study), and those assessing the contribution of health selection to social inequalities in health (type II study). These are distinguished as different domains of investigation.

Healthy worker effect: The 'healthy worker effect' has been described as a phenomenon explaining the lower mortality rate among the employed than among the general population. This effect has long been understood as a potential source of selection bias in an occupational cohort [Li and Sung, 1999; Baillargeon and Wilkinson, 1999]. Although this concept typically refers to a follow-up study of occupational exposure, it also concerns the general situation when movements into and out of occupation involve health selection [Baillargeon and Wilkinson, 1999, Bartley *et al*, 1999, p82; Dahl, 1993a; Östlin, 1989]. The current thesis employs the term in the latter context, which is analogous to the notion of health selection being specified to the stage of entry into and exit from employment. The following expressions describe the same situation: 'health selection by leaving employment' [Dahl, 1993a], 'health-selection force' [Baillargeon and Wilkinson, 1999], and 'health-related selection' [Romao and Roth, 2008; Payne *et al*, 2007; Östlin, 1989].

Component of health: Throughout this thesis, health is identified as having two sources: genetic and social background. Both sources may vary among different categories of disease. For example, a congenital disorder, if it is randomly distributed among social groups, may have more genetic properties than socially defined properties. In contrast, an occupational injury is likely to be confined to a specific social group, hence it may originate primarily as a social background. Most diseases, e.g., asthma, fall somewhere in between the two extremes as a gene-environment interaction hypothesis implies [Payne *et al*, 2007; Horwitz, 2005; Ottman and Rao, 1990].

Chapter 2: Methodological review of health selection studies

2.1 Introduction

The review in Chapter 1 focused mainly on describing the observations drawn from the study of health selection without discussing any methodological issues. This chapter deals with some common limitations that affect design and analysis in this study area. In the previous chapter, the review was based on two types of health selection study. This chapter follows the same typology. The first section examines some design issues in the type I study (the presence of health selection). This section focuses on the statistical definition of the mobility concept, including the limitation of the basic formulation of social mobility (e.g., three directions; upward, stable, and downward mobility). Methodological consideration of the type II study (the contribution of health selection to social inequalities in health) takes into account the special features of this type of study.

2.2 An assessment of type I study (the presence of health selection)

Type I health selection study has associated health with subsequent social mobility and regarded social mobility as the outcome variable [Blane *et al*, 1993]. Logistic regression has been used primarily to deal with multivariate models on this topic. This methodological review starts with a brief description of the effort involved in the application and development of statistical modelling for social mobility studies. It is highlighted that multivariate decomposition of a social mobility table has long been a topic of great interest in the study of social mobility. This section also investigates whether a simplified mobility variable (e.g., upward, stable, and downward mobility) could effectively replace a full mobility trajectory between origin and destination.

2.2.1 Modelling a third variable in the mobility table

To explain the underlying mobility mechanism, social mobility was studied in comparison to any third variable such as education [Erikson and Goldthorpe, 2002], intelligence [Breen and Goldthorpe, 1999; Savage and Egerton, 1997; Saunders, 1997], different time periods [Goldthorpe, 1980, pp68-89], variation of countries [Breen, 1985], health, or other factors. This concept was often presented as a three-way interaction. An interaction between three factors (referred to as the interaction A×B×C) provides explanations about how the combination of each level from two factors (A×B) varies over the level of factor C. In this manner, a three-way interaction between class of destination, class of origin, and the third variable can be used to identify the difference in social mobility associated with the third variable [Fox, 1990; Logan, 1983]. Accordingly, the joint distribution of class of destination and class of origin (social mobility) is explained as a function of a third variable. Due to the limitation of the mobility table in incorporating additional variables, however, considerable attention was then given to multivariate models to introduce explanatory variables [Logan, 1983]. A log-linear model was pioneered by Goodman [Goodman, 1979; Goodman, 1969]. A log-linear model was developed to fit a marginal distribution, and then later the estimation of parameters became the centre of interest [Dessens *et al*, 1995]. A three (or more)-way-interaction, typically in the form of a 'class of origin × destination × explanatory variable', was applied in a log-linear analysis.

Before the 1980s, few studies [Illsley, 1955; Goldberg and Morrison, 1963] investigated social mobility with respect to health status. In particular, researchers studying mental health took an active interest in introducing the health-related social mobility concept. On a small number of occasions, the log-linear model was used to examine the health selection effect [Manor *et al*, 2003; Lundberg, 1991; Fox, 1990]. For the evaluation of a model, likelihood-ratio statistics were used for comparing pairs of models after and before introducing a health term to test whether the goodness of fit was improved significantly. In the log-linear model, an interaction term was used to define the health selection concept. Abundant studies have recognized three way terms between social class of origin, social class of destination and health as the way to compare social mobility differences against a third variable [Agresti, 2002, pp320-323; Goodman, 1979; Logan, 1983]. Fox [1990] referred to the three way interaction as 'a basic formulation of nearly all contemporary social mobility research'.

2.2.2 Collapsibility of a mobility table

Along with the log-linear model, several attempts have been made to suggest comparative mobility models which would accommodate a predictor variable for social mobility [Erikson and Goldthorpe, 2002; Breen, 1994; DiPrete, 1990; Yamaguchi, 1987; Logan, 1983; Duncan and Hodge, 1963]. However, the logistic regression model soon became popular for its ease of use. A fairly large effort was made to investigate the relationship between the log-linear model and the logistic regression model [Logan, 1983; Agresti, 2002, pp830-833]. In the current thesis, no attempt is made to provide an exhaustive review. Instead, a brief description is given, with a particular emphasis on the exchangeability of the logistic regression model and the log-linear model.

In fact, both log-linear and logistic models belong to the same group of generalized linear models [Dessens *et al*, 1995] mediated by the logit function. Therefore, fitted values, goodness-of-fit statistics, and residual df (degree of freedom) for the logistic model are identical to those for the log-linear model [Agresti, 2002, pp330-333]. In spite of the exchangeable nature of the logistic regression and log-linear model, it has been recognized that not all logistic regression analyses directly correspond to log-linear models. A log-linear model is able to describe the joint distribution of all variables in the model, and relationships among all variables are analyzed simultaneously. A logistic regression model, in contrast, describes how a response variable is accounted for by explanatory variables. Subsequently, the log-linear model is preferred when the response variable requires more than two variables (multivariate outcomes), whereas logistic regression is usually employed for a single response variable. In this context, the non-identical property of logistic models to log-linear models was discussed [Agresti, 2007, pp221-222; Agresti, 2002, pp330-333]. Therefore, there have been serious discussions on how to introduce a logistic model when an outcome variable (social mobility) is composed of two variables; class of destination and class of origin.

The point of specifying the logistic model for health-related social mobility has therefore been to preserve the feature of mobility as a dependent variable, while placing health and other terms as independent variables. To handle this situation, social mobility was simplified into upward, stable, and downward [Cardano *et al*, 2004; Manor *et al*, 2003; Blane *et al*, 1999b], and sometimes into just mobile and immobile (or stable) groups [Claussen *et al*, 2005; Cardano *et al*, 2004]. This contraction of the mobility term might have been guided by the need for a single dependent variable in ordinary logistic regression.

When transitions are condensed into a summary measure of mobility direction (e.g., upward, stable, and downward), without denoting both origin and destination, this may produce a result that does not fully reflect the underlying pattern. Under certain conditions, this may even reverse results. Accordingly, the collapsible property in the analysis of a multi-way contingency table has been widely discussed [Agresti, 2002, pp51-54, pp358-360; Powers and Xie, 2000, pp129-135; Fox, 1990]. Consider the joint distribution of a three-way table between health status (X), mobility direction (Y) and class of origin (Z) and consider the association between health and mobility direction (X×Y) as a main interest. It is collapsible from the three-way table (X×Y×Z) into the two-way table (X×Y), if X is conditionally independent at every level of Z, or if Y is conditionally independent of Z[2] [Agresti, 2007, pp224-225; Agresti, 2002, p52]. Only when this condition of collapsibility is satisfied, can the association between health and mobility direction be collapsed over class of origin. However, it is too rigorous an assumption that both health (X) and mobility direction (Y) are independent of class of origin (Z). Fox [1990] observed a difference between a psychotic group and the general population with regard to class of origin and destination, and he concluded that 'these between-group differences in origins and destinations and their effects on social mobility are not incorporated into the *collapsed* [author's emphasis] social mobility distributions' [Fox, 1990, p346]. The merged table in Appendix 2-1 provides an empirical example of the reversal of results when the rule for collapsibility is violated. Since it does not take into account the fact

[2] Likewise, it is also possible to collapse YZ association over X, as X is conditionally independent of Z. On the other hand, XZ association is not collapsible, if we assume that Y is conditionally independent of Z.

that the distribution of the unhealthy population typically differs from that of the healthy population across different categories of social origin, a biased estimation of mobility occurs.

Apart from its statistical weakness, this approach using a collapsed variable is subject to a logical challenge. This approach has been questioned regarding the extent to which the terms ‘upward’ and ‘downward’ mobility reflect an underlying mobility pattern, because it might be unreasonable to suppose that all transitions within the three directions are similar [Elstad and Krokstad, 2003; Fox, 1990; Duncan and Hodge, 1963]. The distinction between directions of mobility may be arbitrary, since each category contains wide ranges of mobility and it assumes the ‘rigorous theoretical perspective’ that ‘social mobility is uniform across all dissimilar pairs of social strata regardless of the distance or direction of social mobility’ [Fox, 1990, p348]. When origin and destination status are simplified into three categories, any transitions in the same direction share statistically common parameters of covariates. It would mean that all individuals within one direction (e.g., upward mobility) experience the same effect of covariates. In other words, those who transit from class IV to class V are assumed to resemble those who move from class II to class I, not those who move from class V to class V. Because the former two groups are coded as upward, while the latter group is coded as stable regardless of class of origin, the simplified mobility variable identifies the former two groups as statistically the same entity, and the latter dissimilar. This simplification cannot help but constrain the varied effect of covariates on social mobility. When a full mobility trajectory is allowed, however, different sets of origin-destination categories respond differently to a covariate [Logan, 1983]. For instance, education showed differential effects on white-collar and blue-collar occupation mobility [Savage and Egerton, 1997].

2.3 An assessment of type II study (the contribution of health selection to social inequalities in health)

This section assesses the second category of health selection studies (type II study) according to the typology concerning health selection and subsequent social inequalities in health. Two approaches associating health selection with social inequalities in health, termed the 'gradient constraint hypothesis' and 'health selection adjustment approach' are reviewed. Some statistical properties of these approaches are then discussed. Although there may be other ways to explain the relationship between health selection and social inequalities in health, these two explanations have been the main themes and have been representative approaches in this area.

2.3.1 Gradient constraint hypothesis

Many studies have confirmed repeatedly that those who remain in the same social class (stable group) experience lower mortality (or morbidity) than those who drift down, and higher mortality (or morbidity) than those who were upwardly mobile [Bartley and Plewis, 2007; Claussen *et al*, 2005; Cardano *et al*, 2004; Adams *et al*, 2004; Elstad, 2001; Blane *et al*, 1999a; Hart *et al*, 1998; Bartley and Plewis, 1997]. The explanation for the gradient constraint hypothesis was drawn from the same finding, whereby it was argued that social mobility acted to constrain rather than to widen social inequalities in health [Bartley and Plewis, 2007; Claussen *et al*, 2005; Elstad and Krokstad, 2003; Blane *et al*, 1999a; Hart *et al*, 1998; Bartley and Plewis, 1997]. The gradient constraint hypothesis has been used as evidence against health selection because seemingly, health selection is a part of social mobility and social mobility did not work to widen social inequalities in health. A more detailed logic of this hypothesis is given below.

If we assume two class positions, for example manual and non-manual, class experience over two time phases can build up four categories of mobility groups; those who are stable in non-manual class, the downward mobile, the upward mobile, and those who are stable in manual class. It may be expected that the risk of poor health among the two mobile groups is intermediate between the two stable groups. From this fact, the notion that social mobility has a narrowing effect on social inequalities in health was inferred. Subsequently, an inference was made that the socially mobile groups moderate the size of the social class differential among the socially stable groups because steep gradients are found between the two stable groups [Bartley and Plewis, 2007; Blane *et al*, 1999a; Hart *et al*, 1998]. Accordingly, it was argued that ‘gradient constraint can be described as the process whereby social mobility moderates, rather than creates or widens, the size of social class differential’ [Blane *et al*, 1999a, p68]. This understanding of gradient constraint has been consistent and widely found [Claussen *et al*, 2005, p2519; Cardano *et al*, 2004, pp1571-1572; Manor *et al*, 2003, p2226; Elstad, 2001, p137].

Attention needs to be paid to the way of inference in the gradient constraint hypothesis. The hypothesis was assessed by measuring the proportion in poor health in subpopulations of the mobility measure (two stable and two mobile groups). This approach which examines the change in the proportion in poor health among subpopulations is applied to the current thesis (see Chapter 8).

2.3.1.1 Gradient constraint in a specific condition

It is to be observed that gradient constraint may be found under a specific condition. This condition was specified by a previous study as weak selection [Elstad, 2001]. The current thesis is a further generalization of these studies, to demonstrate the impact of social mobility on social inequalities in health. The simplest model composed of two mobile groups and two stable groups can be illustrated.

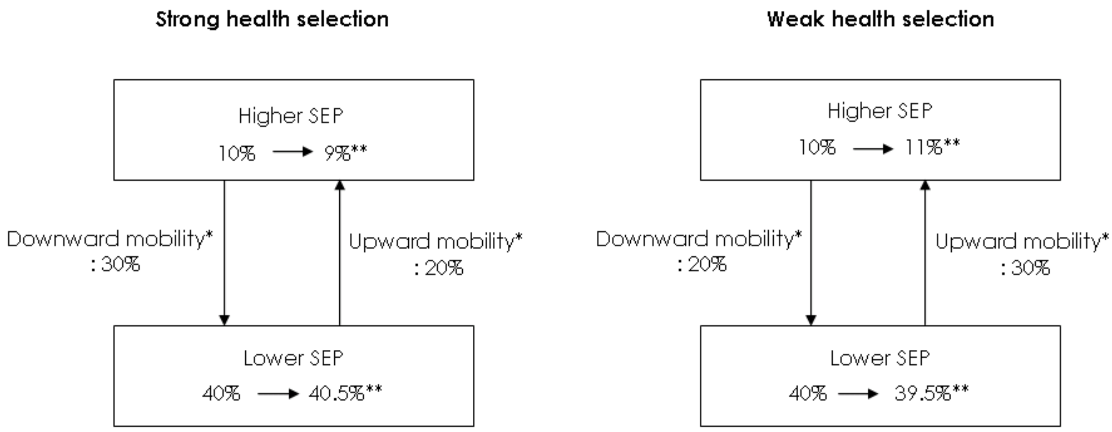

Figure 2-1 Contrast between strong and weak selection defined by the risk difference in the effect of poor health on downward and upward mobility

* For numerical calculation, the sizes of groups which appear on this figure are presumed, and the size for higher SEP is 1000, for lower SEP is 2000, and for downward and upward mobile groups, the sizes are equally 100.

** The arrow indicates the change in the proportion in poor health before and after mobility.

Suppose the proportion in poor health in the higher SEP is 10% (100/1000), and that of the lower SEP[3] is 40% (800/2000) before mobility. Strong health selection is conceptualized if the proportion in poor health among the downward leavers from higher SEP is 30% (30/100) compared to 20% (20/100) of the upward arrivals, and this results in the widening of social inequalities in health. On the contrary, weak health selection is presented when the proportion in poor health between upward and downward are reversed, and this leads to a decrease in social inequalities in health. In both cases, the proportions of poor health among the upwardly and downwardly mobile are between the proportions of those who stay in the same SEP, and, therefore, both situations fully satisfy the condition that the prediction of the gradient constraint hypothesis will occur.

To summarize this illustration, it is necessary to account for the two health selective movements between downward and upward mobility. As a result, the net effect of

[3] For consistency, when two statuses model is supposed to be specified, the terms, higher and lower SEP, are used throughout thesis. The terms are used to categorize two basic socioeconomic position (SEP) such as non-manual class and manual class, and employment and non-employment. Therefore, when it comes to social mobility between employment statuses, the terms, upward and downward mobility, needs to be understood in the same sense of entry into and exit from employment.

health selection is derived from the difference between two health selective movements. A reduction of social inequalities in health occurs when weak health selection is presented. This condition may bring more people with poor health to higher SEP and less people with poor health to lower SEP. Consequently, an increase in the proportion in poor health in the higher SEP and a decrease in the proportion in the lower SEP result in narrowing of social inequalities in health. Therefore, gradient constraint hypothesis may be plausible in the condition of weak selection.

The notion of the net effect of health selection can be connected to the labour supply, which is affected by economic fluctuation and social welfare. Strong health selection may be observed when the economic situation is unfavourable to those with poor health. Under these circumstances, the net effect of health selection between downward mobility (exit from employment, if it is applied to employment status) and upward mobility (entry into employment) becomes large, leading to increases in social inequalities in health. Thus, the increase of social inequalities in health is likely to be proportional to the deepening of discrimination in the labour market against those with poor health, and the resulting increase in the net effect of health selection.

Elstad [2001] associated the changes in the health differential with the net effect of health selection. According to him, weak health selection leads to a narrowing of social inequalities in health, while strong health selection leads to a widening of social inequalities in health. This concept is further developed and presented with an empirical example later in Chapter 8.

2.3.2 Health selection adjustment approach

One group of studies has adopted a common approach by adjusting for a health selection term to evaluate the effect of health selection on social inequalities in health. The logic of this approach is reviewed and it is proposed that the design is not precise for the purpose of adjustment.

2.3.2.1 The way to adjust for health selection

There was an attempt to relate health selection to social inequalities in health by controlling for the effect of health selection [Manor *et al*, 2003; Benzeval and Judge, 2001; van de Mheen *et al*, 1998; McDonough *et al*, 1997; Power *et al*, 1996]. Two terms, class of destination and health selection were fitted simultaneously as independent variables for later health (dependent variable). Adjustment for health selection was seen as a way to remove the effect of health selection. The genuine association between class of destination and later health was then believed to be estimated. Judging the effect of health selection in explaining social inequalities in health was decided by comparing the effect (e.g., OR) of class of destination before and after adjustment for health selection. If the unadjusted social inequalities in health are smaller than the adjusted social inequalities in health, this indicates that health selection explains some of health inequalities between social classes. For example, the increase in OR by the class destination variable (i.e., increase in social inequalities) after adjustment was meant to suggest that health selection acts to narrow social inequalities in health [Manor *et al*, 2003, p2222].

Various terms have been utilized to indicate health selection. In one approach, controlling for initial health was regarded as a control for health selection [Benzeval and Judge, 2001; van de Mheen *et al*, 1998; McDonough *et al*, 1997]. For initial health, different health measures such as child health [van de Mheen *et al*, 1998], disability [McDonough *et al*, 1997], and general health [Benzeval and Judge, 2001] were applied. In the other approach, controlling for health selection was carried out by specifying interaction terms such as social mobility (class of origin and class of destination) [Power *et al*, 1996] and health selection (prior health and class of destination) [Manor *et al*, 2003]. Despite the differences in defining the health selection term, they seem to use the same logic with respect to adopting an approach for the adjustment of the health selection term. Let's take some of these instances.

In one study [van de Mheen *et al*, 1998], the adjustment of childhood health was regarded as controlling for health selection and the change in OR by SEP measure (educational level) for adult health was indicated as a marker for the effect of health selection. This study found that the OR by the SEP variable in explaining adult health decreased by 5-10%, when childhood health (severe disease and hospitalization) were added to the model. The decrease was attributed to the effect of childhood health and this adjustment was interpreted in terms of a health selection effect. In a similar way, Power *et al* [1996] placed social mobility and class of destination as independent variables to predict a later health status. Incorporating social mobility was considered as a way to adjust the effect of health selection. Since they found a small reduction in ORs by the SEP variables, they concluded that health selection has only a small effect on social inequalities in health [Power *et al*, 1996].

A common feature to all these studies is the adjustment of the health selection term and the comparison of two social inequalities in health before and after the adjustment. The next section questions whether two social inequalities in health with before- and after-adjustment are equal to the notion of pre- and post-mobility inequalities in health, assuming the latter pair is what truly needs to be specified.

2.3.2.2 A comparison of two measures of health inequalities

To test the health selection hypothesis, it was asked whether health selection narrows or widens social inequalities in health. Changes in social inequalities in health were evaluated by comparing two measures of social inequalities in health which were collected at different time points. Comparison needs a reference against which we can monitor the change, and pre-mobility inequalities (initial social inequalities in health) might be used for this reference. Figure 2-2 presents the fact that social mobility mediates two different social inequalities in health pre- and post-mobility.

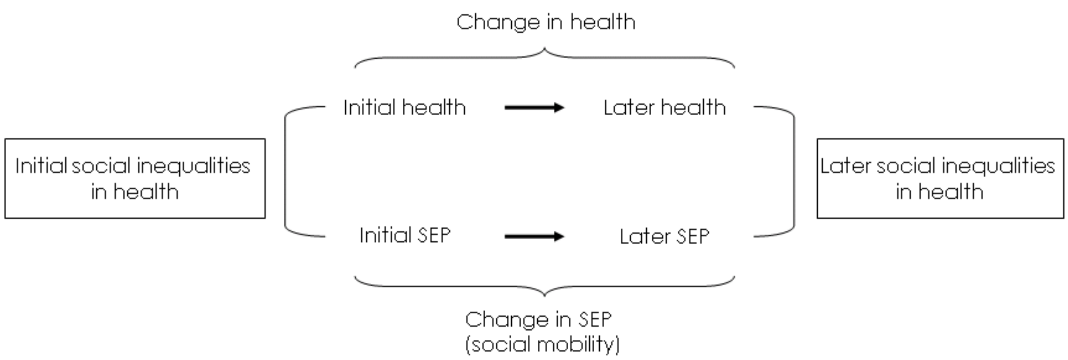

Figure 2-2 Changes in social inequalities in health between two time points

This figure illustrates that mobility intervenes between social inequalities in health at two time points. From the left to the right, time passes with changes in the indices. Alterations both in health and SEP are followed by the new status. As a consequence, the initial inequalities become later inequalities. In the figure, social mobility is synonymous with change in social distribution. Health selection is contained as part of the change in social distribution. It must be stressed that the change we wish to measure is the difference between initial and later social inequalities in health. To measure this, we must compare social inequalities in health at two time points.

For instance, Manor *et al* [2003] made the comparison between social inequalities in health before and after 'intragenerational health selection' which took place between 23 and 33 years of age. The two measures of social inequalities in health (initial and later social inequalities in health) should have referred to those at 23 and 33, respectively. However, the studies in this category introduced here have made the comparison in other contexts without the application of initial social inequalities. As described earlier, these studies have relied on the change of OR in the SEP variables to decide the statistical significance of health selection. One study [Manor *et al*, 2003] found an increase of an OR after adjusting for the health selection term as a sign for narrowing social inequalities in health for men. On the other hand, most of them [Benzeval and Judge, 2001; van de Mheen *et al*, 1998; McDonough *et al*, 1997; Power *et al*, 1996] found the 'small' reduction of an OR to be too minor to indicate a significant role for health selection.

Unfortunately, a change induced by allowing the health selection term does not correspond to the change in inequalities in health between before and after mobility. Two social inequalities in health, before and after controlling for the health selection term, are based on the same elements of 'later' SEP and 'later' health in figure 2-2. Thus, both social inequalities in health are basically 'later' social inequalities in health and this model therefore never referred to initial social inequalities in health.

In a comparison of two social inequalities in health, what should be compared is the difference between initial and later social inequalities in health. But, in the practical application, this was incorrectly substituted for a comparison between 'later social inequalities in health without and with adjustment'. Although the comparison of social inequalities in health was attached to this model, it is not likely to be an exact realization of the idea to relate health selection to the change of social inequalities in health. As the comparison is conceptually distinguished from that in the logic of the model, the inference from change may be inevitably biased. Therefore, this modelling cannot answer whether the change in social inequalities in health comes from health selection, and whether health selection accounts for the widening or narrowing of the change in social inequalities in health.

2.3.3 Summary

In dealing with the statistical analysis of the health selection debate, a typology of study design was created. Two types of health selection study were distinguished. 'The presence of health selection' (type I study) is defined to relate prior health to later changes in socioeconomic position, while 'the contribution of health selection to social inequalities in health' (type II study) tests whether health selection increases or decreases social inequalities in health. Regression modelling has been widely used for health-related social mobility and the health selection hypothesis. A few limitations in applying this type of model were discussed.

Regarding the type I study, this review highlighted the key points in the statistical conversion of a mobility table. A mobility table with a third variable for comparative purposes produced a three way mobility table. In statistical modelling, an ordinary logistic regression model was not able to keep the identical characteristics of a three way mobility table and necessarily demanded a simplification of the mobility table into three or two mobility directions. This led to a violation of collapsibility which may have led to a biased result. The type II study was also subject to a few methodological issues. Two approaches were categorised; 'gradient constraint hypothesis' and 'health selection adjustment approach'.

According to the interpretation of the gradient constraint hypothesis, social mobility decreases social inequalities in health, because the prevalence of poor health among upward and downward mobile groups lies between the stable groups in the high class and in the low class. Therefore, it was concluded that two mobile groups moderate social inequalities in health of the stable groups at both ends of the class spectrum.

In the change of health composition as a result of social mobility, downward and upward mobility are coexisting, and thus an outflow from a SEP is offset by an inflow. In certain situations, the proportion in poor health among the upwardly mobile group may be low (similar to those in lower SEP), and that of the downwardly mobile group may be high (similar to those in higher SEP). This situation may occur when poor health has little impact on downward and upward mobility processes. Consequently, the net effect of health selection becomes small (weak health selection), and then, this results in narrowing of social inequalities in health. The reverse situation appears to increase social inequalities in health, if the net effect of health selection between upward and downward mobility becomes large.

Therefore, the gradient constraint hypothesis can be understood in the context of weak health selection. In this scenario, overall social inequalities in health decrease, which might be observed in a society that is relatively less discriminatory against those with poor health. In the appreciation of the gradient constraint hypothesis, it should be emphasized that the main inference was drawn from the comparison of risk across subpopulations via categories of a mobility variable.

In one approach, a health selection term was included for the purpose of adjustment (the health selection adjustment approach). The association between the explanatory variable of SEP and outcome variable of health was assumed to be affected by health selection. The alteration of the OR for SEP variable on health outcome followed the adjustment for health selection. Little reduction in the OR was found and this was suggested as evidence that there was no substantial contribution of health selection in widening social inequalities in health.

In this argument, one main issue was raised. To make a judgment on whether health selection narrows or widens social inequalities in health, it is necessary to compare two social inequalities in health; one in a sample taken before the health selection process and the other from a sample after the health selection process. However, these two measures of social inequalities in health were instead replaced with two later social inequalities in health with and without controlling for health selection. Because the comparison was made in the wrong way, this approach may not be a reliable way to evaluate the role of health selection.

Chapter 3: Study hypotheses

The earlier chapters addressed at length the detailed review and the major methodological limitations according to the typology of health selection studies. Subsequent to these review chapters**,** this chapter highlights the research hypotheses of this thesis.

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3.1 Objectives of this thesis

The objectives of this thesis are:

1) to provide evidence on the magnitude and mode of health selection using the latest improvements in statistical methods, and

2) to present the process from health selection and non-health related social mobility to social inequalities in health.

3.2 Research hypotheses

3.2.1 Effect of health selection using various social indices

This study attempts to contribute to the understanding of whether health difference influences the chances of social mobility. To answer this question, three socioeconomic indices are adopted; social class, income, and employment status. In the study of social mobility, researchers have usually worked with social class, and there have been some disputes about whether class mobility is only sensitive to marked change [West, 1991; Gilbert, 1986]. Along with social class, the other two measures are expected to provide a complementary picture of health selection. Allowing for age and education as covariates, health is associated with the risk of social mobility. The effects of health on social mobility also depend on a health measure used, but this issue is not addressed in this thesis.

Hypothesis 1: *The effects of health on social mobility vary according to the social* *indices used.*

3.2.2 The mode of health selection

Health selection may not have an even effect across every social position. Poor health might affect social mobility differently according to the initial socioeconomic position (differential health selection). For example, a person from a disadvantaged group might be more vulnerable to the impact of poor health than a person who belongs to a privileged group.

Additionally, the impact of health may operate differently for social mobility between classes and social mobility into/out of employment. These two types of health selection may occur in conjunction with one another, and one health selection may be affected by the other. Therefore, by comparing two types of health selection, the more comprehensive picture is to be obtained.

Hypothesis 2: *The effect of health on social mobility varies according to socioeconomic origins and destinations.*

Hypothesis 3: *Because of differential health selection, those from lower SEP are more likely to be disadvantaged as a result of poor health.*

Hypothesis 4: *The effect of health on social mobility between classes is related to the effect of health on the transition out of/into employment.*

3.2.3 The process from health selection and social mobility to social inequalities in health.

Greater social mobility has been believed to be associated with narrowing of social inequalities [BBC internet, 2008; Hassler *et al*, 2007]. Likewise, changes in social mobility and health selection might have an impact on social inequalities in health. The details of the mechanism connecting all three concepts, social mobility, health selection, and social inequalities in health, need to be clarified.

Hypothesis 5: *Changes in health selection and social mobility result in changes in social inequalities in health at the population-level.*

Chapter 4: Method

4.1 Study sample

4.1.1 Data

The British Household Panel Survey (BHPS) is an annual survey which began in 1991. The BHPS contains a total of approximately 10,000 interviewed individuals within around 5,500 households. The BHPS primarily represents the population of England, Wales, and Scotland (south of the Caledonian Canal). The sample was drawn from a stratified clustered design using the Postcode Address File, and all residents present at those addresses in the first wave of the survey were designated as panel members. These same individuals and their children, once aged over 16, have been re-interviewed each successive year [Lynn *et al*, 2006]. Thirteen waves of data from 1991 to 2003 are used for this study.

The BHPS has some unique benefits with respect to the study of social mobility. Firstly, most previous studies cannot evaluate social mobility in later age properly, because of their relatively young age composition. As the BHPS only includes individuals aged 16 and over, such data dependent limitations are successfully avoided. This allows the data more flexibility in dealing with intragenerational mobility. Secondly, as the data collection has been repeated every year, these data can build up a short-term transition model: modelling these data might therefore be sensitive to health-related social mobility which occur relatively short period after after a health problem.

4.1.1.1 Aggregated Sample from 13 waves

The BHPS is particularly suitable for longitudinal research, since the survey was intrinsically designed to aid the understanding of the dynamics of change experienced by the British population [Lynn *et al*, 2006]. Thirteen waves from the record named wINDRESP[4] in BHPS are used for the current study. Information about demographics, education, health, labour market, income, and employment history are used for the analysis. These data from all individual respondents are linked together with a cross-wave personal identification number (PID) to connect information across waves [Taylor *et al*, 2007]. The initial sample is composed of individuals who have ever been a member of a respondent household (n = 29097). Several inclusion/exclusion criteria are applied to deliver the sample used in this analysis.

Firstly, additional samples that were added to the original sample members for specific purposes are not included. Thus, the members of European Community Household Panel (ECHP) sample added after wave 7, and the booster sample for the Scotland, Wales, and Northern Ireland added after wave 9 are excluded. Secondly, the sample is restricted to men aged between 21 and 64, and women between 21 and 59 at the point of each survey, because this age group is generally considered to be economically active, as this criterion is consistent with State Pension age [Black, 2008, p29; Bartley *et al*, 2004b]. The sample is therefore reduced to 12532 (Sample A). Table 4-1 shows the sample size at each wave and their selection process.

[4] In wINDRESP, prefix 'w' of all record replaces the wave-specific letter (e.g., AINDRESP = wave one, BINDRESEP = wave two) [Taylor *et al*, 2007].

Table 4-1 Study samples with exclusion criteria

	Initial sample	Exclusion of ECHP*	Exclusion of Scottish, Welsh , and NI* Booster	Exclusion of economically non-active age†	Study sample (Sample A)
Wave1	10264			3031	7233
Wave2	9845			2877	6968
Wave3	9600			2768	6832
Wave4	9481			2729	6752
Wave5	9249			2679	6570
Wave6	9438			2684	6754
Wave7	11193	1820		2659	6714
Wave8	10906	1691		2584	6631
Wave9	15623	1609	4913	2549	6552
Wave10	15603	1569	5028	2520	6480
Wave11	18867	1523	8408	2491	6445
Wave12	16597		7779	2485	6333
Wave13	16238		7537	2508	6193
Total	29097	2137	10365	4063	12532

* ECHP refers to European Community Household Panel, and NI refers to Northern Ireland.

† Economically active age is defined as aged between 21 and 64 for men, 21 and 59 for women

By converting the individual observations (12532), sample A provides 86463 person year observations[5]. Thirdly, this sample is restricted to those who are aged 30 and over (Sample B, n = 63599), when they are assumed to be less affected by the fluctuation in their early careers to examine intragenerational mobility [Erikson and Goldthorpe, 2002; Miller, 1998]. Finally, since this study conceptualizes mobility as happening over two years, between year t-1 and year t, observations covering two consecutive years are retained for consideration. Sample C comprises 51488 observations (transitions) from 7416 individuals, after further restriction by excluding those with missing data on social class and other independent variables such as health, education, and age. This sample is analyzed in Chapter 5 with regard to the effect of health on class mobility. After dealing with missing variables, sample D (with regard to income mobility) and sample E (with regard to transition between

[5] Data restructuring process is introduced from Appendix 4-1 to 4-3. To change data from one observation per subject to person year observations per subject, SAS Multi-dimensional Arrays is used. In the appendix, the statistical command is illustrated with the presentation of actual data.

employment statuses) appear in Chapter 6 and Chapter 7 respectively. This data constructing process is briefly sketched in figure 4-1.

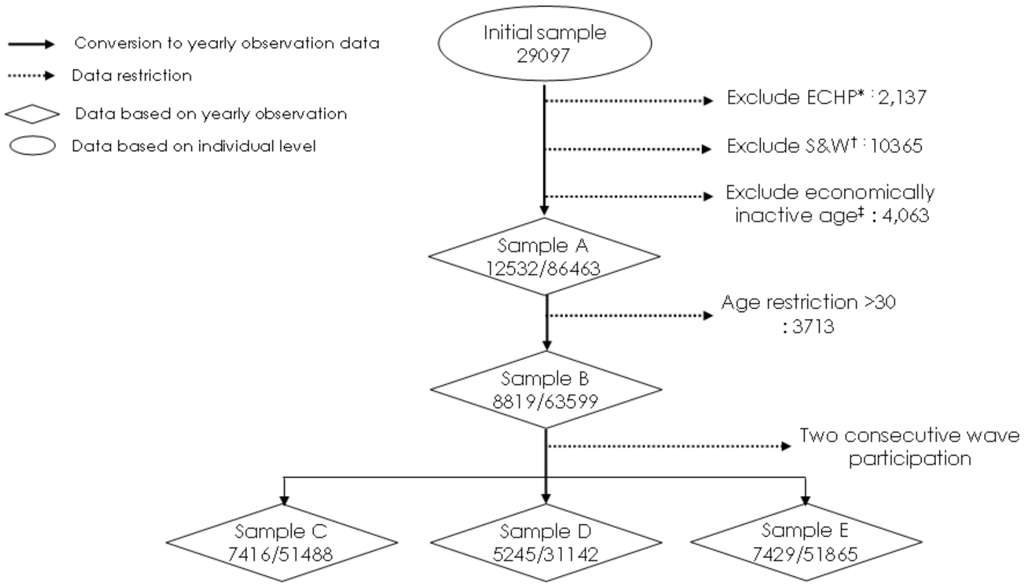

Figure 4-1 The process of study sample construction
*Members of European Community Household Panel (ECHP). †Booster sample for the Scotland, Wales, and Northern Ireland. ‡Economically active ages are defined as between 21 and 64 for men, 21 and 59 for women.

4.1.1.2 The comparison of samples with individual and person year observation

The following table presents the distribution of respondents according to sex. Two sets of individual observation data (wave 1 and wave 13) and two sets of person year observation data (Sample A and B) are introduced. This comparison presents the likely influence of the data construction process, by converting individual observations to person year observations. Wave1 (n=7233) and wave13 (n=6193) represent data from each wave.

Table 4-2 Sample characteristics on demographic and social variables in the four distinctive samples*

Variables†	Men				Women			
	Wave1	Wave13	Sample A	Sample B	Wave1	Wave13	Sample A	Sample B
Number of yearly observation	-	-	42737(49.4)	31860(50.1)	-	-	43726(50.6)	31739(49.9)
Number of individuals	3608(49.9)	3042(49.1)	6415(51.2)	4518(51.2)	3625(50.1)	3151(50.9)	6117(48.8)	4301(48.8)
Number of observations per an individual	-	-	6.66	7.05	-	-	7.15	7.38
Age [mean (±SD)]	40.3(±12.1)	41.4(±11.9)	40.4(±12.0)	45.5(±9.5)	38.4(±10.8)	39.8(±10.9)	38.8(±10.8)	43.8(±8.2)
Ethnicity (%)								
White people	95.5	96.2	96.2	96.6	95.5	97.9	95.5	95.7
Non-white people	4.5	3.8	3.8	3.4	4.5	2.1	4.5	4.3
Educational level (%)								
No qualification	26.1	11.0	17.3	20.8	28.4	11.1	18.6	23.2
GCE O levels or less	22.6	19.3	21.7	19.5	29.7	21.6	26.9	25.8
GCE A levels	13.1	12.9	13.6	11.4	8.7	11.9	11.2	8.2
Vocational qualification	27.3	38.2	32.2	34.1	25.0	37.1	30.4	31.4
Higher degree	10.9	18.5	15.2	14.2	8.2	18.2	13.0	11.5
Social classes‡ (%)								
I/II	37.9	42.9	42.0	45.0	31.9	41.9	36.7	37.5
III NM	12.2	12.5	12.3	10.5	37.0	34.1	36.2	34.2
III M	34.2	29.4	30.7	30.7	9.3	7.3	8.5	8.4
IV/V	15.6	15.2	15.1	13.9	21.8	16.7	18.6	19.9
Health status (%)								
Good	78.9	74.4	76.2	74.8	75.5	70.7	72.7	71.5
Poor	21.1	25.6	23.8	25.2	24.5	29.3	27.3	28.5

* While wave1 and wave13 data are obtained from person-oriented data, the rest data are based on yearly observation data. Wave 1 and wave 13 data represent wave 1 British Household Panel Survey (BHPS) and wave 13 BHPS. Sample A is obtained after converting individual data, and sample B with restriction on age (>30).

† Estimates are presented in three ways; [frequency (percentile)], [mean (SD)], and [percentage].

‡ Professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), partially skilled and unskilled (IV/V)

The general characteristics of the sample are presented for men and women separately. Both samples from wave1 and wave13 present a cross-sectional view of characteristics. In contrast, samples A and B offer a longitudinal view of the years through 1991 to 2003, as an individual may experience various conditions across the different waves.

By taking two cross-sectional samples (i.e., wave 1 and wave 13), it is possible to observe a change across a thirteen year gap, and these samples display a fairly dramatic change in education, class composition, and health status. For example, the membership of Classes I/II increased from 37.9% to 42.9% in men, and the increase is far more notable, from 31.9% to 41.9%, in women. These changes are more marked for women, but overall the results are still unfavourable for women compared to men across all indices.

A comparison between individual observation data and person year observation data shows some differences between before and after data pooling. Although in the cross-sectional data (i.e., wave 1 and wave 13), there are slightly more women than men, in the longitudinal data (i.e., sample A and B), this was reversed; this is because more men tended to take part in more survey years over 13 waves. Mostly, the figures from person year observation data are likely to demonstrate results which fall somewhere between wave 1 and wave 13. This suggests that these measures would provide a good approximation for the average results from the 13 waves.

Compared to sample A (N=86463), sample B (N=63599) contains an older population, after the age restriction to participants aged 30 and over. This restriction also creates differences in other characteristics. The distribution of sex and ethnic group is similar in both samples in men and women. However, other indicators identify that sample B, containing the older group, is less educated, slightly more affluent in class distribution, and less healthy than the younger sample A. One further restriction is to only include those participants who were sampled in two consecutive waves, and the influence of this is reviewed in Appendix 4-4. The magnitude and direction of possible bias introduced by the sample restriction is assessed, as it cannot be precisely estimated or controlled.

Although sample restriction is the main reason for sample loss, sample attrition over repeated surveys is an important issue in longitudinal research. In order to adjust for attrition, sample weights can be a solution. In this thesis, along with unweighted results, estimations with sample weights are made in the descriptive analysis. However, for the multilevel analysis, results are produced based on the unweighted sample. This is because, despite missing data, samples from BHPS are generally reported to remain representative without fundamental change [Jones *et al*, 2006; Marzano, 2006]. The issue of sample weights is further discussed in Appendix 4-5 including the application of sample weights to the samples in table 4-2.

4.2 Variables

4.2.1 Measurement of socioeconomic position and health status

Three socioeconomic variables are used to indicate social mobility: social class, income level, and employment status. Each socioeconomic variable has different states, and this can reflect socioeconomic change at the individual level. Social class is taken from the RGSC, which is based on occupation. The six scale classification is converted to four categories: professional and managerial (classes I/II), skilled non-manual (class III Non-manual), skilled manual (class III Manual), and partially skilled and unskilled (classes IV/V). Hourly wage, instead of other income measures such as household income, is used to assess the economic influence of poor health. Income mobility is conceptualized using the quintile and percentile rank of wage distribution. Employment status has three states, employed, unemployed, and economically inactive, among which individual transitions can take place.

For a health measure, self-reported general health status is used. A response to a question of ‘over the last 12 months how your health been compared to people of your own age?’ (variable code: wHLSTAT) is used to encode a binary variable. A rating of ‘good health’ is defined when the respondents replied that they were ‘good’ or ‘excellent’, whereas when they responded with ‘fair’, ‘poor’, or ‘very poor’ the cases are identified as demonstrating ‘poor health’. For wave nine, ‘IHLSF1’ is inputted instead of ‘wHLSTAT’, which was not asked at this wave[6]. IHLSF1 has a similar question to wHLSTAT (‘In general would you say your health is - excellent, very good, good, fair, or poor?’) but with different categories. Therefore, wave nine identifies those who had ‘excellent’, ‘very good’, or ‘good’ status as a good health category, while treating ‘fair’ or ‘poor’ as a poor category. A simple sensitivity analysis regarding the health measure in wave 9 is performed, and the results are presented in Appendix 4-6. As self-reported general health is the only health measure, it is limited to look at the issue that the effect of health on social mobility also depends on health measure used.

4.2.2 Covariates

A range of factors have been shown to influence social mobility. Some factors are introduced to test the influence of social background, while others are introduced to test meritocratic dimensions. These include class of origin [Erikson and Goldthorpe, 2002; Savage and Egerton, 1997], family background, ethnicity [Aldridge, 2003], social capital, cultural capital [Nunn *et al*, 2007], education [Erikson and Goldthorpe, 2002], age [Egerton and Savage, 2000], intelligence, IQ score, aptitude, motivation, ability, individual effort [Saunders, 1997; Nettle, 2003], health [Nunn *et al*, 2007], and so on. Among these factors, education and age are taken as covariates for adjustment in the multivariate analysis to account properly for the effect of health on social mobility.

Of the two variables selected, education has been considered to play a crucial role for social mobility, especially for long range upward social mobility [Aldridge, 2003]. Educational attainment is assessed on a five point scale as follows; 1) no qualifications; 2) CSE grade 2-5 or GCSE grade D-F / CSE grade 1, GCE O level, or GCSE grade A-C; 3) GCE A level; 4) vocational qualification; 5) higher degree level qualification. Age is included in the analysis because the study sample covers a wide range of age groups, and because the process of aging is known to be related to social mobility [Egerton and Savage, 2000]. The varying effects of age are categorized into

[6] For more information, please refer to the BHPS website (http://www.iser.essex.ac.uk/ulsc/bhps/doc/volb/wave9/iindresp7.php#IHLSF1) : visit 26 April 2008

three groups; 30s (31-40), 40s (41-50), and over 50 (51-64).
In longitudinal data, however, age reflects not only the biological age effect but also cohort and period effects [Lauderdale, 2001; Jacobs *et al*, 1999; Holford, 1983]. Since the age effect is confounded with period and cohort effects, this interference needs to be incorporated into analysis to investigate whether the aging process is a key determinant of social mobility. Period effect refers to the impact of events at a particular time point and the impact will be the same for all age groups. Cohort effect is observed when changes in the risk are associated with the year of birth. For instance, social mobility process in a certain year may exceed that of another year (period effect), and earlier born cohorts may have different transition probabilities between employment statuses from that of later born cohorts (cohort effect).
There was early recession in early 1990s, which resulted in adverse economic trends [Lindsay, 2003; Gregg and Wadsworth, 1999, pp7-28]. This trend is also observed in the current dataset (the details of logic to distinguish a particular period in relation to changes in economic trend is described in Appendix 4-7). A period specific dummy variable is coded as '1' when the year indicates early 1990s recession. This is used for the proxy for period effect. Cohort effect is also included as a covariate. Due to the insufficiency of theoretical supports for the idea that there is clearly a distinctive birth cohort, birth cohorts are grouped into 5 year intervals. Consequently, eight strata of birth year are created.

The association of ethnicity and marital status are also illustrated in bivariate analysis. The values of covariates must be recorded to correspond to each time period. Time-invariant covariates are those which have been identical in all time periods, whereas time-varying covariates might differ across periods [Singer and Willett, 1993]. In the application, all variables are assumed to be variable over time dimension apart from gender, ethnicity, and cohort effect. Details of the variables are listed in the following table.

Table 4-3 Overview of variables

Classification	Variables
Variables of interest	
Socioeconomic position	social class, income level, employment status
Health dimension	general health status
Covariates	
Demographic factors	sex†, ethnicity†, age, marital status
Socioeconomic factors	educational attainment
Time factors	period effect, cohort effect†

† time independent variables

4.3 Statistical modelling for the type I study

An application of the type I study (the presence of health selection) is considered in this section. This approach takes social mobility as a dependent variable and prior health status as an independent variable, which is similar to other type I studies investigated elsewhere. This section starts with the presentation of an advance in longitudinal modelling with particular attention to the random effect model for repeated responses (lower level, or level 1) nested within an individual (higher level, or level 2). Subsequently, the multilevel multinomial model is introduced with its potential applicability to longitudinal data. This type I study is subsequently used through Chapter 5 to Chapter 7 with different social indices.

4.3.1 Some features of longitudinal data

Longitudinal data are often characterized by common features, including repeated events, serial correlation, time dependent covariates, multiple states, and multiple types of transition from each state. Thus, more advanced statistical methods must be applied to utilise data of this nature as much as possible.

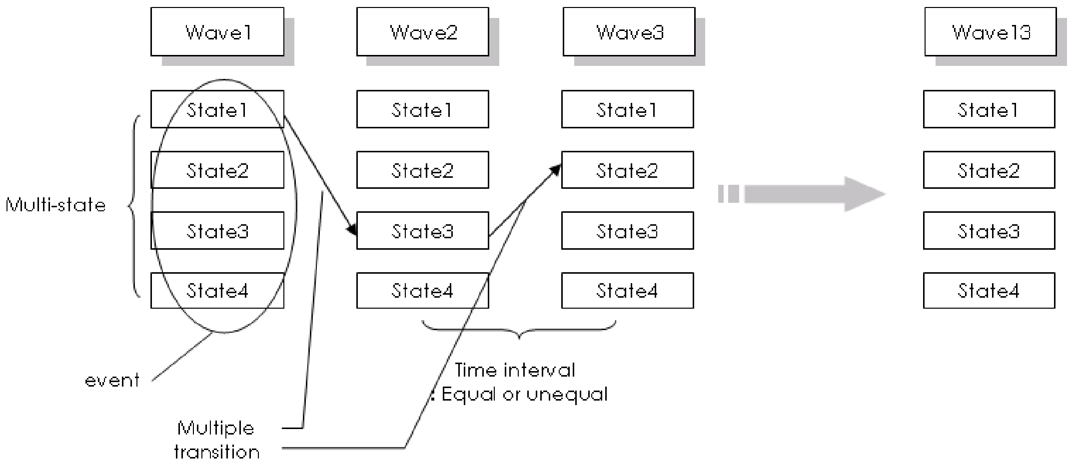

Figure 4-2 Common features of longitudinal data with repeated survey on one variable with four states

Figure 4-2 illustrates a series of successive events with four states over 13 waves. In the current thesis, the event corresponds to any socioeconomic position (SEP). An individual is assumed to be able to change the position throughout the observation period. Usually individuals will move in and out of, or up and down, from different states such as employed, unemployed, and economically inactive over time.

A change of state is described as a transition which in this study corresponds to social mobility from one socioeconomic position to another. Multiple transitions with competing risks are another common feature of multi-state data. In many situations, there are several competing destinations from a given state [Steele and Goldstein, 2004], where more than one possible end point exists. In a longitudinal study, the observations from each individual are not independent of each other (serial correlation), and it is therefore necessary to apply special statistical treatment to take the correlation into account.

4.3.2 Introduction of study concept

This study assesses the presence of health selection when previous health status in year *t*-1 exerts its effects on social mobility measured by a change in SEP between year t-1 and year t. The following figure displays the operation of this concept.

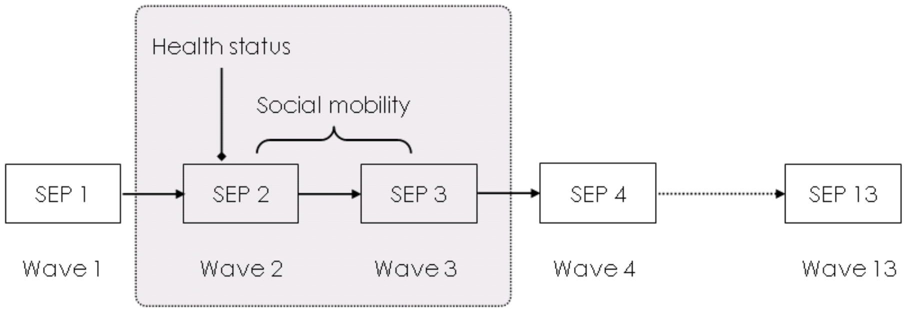

Figure 4-3 Conceptualization of health selection in the current thesis

In this model, social mobility is defined by a transition from a previous SEP to a new SEP in two consecutive waves. In order to secure the time sequence between health and social mobility, this model assumes health is temporally ahead of mobility.

It needs to be noted that the model is presented in terms of a *change* in SEP state, rather than SEP state itself [Buckley *et al*, 2004]. Although longitudinal studies may be taken in proper temporal order, it is not enough to justify causality between earlier exposure and later outcome [Rothman and Greenland, 1998, p422-424], in particular, in a situation when the outcome is recurrent and is confined to state [Buckley *et al*, 2004]. Modelling outcome with states instead of a change in states may be less effective in dealing with a situation where some of the association reflects an earlier relationship before model specification. If people from a lower SEP were already in poor health outside the specification of the model, then modelling the impact of health on SEP 'state' can overestimate the effect of health. States may conceivably be a cumulative effect, not only from the latest outcome, but also from any past outcome. In contrast, since the change is newly developed during a specific time period inside modelling, it is not affected by previous outcomes. In section 4-5, this topic is discussed in the context of endogeneity.

4.3.3 Application of multilevel multinomial model

Recently, some statistical methods have been developed for extending ordinary regression analysis, and these have received considerable attention. They include, for example, the multilevel regression model, the structural equation model, and the generalized estimating equation [Skrondal and Rabe-Hesketh, 2004, pp49-93]. The current study uses the multilevel multinomial model to reflect the full transitions from longitudinal data with repeated measures, which is treated as two-level data: repeated measures (level 1) are nested in an individual (level 2). By including random effects, multilevel modelling is expected to control both for unobserved heterogeneity and dependency between observations [Skrondal and Rabe-Hesketh, 2004, p50]. In this thesis, the multilevel multinomial model is used to estimate both random effects and fixed effects. A fixed effect is the estimation for the overall mean effect of the variables defined by a fixed coefficient. In multilevel analysis, individual level (level 2) effects are assumed to be random effect whose distribution follows the mean (zero) and variances[7]. Random effects are obtained through a variance-covariance matrix. Individual-level (level 2) variance explains the between-individual variation in a transition, while covariance accounts for the correlation between individual-level variances. As variances are specific to a transition, a covariance could represent a tendency for resemblance between transitions [Steele *et al*, 2005a; Steele, 2005b, p4].

In addition to the multilevel analysis, the analysis employed here needs to cope with multinomial features in longitudinal data. Changes of state may involve transition with more than two destinations, and therefore needs to provide a relevant modelling framework for a multinomial state. Multilevel multinomial modelling is able to deal with data obtained by observing individuals who moved between multinomial states over time.

[7] Another classical method for repeated measures data is a growth curve analysis via multilevel modelling where the time periods are added to the model as dummy variables [Goldstein, 2003, pp128-129; Sacker *et al*, 2005]. This model is sometimes called 'compound symmetric' structure because this specific covariance structure specifies the two variances, between individual variance and within individual variance, as being same as the random intercept model [Littell *et al*, 2000; Snijders and Bosker, 2000, pp168-169]. This model can be analyzed in MLwiN and in SAS using PROC MIXED with a REPEATED statement [Singer, 1998; Yang, 2003]. Despite the relevance of the model to data with repeated measure, this model deemed not to be appropriate for the health selection study, because this model is used to characterize a growth trajectory formed by repeated measurements [Goldstein, 2003, p127; Yang, 2003].

The data are separated into sub-data according to the socioeconomic origin since the model can accommodate transitions from one class of origin at a time: for example, if there are four categories of class, every transition from each class of origin constructs four sub-data. The impact of health on the risk of transitions to move from one class of origin to a different destination (e.g., from classes I/II to class III M, III NM, IV/V) can then be estimated in one multinomial model simultaneously. A separate risk for each type of transition is obtained by referring to the transition that stays in the same states (reference category). This model includes not only those with complete transition history over the 13 waves from 1991 to 2003 but also those whose follow-up was interrupted. This means that all individuals are recruited as long as they had two years participation successively because every transition begins in year *t*-1 and ends in year *t*.

4.3.4 Detail of model specification with common random effects

The term 'multinomial' describes a situation where there are multiple outcomes. More specifically, in a social mobility study, the term is used to refer to the fact that there are multiple possible destinations. In addition to the multiple destinations, it needs to be acknowledged that diverse transitions start from multiple origins. In the current study, a multilevel multinomial model is fitted for each origin separately on the assumption of independence that a series of transitions from a particular origin is unaffected by transitions from other origins [Fieuws and Verbeke, 2006; Curtis and Blanc, 1997].

Prior to the specification of multilevel multinomial model, the simpler case is fitted with a logistic regression model. For a binary response variable, the logistic regression model is commonly used. If the outcome follows binomial distribution (e.g., yes (0) or no (1)), the probability for one outcome ($P_i = Pr(y_i = 0)$) is denoted by logit link. This probability predicts the statistical chance of the individual *i* experiencing a certain outcome (e.g., $y_i = 0$) as a function of a number of variables (x_i). Let us consider an ordinary logistic regression with a single independent variable (x_i).

$$\text{Logit}(\text{P}_i) = \log\text{odds} = \log(\frac{\text{P}_i}{1-\text{P}_i}) = \beta_0 + \beta_1 \chi_i \qquad (4.1)$$

From the equation, the probability (P_i) can be obtained:

$$\text{P}_i = \frac{\exp(\beta_0 + \beta_1 x_i)}{1+\exp(\beta_0 + \beta_1 x_i)} \qquad (4.2)$$

where β_0 and β_1 are the parameters to be estimated from as a function of covariate x_i [Rasbash *et al*, 2004, pp103-104].

We now consider a dataset consisting of repeated measurements (i : level 1) within the same individual (j : level 2) using multilevel logistic regression. If there is a binary response which repeats within an individual, the probability P_{ij} (y_{ij} = 0 or 1) is statistically dependent on both level 1 and level 2 variance. To allow individual-level effects on the probability of an outcome (i.e., y_{ij} = 0), a multilevel logistic regression can be considered. Like in the logistic regression, multilevel logistic regression fits the logit link:

$$\log(\frac{p_{ij}}{1-p_{ij}}) = \beta_0 + \beta_1 x_{ij} + u_{0j} \qquad (4.3)$$

Unlike equation for logistic regression in (4.1), a j subscript is added to represent two-level structure. The level 2 random effect (u_{oj}) is assumed to follow a normal distribution with mean zero and variance σ_u^2. Rearranging equation (4.3), the probability (P_{ij}) of being in a particular category can be estimated from the following formula:

$$\text{P}_{ij} = \frac{\exp(\beta_0 + \beta_1 x_{ij} + u_{0j})}{1+\exp(\beta_0 + \beta_1 x_{ij} + u_{0j})} \qquad (4.4)$$

The overall probability is defined as containing a level 2 random intercept. Without the random effect, equation (4.4) is simply the same as the logistic regression in equation (4.2) [Merlo *et al*, 2006; Rasbash *et al*, 2004, p111; Goldstein, 2003, p98].
The multilevel logistic model can be extended to allow multinomial transition for individuals at the higher level and repeated measurements at the lower level. Suppose

to fit a multilevel multinomial model with t categories (h=1, …, t) of response variable (y_{ij}). Then a series of t-1 equations for the remaining categories is formulated based on the reference category (t). Using a logit link, the multinomial multilevel model can be written:

$$\log\left(\frac{p_{ij}^{(s)}}{p_{ij}^{(t)}}\right) = \beta_0^{(s)} + \beta_1^{(s)} x_{ij} + u_{0j}^{(s)} \qquad (4.5)$$

In the above equation, s superscript (s=1, …, t-1) denotes each transition with transition specific intercepts and slopes. The random effects ($u_j^{(s)}$) are also transition-specific assuming that individual level (level 2) effects may vary by type of transition. At the same time, a correlation between two types of transition may arise because of a shared common effect underlying both transitions. A covariance between a set of transition specific random effects can demonstrate if transitions are correlated [Rasbash *et al*, 2004, p131; Steele and Curtis, 2003; Goldstein, 2003, p101].

From the above equation, the probability for a transition ($P_{ij}^{(s)}$) can be obtained as the following expression.

$$P_{ij}^{(s)} = \frac{\exp(\beta_0^{(s)} + \beta_1^{(s)} x_{ij} + u_{0j}^{(s)})}{1 + \sum_{h=1}^{t-1} \exp(\beta_0^{(h)} + \beta_1^{(h)} x_{ij} + u_{0j}^{(h)})} \qquad (4.6)$$

where t-1 transitions are available (s=1,…, t-1) from an origin (reference category, t). In this application, $P_{ij}^{(s)}$ is the probability for i^{th} response within an individual j in a transition s, which is defined as the product of both levels: level 1 and level 2 [Rasbash *et al*, 2004, p125; Yang, 2003; Chen and Kuo, 2001].

So far, the transition probabilities have been considered in generic terms without specifying any particular transition. The statistical model used in the analysis is described in the following section. The transition probabilities for an observation i of person j at time t are illustrated using logit function;

$$\text{Logit}(P_{ij}^{(s)}) = \beta_0^{(s)} + \beta_1^{(s)}\text{H}_{ijt} + \beta_2^{(s)}\text{E}_{ijt} + \beta_3^{(s)}\text{A}_{ijt} + \beta_4^{(s)}\text{C}_{ij} + \beta_5^{(s)}\text{P}_{ijt} + u_j^{(s)} \qquad (4.7)$$

H, E, and A represent the health, education, and age variables. In addition, all models are fitted dwith dummies for cohort (C) and period (P) effects. Individual level variability is considered by including random effects ($u_j^{(s)}$). After exploring a range of models, this final model is selected based on the comparison of goodness of fit tests. Deviance Information Criterion (DIC) for MCMC methods and deviance statistics for SAS proc NLMIXED analysis are used for measuring diagnostic statistics, and detailed explanations about the model selection process is given in Appendix 4-8.

In general, the logistic model is interpreted using ORs – the ratio of odds of a category (e.g., x_i = 1) relative to odds for a reference (e.g., x_i = 0) for an event occurrence (y_i = 1). Given a logistic model, odds for a reference category can be obtained by taking exponentials of equation (4.1):

$$\frac{P_i}{1-P_i} = e^{\beta_0+\beta_1 x_i} = e^{\beta_0} \times e^{\beta_1 x_i} \qquad (4.8)$$

In similar way, odds of one category can be obtained by 1 unit increase in x_i:

$$\frac{P_i}{1-P_i} = e^{\beta_0+\beta_1 (x_i+1)} = e^{\beta_0} \times e^{\beta_1 x_i} \times e^{\beta_1} \qquad (4.9)$$

To calculate OR, the odds for a category is divided by the odds for reference category. Then, OR between two categories of x_i is given below:

$$\text{odds ratio} = e^{\beta_1} \qquad (4.10)$$

Thus, regression coefficients in logistic regression models can yield an OR by taking the exponential form (e^{β_1}). This interpretation of the coefficients can be applied to the comparison of any pair of categories (e.g., x_i = 0 versus 1, x_i = n versus n+1). If the equivalent procedure is applied to the multilevel logistic model, the same formula for the OR is obtained. In equation (4.3), the OR between two odds derived from two exponentials equals to the OR in equation (4.10).

In a multilevel multinomial model, the OR provides the same interpretation as in the binomial multilevel model. Odds of being in category *s* compared to odds of category *t* (reference) are calculated as below:

$$\text{odds ratio} = e^{\beta_1^{(s)}} \qquad (4.11)$$

The exponentiated coefficient is interpreted as the OR between two categories of variable x_{ij} [Rasbash *et al*, 2004, pp102-104; pp124-125; Kleinbaum and Klein, 2002, pp22-25].

4.3.5 Specific constraints in the model building

It is important to note that there are three specific constraints used in the current application of multilevel multinomial modelling. Firstly, the multilevel modelling introduced above only allows the random intercept to vary across individuals, while assuming the effects of the independent variables are the same for each individual (j). If we further extend the random intercept model to allow random coefficients (u_{1j}), then the specific coefficient for each individual is calculated as $\beta_{1j} = \beta_1 + u_{1j}$. In principle, the random coefficient model can introduce a random variation of an independent variable, whereas the random intercept model provides the average coefficient (β_1) for an independent variable. However, most previous studies that dealt with repeated transitions within an individual have typically not included a random coefficient [Steele *et al*, 2005a; Steele and Curtis, 2003; Steele *et al*, 1996]. Based on this routine application, the model specified in the current study does not introduce a random coefficient.

Secondly, it is worthwhile to observe that the multilevel multinomial (or logistic) regression with discrete outcomes does not comprise a separate parameter for the level 1 variance through equation (4.3) to (4.7). In the multilevel linear regression model with a continuous outcome, level 1 variance (e_{ij}, level 1 residual or level 1 random effect) is included alongside level 2 random effect (u_{0j}). For a random intercept model with continuous outcome, the level 1 residual (e_{ij}) is parameterized with mean (zero) and variance (σ_e^2). In the discrete response model, the level 1 residual can have mean zero, but its variance becomes a function of the probability. If y_{ij} follows binary outcome, it can be coded either 1 (P_{ij}) or 0 ($1- P_{ij}$). Then, variance (y_{ij} =1) equals $P_{ij}(1- P_{ij})$. [Snijders and Bosker, 2000, pp207-209, 127-128]. This means that the variance of the level 1 residual itself directly depends on the probability, and it can be decided after the probability is known [Merlo *et al*, 2006; Snijders and Bosker, 2000, p213; Hox, 1995, p77]. Moreover, Merlo *et al* [2006] discussed another important point when estimating the level 1 variance, namely that, in a multilevel logistic regression, the scale of the level 1 variance is not the same with that of level 2 while, in multilevel linear regression, level 1 and level 2 variances are on the same scale.

Since level 1 variance is unknown in the multilevel logistic regression, variance partitioning is not straightforward [Browne, 2005]. As a result, several alternative approaches have been proposed. Snijders and Bosker [2000, pp223-224] suggested the linear threshold model or latent variable method where level 1 variance (σ_e^2) is assumed to follow a logistic distribution with variance $\pi^2/3 \approx 3.29$. Goldstein *et al* [2002] suggested a simulation method in which level 1 variance is computed to have a range of values from which the mean of the level 1 variance is calculated. A comprehensive description of this matter is found in Goldstein [2002; 2003, pp108-111] and Snijders and Bosker [2000], and a recent discussion is provided by Browne [2005] and Merlo *et al* [2006].

Although some approximation methods for variance partitioning have been suggested for a multilevel logistic analysis [Browne, 2005; Rasbash *et al*, 2004, pp113-115], an available method for multilevel multinomial model is yet to be developed. As a result, no study has yet conclusively demonstrated variance partitioning in a multilevel approach with multinomial outcomes [Steele *et al*, 2005a; Steele, 2005b; Steele and Goldstein, 2004; Hedeker, 2003; Steele and Curtis, 2003; Chen and Kuo, 2001]. Therefore, in the current modeling, the variance component is not quantified.

Thirdly, instead of specifying a transition specific random effect ($u_{0j}^{(s)}$, s=1 to t-1), individual-level variance is accommodated by a single common random effect (u_{oj}), while covariance between the transitions is neglected. The model can be written as:

$$\log\left(\frac{p_{ij}^{(s)}}{p_{ij}^{(t)}}\right) = \beta_{0j}^{(s)} + \beta_1^{(s)} x_{ij} + u_{0j} \qquad (4.12)$$

where s denotes the particular transition (s=1, …, t-1) from a origin (t), just as in equation (4.5). However, a common random effect (u_{oj}) is fitted to vary across transitions for an individual (j) [Yang, 2003; Curtis and Blanc, 1997]. Thus, in this modelling, it is assumed that individual-level variation is not transition specific but is the same for any individual (j) regardless of the types of transition.

One shortcoming of a multilevel multinomial model with a common random effect is inevitable, since it is less informative in comparison to the model with a transition specific random effect which is able to estimate the correlation between various transition pairs. Fitting a common random effect has some advantages, however, since this approach potentially has fewer numbers of parameters than when random effects are specified for every transition. An increase in the number of estimates can result in a computational problem, with parameters for random effects with variances and covariance [Fieuws and Verbeke, 2006], and this was also the case for the current application. When random effects are specified for every transition, it is seen to result in convergence failure, apart from in mobility between employment statuses, where a small number of random components are required. Convergence failure is observed both in MLwiN and SAS. As convergence problems are often encountered with increasing complexity in multilevel modelling [Hox, 2002, p39], the model is fitted in a stepwise fashion, starting with a simple model. The details of the computation procedure follow in the next section. As such, a common random effect fits a series of multinomial model for class mobility (Chapter 5) and income mobility (Chapter 6), while a transition specific random effect fits a model for transitions between employment statuses (Chapter 7).

4.3.6 The process of computation for parameter estimation

This study uses two well known statistical software programs for the random effects model. One is SAS 9.1 (for class mobility and income mobility), and the other is MLwiN 2.01 (for transitions between employment statuses), because MLwiN is more effective in managing a transition specific random effect model. Results from SAS NLMIXED and MIXED confirm a previous study that SAS yields almost the same estimates, except variances and standard error, in comparison with MLwiN [Yang, 2003]. This is illustrated in Appendix 4-9.

NLMIXED and MIXED procedure in SAS have been introduced relatively recently to accommodate repeated measurements within individuals. This generalized mixed model is an extension of the generalized linear model, achieved by adding random effects arising due to the correlation of repeated measures.
The multilevel models are separately fitted for each origin through the procedure NLMIXED. A programming statement is provided in the Appendix 4-10. The inference is based on log-likelihood. Likelihood approximation is gained using an adaptive Gaussian quadrature algorithm. It is recommended that quadrature points are ranged from 15 to 20 [Hartzel *et al*, 2001]. To facilitate convergence and to shorten iteration time, optimum starting values are obtained from estimates of the corresponding fixed-effects model without any random effects [Wolfinger, 1999]. The RANDOM statement defines random parameters.

Regarding social mobility between employment statuses (Chapter 7), multilevel multinomial analysis is carried out using MLwiN version 2.01. This model considers the fact that repeated responses within the same individual are correlated and that unobserved factors may influence the competing transition processes [Rasbash *et al*, 2004, pp162-177]. This model estimates simultaneously every type of transitions from each origin. To denote multinomial responses, the binary response indicator is produced to identify the occurrence of transition, using a sequence of dummy variables [Steele, 2005b].

As it is always recommended to build a complex multilevel model gradually, the model fitting starts from a simple model [Steele and Goldstein, 2004]. Firstly, the model with intercepts and one independent variable is fitted for each transition, and then a more complex model is built up by adding covariates and random effects. Secondly, Monte-Carlo Markov chain (MCMC) methods are used to estimate coefficients because, in the current study, quasi-likelihood procedures are unreliable when sample size within level 2 is small [Steele, 2005b, p4], and because 1st order MQL (Marginal Quasi Likelihood) may produce biased estimates for the multinomial model [Rasbash *et al*, 2004, p133]. After convergence with quasi-likelihood procedures, it is switched into MCMC methods to avoid any convergence problems [Browne, 2005, p22]. The basic idea of MCMC is that prior distributions for each of the parameters are combined with the data (via the likelihood for the data) to produce a posterior distribution for the parameter. Results are gained from a burn-in (iteration for initial parameter) of 5000 and a chain length (iteration for final parameter) of 50000. The conclusion of convergence is taken from the Raftery-Lewis diagnostic via the Trajectories window in MLwiN. This diagnostic suggests that MCMC chain (50000 iterations) is sufficiently long enough [Browne, 2005, pp262-273]. The MLwiN macro (Appendix 4-11) has been used to create a new dataset including dummies for employment status, and to set up the multilevel multinomial model. The way to interpret the results from MLwiN is introduced in Appendix 4-12.

4.3.7 Diagnostics for multilevel multinomial model

A multilevel multinomial model is composed of two parts, fixed and random. The random effects for each state are added to allow the coefficients of the variables to vary across individuals. The model will estimate a variance-covariance matrix for the random effects. The extent to which individuals vary is represented by the between-individual variance. The covariance gives information about whether different types of transitions are dependent or independent by evaluating the correlation between random effects. When the covariance is close to zero, each transition can be modelled separately.

Testing statistical parameters in the multilevel multinomial analysis necessarily separates information into two parts, regression coefficients (fixed effect) and the variance and covariance component (random effect). The significance of included variables is appraised by the ratio of effect size to standard error (t-value).

$$t = \frac{estimate\,(\beta_k)}{standard\ error\,(S.E.)}$$

Estimates for fixed effects are used to test this statistics. Because the total number of units is large enough, compared to number of explanatory variables, the t-distribution follows a standard normal distribution [Snijders and Bosker, 2000, p86; Rasbash *et al*, 2004, p25].

For judging the significance of random effects, a likelihood ratio test (or deviance test) is preferred, which is used to test improvements in the fit between models due to the introduction of random effects [Snijders and Bosker, 2000, pp86-90; Rasbash *et al*, 2004, p32]. However, for discrete response models, the likelihood ratio test is unavailable because the estimation is gained from quasi-likelihood methods [Rasbash *et al*, 2004, p113]. In practice, when variances are clearly high comparing to their standard errors, the Normal test 'can act as a rough guide' straightforwardly [Rasbash *et al*, 2004, p32, p133], although variance follows only approximately Normal distribution. Alternatively, the Wald test can be computed to assess the significance of variance and covariance. In the current thesis, the Wald test is used for the significance test of random effect. The Wald statistic is tested against a chi-square distribution with 1 degree of freedom [Rasbash *et al*, 2004, p113].

4.4 A population-level approach to the type II study

An approach is put forward, which is able to account for the changes in social inequalities in health after the social mobility process. A brief preview of the approach follows, and a more detailed account is found in Chapter 8.

Every participant within a population is observed across a period between two time points over which social mobility operates. Some of those with poor health may move to enter other social classes, and in turn this compositional change of poor health across social classes results in changes in social inequalities in health. A mobility table is used to indicate social movements from each class, and social inequalities in health before and after mobility. It is demonstrated how a simple tabulation can account for both pre- and post-mobility inequalities in health mediated by social mobility.

Components of social mobility are identified, which respond simultaneously to the social mobility process in the change of social inequalities in health. To explain a viable mechanism of social mobility and to apply numerous scenarios, simulations are developed with varying conditions of the components.

4.5 Consideration of endogeneity between health and SEP

4.5.1 Possible sources of endogeneity

The issue of endogeneity appears in literature in various forms. In biology, the term endoegeneity refers to something that originates from an organization such as a cell and a body, while exogeneous means something that originates outside of the organization. In a similar way, in statistics, a variable is endogenous if it is determined within the context of model, and exogenous if not. When a covariate is correlated with an error term, or in another way, when ‘a value [of the covariate] is at least partially determined by the value of other variables within the model’ [Berg and Mansley, 2004, p561], then the covariate is an endogenous variable. On the contrary, an exogeneous variable indicates that an independent variable is uncorrelated with the error term or ‘totally determined by factors that lie outside of the model’ [Berg and Mansley, 2004, p561; Hogan and Lancaster, 2004; Zohoori, 1997a].

Endogeneity can arise from several potential sources, such as unobserved heterogeneity (the omission of relevant variables), measurement error, and simultaneity [Wooldridge, 2002, pp50-51, Hogan and Lancaster, 2004]. Correlation between covariates and error terms can occur because relevant variables are not available, which constitutes part of the error term. Omitting relevant variables can occur either because the variable is intrinsically unobservable, like ability and motivation [Gangji *et al*, 2005], or simply because information on the variable was not collected in advance. Measurement errors in one or more of the variables with imperfect measures have a similar statistical consequence [Wooldridge, 2006, p318]. In this situation, the ordinary least square (OLS), which is implicitly based on ‘no unmeasured confounders’ assumption, may generate inconsistent and biased estimates [Hogan and Lancaster, 2004, p22].

Simultaneity is another major source of endogeneity [Wooldridge, 2006, p552; Goldberger, 1972]. It appears when dependent and independent variables influence simultaneously from both directions. For example, in a case where the severity of disease is the dependent variable as a function of treatment, the model assessing the effect of treatment on severity level might be biased because severity may decide the type of treatment. In this circumstance, so-called 'dual causality' [Deaton, 2003] or 'reverse causality' [Rothman and Greenland, 1998, p587], the estimations from an ordinary regression model may be erroneous [Berg and Mansley, 2004]. Likewise the relationship between health and SEP might potentially cause trouble in separating causality from one to the other. SEP can risk health and now, health can lead to the selection of an occupation which might turn out to change SEP again. Consequently, modelling with OLS may bring about a biased result by ignoring possible endogeneity.

4.5.2 Endogeneity in epidemiology research

The topic of endogeneity has previously been addressed in epidemiological studies by some researchers [Au *et al*, 2005; Hogan and Lancaster, 2004; Zohoori, 1997a; Briscoe *et al*, 1990], because the problem obviously appears over various natural settings: severity and treatment [Berg and Mansley, 2004], health status and income [Contoyannis and Rice, 2001], prenatal care and infant health [Schultz, 1984], health and health related behaviour [Briscoe *et al*, 1990; Contoyannis and Jones, 2004], alcohol dependence and employment probability [Johansson *et al*, 2007], and contraceptive intention and method choice [Steele and Curtis, 2003].

There are several studies reporting considerable deterioration in parameter estimation unless there is a proper recognition of endogeneity [Currie and Madrian, 1999, p3312, p3331]. One study found that the accountability of alcohol dependence on labour force participation increases substantially after controlling for endogeneity by employing an instrumental variable, implying the importance of incorporating endogeneity [Johansson *et al*, 2007]. Another study also suggested that ignorance of taking account of the notion of endogeneity led to an underestimation of life-style in explaining health in epidemiological studies [Contoyannis and Jones, 2004]. Pioneering works by Zohoori [1997a, 1997b] in epidemiologic study advocated using methods that appreciate endogeneity. When he tested the effect of breast feeding frequency and duration on time to restore menstruation with and without endogeneity, surprisingly the clear negative effect of breast feeding on returning to menses entirely disappeared by introducing endogeneity [Zohoori, 1997a].

4.5.3 Treatment of endogeneity

This topic, the treatment of endogeneity, is so huge that this study intends to deliver a brief summary rather than a comprehensive coverage of the subject. The instrumental variable (IV) method can be a basic way to adjust unmeasured confounding (unmeasured heterogeneity) and reduce or eliminate biased estimation [Berg and Mansley, 2004]. Since the IV method aims to mitigate the correlation between the independent variable and the error term, an instrumental variable is correlated with the independent variable but is not correlated with the error term, nor with the dependent variable. For example, random assignment in a cohort study [Hogan and Lancaster, 2004] can be an IV which satisfies this standard. As a specific example, religiosity can be a good candidate IV for studying the influence of alcohol dependence on employment probability, since religious people drink less but normally perform on the labour market like anyone else [Johansson *et al*, 2007]. However, the choice of a valid IV is somewhat difficult and arbitrary [Wooldridge, 2006, pp519-520].

Two-stage least square method is an extension of IV regression [Johansson *et al*, 2007]. At the first stage, an endogenous variable is replaced by an instrument obtained from the regression of the endogenous variable on all the IV in the model. This predicted value for an endogenous variable is said to be the best instrument. At the next stage, the derivative variable then substitutes for the endogenous variable in the original equation before running the ordinary least square [Wooldridge, 2006, pp536-538; Zohoori and Savitz, 1997b].

While the above two approaches are proposed to solve unobserved heterogeneity or measurement error, the structural equation model (SEM) aims at another important source of endogeneity, that is simultaneity [Wooldridge, 2006, p552].The SEM is able to simultaneously introduce multiple model equations based on multiple causal relations.

If the mutual influence between two variables is jointly determined, SEM might consist of two equations. For instance, the first equation describes health as a function of SEP and the second describes SEP as a function of health. Two equations are assumed to share an unexplained correlation by specifying errors (or residuals) [Wooldridge, 2006, pp557-559]. Another way of accounting for simultaneity is the multilevel multi-process model. Steele and Curtis [2003] explore endogeneity between the processes of contraceptive method choice and discontinuation process. Two separate equations, method choice and discontinuation processes, are modelled simultaneously and endogeneity is specified as a correlation between the random effects from two equations.

Chapter 5: health selection operating inside and outside employment

5.1 Introduction and literature review

As outlined in previous chapters, there have been two specific types of health selection studies. One concerns the presence of health selection (type I study) and the other examines the contribution of health selection to social inequalities in health (type II study). This chapter investigates the association between prior health and subsequent social mobility indicated by social class and the non-employed; this association is an example of a type I study.

Briefly, the findings from type I studies which were reviewed in section 1.2.3 indicated that the findings remain inconclusive. Some studies found that health played a major role in intergenerational [Manor *et al*, 2003; Power *et al*, 1986; Wadsworth, 1986; Illsley, 1955] or intragenerational mobility [Manor *et al*, 2003; Power *et al*, 1996; Dahl and Kjaersgaard, 1993b; Lundberg, 1991; Power *et al*, 1986], while other studies reported a minimal influence of health on social mobility [Cardano *et al*, 2004; Chandola *et al*, 2003a; Lundberg, 1991].

The major limitations of type I studies were also discussed in section 2.2. One weakness is due to the fact that most type I studies were based on a simplification of the mobility table. Collapsing the mobility table into three (upward, stable, and downward) or two directions (stable and mobile) does not adequately reflect the changing pattern of social mobility, and this approach cannot avoid losing the detailed description of social mobility. The other major limitation lies in the study population. The effects of health on social mobility might be diverse in the context of the population, depending on whether the non-employed are included or not [Dahl, 1996]. These limitations suggest that in order to move research in this area forward, it is necessary to develop a methodology which can accommodate a wide range of categories of social mobility. This point is explored in this chapter.

Most type I studies [Manor *et al*, 2003; Chandola *et al*, 2003a; Power *et al*, 1996; Illsley, 1955] carried out analysis on study samples which contained only those who were employed. It was suggested that health selection might not be effectively represented in a study based on the occupational class, as health selection is more likely to be present when moving out of employment [Dahl, 1993a; West, 1991]. Moreover, there was a suggestion that the effect of health on social mobility may differ according to different origin-destination matrices [Dahl, 1996]. However, an analysis to comprehend the complexity of health selection over multiple transitions across social classes and non-employment, has simply not been available previously[8]. A method to fit this idea needs to accommodate more comprehensive range of social mobility. In the current study, a multilevel multinomial model, which includes the non-employed as a distinct category along with social classes [Miller, 1998], is used to deal with this complex situation.

5.2 Specific aims of this chapter

The specific aims of this chapter are to investigate:

1) whether class mobility is associated with previous health status,

2) whether the effects of health on social mobility varies according to socioeconomic origins and destinations, and

3) how health and other predictors are involved in accounting for social mobility after taking the random effect into account.

5.3 Method

Data on 51488 observations from 7416 individuals over the age of 30 are analyzed

[8] A few studies [Cardano *et al*, 2004; Lundberg, 1991] have been performed on the entire population, ensuring affiliation of the non-employed to the labour force. Despite the comprehensive nature of the populations included in these studies, when they assessed the health selection effect between the employed and the non-employed, all social classes were aggregated into one category (i.e., the employed) instead of maintaining the detailed categories. This kind of approach is dealt with in Chapter 7, in which the focus is laid on health selection in the transitions between employment statuses.

for social mobility with regard to general health status. General health status which represents subjective health condition over the last 12 months was labelled from ‘excellent’ to ‘very poor’. To dichotomize this variable, ‘good status’ combines excellent and good values, whereas ‘poor status’ combines fair, poor and very poor values. The Registrar General's Social Class (RGSC) is used for social class based on participant’s own occupation. The six scale classification is converted to a four scale index: classes I/II (Professional and Managerial), class III NM (Skilled non-manual), Class III M (Skilled manual), Class IV/V (Partially skilled and unskilled). Additionally, the non-employed are included as a separate category. This category is made up of unemployed and the economically inactive group, who were early retired, involved in family care, or on long term sick-leave. Detail information about these selection criteria is found in section 7.4.

The pooling and simultaneous analysis of data over 13 waves of the BHPS was carried out. Firstly, the association of various factors with social mobility was described by simple tabulation. Secondly, to demonstrate the effects of variables and to account for data structure with repeated measurements, the multilevel multinomial models regarding each class of origin are fitted for multivariate analysis. The multilevel multinomial model is a two-level model of repeated measure (level 1) within individuals (level 2). Two random intercept models are developed to take into account individual-level variability. Model I relates health as the only predictor of subsequent SEP transition, which is defined as a change between year t-1 and year t. Model II extends model I by adding covariates such as education, age, period, and cohort effects. The changes in OR by health status between model I and model II without and with controlling for covariates, may account for the independent association of the health variable on social mobility. Details of modelling have been described previously (see Chapter 4).

5.4 Result

5.4.1 Summary of sample description

Table 5-1 describes demographic and social information for men and women, and comparisons are made for un-weighted and weighted samples.

Table 5-1 Sample characteristics on demographic and social variables over 13 years (1991-2003)

Variables*	Men		Women	
	Un-weighted	Weighted†	Un-weighted	Weighted†
Number of observations [frequency (%)]	25611(49.7)	25497(50.9)	25877(50.3)	24565(49.1)
Number of individuals [frequency (%)]	3765(50.8)	3467(52.4)	3651(49.2)	3149(47.6)
Age [mean (±SD)]	45.2(±9.19)	45.9(±9.43)	43.4(±7.93)	43.9(±7.85)
Ethnicity (%)				
White	96.8	96.5	95.9	95.2
Non-white	3.2	3.5	4.1	4.8
Educational level (%)				
No qualification	20.4	21.5	23.0	23.9
GCE O levels or less	19.7	19.4	26.5	25.9
GCE A levels	11.7	11.4	8.2	7.9
Vocational qualification	34.1	34.0	31.1	31.3
Higher degree	14.1	13.7	11.3	11.1
Occupational social class‡ (%)				
I/II	38.5	37.9	27.7	27.2
III NM	8.9	8.8	25.7	25.8
III M	25.9	25.7	6.2	6.1
IV/V	10.9	11.1	14.1	14.3
Non-employed¶	15.8	16.4	26.3	26.7
Health status (%)				
Good	75.5	75.0	72.0	71.6
Poor	24.5	25.0	28.0	28.4

* Estimates are presented in three ways; [frequency (%)], [mean (±SD)], and [%]. † Cross-sectional weights of each year are used as the calculation for mean and proportions are based on cross-sectional description. Sample weight ranges from 0.12 to 2.50. ‡Professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), and partially skilled and unskilled (IV/V) ¶ Non-employed represents both from economically inactive and the unemployed group.

Table 5-1 presents a cross-sectional view of the characteristics of the sample after data pooling in the 1991-2003 waves from the BHPS. After converting the individual level data into person-year data, this sample comprises 25611 person-year observations from 3765 men and 25877 person-year observations from 3651 women. A cross-sectional weight has been applied for all measures. Because of the presence of respondents who did not receive weight value, the weighted sample size is smaller than the un-weighted. As there is no contrasting difference between the weighted and un-weighted samples, the figures in the un-weighted sample are considered for the description of the sample.

The distribution of ethnic groups shows that the non-white group is more common among women than among men by 0.9%. In education, men reached higher attainment level than women, and vocational qualification is the largest single category for both men and women. In social class, around 38.5% of men are in classes I/II, compared to 27.7% of women, and 25.7% of men are in class IIIM, which is sharply compared to 6.2% of women. Women are equally distributed between classes I/II and class III NM (non-manual classes), while men disproportionately tend to be in classes I/II.

The rate of non-employment is about 16% among men, while the figure increases up to 26.3% among women. These figures reflect prior expectation as this category combines both economically inactive and unemployed groups, in comparison with the Labour Force Study where the corresponding figures were 18.8% and 30.6% in 1997-1999 [Dickens *et al*, 2003, p42]. The figures in the current study falls short of the Labour Force study because the inactive group in the current thesis does not include those on maternity leave, full time students, and those under government schemes[9]. General health status is somewhat different for men and women and poor health is more common among women. This sample is similar to samples B in table 4-2 on most characteristics including health measures, although the sample is restricted to those participating in two consecutive waves.

5.4.2 A brief description of social mobility

The number of transitions per individuals are counted and summarized into mobility

[9] The reason for this restriction is acknowledged in Chapter 7 (7.3) where employment statuses are modelled.

direction; downward, stable, and upward. As class mobility is measured on its own independently of other variables, the overall mobility direction can be used for this purpose without violating the 'collapsibility condition' which was described in Chapter 2. The average number of transitions during 13 years is summarized in the next table.

Table 5-2 Description of transition† and poor health experience‡ over 13 years (percentile)

	Men	Women
Total number of transition	25611(49.7)	25877(50.3)
Downward transitions	2426(9.5)	2485(9.6)
Stable transitions	20912(81.7)	20801(80.4)
Upward transitions	2273(8.9)	2591(10.0)
Total number of individuals	3765(50.8)	3651(49.2)
Average number of transitions [mean(±SD)]		
Total transition	6.8(±4.0)	7.1(±3.9)
Downward transitions	0.6(±0.9)	0.7(±0.9)
Upward transitions	0.6(±0.9)	0.7(±1.0)
Stable transitions	5.6(±3.7)	5.7(±3.6)
Poor health experience‡	2.0(±2.8)	2.4(±3.0)
Number of downward transitions		
Zero	2144(57.0)	1998(54.7)
One	1055(28.0)	1047(28.7)
Two or three	522(13.9)	564(15.4)
Four to six	44(1.1)	42(1.2)
Number of upward transitions		
Zero	2317(61.5)	2027(55.5)
One	885(23.5)	930(25.5)
Two or three	509(13.5)	646(17.7)
Four or five	54(1.4)	48(1.3)
Number of poor health experience‡		
Zero	1675(44.5)	1298(35.6)
One or two	1086(28.8)	1101(30.2)
Three to five	546(14.5)	699(19.1)
Six to twelve	458(12.2)	553(15.1)

† Transition states class transition between consecutive years and, for example, stable mobility occurs when staying the same class for two consecutive years. Note that transition from the employed to the non-employed is considered as a downward mobility and, therefore, this table only provides a simple overview. Apart from this table, the non-employed are distinguished as a distinct category.

‡ Poor health experience is counted when it precedes transition. Thus, the maximum number of transitions and poor health experiences is 12.

Table 5.2 shows the longitudinal information about the main variables of this study (e.g., health and transition) based on 3765 men and 3651 women. Among the total of 25611 transitions for men, downward and upward mobility account for 18% of overall movements, while the rest are stable, although mobility is higher for women, accounting for 20% of the total movements. The average number of transitions shows that staying in the same position is the most common state for both men (5.6 out of 6.8 average transitions), and women (5.7 out of 7.1 average transitions). In contrast to men, women suffer poor health more frequently with an average of 2.4 experiences, while the corresponding figure for men is 2.0.

For both men and women, the number of downward transitions peaks at zero times (never having experienced downward mobility), with 57 % and 54.7% respectively. 15% of men and 16.6% of women experienced downward mobility two or more times. Approximately 62% of men and 56% of women never experienced upward mobility, whereas approximately 15% of men and 19% of women experienced upward mobility more than two times. More men than women never experienced poor health, with 44.5% versus 35.6% respectively. Overall, women generally experience more mobility and poor health compared with men.

5.4.3 The association of transitions with socio-demographic measures

Table 5-3 shows the bivariate analysis of mobility by social and demographic characteristics in men.

Table 5-3 Bivariate analysis on the associations between class transitions and demographic and social measures* among men (N=25611)

Class origin / Class destination†		No	Health status		Age				Ethnicity		Marital status		Educational attainment				
			good	poor	30s	40s	50s	Mean	White	Non-white	Yes	No	I	II	III	IV	V
I/II	⇒ I/II	8632	85.2	14.8	40.2	36.4	23.4	43.8	96.7	3.3	75.9	24.1	5.5	10.9	11.2	39.2	33.2
	⇒ IIINM	415	82.7	17.3	42.2	33.3	24.6	43.4	94.9	5.1	78.8	21.2	7.4	22.4	13.0	37.8	19.4
	⇒ IIIM	365	81.9	18.1	46.0	30.1	23.8	43.2	96.1	3.9	77.2	22.8	13.4	23.3	11.3	44.2	7.8
	⇒ IV/V	162	80.3	19.7	44.4	29.0	26.6	43.4	98.1	1.9	67.9	32.1	9.7	27.1	12.9	43.9	6.4
	⇒ non-emp	288	72.6	27.4	16.7	27.4	55.9	50.7	96.8	3.2	74.7	25.3	6.9	12.3	15.9	42.7	22.1
IIINM	⇒ I/II	472	85.4	14.6	45.1	32.8	22.0	42.8	95.1	4.9	75.9	24.1	7.0	21.3	14.3	38.8	18.6
	⇒ IIINM	1519	81.0	19.0	46.4	31.8	21.8	42.9	97.4	2.6	75.5	24.5	9.3	27.9	19.3	36.2	7.3
	⇒ IIIM	122	73.8	26.2	42.6	35.2	22.1	43.5	96.7	3.3	74.6	25.4	20.3	33.9	11.9	32.2	1.7
	⇒ IV/V	87	79.3	20.7	39.1	26.4	34.5	45.2	96.5	3.5	67.8	32.2	21.4	38.1	13.1	26.2	1.2
	⇒ non-emp	74	71.6	28.4	16.2	24.3	59.5	51.2	95.9	4.1	67.6	32.4	20.6	19.2	17.8	37.0	5.5
III M	⇒ I/II	408	81.6	18.4	49.0	32.1	18.9	42.8	96.8	3.2	75.5	24.5	12.7	24.3	11.7	44.3	7.1
	⇒ IIINM	120	72.5	22.5	46.7	28.3	25.0	43.1	97.5	2.5	75.8	24.2	23.9	27.4	14.2	31.9	2.6
	⇒ III M	5351	79.9	20.1	39.1	34.6	26.3	44.2	97.6	2.4	77.6	22.4	25.2	27.8	13.7	32.4	0.8
	⇒ IV/V	481	74.8	25.2	40.5	35.8	23.7	43.7	96.6	3.4	72.9	27.1	32.3	28.6	11.2	26.9	1.1
	⇒ non-emp	264	65.5	34.5	31.4	19.3	49.2	48.0	96.5	3.5	73.9	26.1	34.7	20.5	11.4	32.7	0.8
IV/V	⇒ I/II	135	77.8	22.2	45.2	28.9	25.9	43.8	96.3	3.7	70.4	29.6	16.9	24.6	13.1	40.8	4.6
	⇒ IIINM	97	81.4	18.6	36.0	32.0	32.0	45.1	97.9	2.1	69.1	30.9	17.9	31.6	12.6	34.7	3.2
	⇒ IIIM	496	78.6	21.4	42.1	34.7	23.2	43.5	97.1	2.9	71.8	28.2	30.1	28.5	9.8	30.8	0.8
	⇒ IV/V	1907	74.4	25.6	38.6	30.5	30.9	44.9	97.0	3.0	71.9	28.1	40.0	27.3	6.1	24.9	1.7
	⇒ non-emp	168	57.7	42.3	35.1	24.4	40.5	46.6	95.7	4.3	62.5	37.5	54.4	11.4	8.2	23.4	2.5
non-emp	⇒ I/II	151	75.5	24.5	27.2	39.7	33.1	46.1	96.0	4.0	68.9	31.1	8.8	13.6	15.7	39.5	22.5
	⇒ IIINM	68	76.5	23.5	36.8	26.5	36.7	45.5	94.1	5.9	63.2	36.8	7.5	28.4	17.9	29.9	16.4
	⇒ III M	161	70.2	29.8	42.2	28.6	29.2	43.4	95.0	5.0	61.5	38.5	30.6	22.3	10.8	33.8	2.5
	⇒ IV/V	165	60.6	39.4	49.1	24.9	26.0	43.0	96.9	3.1	52.1	47.9	43.0	19.0	10.8	24.7	2.5
	⇒ non-emp	3503	41.3	58.7	15.1	20.8	64.1	52.3	96.6	3.4	68.9	31.1	43.9	15.9	8.8	26.0	5.4

*Health, age, ethnicity, marital status, education attainment are measured in year *t*-1, while transitions are measured across year *t*-1 and year *t*. †Based on own occupation which are professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), partially skilled and unskilled (IV/V), and non-emp (non-employed). ‡ No qualification (I), GCE O levels or less (II), GCE A levels(III), Vocational qualification(IV), and Higher degree (V). Note; In a given class of origin, stable group is marked with shade in the table.

This table describes the association between various demographic and social measures and transitions across every class in men. In a given class of origin, shadows mark where the stable transition is. Within each class of origin, rows above and below the shadow line correspond to upward and downward mobility respectively. Below the shadow line, the downward groups appear to have had a high poor health rate compared with the stable group in each class of origin. For example, those groups on the downward trend from Class III NM had a higher proportion in poor health in year *t*-1 (from 20.7% to 28.4%) than those staying on III NM (19.0%). The association between downward mobility and a higher rate of poor health suggests that an unhealthy population group tends to move to a lower social position. In contrast, the upward groups had a lower poor health rate with one exception, transition from Class IIIM to Class IIINM.

The effect of age shows the tendency that the younger group (in their thirties) are likely to be more mobile both in downward and upward directions, and the level of mobility rebounds among the aged group (in their fifties) after middle age figuring a U-shaped distribution [Cappellari and Jenkins, 2003]. Later in life (those in their fifties and older), the number of people who are relegated to the non-employed rapidly rises in every class. Ethnicity appears to be loosely bounded to the mobility direction, although a high proportion of the non-white group is present among the non-employed. Being married appears to be associated with a higher probability of being within the higher SEP, whilst the lower SEP, for example classes IV/V and the non-employed, is associated with a lower rate of marriage. However, marriage does not seem to be connected with mobility direction among those who are already employed. For education, having better educational qualifications has a positive impact on maintaining high social class, in particular, in managerial and professional occupations (classes I/II).

This table reveals that the use of general mobility directions (grouped in stable, upward, and downward) is unlikely to provide a valid assessment, because this form of grouping does not take account of heterogeneous features within the same grouping. For example it is difficult to say that those involved in a stable transition from classes I/II to classes I/II share common characteristics in health status, marital status, degree of education and so on with those involved in a stable transition from classes IV/V to classes IV/V. This suggests social mobility is distinctive relative to class of origin.

Table 5-4 Bivariate analysis on the associations between class transition on demographic and social measures* among women (N=25877)

Class origin / Class destination†		No	Health status: good	Health status: Poor	Age: 30s	Age: 40s	Age: 50s	Age: mean	Ethnicity: White	Ethnicity: Non-white	Marital status: Yes	Marital status: No	Educational attainment‡: I	II	III	IV	V
I/II	⇒ I/II	6098	81.3	18.6	44.2	37.2	18.6	42.5	96.0	4.0	67.1	32.9	4.7	12.1	7.1	42.8	33.3
	⇒ IIINM	504	76.2	23.8	43.9	38.1	18.1	42.3	97.6	3.4	71.2	28.8	9.0	39.6	9.6	31.6	10.2
	⇒ IIIM	109	75.2	24.8	39.5	30.3	30.3	44.1	98.1	1.9	56.9	43.1	21.9	17.1	13.3	41.9	5.7
	⇒ IV/V	156	74.4	25.6	41.0	42.3	16.7	42.7	92.9	7.1	70.5	29.5	18.3	26.8	6.5	37.9	10.5
	⇒ non-emp	302	68.8	31.1	40.1	31.8	28.1	43.8	96.7	3.3	78.5	21.5	9.9	12.7	10.6	40.4	26.4
IIINM	⇒ I/II	608	80.4	19.6	45.7	39.8	14.5	42.0	96.9	3.1	72.5	27.5	7.7	40.9	11.0	31.3	9.1
	⇒ IIINM	5339	79.3	20.7	40.5	38.8	20.7	43.3	97.7	2.3	75.8	24.2	14.7	40.1	12.0	30.3	2.9
	⇒ IIIM	105	77.1	22.9	37.1	42.9	20.0	43.1	98.1	1.9	77.1	22.9	16.5	28.2	14.5	35.9	4.8
	⇒ IV/V	225	75.6	24.4	43.1	38.7	18.2	42.5	96.4	3.6	77.7	22.3	30.9	33.6	10.0	22.3	3.2
	⇒ non-emp	382	68.1	31.9	46.1	27.8	26.2	43.1	96.9	3.1	76.7	23.3	20.6	37.6	10.0	26.5	5.3
III M	⇒ I/II	147	74.2	25.8	42.2	36.0	21.8	43.0	97.3	2.7	65.3	34.7	20.0	21.4	11.7	42.1	4.8
	⇒ IIINM	122	79.5	20.5	44.3	41.0	14.7	42.2	100.0	0.0	63.1	36.9	18.3	29.2	13.3	37.5	1.7
	⇒ III M	998	72.9	27.1	37.5	40.4	22.1	43.5	95.7	4.3	69.2	30.8	26.9	25.7	10.6	34.7	2.0
	⇒ IV/V	224	79.5	20.5	36.6	40.6	22.8	43.9	91.8	8.2	73.5	26.5	37.9	29.4	6.1	25.2	1.4
	⇒ non-emp	109	60.6	39.4	39.4	36.7	23.9	43.3	97.2	2.8	67.9	32.1	38.5	30.8	12.5	16.4	1.9
IV/V	⇒ I/II	181	74.0	26.0	49.2	36.5	14.3	41.5	95.6	4.4	69.1	30.9	16.2	24.6	9.5	36.9	12.8
	⇒ IIINM	225	72.4	27.6	44.9	39.6	15.5	42.1	96.0	4.0	77.3	22.7	28.7	35.9	8.5	23.3	3.6
	⇒ IIIM	277	71.8	28.2	41.5	37.9	20.6	43.1	92.7	7.3	75.8	24.2	37.1	28.1	6.7	27.3	0.8
	⇒ IV/V	2602	75.6	24.4	37.9	37.4	24.7	43.9	95.6	4.4	76.1	23.9	44.5	26.1	5.1	23.0	1.3
	⇒ non-emp	369	63.4	36.6	45.8	27.6	26.6	43.1	95.7	4.3	69.7	30.3	46.1	26.0	3.6	22.9	1.4
non-emp	⇒ I/II	185	74.6	25.4	49.7	34.6	15.7	41.8	94.6	5.4	74.1	25.9	10.4	18.6	9.3	36.6	25.1
	⇒ IIINM	365	73.4	26.6	61.4	27.1	11.5	39.9	97.3	2.7	72.6	27.4	17.6	34.4	13.4	27.9	6.7
	⇒ III M	81	59.3	40.7	53.1	38.3	8.6	40.9	96.3	3.7	66.7	33.3	30.4	34.2	12.7	20.3	2.5
	⇒ IV/V	400	67.8	32.2	57.3	26.0	16.7	40.9	96.0	4.0	69.5	30.5	37.8	29.7	6.4	23.3	2.8
	⇒ non-emp	5764	53.0	47.0	34.6	30.6	33.0	45.3	94.0	6.0	71.9	28.1	40.2	25.3	5.7	23.5	5.3

* Health, age, ethnicity, marital status, education attainment are measured in year *t*-1, while transitions are measured across year *t*-1 and year *t*. † Based on own occupation which are professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), partially skilled and unskilled (IV/V), and non-emp (non-employed). ‡ No qualification (I), GCE O levels or less (II), GCE A levels(III), Vocational qualification(IV), and Higher degree (V). Note; In a given class of origin, stable group is marked with shade in the table.

Table 5-4 presents the socio-demographic distribution for the 25 transitions among women. Most of the downward groups had a higher proportion in poor health in previous year compared to stable groups, while upward groups had a lower proportion, except for transitions from classes IV/V. For instance, the proportion in poor health falls from 27.1% among those who stay in class III M, to 20.5% among those who are upwardly mobile to class III NM.

For most transitions, the risks of experiencing downward mobility are greater among the less advantaged across the indicators, as the proportions of poor health, poor education, and old age increase relative to SEP origin. The increase in downward risk occurs in women over the age of 50. For ethnicity, being the non-white increases the risk of becoming classes IV/V from every class of origin but not the risk of becoming non-employed. The same pattern is also true for marital status. Regarding education, higher education is even more effective in maintaining high class status in women than it is for men, particularly in classes I/II. Interestingly, the circulation between classes I/II and the non-employed is likely to be mediated by higher education. The highly educated (V) differ remarkably from the less educated in the process of exit from classes I/II to the non-employed (26.4%) and entry from non-employed to classes I/II (25.1%).

5.4.4 Mobility table with and without poor health

The following table describes overall patterns of mobility in relation to health.

Table 5-5 Annual transition rate (row percentage) between social classes[†] and the non-employed over year *t*-1 and year *t* with regard to health status[‡] across 13 waves of the BHPS among men (N = 25611)

Social class in year *t*-1	Social class in year t					
	I/II	III NM	III M	IV/V	Non-employed	Total transitions
Those with good health						
I/II	7352(88.2)	343(4.1)	299(3.6)	130(1.6)	209(2.5)	8333(43.1)
III NM	403(21.8)	1230(66.7)	90(4.9)	69(3.7)	53(2.9)	1845(9.6)
III M	333(6.4)	87(1.7)	4275(81.8)	360(6.9)	173(3.3)	5228(27.1)
IV/V	105(5.0)	79(3.8)	390(18.7)	1419(67.9)	97(4.6)	2090(10.8)
Non-employed	114(6.2)	52(2.9)	113(6.2)	100(5.5)	1448(79.3)	1827(9.5)
Total	8307(43.0)	1791(9.3)	5167(26.7)	2078(10.8)	1980(10.2)	19323(100.0)
Those with poor health						
I/II	1280(83.7)	72(4.7)	66(4.3)	32(2.1)	79(5.2)	1529(24.3)
III NM	69(16.1)	289(67.4)	32(7.5)	18(4.2)	21(4.9)	429(6.8)
III M	75(5.4)	33(2.4)	1076(77.1)	121(8.7)	91(6.5)	1396(22.2)
IV/V	30(4.2)	18(2.5)	106(14.9)	488(68.4)	71(10.0)	713(11.3)
Non-employed	37(1.7)	16(0.7)	48(2.2)	65(2.9)	2055(92.5)	2221(35.3)
Total	1491(23.7)	428(6.8)	1328(21.1)	724(11.5)	2317(36.9)	6288(100.0)

[†] Based on own occupation which are professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), partially skilled and unskilled (IV/V), and non-employed.
[‡] Health status in year *t*-1

Out of 25611 transitions among men, the risk of transitions from every class is calculated in row probability. The table can be divided into three sections representing stable (cells on matrix diagonal), downward (cells above diagonal), and upward (cells below diagonal) groups. As presented in the diagonal section, the majority of individuals remained in the same SEP; this figure is 66.7% to 88.2% among the healthy (upper panel) and 67.4% to 92.5% among the unhealthy (lower panel). In the comparison between those with and without poor health, the people who have poor health tend to be more downwardly mobile and less upwardly mobile with one exceptional transition (social class IIIM to social class IIINM). This tendency has been consistently observed throughout all transitions. For example, among those in social class III NM who were healthy in year *t*-1, the probability of downward transition to social class III M in year *t* is 4.9%, compared to 7.5% of those who are unhealthy in year *t*-1.

Table 5-6 Annual transition rate (row percentage) between social classes[†] and the non-employed over year *t*-1 and year *t* with regard to health status[‡] across 13 waves of the BHPS among women (N=25877)

Social class in year *t*-1	Social class in year t					
	I/II	III NM	III M	IV/V	Non-employed	Total transitions
Those with good health						
I/II	4962(86.3)	384(6.7)	82(1.4)	116(2.0)	208(3.6)	5752(30.9)
III NM	489(9.4)	4232(80.9)	81(1.5)	170(3.3)	260(5.0)	5232(28.1)
III M	109(9.2)	97(8.2)	728(61.8)	178(15.1)	66(5.6)	1178(6.3)
IV/V	134(5.0)	163(6.0)	199(7.4)	1967(72.9)	234(8.7)	2697(14.5)
Non-employed	138(3.7)	268(7.1)	48(1.3)	271(7.2)	3056(80.8)	3781(20.3)
Total	5832(31.3)	5144(27.6)	1138(6.1)	2702(14.5)	3824(20.5)	18640(100.0)
Those with poor health						
I/II	1136(80.2)	120(8.5)	27(1.9)	40(2.8)	94(6.6)	1417(19.6)
III NM	119(8.3)	1107(77.6)	24(1.7)	55(3.9)	122(8.5)	1427(19.7)
III M	38(9.0)	25(5.9)	270(64.0)	46(10.9)	43(10.2)	422(5.8)
IV/V	47(4.9)	62(6.5)	78(8.2)	635(66.3)	135(14.1)	957(13.2)
Non-employed	47(1.6)	97(3.2)	33(1.1)	129(4.3)	2708(89.9)	3014(41.7)
Total	1387(19.2)	1411(19.5)	432(6.0)	905(12.5)	3102(42.9)	7237(100.0)

[†] Based on own occupation which are professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), partially skilled and unskilled (IV/V), and non-employed.
[‡] Health status in year *t*-1

In general, table 5-6 shows that the chance of downward transition from one year to the next is greater among women who had been in poor health in the previous year than those among those who had good health. On the other hand, those who did not report poor health are more likely to be found in upward transition besides one transition from social classes IV/V to social class III NM. Generally, women are more mobile than men, particularly in the transition into/out of the non-employed.

5.4.5 The multilevel multinomial model

The multilevel multinomial model is used for estimating the risk of transition from four classes of origin and the non-employed. A total of 20 possible transitions with four transitions per origin (five separated models with regard to each origin) are illustrated in the following tables. For each model, estimates are categorized into fixed and random effects. Fixed parts are the effects of the covariates, whereas random effects are variances which represent individual level variability. The results of fitting the multilevel multinomial model have been described separately for men and women in table 5-7 and table 5-8.

Table 5-7 The estimated odds ratio and 95% confidence interval[a] from two mutilevel multinomial models[b] with transitions from every class having repeated measurements in men

			Model I		Model II[c]							
			Fixed effect	Random effect	Fixed effect							Random effect[e]
			Poor health vs		Poor health vs	Age		Education[d]				
		N[f]	good health	Variance	good health	40s vs 30s	50s vs 30s	I vs V	II vs V	III vs V	IV vs V	Variance
I/II	⇒ III NM	9862	1.17[0.86, 1.57]	1.60(0.09)‡	1.13[0.84, 1.53]	1.05[0.73, 1.5]	2.14[1.27, 3.62]‡	4.39[2.47, 7.81]‡	5.96[3.93, 9.01]‡	3.07[1.94, 4.86]‡	2.43[1.7, 3.46]‡	1.46(0.08)‡
	⇒ III M		1.23[0.90, 1.69]		1.13[0.82, 1.55]	0.65[0.44, 0.96]†	1.25[0.71, 2.21]	21.8[11.7, 40.6]‡	15.7[9.36, 26.5]‡	6.79[3.82, 12.0]‡	7.16[4.48, 11.4]‡	
	⇒ IV/V		1.26[0.81, 1.95]		1.18[0.76, 1.82]	0.78[0.45, 1.35]	1.57[0.72, 3.4]	17.3[7.04, 42.6]‡	22.1[10.4, 46.6]‡	9.22[4.07, 20.8]‡	8.43[4.17, 17.0]‡	
	⇒ non-emp[g]		2.13[1.57, 2.89]‡		2.19[1.60, 2.99]‡	0.95[0.58, 1.56]	2.32[1.24, 4.35]‡	1.87[0.96, 3.62]*	2.72[1.6, 4.62]‡	2.81[1.68, 4.7]‡	1.91[1.27, 2.86]‡	
III NM	⇒ I/II	2274	0.77[0.51, 1.16]	2.06(0.15)‡	0.79[0.51, 1.22]	1.24[0.7, 2.2]	0.78[0.32, 1.9]	0.2[0.07, 0.56]‡	0.23[0.1, 0.51]‡	0.18[0.07, 0.43]‡	0.34[0.16, 0.72]‡	2.13(0.16)‡
	⇒ III M		1.73[1.03, 2.89]†		1.55[0.9, 2.65]*	0.88[0.36, 2.15]	0.28[0.07, 1.05]	1.91[0.6, 6.11]	1.22[0.46, 3.29]	0.44[0.14, 1.37]	0.87[0.34, 2.21]	
	⇒ IV/V		1.27[0.69, 2.33]		1.07[0.56, 2.04]	1.16[0.45, 3.04]	0.82[0.22, 3.09]	1.55[0.4, 5.96]	1.08[0.34, 3.42]	0.38[0.11, 1.33]	0.56[0.18, 1.69]	
	⇒ non-emp		1.87[1.03, 3.41]†		1.87[0.98, 3.56]*	0.99[0.28, 3.56]	1.01[0.21, 5.0]	0.38[0.11, 1.35]	0.23[0.08, 0.71]‡	0.29[0.09, 0.93]†	0.35[0.13, 0.96]†	
III M	⇒ I/II	6624	0.93[0.69, 1.25]	1.51(0.09)‡	0.9[0.66, 1.21]	0.91[0.61, 1.36]	1.00[0.52, 1.93]	0.04[0.02, 0.09]‡	0.05[0.02, 0.12]‡	0.05[0.02, 0.13]‡	0.1[0.04, 0.22]‡	1.49(0.09)‡
	⇒ III NM		1.49[0.95, 2.32]*		1.48[0.95, 2.32]*	0.56[0.26, 1.18]	0.62[0.21, 1.84]	0.19[0.05, 0.79]‡	0.17[0.04, 0.68]‡	0.19[0.04, 0.79]‡	0.19[0.05, 0.77]‡	
	⇒ IV/V		1.37[1.05, 1.77]†		1.35[1.04, 1.75]†	1.08[0.74, 1.57]	1.33[0.73, 2.4]	0.62[0.2, 1.95]	0.44[0.14, 1.39]	0.35[0.11, 1.14]	0.39[0.13, 1.23]	
	⇒ non-emp		2.07[1.53, 2.80]‡		1.95[1.43, 2.65]‡	0.47[0.26, 0.85]‡	0.99[0.43, 2.28]	0.67[0.14, 3.31]	0.44[0.09, 2.17]	0.5[0.1, 2.58]	0.59[0.12, 2.92]	
IV/V	⇒ I/II	2803	0.86[0.53, 1.37]	1.49(0.11)‡	0.93[0.57, 1.52]	0.56[0.3, 1.07]*	0.52[0.18, 1.5]	0.13[0.03, 0.49]‡	0.3[0.08, 1.18]	0.78[0.18, 3.27]	0.58[0.15, 2.17]	1.51(0.13)‡
	⇒ III NM		0.72[0.42, 1.27]		0.76[0.43, 1.36]	0.95[0.4, 2.27]	0.63[0.18, 2.22]	0.14[0.03, 0.59]‡	0.43[0.1, 1.77]	0.92[0.2, 4.27]	0.51[0.11, 2.33]	
	⇒ III M		0.85[0.62, 1.15]		0.86[0.63, 1.17]	0.71[0.46, 1.1]*	0.44[0.22, 0.9]†	0.98[0.3, 3.16]	1.3[0.4, 4.22]	2.23[0.64, 7.77]	1.57[0.49, 5.04]	
	⇒ non-emp		2.42[1.65, 3.54]‡		2.35[1.57, 3.51]‡	0.69[0.35, 1.35]	0.68[0.24, 1.96]	0.66[0.13, 3.32]	0.27[0.05, 1.49]	0.92[0.16, 5.26]	0.59[0.11, 3.02]	
Non-emp	⇒ I/II	4048	0.21[0.13, 0.35]‡	2.87(0.23)‡	0.24[0.14, 0.4]‡	1.29[0.48, 3.48]	0.6[0.14, 2.47]	0.03[0.01, 0.08]‡	0.14[0.05, 0.38]‡	0.27[0.09, 0.78]‡	0.34[0.14, 0.85]‡	2.13(0.17)‡
	⇒ III NM		0.20[0.11, 0.39]‡		0.22[0.11, 0.45]‡	1.15[0.26, 5.11]	0.65[0.09, 4.85]	0.04[0.01, 0.14]‡	0.55[0.17, 1.71]	0.47[0.13, 1.65]	0.41[0.14, 1.21]	
	⇒ III M		0.29[0.18, 0.47]‡		0.27[0.17, 0.43]‡	0.79[0.32, 1.92]	0.81[0.23, 2.86]	1.12[0.33, 3.72]	2.62[0.76, 9.01]	1.96[0.5, 7.65]	3.42[1.04, 11.2]†	
	⇒ IV/V		0.47[0.30, 0.73]‡		0.44[0.28, 0.7]‡	0.61[0.24, 1.57]	0.38[0.09, 1.64]	0.72[0.23, 2.25]	1.04[0.31, 3.45]	0.95[0.25, 3.52]	1.23[0.39, 3.93]	

a. For variance, coefficients (standard error) are given. b. Model I fits only with health variable, while model II fits along with other covariates.
c. Model II is adjusted for period and cohort effects as well as covariates listed in the table. d. No qualification (I), GCE O levels or less (II), GCE A levels (III), Vocational qualification (IV), and Higher degree (V). e. The variance of random intercepts represents the variability across individuals. The random effect appears once a model, as a common single random effect is assumed.
f. N denotes observations for each origin. g. non-emp means non-employed status.
*Statistically significant <0.1, †Statistically significant <0.05, ‡Statistically significant <0.01

Table 5-7 shows the estimated impact of health and other covariates on subsequent transitions. Using the stable group as a reference category, the effects of predictors on every transition are estimated. Once again, the difference between model I and model II only denotes that covariates are included in the latter model. Fitting the data in multilevel scheme finds that the health variable demonstrates little influence on social mobility for transitions inside employment (e.g., between classes). The parameters from the fixed parts mostly show insignificance. To illustrate, only 3 out of 12 coefficients regarding transitions between classes are statistically significant at a relaxed p=0.1 level.

However, all relevant coefficients demonstrate that the effects of health appear to be significant when transitions moving into/out of employment are considered. For instance, if anyone had poor health, the probability of moving from classes IV/V to the non-employed is significantly higher than the probability of staying in classes IV/V in successive years (OR = 2.35). For transitions from the non-employed, a lower OR compared with the groups staying in non-employed implies that poor health lowers the probability of transitions from the non-employed to employment. Without doubt, the least selective entry to the labour force for the non-employed with poor health is a transition to classes IV/V (OR = 0.44).

These relationships persist even after controlling for covariates (model II). The adjustment of education, age, period, cohort effects brings a minimal decrease in the OR, and statistical significance remains to the same degree. This indicates an independent effect of health on transition into/out of employment. It is suggested that a factor that is influential for one transition may be less influential for another. The attainment of educational level remains strongly predictive of leaving and entering classes I/II. However, for other classes, in particular manual classes such as class III M and classes IV/V, academic success is not a meaningful indicator. For the effect of age, all transitions into/out of the non-employed appear to be significant in a similar way to health. Age seems to take a role in the movements into/out of employment when education appears to bear little importance.

Fitting a mixed effect model yields the parameter estimates for random parts. The random effects (level 2 residual) describe whether individual-level variability explains some of the variance in transition. For example, for class III M, random effects are distributed with a variance of 1.49 (standard error 0.09), implying individual-level difference is significantly associated with all transitions from class III M.

The following table shows the effects of health and other covariates on subsequent social mobility using a multilevel framework for women.

Table 5-8 The estimated odds ratio and 95% confidence interval[a] from two mutilevel multinomial models[b] with transitions from every class having repeated measurements in women

			Model I		Model II[c]							
			Fixed effect	Random effect	Fixed effect							Random effect[e]
			Poor health vs		Poor health vs	Age		Education[d]				
		N[f]	good health	Variance	good health	40s vs 30s	50s vs 30s	I vs V	II vs V	III vs V	IV vs V	Variance
I/II	⇒ III NM	7169	1.60[1.21, 2.10]‡	2.00(0.11)‡	1.65[1.25, 2.16]‡	1.0[0.68, 1.46]	1.15[0.63, 2.09]	18.14[9.9, 33.2]‡	29.1[18.6, 45.5]‡	10.9[6.33, 18 8]‡	5.13[3.43, 7.69]‡	1.66(0.08)‡
	⇒ III M		1.68[1.04, 2.71]†		1.18[0.73, 1.88]	0.56[0.25, 1.27]	0.74[0.24, 2.32]	14.8[7.04, 31.3]‡	4.18[2.2, 7.93]‡	5.03[2.44, 10.3]‡	2.26[1.37, 3.72]‡	
	⇒ IV/V		1.75[1.16, 2.62]‡		1.43[0.96, 2.14]*	1.51[0.87, 2.64]	2.54[1.03, 6.27]†	19.0[9.51, 38.2]‡	7.92[4.6, 13.6]‡	2.76[1.27, 6.01]‡	2.48[1.55, 3.98]‡	
	⇒ non-emp[g]		2.20[1.62, 3.00]‡		2.36[1.74, 3.2]‡	0.95[0.59, 1.53]	1.82[0.87, 3.83]	5.39[2.84, 10.2]‡	3.37[1.99, 5.73]‡	4.64[2.58, 8.36]‡	2.34[1.54, 3.56]‡	
III NM	⇒ I/II	6659	0.97[0.76, 1.23]	1.20(0.07)‡	0.98[0.76, 1.25]	1.5[1.09, 2.05]†	1.55[0.97, 2.47]*	0.17[0.09, 0.29]‡	0.26[0.16, 0.41]‡	0.21[0.12, 0.37]‡	0.27[0.17, 0.44]‡	1.20(0.08)‡
	⇒ III M		1.21[0.75, 1.96]		1.17[0.73, 1.89]	1.15[0.59, 2.25]	1.25[0.5, 3.11]	0.61[0.2, 1.81]	0.33[0.12, 0.93]†	0.53[0.18, 1.59]	0.58[0.21, 1.59]	
	⇒ IV/V		1.30[0.93, 1.82]		1.23[0.88, 1.73]	1.08[0.68, 1.73]	1.31[0.67, 2.54]	1.95[0.8, 4.75]	0.6[0.25, 1.42]	0.56[0.22, 1.45]	0.57[0.24, 1.37]	
	⇒ non-emp		1.88[1.46, 2.43]‡		1.89[1.47, 2.45]‡	0.59[0.4, 0.87]†	0.97[0.57, 1.64]	0.65[0.34, 1.25]	0.4[0.22, 0.73]‡	0.36[0.18, 0.72]‡	0.41[0.22, 0.76]‡	
III M	⇒ I/II	1600	1.00[0.63, 1.59]	1.38(0.13)‡	1.03[0.65, 1.64]	0.83[0.38, 1.83]	0.83[0.27, 2.63]	0.17[0.04, 0.67]†	0.22[0.05, 0.87]†	0.3[0.07, 1.32]	0.29[0.07, 1.11]*	1.38(0.13)‡
	⇒ III NM		0.73[0.43, 1.23]		0.75[0.44, 1.26]	0.71[0.32, 1.56]	0.39[0.12, 1.32]	0.44[0.07, 2.79]	0.82[0.14, 5.01]	0.99[0.15, 6.46]	0.69[0.11, 4.13]	
	⇒ IV/V		0.74[0.48, 1.13]		0.73[0.47, 1.13]	1.03[0.53, 2.0]	1.12[0.41, 3.05]	1.13[0.22, 5.68]	1.09[0.22, 5.46]	0.59[0.11, 3.29]	0.61[0.12, 3.02]	
	⇒ non-emp		1.91[1.19, 3.06]‡		1.92[1.18, 3.12]‡	0.73[0.29, 1.8]	0.82[0.22, 3.0]	0.84[0.13, 5.22]	0.76[0.12, 4.72]	0.78[0.12, 5.23]	0.28[0.04, 1.78]	
IV/V	⇒ I/II	3654	1.10[0.75, 1.60]	1.36(0.09)‡	1.21[0.82, 1.78]	1.58[0.85, 2.93]	1.76[0.65, 4.81]	0.04[0.02, 0.1]‡	0.1[0.04, 0.21]‡	0.18[0.07, 0.46]‡	0.17[0.08, 0.38]‡	1.33(0.12)‡
	⇒ III NM		1.17[0.83, 1.64]		1.2[0.85, 1.7]	1.52[0.87, 2.66]	1.47[0.57, 3.75]	0.23[0.09, 0.57]‡	0.5[0.21, 1.2]	0.5[0.18, 1.38]	0.36[0.15, 0.87]†	
	⇒ III M		1.21[0.88, 1.67]		1.18[0.85, 1.62]	1.09[0.66, 1.8]	0.68[0.3, 1.55]	0.43[0.17, 1.05]*	0.59[0.24, 1.43]	0.63[0.23, 1.75]	0.64[0.26, 1.54]	
	⇒ non-emp		1.84[1.40, 2.42]‡		1.84[1.39, 2.44]‡	0.64[0.39, 1.06]*	1.01[0.48, 2.12]	0.62[0.27, 1.47]	0.63[0.27, 1.45]	0.4[0.15, 1.12]	0.64[0.28, 1.49]	
Non-emp	⇒ I/II	6795	0.33[0.23, 0.48]‡	1.64(0.10)‡	0.47[0.32, 0.69]	1.33[0.77, 2.3]	0.88[0.36, 2.17]	0.09[0.04, 0.18]‡	0.21[0.11, 0.39]‡	0.55[0.25, 1.18]	0.62[0.35, 1.1]*	1.43(0.08)‡
	⇒ III NM		0.36[0.28, 0.48]‡		0.49[0.3, 0.75]	0.72[0.45, 1.13]	0.36[0.17, 0.74]‡	0.6[0.33, 1.09]*	1.22[0.7, 2.13]	2.51[1.3, 4.84]‡	1.62[0.93, 2.84]*	
	⇒ III M		0.73[0.46, 1.18]		0.66[0.42, 1.03]*	0.6[0.29, 1.24]	0.12[0.03, 0.43]‡	0.21[0.1, 0.42]‡	0.24[0.12, 0.47]‡	0.45[0.18, 1.11]	0.23[0.11, 0.49]‡	
	⇒ IV/V		0.49[0.38, 0.64]‡		0.52[0.4, 0.68]‡	0.95[0.61, 1.47]	0.75[0.38, 1.48]	1.54[0.88, 2.7]	1.24[0.71, 2.16]	1.41[0.69, 2.89]	1.62[0.92, 2.85]*	

a. For variance, coefficients (standard error) are given. b. Model I fits only with health variable, while model II fits along with other covariates.
c. Model II is adjusted for period and cohort effects as well as covariates listed in the table. d. No qualification (I), GCE O levels or less (II), GCE A levels (III), Vocational qualification (IV), and Higher degree (V). e. The variance of random intercepts represents the variability across individuals. The random effect appears once a model, as a common single random effect is assumed.
f. N denotes observations for each origin. g. non-emp means non-employed status.
*Statistically significant <0.1, †Statistically significant <0.05, ‡Statistically significant <0.01

The risks of transition experienced by women are shown in table 5-8. Fixed parts provide the OR for a comparison of the two models. Very few health effects in 2 out of 12 transitions between classes are statistically significant at a p=0.1 level. Among the four class of origins, transitions from classes I/II are more likely to be influenced by poor health (OR=1.65 for transition to class III NM, OR=1.43 for transition to classes IV/V), which was not the case for men.

Health status is associated with all transitions into/out of the non-employed, with the only exception seen in the transition from the non-employed to class III M. Classes I/II in relation to the non-employed is revealed to be the most health selective, both at the entry with the lowest OR (= 0.47) and at the exit stage with the highest OR (= 2.36).

The OR for poor health versus good health in model II is slightly lower than that in model I after adjusting covariates. The effects of covariates in model II show pronounced variations across different types of transition. For instance, educational attainment presents a greater protective effect against downward mobility from the high class, in particular classes I/II, and the significant effect of education for moving upward to classes I/II is also clear. However, the effect of age is mainly concerned with transitions from the non-employed; as people get older, there is a higher risk (negative coefficients) of becoming non-employed.

Random intercept terms (variance between individuals) in all transitions are significant with a large variance but a small standard error. This result seems to provide considerable evidence that between-individual variability is apparent for every transition.

5.5 Discussion

5.5.1 Main findings

Using a multilevel multinomial approach on the basis of 25 transitions, the presence of health selection between classes and into/out of employment was concurrently tested and compared. By looking at the effect of previous health status in year *t*-1 on subsequent transitions between year *t*-1 and year *t* among the over 30s, this study set out to examine the effect of health selection. In the descriptive analysis, poor health was consistently associated with moving downward, while the outcome was inverse for upward movement. After accounting for the data structure using multilevel analysis, health was a predictor for social mobility when leaving and entering employment, but the effect was minimal for transitions between classes for both men and women. This weak sign of health-related intragenerational mobility between classes is broadly opposite to the findings of some studies [Manor *et al*, 2003; Power *et al*, 1996; Lundberg, 1991; Power *et al*, 1986], although consistent with others [Cardano *et al*, 2004; Chandola *et al*, 2003a].

It seems that predictors for social mobility entered in the model have specific roles of their own, and their effect is more concentrated among specific transitions. For example, health and age were likely to be substantial in moving into/out of the labour force, whereas education was a relevant predictor for mobility into/out of upper classes, in particular, classes I/II. This model has been framed as a mixed model holding a random effect with repeated measures at level 1 and individuals at level 2. Since all individual-level variances were large enough relative to their standard error, it seems clear that there is significant variability between individuals.

5.5.2 Different presentations of health selection

By containing both populations from the employed and the non-employed, this analysis was able to test a more comprehensive range of health selection at different moments simultaneously. It was found that health selection between classes is unlikely to be significant, while health selection out of and into employment is likely to be significant, as observed in previous studies [Elstad and Krokstad, 2003; van de

Mheen *et al*, 1999; Lundberg, 1991].

One possible explanation for this outcome could be that, when coping with poor health, unhealthy individuals would rather remove themselves from employment instead of moving down through a job change [van de Mheen *et al*, 1999]. This implies that people with poor health make a decision based on economic reasons, as well as health reasons. If so, two health selection processes (i.e., health selection between social classes and health selection between employment and non-employment) are interdependent (hypothesis 4) in the sense that the favourableness of social policy may enhance a dominant orientation of health selection [Lundberg, 1991].

This explanation may be relevant to UK social policy. Welfare policy may allow workers with poor health leave employment, with the prospect of improving their health and securing a job in the meantime. In the UK, those with poor health showed higher rates of economic inactivity and lower rates of the labour market participation compared to the US [Sacker *et al*, 2007]. Negligible manifestations of health selection between classes may be related to the positive sign that social protection or working conditions may buffer the impact of poor health. This may imply that, despite poor health, workers usually sustain their position within employment or undergo an occupational shift, which does not necessarily result in class mobility.

If we treat this finding in a negative way, however, those with poor health are driven to exit from employment due to the lack of support within employment, or a skewed benefit system may distribute them disproportionately toward the non-employed[10]. If this is the case, then the negligible health selection between classes could mirror the strong health selection into/out of employment. In the current thesis, a hypothesis was proposed that these two health selection processes may be related to each other (hypothesis 4). In this regard, West provides an insightful comment when he said that

[10] In the UK, a few studies reported that the link between ill-health and early retirement is activated by the benefit system [Haardt, 2006; Disney *et al*, 2006]. This trend was reported to continue even after Invalidity Benefit was replaced by Incapacity Benefit in 1995 which was expected to reduce the rate of retirement via the disability route [Disney *et al*, 2006].

'the selection is likely to be stronger when out of employment and therefore does not distinctively feature the economically active population' [West, 1991]. Based on similar ideas, the current study suggests that one health selection relies on the other, and this should be seen from the whole population of the labour force. Further detail of the relationship between two health selection processes are left to explore in a future study, and a related issue (the relationship between healthy worker effect and class inequalities in health) is discussed in section 8.6.2.

5.5.3 Differential health selection according to SEP

It was tested whether the mediating role of health in the mobility process varies in its importance according to initial socioeconomic position (differential selection, hypothesis 3). The present study found that manual occupations, particularly classes IV/V, were vulnerable to health selection. Those with poor health easily lose employment, and this was particularly prominent among workers in classes IV/V. Those with poor health are less likely to return to employment, but classes IV/V were most able to absorb them. This finding is similar to other studies [Holland *et al*, 2006; Dahl, 1996]; When leaving employment, manual classes with poor health are more closely linked to the chances of being non-employed than those with poor health from other classes. However, at the same time, the non-employed are more likely to find employment in manual occupations.

This may be due to the work characteristic of the occupation in classes IV/V, which is less flexible in accommodating those who are less physically fit, whilst the high turnover in this occupation provides a greater chance for the non-employed to be employed as long as they are able to cope with the strain from the physical demand. This point has been described in previous studies: '…in factories and on assembly lines the pace of work is often non-negotiable. People employed in these contexts may have no other choice but to leave their employment if they develop a musculoskeletal disorder' [Holland *et al*, 2006].

Disproportionate health selection during the exit from and entry into employment also suggests that poor health may play a substantial role in the vicious circulation between the manual class and the non-employed as seen elsewhere [Cappellari and Jenkins, 2003; Bradley *et al*, 2003; Diderichsen *et al*, 2001, p18]. Moreover, there were suggestions that those who were trapped in such a vicious cycle gradually experienced transits to ‘physically light occupation’ [Rahkonen *et al*, 1993; Östlin P, 1988], but in-depth evidence on the job shift within manual occupation is not yet available.

5.5.4 Strengths and limitations

One strength of this study is the comprehensive nature of the sample, which includes both the employed and the non-employed. To date, health selection between occupational classes, and into/out of employment has usually been studied separately [Manor *et al*, 2003; Chandola *et al*, 2003a; Power *et al*, 1996; Power *et al*, 1986; Wadsworth, 1986; Illsley, 1955]. However, because the non-employed are not a demarcated population, it might be appropriate to consider them as a continuous status of the labour force when tracing a longitudinal tract. The present study expands the scope by treating non-employment as a separate stratum. It was previously suggested that only including employed people might lead to an underestimation of the real impact of health selection on social mobility [Dahl, 1993a]. Therefore, a study on social mobility and its relation to health might provide a better picture when investigating populations drawn from both inside and outside employment.

The other strength is related to the potential of multilevel multinomial modelling. The multilevel multinomial model makes it possible to preserve every mobility route and to test each route individually, instead of simplifying it. Owing to this advantage, the differential effect of health was detailed. It was found that health may raise the risk of transitions leaving and entering employment, which is not true for other transitions between social classes. If the effects of health on social mobility vary across every transition, a more complicated model to clarify the process might be inevitable.

One limitation is associated with the fact that this study design is less able to detect social mobility because it covers only one year transition. On the other hand, considerable intragenerational mobility was observed in the other study setting where social mobility was defined based on the longer term [Manor *et al*, 2003]. When mobility period was ranged over a ten year period between age 23 and 33, the stable rate was 57% for men and 60% for women in contrast to the current study where the total stable rate amounted to about 80% for both sexes. This difference is partly due to the age difference between two samples, because the younger cohort tends to experience more transitions. The short mobility period may less reflect social mobility [Dickens, 2000; Jarvis and Jenkins, 1998], if social mobility is the slow process. Generally, this study needs to be supplemented with another setting to cover the longer term period. More general evaluation of the current multilevel modelling is provided in Section 9.5.

Chapter 6: Health selection and income mobility

6.1 Introduction

In Chapter 5, the characteristics of health selection were featured by social class. Previously, an appeal was made to the fact that class differentials are too big to reflect mobility by health selection [West, 1991]. Moreover, only a few job shifts necessarily move to another occupation [Kurz and Muller, 1987], and some workers with poor health may prefer different jobs within the same occupation, which might not be sensed by class mobility. In addition, class structure has not been constant over decades. For example, the working class today is basically different from that in a century ago. Therefore, to take account of the socioeconomic consequences led by health, class measures need to be complemented by other indicators, and income measures could help to capture the change. Thus, this chapter examines the impact of health on subsequent income mobility.

It is necessary to recognise that the main focus of this chapter lies in the presence of health selection (type I study), that is the influence of preceding health on the subsequent income loss. In this framework, only one study [Thiede and Traub, 1997] was found to have examined the health selection hypothesis. Therefore, in this review, numerous studies are drawn from various disciplines, including health economic literature as long as they follow a causal direction from health to income. On the contrary, health selection studies [Benzeval and Judge, 2001; McDonough *et al*, 1997] in another framework (i.e., the contribution of health selection to social inequalities in health, type II study) are not reviewed, although these studies used income measures. These studies are based on a common approach in which the effect of health selection was explored by controlling for initial health as an independent variable along with an income variable to explain later health. In section 2.3.2, this approach was already discussed.

6.2 Literature review

6.2.1 Poor health and economic outcomes

Adverse effects of poor health on economic consequences have been studied quite extensively, including large volume of studies from health economics [Currie and Madrian, 1999; Haveman *et al*, 1994; Grossman, 1972]. Despite the wide scope and complexity of this topic, studies reviewed here are common in a framework where the dependent variable is income and the causal direction is from health to income. Common findings support a deterioration of economic status such as labour participation [Kidd *et al*, 2000; Costa, 1996], annual earnings [Ettner *et al*, 1997; Mullahy and Sindelar, 1995], hours of works [Kessler and Frank, 1997], and wages [Baldwin and Jhonson, 1995; Haveman *et al*, 1994] after a poor health occurrence. If we narrow the focus to the change in income and wages, the reduction of these indicators due to the ill-health are observable with respect to various diseases and health conditions. These include occupational asthma [Leira *et al*, 2005], obesity [Finkelstein *et al*, 2005; Bhattacharya and Bundorf, 2005; Averett and Korenman, 1999], rheumatoid arthritis [Backman, 2004; Barrett *et al*, 2000], occupational injury [Boden, 2006; Boden and Galizzi, 1999], disability [Kidd *et al*, 2000], mental disorder [Salkever *et al*, 2007; Whooley *et al*, 2002; Ettner *et al*, 1997], diabetes [Mayfield *et al*, 1999], alcoholism [Mullahy and Sindelar, 1995], and AIDS/HIV [Rajaraman *et al*, 2006].

In contrast, relatively few studies [Bradley *et al*, 2002; Thieda and Traub, 1997] have reported that the effects of health on economic achievements are small. Bradley *et al* [2002] suggested another implication for economic activity of breast cancer survivors in the US. Overall, a negative association of breast cancer with labour participation (employment) was apparent. However, among those with breast cancer who engaged in the workforce, a positive relationship between breast cancer survivors and higher working hours and wages was found. One explanation given for this positive relationship was that health insurance coverage affects the labour market outcomes by providing women with breast cancer an incentive to remain employed [Bradley *et al*, 2002]. Using structural equation models, Thiede and Traub [1997] simultaneously estimated the strength of the influence of health on income change together with the influence of income change on health in Germany. They found a causal relation from income to health route but little evidence for the reverse causation concluding only 3% of the variance of income change was a consequence of illness. They interpreted this finding in relation to the social protection. As the authors themselves pointed, social assistance in Germany is provided for those with disabilities, and it is therefore expected that there might not be a strong income reduction.

Although there is ample evidence supporting the negative effect of poor health on income, most of health conditions have been identified relating to a specific disease. It was argued that the effect of health on income was more apparent when measuring health outcomes using a more objective measure with specific diseases [Manor *et al*, 2003], as the aforementioned examples. Few studies have been done to offer evidence for the impact of health based on self-assessed rating, and moreover, some evidence with self-assessed health measures showed relatively conflicting results. Using the PSID (Panel Study of Income Dynamics) from 1976 to 1983, Haveman *et al* [1994] investigated whether the presence of health problems in the prior period is associated with lower wages among 613 white males. Using simultaneous modelling, both wages and health status are reciprocally taken to be dependent and independent variables, respectively. They found prior self-assessed health has a strong association with wages.

In their regression modelling with instrumental variable estimation, Contoyannis and Rice [2001] considered the effect of self-assessed health on hourly wages as a proxy for labour productivity. Self-assessed health variables from six waves of the BHPS data were coded with three dummy variables (excellent, good, and fair) assigning poor and very poor as a reference group. Excellent and good health variables showed positive coefficients indicating that better health increased hourly wages. These features were more pronounced among women than among men. Using the first eight waves of ECHP (European Community Household Panel) from 1994 to 2001, Gambin [2004] compared the impacts of health on hourly wages across 14 European countries using three models: ordinary least-square (OLS), random effect model, and fixed effect model. Once again, self-assessed health variables were indicated by three dummy variables which were excellent, good, and fair, while poor and very poor categories were used as a reference. She found that the estimates of health variables from OLS and random effect models had positive coefficients in most countries, suggesting a important role of health in wage determination. However, for estimates generated by the fixed effect model, six countries (Austria, Belgium, Finland, Germany, Italy, and the Netherlands) showed minimal effects of health. Furthermore, for women, the effects of health were less pronounced, although there were signs for adverse effects of health in some countries.

Some limitations may lie in the previous work introduced above which assessed the impact of self-assessed health on income. The narrowness of the study sample, as it was composed of only white males may be pointed out as a shortcoming of Haveman's study. In the later study, however, this limitation was mostly overcome by achieving a more comprehensive sample, and they were able to provide more holistic view on gender difference.

A second limitation concerns the fact that the lack of adjustment for inflation over the study period in dealing with income measure. All three studies in this approach used panel data to take advantage of longitudinal information. Income data for each year had inflated year after year. Therefore, when analyzing income simultaneously over different years, a wage needs to be adjusted while considering annual inflation, but this adjustment was neglected in a study [Gambin, 2004].

A third limitation is common ground for all studies illustrated here. In the analysis using pooled data from panel survey, data are structured by multiple responses within an individual. This structure imposes a large dependency between responses for each individual so that more specific modelling is advocated. However, this recent advance has not been available for the early studies, and they were limited in fully treating the data structure with repeated measures.

A fourth limitation is that the relationship between health and income can be mutual. Although this is a serious issue in a cross-sectional design, another complexity in the causation can arise in a longitudinal dynamics between health and income. In the longitudinal setting, the relationship between health and income may reflect what occurred earlier before model specification. If people with poor health already started to receive a lower wage at a time outside the model, and if the relationship had been persistent since then, the model would have to be able to account for what settled before to obtain reliable estimates. In this regard, most studies which treat health and income measure with 'status', and not 'change' in status, are more vulnerable to this weakness. There is a clear difference between two measures because status can be strongly affected by events which took place earlier than the time in the model, whereas change in status represents new events inside the time plan of the model. For this reason, using status measures tend to overestimate a substantial influence of health on income [Benzeval and Judge, 2001]. The studies reviewed above were set up using status measures without adjusting earlier measures or instead of using change measures. Therefore, the estimation for the effect of health on income is less reliable and can risk bias. Thanks to recent methodological developments, the current study can deal with the above limitations effectively. Before describing details of how to approach these issues, it might be better to account for the concept of income mobility.

6.2.2 Income mobility

Intergenerational income mobility is defined, if one takes different position in the income distribution compared to that of one's parents, whereas intragenerational income mobility can be defined, if one possesses a different income status in the distribution at two different times. For example, if one's relative position was in the fifth quintile at one time, and if he/she is placed in the third quintile at a later time, one's income has been upwardly mobile.

Another important distinction in income mobility is that between absolute mobility and relative mobility. The term absolute income mobility is used to capture changes in an individual's real income. Relative income mobility, on the other hand, measures changes in an individual's relative income ranking within a population [Gittleman and Joyce, 1999; Fields and Ok, 1996]. Thus, a disproportionate increase in the income, for instance, between manual and non-manual workers may turn out to involve considerable mobility for both workers in terms of absolute mobility, even when the manual workers experience further down in a relative sense. The current thesis primarily focuses on relative income mobility across income distribution.

Each society is supposed to have its own degree of income mobility at a given time. The most preferred description of intergenerational income mobility is estimated based on a correlation coefficient (or regression coefficient) between parents' and children's income status generally in the form of logarithm [Solon, 1999]. This estimate shows an intergenerational association and the small estimate reflects that one's relative position is independent of that of one's parents. Thus, the estimate represents the degree of inequality in a society: the smaller the fairer [Solon, 1999; Shorroks, 1978]. Comparison studies showed that US and UK had lower mobility, with higher coefficient (around 0.4), compared to countries such as Canada, Sweden, Finland, and Germany, which showed more mobility with lower coefficient (around 0.2) [Blanden *et al*, 2005; Solon, 1999, pp1784-1787; Erikson and Goldthorpe, 2002]. The extent of income mobility in Britain has been surveyed in terms of both intergenerational and intragenerational mobility [Blanden *et al*, 2004; Dearden *et al*, 1997]. Intergenerational mobility appears to have fallen in the recent years [Blanden *et al*, 2004]. Blanden *et al* compared intergenerational income mobility using two British birth cohorts who grew up in a different period: National Child Development Study (1958 cohort) and British Cohort Survey (1970 cohort). By assessing children's economic status (at age 33 for the 1958 cohort and at age 30 for 1970 cohort) on that of their parents (parental income at age 16), he concluded there have been 'sharp falls' in intergenerational income mobility. This decline of mobility rate signifies that a son or daughter's relative position in the income distribution is dependent on that of their parent's, and the income status tends to become more inherit from one generation to another. A comprehensive review on intergenerational income mobility is available in Solon [1999].

Measuring mobility with intragenerational income transition is rare, and it recently received serious interest with increasing availability of longitudinal data [Dickens, 2000; Jarvis and Jenkins, 1998]. Using data from New Earnings Survey of 1975-94 and 1991-94 of the BHPS, Dickens [2000] showed that the level of income immobility from one year to the next is persistent at 48% of the bottom and 70% of the top in decile matrices. He compared the level of mobility in the 1970s and 1980s and he found some evidence that wage mobility fell over the periods. From this outcome, he concluded that immobility was large, and short-run mobility rates also had fallen since the 1970s in terms of intragenerational income mobility.

Another study presented an alternative view about the amount of mobility. Jarvis and Jenkins [1998] attempted to provide an answer as to the scale of income mobility in

Britain. In the single-wave comparison between one year and the next, they showed that 60% of people remain in the same quintile income band, and the wave-on-wave correlation coefficients were ranged from 0.56 to 0.69. This result was interpreted as indicative of a considerable amount of mobility. The disagreement over income mobility is attributed to the difference in analysis, measures, and data used for the estimation of mobility [Solon, 1999], and is also attributed to the fact that sparse evidence is available on intragenerational mobility [Dickens, 2000].

Income mobility study has taken two ways: 1) to make a direct comparison between two years wages with a continuous value, and 2) to use mobility matrix table after categorizing income [Blanden *et al*, 2004; Dickens, 2000; Solon, 1999; Dearden *et al*, 1997]. In the first approach, since the entire variation of actual income is retained, it has been a point of interest among economist. Mostly, Pearson correlation coefficients between income levels in successive waves and slope coefficients from a regression of wave t+1 income on wave t income have been used [Jarvis and Jenkins, 1998]. The closer a correlation or slope coefficient are to zero, the greater the mobility.

Another way of treating actual wage without disrupting the continuous nature is to rank individual wage level usually according to percentile [Dickens, 2000]. An advantage of this ranking scheme over real wages arises from the fact that increase in income inequality has been wider over waves. Thereby, it is difficult for the real wage approach to avoid the potential errors produced by difference in the underlying distribution between waves. However, in the income mobility study, the details about mobility are derived from mobility matrixes analysis [Gittleman and Joyce, 1999; Jarvis and Jenkins, 1998], because, whichever continuous measures are used, the available information is summarized into one measure: coefficients which represent the overall level of mobility. In contrast, a mobility table can provide much wider information about the scale, direction, and distance. So, many studies frequently focused on relative positions in wage distribution using transition matrices with equally spaced boundaries such as quintile distribution between two time points.

All of the income mobility studies discussed so far have been about the degree of income mobility in a society. Unlike the sociology tradition, however, there has been little effort to identify the determinants of income mobility[11]. Only a few studies [Woolard and Klasen, 2005; Aaberge *et al*, 2003] are available to identify the causes of income mobility, although there is growing emphasis on this subject as a future task [Jenkins and Van Kerm, 2006; Zimmerman, 2002, pp336-350; Jarvis and Jenkins, 1998; Solon, 1999]. This thesis attempts to deliver an answer as to why someone stays in the same income grade, while others move up or down, in relation to previous health status.

The design of this thesis addresses the previous limitations described above. This thesis analyzes the impact of health as a potential cause of intragenerational income mobility. The present study focuses on detailed pattern of income mobility linked with health status accommodating 13 waves of the BHPS. In order to analyze transitions from one assigned level of wage to another, a multilevel multinomial model is used. An advantage of multilevel modelling is the avoidance of strict assumption ignoring dependency between responses from the same individual.
To account for endogeneity between health and income, the necessity of modelling change, not status, was mentioned with particular attention to longitudinal setting. To date, though, only a few studies have associated the effect of poor health with the occurrence of income change. To conceptualize income change, income mobility is used as an outcome variable. Introducing income mobility brings about extra gains for the treatment of the limitation that actual income measure is affected by difference in annual distribution of income. Because income mobility is based on relative rank in wage distribution, there is no need to adjust for inflation rate.

6.3 Specific aims of this chapter

Two aims run through this chapter. They include the following:
1) to investigate whether income mobility varies according to previous health status,

[11] As previously described, comparison of income mobility between countries and monitoring trend over periods is implicitly based on the analysis of population-level effects. On the other hand, the approach to identify the cause of income mobility demands individual-level recognition. (See Section 2.3.1)

and

2) to better understand how health and other predictors are related to income mobility after incorporating random effect into the model.

6.4 Method

In this part, a brief introduction about the sample is made, followed by features of the income measure (hourly wage). Then, an outline of analytical procedures is presented. For multilevel multinomial modelling, details of the model are described in Chapter 4.

6.4.1 Sample

Grossly, BHPS provides trustable income data, and it had been validated against official UK income distribution statistics of Department of Social Security (DSS) [Jarvis and Jenkins, 1995]. From 13 waves of the BHPS, the sample is reconstructed to include the economically active age group. The sample has been further restricted to over age 30. As this study is interested in transition, the final sample is composed of those who provided valid information on wage and other independent variables including health. This sample comprises 31142 observations from 5245 individuals. Data construction process was explained in more detail in section 4.1.1.

6.4.2 Measuring income and its mobility

Usually income is the sum from many sources: employment, investment and savings, private and occupational pensions, and other market income, plus cash social security and social assistance receipts [Jarvis and Jenkins, 1998]. Among income measures, studies surveyed income change over time have adopted different measures; net income per week basis [Jarvis and Jenkins, 1998; Dearden *et al*, 1997], gross hourly earnings [Dickens, 2000], average hourly wage obtained from main and secondary jobs [Contoyannis and Rice, 2001; Perrucci *et al*, 1997], all wages received in a calendar year [Krause *et al*, 2001], family income [Gittleman and Joyce, 1999; Blanden *et al*, 2004] and so on.

This study focuses on wages to track a change in the form of gross earning before any deduction. This is mainly for the following reasons. The direct connection between health and loss of other income sources, such as investments, savings, private and occupational pensions, and social assistance receipt seems to be difficult to clarify and to link [Jarvis and Jenkins, 1997]. Thus, measurements like gross income are relatively insensitive to precise which kinds of source affect income change, let alone health status. In contrast, wage has been used as a proxy for productivity, and therefore it is fairy specific to the process of income change due to poor health [Hadley, 2003; Contoyannis and Rice, 2001].

Since annual and monthly wage are a product of both hourly wage and working hours, the outcome reflects a combination effect of both components [Hadley, 2003]. Through this process, poor health can affect the monthly wage by modifying the supply of working hours for health maintenance[12] [Bradley *et al*, 2002; Contoyannis and Rice, 2001]. As hourly wage generally reflects the labour input of production, in economic literature, this measure has been used as the main indicator to state the concept of average productivity [Ozturk, 2007; Contoyannis and Rice, 2001; Haveman *et al*, 1994], hourly labour cost [Adam and Moutos, 2006], wage rate [Henkens *et al*, 2002], and unit labour cost [Acocella, 2005, p50]. In this study, therefore, the influence of health on individual ability to work is measured by hourly wage.

A comparison between two hourly wages, that is, a wage from a main job and a wage from a main and a second job is made by testing which hourly wages correctly reflect a probable yearly increase. Because the hourly wage which includes second job is less likely to reveal an increasing trend when compared to the main job alone (Appendix 6-3), hourly wage from the main job is chosen for an outcome measure. As no correspondent variable is pre-existent in the BHPS, the hourly wage variable is constructed. Hourly wage is calculated by dividing monthly pay with the individual's working hour based on actual working time excluding overtime and meal breaks[13].

[12] In the simple examination, working hours are found to have little to do with general health status in the current data which is presented in appendix 6-1 and 6-2.

[13] For further details, please refer to the BHPS website (http://www.iser.essex.ac.uk/ulsc/bhps/doc/volb/wave13/mindresp9.php#MJBHRS): visit 24

For the construction of hourly wage variable, see the Appendix 6-4.

To measure wage mobility over year *t*-1 and year *t*, actual wage values are converted to two indices. First, every observation is ranked along the quintile grade of wage distribution. This five grade measure is evenly ranged from grade I to grade V (20% for each grade). This measure is used, because, in the income mobility study, it was noticed that greater details about mobility are mainly derived from mobility table analyses [Jarvis and Jenkins, 1998]. With this measure, a pair of origin and destination states generates 25 series of transitions. The second measure is based on percentile scales and it is used to observe mobility distance. In order to generate a percentile index, each observation is assigned a score, ranging from 1 (the highest wage) to 100 (the lowest wage), in accordance with its wage status. This measure is then used to define a mobility distance as a difference between a consecutive percentile score, $M = y_{i-1} - y_i$, which can vary from -99 to +99 [Cardano *et al*, 2004]. Negative values indicate downwardly mobile, whereas positive values signify upward mobility. The quintile measure is a crude tool, as it defines the mobility only when it occurs across five grades of wage distribution. In contrast, the percentile measure is more effective to detect a small change in relative wage distribution, and thus it is better at maintaining the continuous characteristic of income variable.

These two measures are constructed separately with regard to each wave and sex. As the measures are the rank based on wage distribution, it is important to secure a variation of wage. Therefore, the quintile and percentile rank of two measures are based on sample B (N = 63599) in table 4-2 to accommodate the full width of wage variation before restricting the participants to those who ever participated two consecutive years. This ranking is carried out separately with regard to survey year and sex to keep the original distribution. To assess health selection on income grade, three distinctive approaches are adopted. 1) Simple description of mobile direction and distance is illustrated in percentiles [Jarvis and Jenkins, 1998; Gottschalk, 1997] and quintile ranking; 2) Transition matrix with quintile strata serves to compare the risk of transition between those with and without poor health; 3) Quintile strata are also used for multilevel analysis with SAS nlmixed procedure. This model is fitted using a multilevel multinomial model allowing a common random effect to vary across individual.

6.5 Results

6.5.1 Sample characteristics

Table 6-1 presents the distribution of respondents according to sex. This sample is obtained after completing restrictions including wage and health variables with no missing data over two successive waves. Between 1991 and 2003, the 5245 individuals contribute a total of 31142 observations.

Table 6-1 Sample characteristics on demographic and social variables* over 13 waves

Variables†	Men	Women
Number of individuals [frequency (%)]	2584(49.3)	2661(50.7)
Number of observations [frequency (%)]	15321(49.2)	15821(50.8)
Age [mean (±SD)]	43.2(±8.4)	42.9(±7.6)
Ethnicity (%)		
White people	97.3	96.5
Non-white people	2.7	3.5
Educational level (%)		
No qualification	15.7	18.1
GCE O levels or less	19.9	27.7
GCE A levels	12.1	8.7
Vocational qualification	35.8	32.9
Higher degree	16.6	12.6
Social classes‡ (%)		
I/II	45.6	36.2
III NM	11.9	36.9
III M	28.9	8.1
IV/V	13.6	18.8
Health status (%)		
Good	81.4	78.6
Poor	18.6	21.4

* Data are based on the person year observation apart from number of cases which is obtained from individual level.

† Estimates are presented in three ways: [frequency(%)], [mean(±SD)], and (%).

‡ Professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), and partially skilled and unskilled (IV/V)

In general, further restriction of the sample to include only those with data on the wage variable does not differentiate the sample structure from sample A in table 4-2. Compared to women, men are similar in age and ethnicity, but more likely to have higher education, and less likely to be in poor health. Regarding social class, men are relatively more distributed in professional and managerial (I/II, 45.6%) and skilled manual (III M, 28.9%) positions, whereas women were more found concentrated in skilled non-manual (III NM, 36.9%) positions.

The following table shows differences in some of economic outcomes with regard to health status and sex. This analysis is based on the original sample before restricting the sample with wage measurements for two consecutive waves.

Table 6-2 Economic outcomes of population with regard to health status and sex across 13 waves† of the BHPS (N = 63599)

	Men			Women		
	Good health	Poor health	P value¶	Good health	Poor health	P value¶
Hourly wage [Mean (±SD)] ‡	10.9(±7.0)	9.4(±5.4)	<0.001	7.5(±4.8)	6.9(4.7)	<0.001
Monthly wage [Mean (±SD)]	1836.3(±1256.0)	1572.7(±913.6)	<0.001	966.4(±768.7)	878.9(±740.4)	<0.001
Hours worked per week [Mean (±SD)]	40.3(±8.6)	39.8(±8.5)	0.244	28.6(±11.2)	28.4(11.8)	0.127

† The estimates are based on yearly observation data. ‡ For mean wage for each wave, see the Appendix 6-3.
¶ In statistical analyses, t-test is used as indicators are all continuous variable.

In table 6-2, the simple relationship between health and economic activities is illustrated. The factors of being male and experiencing good health are associated with an increase in wage and longer working hours. When comparing two groups with and without poor health, although the difference in working hours is not statistically significant (p=0.244 in men and p=0.127 in women), other wage variables reveal a greater difference. Not only does this trend appear in the estimates based on a yearly observation, it also recurs in the detailed comparison with individual wave (See the Appendix 6-5). It should be observed that this result, however, arises from a cross-sectional view of pooled data collected over 13 years. Although the results only provide a static shot, it is obvious that the initial wage of those with poor health was already low before mobility occurred.

6.5.2 Outline of income mobility

To outline mobility processes, transitions between five wage grades from year *t*-1 and year *t* are simplified into three mobility directions: upward, stable and downward[14]. In addition, to measure the detailed extent of changes, after grouping wages into percentiles, mobile distance is calculated by subtracting wage grade in year *t* from that of year *t*-1. Falling by ten or more percentiles is defined as an indicator of 'income drop' [Dickens, 2000; Duncan, 1996]. The drop rate among those with poor heath was compared with those of good health. Whereas mobility direction is based on quintile rank, income drop and mobile distance is based on percentile rank which is more sensitive to recognize a minor change in wage distribution.

Table 6-3 Characteristics of income mobility derived from two consecutive years with regard to health status and sex across 13 waves of the BHPS (N = 31142)

	Men			Women		
	Good health	Poor health	P value†	Good health	Poor health	P value†
Mobility direction [Frequency(%)][a]						
Upward mobility	2243(18.0)	513(18.0)		2108(16.9)	548(16.2)	
Stable	8252(66.1)	1840(64.7)		8283(66.6)	2235(66.1)	
Downward mobility	1982(15.9)	491(17.3)	0.177	2050(16.5)	597(17.7)	0.206
Income drop [Frequency(%)][b]						
No	10655(85.4)	2369(83.3)		10691(85.9)	2867(84.8)	
Yes	1822(14.6)	475(16.7)	0.005	1750(14.1)	513(15.2)	0.102
Mobile distance [Mean (±SD)][c]	0.47(±14.1)	0.23(±14.3)	0.458	0.08(±14.9)	-0.27(±15.6)	0.001

[a] Mobility direction is based on quintile rank, while two other measures (income drop and mobility distance) are based on percentile rank. [b] The frequency of income drop is calculated from the number of transition falling down more than ten percentile in mobile distance. Thus, this indicator measures only downward mobility. [c] Mobile distance is calculated from changes in percentile rank between year *t*-1 and year *t*. The positive value means upwardly mobile. † In statistical analyses, chi-square test is used for mobility direction and income drop, and t-test is used for comparison of mobile distance.

For men, mobility directions suggest that downward mobility is associated with having poor health in the previous year, although upward mobility has little to do with health status. This tendency becomes notable when the comparison is made with

[14] It was discussed before that the simplification of a mobility table into three mobile directions may bring an inappropriate conversion. But it may not be the case for income mobility where the distribution of income measure is equal on all levels. This means that marginal distribution of quintile boundaries is uniform with 20% for each grade. Therefore, every category of three mobility directions can keep the same independently of every level of original category. This was also noted by Erikson who described this notion by saying: 'when intergenerational income mobility is studied via a contingency table approach, using income quintile groups as the categories, the problem of controlling differing marginal distributions obviously does not arise' [Erikson and Goldthorpe, 2002, p35].

income drop, because this measure only reflects downward mobility. 14.6% of men with good health experience a declining in income distribution of more than 10 percentile points, but this figure increases to 16.7% if they had been in poor health status in the previous year. The results from the income drop rates imply that men with poor health are significantly more likely to move down the income scale (p=0.005). However, a small difference between the number of individuals with and without poor health is observed when income change is indicated by mobile distance. This may occur because mobile distance is a combined measure of both downward mobility, which is affected by health status and upward mobility, which is not affected. For women, the group with poor health tends to be more downwardly mobile and less upwardly mobile, although this tendency is not statistically significant (p=0.206). When downward mobility is being tested by income drop rate alone, the difference between women with and without poor health is not statistically significant (p=0.102). However, it is observed that there is a strong association between health status and mobile distance. As both upward and downward mobility are generally unfavourable to women with poor health, the gross effect results in a large difference in mobile distance.

The difference in income mobility between the two groups with and without poor health is negligible when it is evaluated with quintile distribution (mobility direction). However, with the percentile distribution, the significance of the difference manifests in a specific way associating poor health status among men with further downward mobility, and poor health status among women with general declines of mobility distance in both downward and upward mobility. This finding also suggests that the percentile measure is more able to sense the actual change in wage distribution. When the pre-mobility wage in table 6-2 is considered together with table 6-3, the results from this table suggests that those with poor health experience further declines in wage, even though their wage was already low.

Following table 6-4 provides transition rates between wage grades of two consecutive years (year *t*-1 to year *t*) for men. Data from waves 1 to 13 in BHPS are pooled to describe the transition.

Table 6-4 Transition rate (row percentage) between wage quintile† with regard to health status‡ over year *t*-1 and year *t* based on 13 years of the BHPS data in men (n=15321)

Wage quintile in year *t*-1	Wage quintile in year t					
	Grade I	Grade II	Grade III	Grade IV	Grade V	Total transitions
Those with good health						
Grade I	83.3	12.7	2.3	1.1	0.7	2693(21.6)
Grade II	15.8	62.1	17.7	3.1	1.4	2627(21.1)
Grade III	2.9	20.3	55.1	18.4	3.3	2592(20.8)
Grade IV	1.0	5.0	20.9	57.1	16.0	2412(19.3)
Grade V (Bottom)	0.6	1.4	4.5	20.5	73.1	2153(17.3)
Total						12477(100.0)
Those with poor health						
Grade I	79.7	15.9	2.5	0.7	1.2	408(14.4)
Grade II	15.1	61.6	18.2	3.5	1.6	516(18.1)
Grade III	1.6	18.7	55.3	20.1	4.4	552(19.4)
Grade IV	0.6	2.8	18.1	55.0	23.5	651(22.9)
Grade V (Bottom)	0.6	1.4	3.6	19.9	74.5	717(25.2)
Total						2844(100.0)

† Quintile ranking was made before restriction of the sample to those who participated two consecutive waves (sample B in table 4-2) ‡ Health status in year *t*-1

In this mobility matrix table, the summary of income mobility in table 6-3 is unfolded to full wage grades to see the detailed pattern. The mobility from any wage grade is loaded heavily on the same band (stable), and around 95% of mobility is confined to within the neighbouring bands from any of grade. Mobility further than two grades in distance is rare with a maximum of 6.2% from grade III among healthy men. Both ends (grade I and V) of the wage distribution record a far higher stable rate, probably because these grades are allowed to move into one direction (ceiling and floor effects).

Poor health seems to play some role in subsequent wage mobility. In the majority cases, those with poor health are more likely to be downward (upper diagonal) and less likely to be upward (under diagonal) with one exception, transition from grade I to IV.

Following table 6-5 presents the transition matrix for women.

Table 6-5 Transition rate (row percentage) between wage quintile[†] with regard to health status[‡] over year *t*-1 and year *t* based on 13 years of the BHPS in women (n = 15821)

Wage quintile in year *t*-1	Wage quintile in year t					
	Grade I	Grade II	Grade III	Grade IV	Grade V	Total transitions
Those with good health						
Grade I	82.8	13.0	1.7	1.4	1.1	2685(21.6)
Grade II	14.3	63.4	16.7	3.8	1.8	2616(21.0)
Grade III	2.2	17.5	58.8	17.8	3.7	2538(20.4)
Grade IV	1.1	4.3	18.5	57.1	18.9	2440(19.6)
Grade V (Bottom)	0.8	3.0	5.5	20.7	70.0	2162(17.4)
Total						12441(100.0)
Those with poor health						
Grade I	77.9	16.7	2.1	2.4	0.9	533(15.8)
Grade II	12.5	62.4	17.1	5.8	2.3	656(19.4)
Grade III	0.9	13.4	61.2	19.3	5.2	694(20.5)
Grade IV	1.1	4.0	16.3	58.1	20.4	704(20.8)
Grade V (Bottom)	1.5	1.8	4.7	19.3	72.8	793(23.5)
Total						3380(100.0)

[†] Quintile ranking was made before restriction of the sample to those who participated two consecutive waves (sample B in table 4-2) [‡] Health status in year *t*-1

Table 6-5 shows the tendency that less upward and more downward mobility for those with poor health occurs for women in all but two circumstances, transitions from grade I to V and from V to I. When monthly wage is used, similar results confirm this tendency (Appendix 6-6). Nevertheless, the results obtained so far are from pooled data without considering multilevel structure with repeated measurements within an individual.

6.5.3 Income mobility with multilevel multinomial analysis

A multilevel multinomial model is used to consider the influence of a data structure with repeated measurements. Two models fit the data. The simpler model (model I) includes only the health variable, and the other model (model II) introduces the influence of other covariates along with health variables. Using the quintile distribution of wages, four multilevel multinomial models assess the risk of every type of transition from each wage grade using a transition of staying in the same grade as a reference.

Poor health, old age, and lower education are expected to be associated with the likelihood of mobility, reducing upward and increasing downward mobility. The estimates are expected to show the direction of effects, and an Odds Ratio > 1 for health, education, and age means that people with poor health or lower education or older age are more likely to have the risk of a transition than the reference (good health, highest education). If downward mobility is experienced, such as mobility from grade III to V, Odds Ratio > 1 for the variables indicates that poor health, lower education, and older age promote the downward transition.

Table 6-6 The estimated odds ratio and 95% confidence interval[a] from a multilevel multinomial models[b] with transitions from every class having repeated measurements in men

			Model I		Model II[c]							
			Fixed effect	Random effect	Fixed effect							Random effect[e]
			Poor health vs		Poor health vs	Age		Education[d]				
		N[f]	good health	Variance	good health	40s vs 30s	50s vs 30s	I vs V	II vs V	III vs V	IV vs V	Variance
Grade I	⇒ II	3101	1.21[0.96, 1.68]†	2.28(0.19)‡	1.18[0.75, 1.87]	1.15[0.71, 1.86]	1.77[0.77, 4.08]	11.9[2.37, 44.3]‡	14.5[4.64, 39.6]‡	3.53[1.19, 9.81]‡	3.75[1.38, 9.78]‡	0.86(0.08)‡
	⇒ III		1.07[0.55, 2.24]		0.74[0.34, 1.64]	0.86[0.37, 1.97]	0.98[0.24, 4.06]	21.7[5.72, 82.9]‡	9.41[3.96, 22.3]‡	1.09[0.3, 3.96]	2.7[1.38, 5.25]‡	
	⇒ IV		0.57[0.16, 1.98]		0.35[0.09, 1.38]	1.14[0.34, 3.82]	1.83[0.23, 14.24]	43.4[8.92, 211.6]‡	6.42[1.84, 22.4]‡	4.44[1.32, 14.9]‡	3.78[1.72, 8.32]‡	
	⇒ V		1.71[0.62, 4.83]		0.76[0.27, 2.11]	0.32[0.07, 1.42]	0.55[0.07, 4.48]	5.86[2.17, 15.8]‡	21.7[4.46, 105.8]‡	2.47[0.15, 40.4]	3.21[0.92, 11.2]*	
Grade II	⇒ I	3143	0.96[0.70, 1.31]	1.01(0.08)‡	0.99[0.73, 1.35]	1.01[0.69, 1.46]	1.13[0.61, 2.1]	0.52[0.26, 1.01]*	0.65[0.44, 0.96]†	0.46[0.3, 0.73]‡	0.6[0.44, 0.82]‡	1.00(0.08)‡
	⇒ III		1.03[0.75, 1.35]		1.05[0.78, 1.41]	0.84[0.59, 1.2]	0.76[0.42, 1.39]	2.94[1.67,5.19]‡	2.24[1.5, 3.34]‡	1.76[1.13, 2.73]‡	1.64[1.16, 2.34]‡	
	⇒ IV		1.20[0.73, 1.98]		1.18[0.68, 2.05]	1.31[0.63, 2.76]	4.72[1.34, 16.6]‡	4.44[1.69, 11.6]‡	3.11[1.44, 6.7]‡	1.34[0.52, 3.43]	2.04[1.01, 4.13]†	
	⇒ V		1.21[0.54, 2.60]		1.13[0.51, 2.51]	1.65[0.55, 4.94]	1.48[0.26, 8.34]	19.9[3.98, 99.6]‡	9.63[2.15, 43.2]‡	3.19[0.57, 17.8]	3.8[0.86, 16.8]	
Grade III	⇒ I	3144	0.47[0.21, 1.09]*	0.89(0.09)‡	0.53[0.26, 1.08]*	2.19[1.0, 4.8]†	2.38[0.63, 9.03]	0.23[0.09, 0.61]	0.22[0.11, 0.46]	0.22[0.1, 0.49]	0.23[0.13, 0.43]	0.88(0.08)‡
	⇒ II		0.89[0.68, 1.18]		0.87[0.66, 1.15]	1.05[0.74, 1.48]	0.68[0.39, 1.2]	0.36[0.22, 0.6]	0.56[0.38, 0.83]	0.51[0.33, 0.78]	0.58[0.41, 0.84]	
	⇒ IV		1.05[0.81, 1.42]		1.02[0.77, 1.34]	0.87[0.61, 1.24]	0.92[0.52, 1.62]	3.45[2.02, 5.9]‡	1.95[1.19, 3.2]‡	1.57[0.92, 2.68]*	1.49[0.93, 2.4]*	
	⇒ V		1.24[0.76, 2.13]		1.21[0.74, 1.97]	0.98[0.47, 2.02]	0.7[0.23, 2.08]	2.87[1.2, 6.87]‡	1.3[0.56, 3.01]	0.88[0.34, 2.26]	0.79[0.35, 1.82]	
Grade IV	⇒ I	3063	0.76[0.26, 2.17]	0.82(0.09)‡	0.47[0.15, 1.44]	0.1[0.02, 0.66]‡	0.03[0.01, 0.49]‡	0.03[0.01, 0.13]‡	0.06[0.02, 0.15]‡	0.03[0.01, 0.15]‡	0.06[0.03, 0.16]‡	0.61(0.12)‡
	⇒ II		0.62[0.35, 1.06]*		0.63[0.37, 1.07]*	0.86[0.47, 1.58]	0.48[0.15, 1.55]	0.11[0.05, 0.22]‡	0.2[0.11, 0.36]‡	0.21[0.1, 0.42]‡	0.31[0.18, 0.53]‡	
	⇒ III		0.95[0.73, 1.21]		1.0[0.77, 1.3]	0.79[0.56, 1.13]	0.44[0.24, 0.78]‡	0.8[0.49, 1.31]	1.01[0.63, 1.62]	1.27[0.77, 2.09]	1.19[0.69, 2.07]	
	⇒ V		1.58[1.23, 2.03]‡		1.58[1.23, 2.03]‡	1.14[0.79, 1.64]	0.84[0.48, 1.49]	0.78[0.49, 1.24]	0.71[0.45, 1.13]	0.56[0.33, 0.96]†	0.69[0.44, 1.08]*	
Grade V	⇒ I	2870	1.10[0.32, 3.12]	1.65(0.14)‡	1.11[0.35, 3.55]	0.64[0.09, 4.44]	1.15[0.07, 19.3]	0.06[0.01, 0.38]	0.22[0.04, 1.17]	0.02[0.001, 8.95]	0.34[0.08, 1.51]	1.53(0.12)‡
	⇒ II		1.13[0.52, 2.38]		1.14[0.53, 2.43]	1.2[0.27, 5.32]	1.24[0.14, 11.1]	0.18[0.04, 0.82]‡	0.66[0.16, 2.68]	0.38[0.07, 2.19]	0.65[0.16, 2.62]	
	⇒ III		0.82[0.48, 1.29]		0.89[0.54, 1.45]	1.56[0.73, 3.3]	1.26[0.39, 4.08]	0.18[0.07, 0.48]‡	0.49[0.19, 1.24]	0.53[0.19, 1.53]	0.55[0.22, 1.37]	
	⇒ IV		0.98[0.74, 1.30]		1.0[0.75, 1.33]	1.34[0.85, 2.14]	1.42[0.72, 2.83]	0.57[0.27, 1.21]	0.94[0.44, 2.0]	0.86[0.37, 1.99]	0.94[0.45, 1.96]	

a. For variance, coefficients (standard error) are given. b. Model I fits only with health variable, while model II fits along with other covariates.
c. Model II is adjusted for period and cohort effects as well as covariates listed in the table. d. No qualification (I), GCE O levels or less (II), GCE A levels (III), Vocational qualification (IV), and Higher degree (V). e. The variance of random intercepts represents the variability across individuals. The random effect appears once a model, as a common single random effect is assumed.
f. N denotes observations for each origin.
*Statistically significant <0.1, †Statistically significant <0.05, ‡Statistically significant <0.01

Table 6-6 shows the effects of independent variables estimated via multilevel multinomial modelling. In the comparison of model I with model II, the change in ORs is observed after adjustment of covariates, but the change is mostly minimal. The results from the fixed parts show that only few transitions are found to have a strong association with poor health, although poor health is generally associated with less upward (OR<1) and more downward transitions (OR>1). Among 20 transitions, three transitions which present a strong relation (at the p<0.1 significance level) are those; transitions from grade III to I, from grade IV to II, and from grade IV to V. Thus, it is likely that poor health exerts little effect through five grades of wage transitions. Although poor health is consistent in the direction of its effects hampering upward mobility and increasing downward mobility, it is not statistically significant. Lower education appears not only to promote downward mobility, but also to prevent upward mobility, in particular for grade I. However, education takes a less active role for the lower wage grades IV and V. Old age comes out to be the barrier to move upward, in particular, from grade IV.

Common random effects at the individual-level show significant variability across transitions over five wage grades. The individual level variability in explaining the risk of transition is larger in grade V. This means that upward wage transition from the lowest wage band highly depends on individual difference than other transitions.

Table 6-7 The estimated odds ratio and 95% confidence interval[a] from a multilevel multinomial models[b] with transitions from every class having repeated measurements in women

			Model I		Model II[c]							
			Fixed effect	Random effect	Fixed effect							Random effect[e]
			Poor health vs		Poor health vs	Age		Education[d]				
		N[f]	good health	Variance	good health	40s vs 30s	50s vs 30s	I vs V	II vs V	III vs V	IV vs V	Variance
Grade I	⇒ II	3218	1.61[1.06, 2.30]†	2.60(0.21)‡	1.54[1.04. 2.26]†	0.73[0.44, 1.2]	1.37[0.62, 3.04]	28.6[9.68, 84.5]	19.6[9.89, 390.0]	4.9[1.97, 12.1]	4.15[2.49, 6.89]	2.18(0.17)‡
	⇒ III		1.41[0.66, 2.95]		1.28[0.6 , 2.71]	1.07[0.39, 2.96]	1.9[0.37, 9.66]	185.0[40.7, 840.1]	53.3[15.8, 179.4]	24.3[5.78, 102.2]	10.6[3.66, 30.8]	
	⇒ IV		1.86[0.88, 3.81]		1.78[0.84, 3.76]	1.69[0.52, 5.51]	8.17[1.27, 52.3]‡	374.9[86.17, 1631.2]	76.7[23.1, 254.7]	15.2[3.23, 71.5]	6.56[2.14, 20.1]	
	⇒ V		1.02[0.34, 2.73]		1.03[0.38, 2.83]	1.1[0.31, 3.92]	4.5[0.61, 33.1]	26.1[4.02, 170.0]	23.6[7.67, 72.9]	6.88[1.47, 32.1]	2.78[1.03, 7.5]	
Grade II	⇒ I	3272	0.95[0.71, 1.26]	1.12(0.09)‡	0.95[0.7, 1.28]	0.91[0.62, 1.35]	1.0[0.52, 1.92]	0.41[0.22, 0.76]‡	0.27[0.18, 0.4]‡	0.31[0.18, 0.54]‡	0.47[0.33, 0.68]‡	1.09(0.09)‡
	⇒ III		1.20[0.91, 1.68]		1.1[0.84, 1.45]	1.23[0.85, 1.78]	1.51[0.84, 2.7]	3.93[2.19, 7.06]‡	2.17[1.35, 3.48]‡	2.87[1.65, 5.0]‡	1.46[0.92, 2.33]*	
	⇒ IV		1.79[1.17, 2.85]‡		1.7[1.12, 2.59]‡	0.81[0.43, 1.51]	1.17[0.44, 3.09]	3.71[1.65, 8.32]‡	1.39[0.7, 2.76]	1.4[0.6, 3.27]	0.73[0.36, 1.47]	
	⇒ V		1.44[0.80, 2.62]		1.34[0.73, 2.48]	1.09[0.46, 2.6]	1.7[0.43, 6.69]	7.1[2.3, 21.9]‡	1.49[0.53, 4.18]	1.63[0.47, 5.68]	0.97[0.34, 2.74]	
Grade III	⇒ I	3232	0.33[0.13, 0.84]†	1.05(0.08)‡	0.36[0.15, 0.86]†	0.58[0.22, 1.55]	0.35[0.09, 1.43]	0.31[0.09, 1.07]*	0.2[0.07, 0.59]‡	0.27[0.08, 0.96]†	0.42[0.15, 1.22]	1.03(0.08)‡
	⇒ II		0.75[0.54, 0.99]*		0.74[0.56, 0.99]†	0.63[0.43, 0.94]†	0.45[0.25, 0.81]‡	0.32[0.17, 0.6]‡	0.33[0.19, 0.58]‡	0.32[0.17, 0.6]‡	0.35[0.2, 0.61]‡	
	⇒ IV		1.04[0.79, 1.35]		1.0[0.77, 1.3]	0.63[0.44, 0.92]†	0.66[0.38, 1.16]	0.88[0.47, 1.65]	0.45[0.25, 0.83]†	0.45[0.23, 0.88]†	0.61[0.33, 1.1]*	
	⇒ V		1.44[0.88, 2.17]		1.29[0.84, 1.97]	0.69[0.37, 1.27]	0.7[0.26, 1.88]	0.87[0.33, 2.27]	0.35[0.14, 0.88]†	0.38[0.13, 1.07]*	0.52[0.21, 1.3]	
Grade IV	⇒ I	3144	1.10[0.48, 2.49]	0.84(0.08)‡	1.11[0.49, 2.51]	0.53[0.16, 1.77]	0.69[0.08, 5.58]	0.13[0.04, 0.42]‡	0.09[0.03, 0.27]‡	0.09[0.02, 0.49]‡	0.22[0.08, 0.62]‡	0.80(0.08)‡
	⇒ II		0.87[0.57, 1.38]		0.94[0.6, 1.47]	0.47[0.27, 0.84]†	0.53[0.2, 1.42]	0.22[0.09, 0.53]‡	0.47[0.22, 1.01]*	0.55[0.23, 1.34]	0.55[0.25, 1.2]	
	⇒ III		0.88[0.67, 1.10]		0.91[0.7, 1.17]	0.98[0.69, 1.4]	1.23[0.72, 2.13]	0.75[0.39, 1.43]	1.23[0.66, 2.29]	1.42[0.72, 2.81]	1.43[0.77, 2.68]	
	⇒ V		1.11[0.87, 1.51]		1.07[0.84, 1.36]	0.92[0.64, 1.32]	1.08[0.63, 1.84]	1.31[0.72, 2.38]	0.82[0.45, 1.49]	0.79[0.4, 1.55]	1.03[0.56, 1.86]	
Grade V	⇒ I	2955	0.98[0.71, 2.02]	1.37(0.13)‡	0.99[0.70, 2.03]	0.45[0.11, 1.74]	0.61[0.08, 4.79]	0.01[0, 0.05]‡	0.03[0.01, 0.11]‡	0.08[0.02, 0.35]‡	0.05[0.02, 0.16]‡	1.11(0.10)‡
	⇒ II		0.58[0.32, 1.07]		0.62[0.34, 1.15]	1.64[0.73, 3.69]	1.18[0.31, 4.5]	0.04[0.02, 0.12]‡	0.1[0.04, 0.27]‡	0.17[0.05, 0.55]‡	0 16[0.06, 0.42]‡	
	⇒ III		0.82[0.54, 1.25]		0.82[0.55, 1.24]	0.64[0.35, 1.16]	0.73[0.28, 1.88]	0.12[0.05, 0.31]‡	0.21[0.09, 0.52]‡	0.39[0.14, 1.07]*	0.21[0.08, 0.52]‡	
	⇒ IV		0.89[0.72, 1.21]		0.91[0.71, 1.17]	1.06[0.72, 1.55]	0.91[0.51, 1.63]	0.27[0.13, 0.58]‡	0.36[0.17, 0.75]‡	0.61[0.27, 1.39]	0.55[0.26, 1.15]	

a. For variance, coefficients (standard error) are given. b. Model I fits only with health variable, while model II fits along with other covariates.
c. Model II is adjusted for period and cohort effects as well as covariates listed in the table. d. No qualification (I), GCE O levels or less (II), GCE A levels (III), Vocational qualification (IV), and Higher degree (V). e. The variance of random intercepts represents the variability across individuals. The random effect appears once a model, as a common single random effect is assumed.
f. N denotes observations for each origin. *Statistically significant <0.1, †Statistically significant <0.05, ‡Statistically significant <0.01

Table 6-7 presents the effect of health and other covariates on income mobility between quintile grades. For women, the effects of health remain similar after adjustment of covariates. Between model I and model II, small changes in OR occur in all transitions.

In most transitions, having been in poor health in a previous year appears to have little effect on a person's wage. The impact of poor health is significant (at the $p<0.1$ significance level) only in four out of 20 transitions, and those are from grade I to II, from grade II to IV, from grade III to I, and from grade III to II. It seems that if women have better education, this provides strong protection against a decrease of wage and higher probability for a better wage. However, this is less distinctive in middle wage grades II, III, and IV. In general, old age appears to hinder upward mobility, in particular, grades III and IV. However, interestingly a transition exhibit contrasting results as old age reduces downward mobility in transitions from grade III to IV at a statistically significant level.

The random effects have a large influence on total variation of wage. This signifies that the risk of wage mobility is highly affected by individual variability, and therefore the consideration of the multilevel structure of data is essential.

6.6 Discussion

6.6.1 Main findings

In this chapter, it is hypothesized that poor health causes an individual's movement up and down within the scale of income distribution. Repeated income measures are pooled from 13 waves of the BHPS, and structured to set income mobility between year t-1 and year t with respect to the previous self-assessed health rating. Income mobility is measured using hourly wages on the basis of relative terms, rather than absolute terms. The relative income mobility primarily focuses on the quintile order in the wage distribution and is complemented by the percentile order. Simple analysis is carried out for a basic comparison of two groups with and without poor health, and subsequently a more robust method is used to take the multinomial multilevel structure of the data into account.

Several findings were drawn from a series of analyses. First of all, poor health status was accompanied by a decline in wage, as well as a lower wage at the baseline. This tendency was fairly evident when income mobility was measured using a percentile rank, rather than a quintile rank. However, after allowing for the random effect model and adjusting for other covariates, the effect of health status became largely negligible. The effect of education appeared substantial in reinforcing the chance of upward mobility and in reducing that of downward mobility. Old age tended to be associated with less upward and more downward transitions. Overall, the effect of health, education, and age on wage mobility varies over different wage grades. The performance of educational level seemed to be distinctive in the upper wage grades; on the contrary, health and age acted in the lower grades, although the estimated effect of health was small.

6.6.2 Negligible health selection and the choice of income measure

This study shows that the effect of health on income mobility is minimal. This finding may be interpreted as providing supportive evidence for social causation. It may also be viewed as a contrary finding to the main theme in health economics, where health is mostly regarded as a part of human capital, along with skills and knowledge, and poor health therefore reduces the ability to work to some degree [Zweifel and Breyer, 1997, p56; Grossman, 1972]. This conceptual conflict will be discussed extensively later in section 9.2, in which health selection is expected to vary across countries (e.g., welfare status) and other study settings (e.g., study population). For now, it is attempted to clarify whether the choice of the income index is responsible for the study findings.

To date, some studies [Mullahy and Sindelar, 1994; Baldwin and Jhonson, 1995; Berkovec and Stern, 1991] have associated the occurrence of poor health with income change, and more so with income level. Income change is calculated by comparing a wage after a health event with a wage received before the event. It was observed that, when both income change and income level are tested in a statistical model, income level appears to be more significant [Benzeval and Judge, 2001]. The advantage of the change measure is obvious: it is independent of previous associations between health and income. Due to the robust nature of this measure, it allows less generosity in assessing the impact of health on income.

In the current usage, income change is conceptualized as income mobility which indicates a change in quintile distribution. The quintile rank, rather than real income, is decided relative to the entire sample distribution, in order to specify mobility between each income grade. This categorization may not be satisfactory because it does not fully accommodate a whole range of movement, and instead only recognizes the change when it occurs between quintile ranks. This conceptualization treats movements within one grade as ‘immobile’, whilst a small movement between grades is regarded as ‘mobile’, regardless of distance. Moreover, using this design, it is impossible to test if those at the top and bottom of wage strata experience mobility. Alternatively, percentile scale was used to complement the quintile measure. Although the application of this measure was limited to calculating mobile distance, the results from this measure appear to be significant.

This implies that the choice of income measure might be influential, when investigating the impact of health on income. Thus, the outcome of negligible health selection should be viewed in the light of the measure used in this study. Income mobility measured as quintile rank may not be sensitive enough to reveal the link between illness and subsequent income change.

6.6.3 Income mobility and health measures

As previously stated, the effects of health on income are sensitive to the health measure used here, and it was suggested that the effect might be more prominent for specific diseases than for self-rated general health [Cardano *et al*, 2004]. This might be because the effect varies depending on disease characteristics such as type, stage, and severity.

Several studies have investigated the association between self-rated health and an objective health measure [Molarius and Janson, 2002; Jonsson *et al*, 2001; Cott *et al*, 1999; Pijls *et al*, 1993]. Although self-rated health is strongly associated with various morbidity and mortality measures, this measure is not the same as objective health measures. In fact, non-specific conditions, such as tiredness/weakness and chronic stress, constituted a large part of explaining self-rated health [Molarius and Janson, 2002; Cott *et al*, 1999]. Indeed, the largest contribution to self-rated health was attributable to tiredness/weakness, due to its high prevalence in the population. Despite this subjective element of self-rated health status, self-reported health has long been supported as a measure of overall health status [Jones *et al*, 2006; Humphries and van Doorslaer, 2000; Grossman, 1972]. Additionally, it is difficult to argue that an objective measure is superior to a subjective measure because economic decision inherently involves a subjective matter [Gerdtham and Johannesson, 1999].

Hence, it is unlikely that the subjectivity of the self-rated health measure gives rise to a limitation, but other aspects of the handling of this health measure in the model of labour participation need to be considered. If health changes the risk of economic activity, the effect would not be evenly spread throughout the entire duration of disease, but it would instead have a time dimension. It has been acknowledged that self-rated health is not sensitive to time of disease onset and the duration after disease occurrence [Jonsson *et al*, 2001]. In the current statistical model, health is treated as if it had the same risk regardless of the time of onset and the length of time that an individual was exposed to the poor health condition. This assumption is quite strict and, in future studies, it would be useful to consider both onset and duration of poor health.

Another potential limitation in the usage of the health measure in the current study is the ignorance of the severity of health condition [Kidd *et al*, 2000; Smith, 1999; West *et al*, 1996; Krause *et al*, 2001]. Some studies have reported that the stages of cancer [West *et al*, 1996] and the severity of disability [Boden and Galizzi, 1999] are positively correlated with income reduction. It has also been indicated that the adverse effects of chronic illness on wage were largely confined to severe cases [Smith, 1999; Rizzo *et al*, 1996]. This implies that a dichotomous health measure, as used in the current study, may be less precise in estimating the relationship between health and the labour market status. Thus, in the estimation of whether and how much health interferes with the decision to work, a measure to reflect disease severity would be desirable. In practice, when the approach is based on self-rated health, full categories of this health measure might be more informative, as a substitute for the rating of severity [Gambin, 2005; Contoyannis and Rice, 2001]. In conclusion, as health is a multi-dimensional concept, it is advantageous to combine different dimensions, such as duration and severity.

6.6.4 Strengths and limitations

As methodological strengths are discussed later (section 9.5), in this section it is stressed that the strength of the current study lies in its conceptual framework. Firstly, this study tried to expand this research field by conceptualizing the studies from health economics in the context of health selection, where causality runs from health to income. This general definition of health selection may contribute to fill the gap between two different disciplines: epidemiology and health economics. The second strength of the current study is the use of income mobility as an outcome measure to assess income change. By looking at income mobility, this study examines an economic view that health has a value as a precondition for success in economic activity.

Although this delivers a new approach, it has its limitations. The first limitation of the study concerns the income measure, which has already been discussed. Additionally, it has to be stated clearly that, in order to be a reliable measure for the assessment of income change, mobility measures need to account for the continuous nature of income. Income mobility is not treated as continuous variable in this study, because relative position in the income distribution is the centre of interest. Percentile distribution was used, assuming that it can partly reflect the continuous feature of the wage variable. However, since this measure is not a truly continuous variable, it was hard to illustrate the strength of the income variable in quantifying mobility across two time points. Therefore, it may be valuable in the future to keep income change as a continuous variable rather than to construct it as a discrete variable.

The second limitation arises from the fact that this study restricted the sample to wage earners. By this definition, only workers who reported wages are included. In this approach, the non-employed are treated as if missing [Miller, 1998]. This differentiation ignores the transition between any income grade and the non-employed. Selecting only the employed in the analysis leaves poor health in the remaining population underrepresented. This might underestimate the full effect of health on wage, as those who leave the labour force are likely to be those with worst health [Contoyannis and Rice, 2001]. Due to the loss of these transitions, the sample (respondents with a paid job) is less effective in recognizing the effect of health on income change.

6.6.5 Future study

There are several points that should be considered in future studies. As some of general design issues are addressed in Chapter 9, the focus presented here is specifically laid on income measurement. Firstly, poor health is supposed to limit both working hours and hourly wage of the affected person [Zweifel and Breyer, 1997, p52-55]. One common finding has been that actual decline in income is mainly due to changes in working hours, with changes in hourly wages exercising less pronounced effects [Newcombe, 2007; Hadley, 2003, p575; Mayfield *et al*, 1999; Currie and Madrian, 1999, p3319; Smith, 1999]. Nevertheless, the comparison with the BHPS between two groups with and without poor health does not show a large difference in working hours. As such is the case, in the current study, changes in hourly wage is used as the measure of income mobility.

Although there is a lack of evidence in the current study that poor health affects earnings through reducing working hours, the reliance on a single economic measure makes it difficult to investigate a buffering relationship between economic activities, which are presumably interactive. For instance, someone may adjust to a poor health event by reducing their current earnings, if other household members agree to work more, or if there are savings to use, or if extra benefits are available; or someone may choose to work for the same amount of earnings, despite poor health, if there is no option to compensate the income loss [Smith, 1999]. Thus, wage level via adjusting the labour market participation level would be determined, not only by work ability itself, but also by other economic conditions [Mayfield *et al*, 1999; Warner and Polak, 1995]. Mullahhy and Sindelar [1994] pointed out that a narrow focus on wages may be misleading, as the decision to work by those with poor health involves a variety of dimensions. The present finding, taken solely from the wage measure, needs to be supplemented by other approaches of collecting information about various economic measures.

Secondly, there is also some literature demonstrating that the macroeconomic environment may either amplify or attenuate the effect of health on income [Currie and Madrian, 1999, p3333; Costa, 1996]. In the review of injury-related loss of earnings, one study [Boden, 2006] showed the important difference between countries with a comprehensive social scheme and those without one. A large wage decline occurring after the return to work was found among workers in the US, UK, and Canada, while little comparable wage decline was reported in France and Germany. Labour market protection and social insurance programmes are also acknowledged as causes of such a disparity. Understandably, Costa [1996] reported that health is a more important determinant of wages in less developed, rather than more developed countries. Thus, the impact of health on subsequent income change may differ across countries and periods, and this comparison may be interesting in a future study.

Chapter 7: The different involvement of health in the transitions between employment statuses

7.1 Introduction

Looking at whether poor health is a determinant of different labour market activity may have a different implication according to the index under consideration. The previous two chapters provided broad coverage of this issue based on indices of social class and income. This chapter focuses on the impacts of health on labour market transitions: employment, unemployment, and inactivity (so a type I health selection study, regarding the presence of health selection).

7.2 Literature review

The overall association between employment status and health in Britain is substantial. The obvious inequalities in health across employment status have been consistently indicated across studies. Concerning the causal relationship, two paths have been suggested. In some studies, the causal relationship runs from employment to health (social causation), whereas others follow causal direction from health to employment status (health selection). A large number of studies have shown that unemployment has a strong negative effect on health [Fone *et al*, 2007; Thomas *et al*, 2005; Virtanen P *et al*, 2003; Kasl and Jones, 2000; Bartley *et al*, 1999; Bartley, 1988; Cook, 1985], whilst other studies have indicated that poor health could increase the risk of leaving the labour market, and decrease the probability of returning to the labour market [Schuring *et al*, 2007; Disney *et al*, 2006; Cai and Kalb, 2006; Cardano *et al*, 2004; Elstad and Krokstad, 2003; Lindholm *et al*, 2001; Flippen and Tienda, 2000; Dwyer and Mitchell, 1999; van de Mheen *et al*, 1999]. Therefore, health selection has been recognized as a partial explanation for social inequalities in health by employment status, although social causation has been regarded as the dominant explanation [Benach *et al*, 2007, p89; Kasl and Jones, 2000, p120; Acheson, 1998, p46]. The Acheson report described the combination of social causation and health selection as a ‘double disadvantage’ to people with poor health [Acheson, 1998, p46].

A causal relationship supporting social causation has been well recognized as a major contribution to inequalities in health across employment status. There are many studies which found that unemployed individuals report a higher risk of morbidity than employed individuals across various measures: self-rated health [Giatti *et al*, 2008; Rugulies *et al*, 2008], limiting long-term illness [Bartley *et al*, 2004b], mental illness [Hämäläinen *et al*, 2005; Thomas *et al*, 2005], and cardio vascular disease [Gallo *et al*, 2006; Gallo *et al*, 2004]. The experience of unemployment has been also consistently associated with an increase in overall mortality [Lenthe *et al*, 2005; Voss *et al*, 2004; Osler *et al*, 2003; Jin *et al*, 1997], in particular suicide [Voss *et al*, 2004; Platt and Hawton, 2000]. Unemployed people of working age have shown much higher hospital admission rates [Madan *et al*, 2007], an increased use of medication [Jin *et al*, 1997], and much worse prognosis and recovery rate [Leslie *et al*, 2007; Thomas *et al*, 2005; Bartley *et al*, 2004b]. The immediate effect of unemployment has also been of interest to researchers, and a negative impact of redundancy on health outcome has been frequently reported [Sullivan and Wachter, 2006; Ruhm, 2000; Gibbons and Lawrence, 1991].

Recent growth of non-traditional types of employment has urged researchers to look into whether different types of employment (e.g., temporary-permanent employment, part-full time employment) has an impact on health in different ways. Traditional approach treating a single category by encompassing various types of employment does not reflect considerable heterogeneity between different types of employment [Kivimäki *et al*, 2003]. In this sense, Bartley [2005] pointed out that vulnerable employment may harm health as much as unemployment. Deregulated labour market was shown as being a potential risk for increased mortality and morbidity [Benavides *et al*, 2006; Vritanen M *et al*, 2005; Artazcoz *et al*, 2005; Kivimäki *et al*, 2003; Virtanen P *et al*, 2003], which was described by various dimensions such as flexibility [Artazcoz *et al*, 2005], precarious work [Virtanen P *et al*, 2003], part time work, temporary work [Benavides *et al*, 2006; Virtanen M *et al*, 2005; Kivimäki *et al*, 2003; Virtanen M *et al*, 2002], and job insecurity [Ferrie *et al*, 2005; Virtanen P *et al*, 2003; Virtanen P *et al*, 2002]. Bartley [2005; 2004b; 2002; 1999; 1996; 1994; 1988] contributed greatly to the understanding of the relationship between unemployment and health, and she identified three tentative explanations for how unemployment affects health status: poverty related to unemployment, a stressful life event due to unemployment, and changes in health-related behaviours at the time of unemployment [Bartley *et al*, 1999, p85].

Alternatively, many studies which were set in the context of health selection consistently found that transitions into and out of employment were related to health status [Schuring *et al*, 2007; Cardano *et al*, 2004; Elstad and Krokstad, 2003; Dwyer and Mitchell, 1999; van de Mheen *et al*, 1999; Mastekaasa, 1996; Lundberg, 1991]. Although the negative effects of poor health on employment status are consistent [Disney *et al*, 2006; Bound *et al*, 1999], the impacts of health varied in response to other factors. The reduction of labour participation due to health was reinforced when the effect of lower payment was incorporated into the effect of poor health [Disney *et al*, 2006; Cappellari and Jenkins, 2003]. Receiving disability benefit potentially accentuated a route to early retirement related to poor health [Little, 2007; Haardt, 2006; Faggio and Nickel, 2003, p41; Flippen and Tienda, 2000][15]. The effect of health is also known to be modified by the existence of other factors; gender [Cai and Kalb, 2006], age [McDonough and Amick, 2001], ethnicity [Flippen and Tienda, 2000], marital status [Jime´nez-Martı´n *et al*, 1999], employment history [Agerbo, 2005; Arrow, 1996] and working environment such as flexibility in the working hours [Currie and Madrian, 1999, p3320], and health insurance provision [Bradley *et al*, 2004; Burström *et al*, 2003]. Despite the influence of other factors, it has been argued that poor health plays a key role in the process of labour market transitions [Disney *et al*, 2006; Haardt, 2006; Faggio and Nickel, 2003, p41; Elstad and Krokstad, 2003]; furthermore, a study showed that poor health appeared to be more potent in accelerating early retirement than economic variables such as health insurance [Dwyer and Mitchell, 1999].

To date, health selection studies regarding employment status have mostly exclusively focused on the exit from employment [Jusot *et al*, 2008; Cardano *et al*, 2004; Lindholm *et al*, 2001; McDonough and Amick, 2001; Arrow, 1996; Lundberg, 1991] with particular attention to the early retirement [Disney *et al*, 2006; Flippen and

[15] In a dramatic rise in inactivity, health and incapacity benefit are often considered as one of most potent ‘push’ and ‘pull’ factors [Little, 2007, Faggio and Nickel, 2003, p41; Flippen and Tienda, 2000].

Tienda, 2000; Dwyer and Mitchell, 1999; Loprest *et al*, 1995], whilst entry to employment is often neglected. Accordingly, there are only a handful of studies which dealt with both exit and entry at the same time [Schuring *et al*, 2007; Haardt, 2006; van de Mheen *et al*, 1999]. However, none of these studies have examined all the possible transitions from every origin of employment status. Accordingly, little information is available on several other forms of transitions: for example, transitions from unemployment to inactivity and from inactivity to employment. If a full mobility trajectory is allowed, this may reveal the varied effects of health across transitions between all pairs of employment statuses. In the current study, this issue is addressed by using a multinomial multilevel analysis to accommodate a wide range of transitions across exit and entry. Moreover, some studies within a health selection framework have used the term 'non-employment (or unemployment)' to mean all those not currently working [Ojeda *et al*, 2009; Haardt, 2006; van de Mheen *et al*, 1999]. By this definition, different forms of labour market states are considered to belong to the same strain, although there is considerable heterogeneity between them [Arber, 1996; Atkinson and Micklewright, 1991]. With this simple employment/non-employment dichotomy, therefore, the role of health in the transition between employment statuses was limited and could not be illustrated in a detailed manner. As such, this study disaggregates non-employment into two dimensions (i.e., unemployment and inactivity) to examine whether different dimensions of non-employment are linked with health status in different ways.

Additionally, this study explores how health is related to different patterns of labour market transitions for men and women. The gender gap in the employment structure, in particular the low proportion of women in paid employment and difference in job characteristics, has been widely observed [Robinson, 2003, pp232-236; Gallie, 2000, pp291-297; Rubery *et al*, 1999, pp55-61]. This implies that the effects of health on employment status may vary according to gender difference. Despite the implications, some studies [Schuring *et al*, 2007; Lindholm *et al*, 2001; Flippen and Tienda, 2000; van de Mheen *et al*, 1999] pooled men and women together in a single analysis, and this fairly impaired the analytical ability to detect a gender difference in the health selection process. Gender differences have been taken into account only in a few prior studies [Ojeda *et al*, 2009; Cardano *et al*, 2004; McDonough and Amick, 2001;

Loprest *et al*, 1995], but the evidence is too inconsistent across different types of transition to draw a reliable conclusion. When moving out of employment, some studies have shown that gender difference with regard to poor health was minimal [Jusot *et al*, 2007; Disney *et al*, 2006; Cardano *et al*, 2004], while some have found that men were more susceptible to poor health [Ojeda *et al*, 2009; McDonough and Amick, 2001; Loprest *et al*, 1995], and others have found that women were more susceptible [Jusot *et al*, 2007; Arrow, 1996]. As for the chance of transition into employment, one study reported that men with poor health were less likely to enter employment [van de Mheen *et al*, 1999]. In contrast, other studies indicated that women with poor health were less likely to enter employment [Schuring *et al*, 2007; Haardt, 2006]. Accordingly, this chapter is concerned with how health involves in the differentiation of labour market experience between men and women.

7.3 Specific aims

Objectives of this study are:

1) to provide an overview about whether being in poor health is one of the predictors of labour market transitions, and if it is, to identify how health accounts for the different categories of non-employment status,

2) to understand how health relates to different labour market transitions between men and women,

3) to examine whether other factors, such as education and age, affect labour market transitions.

7.4 Method

Data are pooled from 13 waves (1991-2003) of the BHPS. These data are restricted to individuals who provide valid information on employment statusl, health, and other covarites. This sample comprises 51865 transitions from 7429 individuals. The labour market status is categorized as (1) employed, (2) unemployed, and (3) inactive. The employed group consists of those who are fully employed and self employed. Unlike Chapter 5, non-employment distinguishes between unemployment and inactivity. The unemployed group represents all those who are looking for work. The inactive group includes those who defined themselves as withdrawn from employment, and comprises the following inactive categories: family care, early retirees, and long term sick, after excluding other categories: students, and those on maternity care and governmental schemes. In the current study, the transitions to full-time student or maternity leave are assumed not to be influenced by poor health, since the category itself is regarded as a reason to voluntarily become inactive. Those on government training schemes are also excluded from the inactive category, because they are considered to have some desire to work [Andersen, 2008; Marzano, 2006; Bartley and Owen, 1996]. The similar identification of inactivity is frequently found in other studies in which some of the inactive categories were excluded [Schuring *et al*, 2007; Chandola *et al*, 2003b; Flippen and Tienda, 2000; Bartley and Owen, 1996].

To capture a slice of transition, nine possible transitions across three categories of labour market status are modelled. Transitions are modelled separately for each of the three origin statuses. Using multilevel multinomial analysis, the effect of health status is estimated in improving and worsening employment status, whilst adjusting for other covariates such as education and age[16]. Unlike the previous two chapters, modelling with employment status is able to fit a transition specific random effect instead of a common random effect, as described in section 4.3.4 and 4.3.5. By doing so, this model allows correlation between transition specific random effects for every destination. Subsequently, this model provides a chance to assess the closeness of unobserved heterogeneity between all types of transitions [Steele and Goldstein, 2004; Steele and Curtis, 2003]. From a covariance matrix, correlation coefficients between each transition are estimated. As an example, a positive correlation between two transitions implies that a high (low) propensity of one transition tend to have a high (low) propensity towards the other transition. This analysis is conducted by using MLwiN 2.01. Before fitting the multilevel multinomial model, a contingency table is used to show raw transition rates. Transitions to and from any of the three employment status generate a matrix of transitions. This analysis presents an overall picture of transitions between employment statuses including the stability of a particular state.

[16] In the modelling, class and income variables defy reasonable accommodation since these variables are assigned only to the employed, so they are not included into the analysis.

7.5 Results

7.5.1 Sample description

Table 7-1 shows the sample characteristic of all participants.

Table 7-1 Demographic and social characteristics of the study sample by gender* over 13 waves

Variables†	Men	Women
Number of observations [frequency (%)]	26220(50.6)	25645(49.4)
Number of individuals [frequency (%)]	3848(51.8)	3581(48.2)
Age [mean (±SD)]	45.1(±9.2)	43.6(±7.9)
Ethnicity (%)		
White people	96.8	95.9
Non-white people	3.2	4.1
Educational level (%)		
No qualification	20.4	23.0
GCE O levels or less	19.9	26.5
GCE A levels	11.6	8.2
Vocational qualification	34.0	31.1
Higher degree	14.1	11.1
Social classes‡ (%)		
I/II	45.0	36.6
III NM	10.4	34.3
III M	30.5	8.5
IV/V	14.1	20.7
Employment status (%)		
Employed	84.4	74.1
Unemployed	5.1	2.4
Inactive	10.5	23.5
Health status (%)		
Good	73.1	69.3
Poor	26.9	30.7

*Data are based on the person year observation apart from number of cases which is obtained from an individual level.

† Estimates are presented in three ways; [frequency (%)], [mean (±SD)], and (%).

‡ Social class is assigned to those within employment. This is categorized into professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), and partially skilled and unskilled (IV/V)

This study sample includes 3848 men and 3581 women with 26220 and 25645 observations respectively. When comparing men and women, across all the measures, women tend to be more socially disadvantaged. In spite of their younger composition, women are more likely to be unemployed, unhealthy, and less educated. Additionally, this sample shows a higher proportion of those people who are older, non-white, less educated, and with poor health, compared to Sample D in section 6.4.1 which included only those employed. The differences suggest that there may be substantial selective movements from employment to non-employment.

7.5.2 Results from bivariate analysis

Table 7-2 summarizes the raw rate of employment and employment transitions with regard to health status, age, and educational attainment. This provides a detailed view on how certain types of employment status are more strongly associated with various measures.

Table 7-2 Bivariate analysis of employment status and transitions on health and other measures[a] among men (N=26220)

	N (%)[b]	Health status		Age				Educational attainment[d]				
		good	poor	30s	40s	50s[c]	mean(±SD)	I	II	III	IV	V
Employment status												
Employment	22138(84.4)	78.3	21.7	40.3	33.9	25.8	44.0(±8.6)	16.7	20.5	12.0	35.3	15.5
Unemployment	1335(5.1)	65.6	34.4	36.7	29.1	34.2	45.4(±9.5)	42.3	19.5	7.8	24.0	6.4
Inactivity	2747(10.5)	34.6	65.4	11.0	18.9	70.1	53.7(±8.6)	39.2	15.1	10.6	28.9	6.3
Inactivity category												
Retirement	1088(39.6)	62.2	37.8	0.8	4.0	95.2	58.8(±4.4)	26.2	12.5	10.6	36.3	14.4
Family care	164(6.0)	65.2	34.8	24.9	52.1	23.0	45.4(±7.4)	46.9	18.1	16.9	14.4	3.7
Long-term sickness	1495(54.4)	11.2	88.8	16.8	26.1	57.1	50.9(±9.1)	48.1	16.7	9.8	24.9	0.5
Employment Transition												
Employment to Employment	21296(81.2/96.2)[e]	78.9	21.1	40.9	34.2	24.8	43.8(±8.5)	16.3	20.7	12.0	35.3	15.8
Employment to unemployment	427(1.6/1.9)	72.4	27.6	37.7	33.6	28.7	44.6(±8.8)	27.5	18.6	12.3	32.6	9.1
Employment to inactivity	415(1.6/1.9)	56.4	43.6	10.8	16.9	72.3	53.5(±8.3)	26.3	13.0	13.2	36.5	11.0
Unemployment to employment	456(1.7/34.2)	73.0	27.0	43.7	32.6	23.7	43.0(±8.5)	24.6	20.3	12.2	33.0	9.9
Unemployment to unemployment	643(2.5/48.2)	68.1	31.9	38.5	27.1	34.4	45.3(±9.6)	52.9	18.7	5.7	17.4	5.4
Unemployment to inactivity	236(0.9/17.7)	44.5	55.5	17.8	28.0	54.2	50.2(±9.5)	47.8	20.0	5.2	24.4	2.6
Inactivity to employment	130(0.5/4.7)	55.4	44.6	21.4	25.2	53.4	49.4(±9.7)	21.1	14.8	14.8	36.7	12.5
Inactivity to unemployment	122(0.5/4.5)	37.7	62.3	23.8	24.6	51.6	49.6(±10.4)	49.6	22.2	4.3	21.4	2.6
Inactivity to inactivity	2495(9.5/90.8)	33.4	66.6	9.9	18.3	71.8	54.1(±8.4)	39.6	14.7	10.7	28.8	6.1

a. Apart from employment transitions which are based on the change between year *t*-1 and year *t*, other measures are measured in year *t*-1. b. The number of total population in employment status and their transition reaches to 25672, while that in employment categories is equal to inactivity category (6036). c. 30s range from 31-40, 40s range from 41-50, while 50s ranges from 51 to 64. d. No qualification (I), GCE O levels or less (II), GCE A levels(III), Vocational qualification(IV), and Higher degree (V). e. The former percentage refers to the total number of transitions, while the latter percentage refers to the number of transitions specific to the same origin.

Table 7-2 shows that, unsurprisingly, those who are employed are in a more favourable situation against three measures listed in the table (i.e., health, age, and education) than those who are in other categories of employment status. Poor health is more prevalent among the economically inactive group. The proportion in poor health among the inactive group is 65.4%, which is dramatically contrasted with the proportion among the employed group (21.7%). The difference in age and educational attainment across employment status is also noticeable.

The detailed inspection of the inactive categories indicates that they are not homogeneous. For health measure, those in the long-term sickness category mostly report poor health (88.8%). This figure drops to a rate of 37.8% and 34.8% among the retired and those on family care. For age, the retired are much older than other inactive men indicating that age is an important determinant of retirement. With regard to educational level, the retired group is also distinguished from the other two inactive groups by a higher level of education.

The most common transitions are from employment to employment (81.2%), followed by transitions from inactivity to inactivity (9.5%) and from unemployment to unemployment (2.5%). It is clear from this table that transitions from employment both to employment and to unemployment are similar in their health and age statuses, whereas they bear no resemblance to the transition from employment to inactivity. For men, those returning to employment among the unemployed in the previous year show a better profile in all three measures than those who moved from unemployment to inactivity.

The following table presents the corresponding figures among women.

Table 7-3 Bivariate analysis of employment status and transitions on health and other measures[a] among women (N=25645)

	N (%)[b]	Health status		Age				Educational attainment[d]				
		Good	poor	30s	40s	50s[c]	Mean(±SD)	I	II	III	IV	V
Employment status												
Employment	18991(74.1)	74.9	25.1	40.4	38.5	21.1	43.2(±7.6)	18.4	26.6	8.8	33.3	12.9
Unemployment	616(2.4)	56.8	43.2	36.7	36.6	26.7	44.3(±8.0)	35.9	20.8	6.5	28.7	8.1
Inactivity	6038(23.5)	52.8	47.2	38.7	29.3	32.0	44.5(±8.6)	36.1	26.8	6.6	24.5	6.1
Inactivity categories												
Retirement	551(9.1)	58.4	41.6	1.4	10.0	88.6	54.6(±3.8)	32.7	18.0	4.4	38.6	6.2
Family care	4342(71.9)	63.0	37.0	48.8	30.0	21.2	42.3(±8.2)	32.9	30.2	7.9	22.3	6.6
Long-term sickness	1145(19.0)	11.2	88.8	18.5	35.9	45.6	48.2(±7.4)	49.9	17.9	2.5	25.7	4.0
Employment transitions												
Employment to Employment	17803(69.4/93.7)[e]	75.6	24.4	40.4	39.0	20.6	43.2(±7.5)	17.8	26.6	8.8	33.7	13.1
Employment to unemployment	290(1.1/1.5)	66.9	33.1	34.1	39.0	26.9	44.2(±7.7)	28.2	27.5	9.5	26.1	8.8
Employment to inactivity	899(3.5/4.8)	64.3	35.8	44.5	27.5	28.0	43.5(±8.6)	27.2	26.7	8.0	28.8	9.3
Unemployment to employment	242(0.9/39.4)	69.0	31.0	42.6	34.3	23.1	43.1(±7.8)	24.2	22.5	8.5	35.6	9.3
Unemployment to unemployment	163(0.6/26.5)	52.1	47.9	30.1	41.1	28.8	45.4(±7.6)	44.7	16.8	4.4	26.1	8.1
Unemployment to inactivity	210(0.8/34.1)	46.2	53.8	35.2	35.7	29.1	44.8(±8.4)	42.4	22.0	5.9	22.9	6.8
Inactivity to employment	801(3.1/13.3)	67.4	32.6	60.1	27.3	12.6	40.3(±7.3)	21.9	31.5	10.8	27.0	8.8
Inactivity to unemployment	141(0.5/2.3)	41.8	58.2	44.0	31.2	24.8	43.5(±8.6)	40.6	21.0	3.6	29.0	5.8
Inactivity to inactivity	5096(19.9/84.4)	50.8	49.2	35.2	29.6	35.3	45.2(±8.7)	38.2	26.2	6.0	24.0	5.6

a. Apart from employment transitions which are based on the change between year *t*-1 and year *t*, other measures are measured in year *t*-1. b. The number of total population in employment status and their transition reaches to 25672, while that in employment categories is equal to inactivity category (6036). c. 30s range from 31-40, 40s range from 41-50, while 50s ranges from 51 to 64. d. No qualification (I), GCE O levels or less (II), GCE A levels(III), Vocational qualification(IV), and Higher degree (V). e. The former percentage refers to the total number of transitions, while the latter percentage refers to the number of transitions specific to the same origin.

The proportion of women with poor health is 25.1% among those who are employed, compared to 47.2% among those who are inactive. However, those in unemployment and inactivity are similar in health status, age, and educational attainment. Women have a high proportion of inactivity largely due to family care (71.9%) with only a small proportion of the retired (9.1%), compared to men.

The details of inactivity show that most of the women who are involved in family care enjoy better conditions in all respects than women in the other categories. Transitions from employment to employment are associated with a lower poor health rate and a younger age, and a higher educational attainment. For a given employment status, this tendency is consistent and those who move to employment are considerably healthier, younger, and more educated than those who remain in unemployment and inactivity.

In many aspects, health seems to have a different effect on labour market experience for men and women. Firstly, the proportion in poor health for economically inactive men (65.4%) is far greater than that of the unemployed (34.4%). In contrast, for women, the proportion in poor health among the inactive (47.2%) is similar to that observed among the unemployed (43.2%). Secondly, for men, the retired (39.6%) and those with long-term sickness (54.4%) account for most of inactivity, while for women those on family care (71.9%) appear to constitute most of the inactive population, alongside a small contribution from those with long-term sickness (19.0%). Thirdly, when comparing the transitions from employment to inactivity between men and women, men in this transition are less healthy with a higher poor health rate (43.6%) than women (35.8%). In contrast, men who experience transition from employment to unemployment also tend to be healthier than women in the same situation. The fourth difference is observed in the transition from inactivity to employment. Re-employment from inactivity is far more frequent among women, whereas it is relatively minimal among men. This may be associated with a lower poor health rate among the inactive women (47.2%), compared to the same group in men (65.4%).

7.5.3 Transition rates from contingency table

Table 7-4 presents transition rates averaged over the period 1991 to 2003 for men with and without poor health.

Table 7-4 Annual transition rate (row percentage) between employment statuses with and without poor health† over 13 years in men

Employment status in year *t*-1	Employment status in year t			
	Employment	Unemployment	Inactivity	Total transitions
Those with good health				
Employment	96.9	1.8	1.3	17339 (90.5)
Unemployment	38.0	50.0	12.0	876 (4.5)
Inactivity	7.7	5.0	87.3	954 (5.0)
Total				19169 (100.0)
Those with poor health				
Employment	93.8	2.5	3.8	4799 (68.0)
Unemployment	26.8	44.7	28.5	459 (6.5)
Inactivity	3.2	4.2	92.5	1793 (25.5)
Total				7051 (100.0)

† Poor health in year *t*-1

Even though the results in table 7-4 are presented in a crude (unadjusted) rate, total transitions between employment statuses show that the trend is less in favour of those with poor health. Compared to those with good health, those with poor health are likely to move to a more adverse status (and less to an advantageous status). If we take an example of transitions from unemployment, men with poor health are less likely to experience a transition to employment (26.8% compared to 38.0% of those with good health) and more likely to move to inactivity (28.5% compared to 12.0% of those with good health). Thus, poor health seems to exert an important influence over men in both directions: accelerating transition from employment to unemployment or inactivity and preventing re-entry to employment.

The following table turns its attention to women with regard to transitions between employment statuses.

Table 7-5 Annual transition rate (row percentage) between employment statuses with and without poor health[†] over 13 years in women

Employment status in year *t*-1	Employment status in year t			
	Employment	Unemployment	Inactivity	Total transitions
Those with good health				
Employment	94.6	1.4	4.1	14225 (80.0)
Unemployment	47.8	24.4	27.8	350 (2.0)
Inactivity	17.1	1.9	81.0	3195 (18.0)
Total				17770 (100.0)
Those with poor health				
Employment	91.3	2.0	6.7	4766 (60.5)
Unemployment	28.2	29.3	42.5	266 (3.4)
Inactivity	9.2	2.9	88.0	2843 (36.2)
Total				7875 (100.0)

[†] Poor health in year *t*-1

In comparison with those with good health, women with poor health have a higher risk of becoming unemployed or inactive and a lower chance of becoming employed. This is persistent for every type of transition. Among the unemployed, for instance, women with good health are more likely to move to employment (47.8% compared to 28.5% of those with poor health), and far less likely to become inactive (27.8% compared to 42.5% of those with poor health).

The stable transition is similar between those with poor health and those without it. In terms of the level of stable transition, the employed are the most stable (91.3 % and 94.6% for women with and without poor health respectively), while the opposite is true for the unemployed (29.3% and 24.4% for women with and without poor health respectively). Compared to men, women have much lower levels of employment and higher levels of inactivity. Women are more likely to leave the workforce directly to inactivity, and are more likely to move back from inactivity to employment than men.

7.5.4 Multilevel multinomial analysis

Transitions from each employment status are modelled to examine if poor health and other covariates predict who will move to other employment status.

Table 7-6 The estimated odds ratio and 95% confidence interval[a] from two mutilevel multinomial models[b] with transitions from each employment status having repeated measurements in men

			Model I		Model II[c]								
			Fixed effect	Random effect	Fixed effect							Random effect	
Transitions		N[f]	Poor health vs good health	Variance	Poor health vs good health	Age 40s vs 30s	50s vs 30s	Education[d] I vs V	II vs V	III vs V	IV vs V	Variance[e]	Correlation
Emp[h]	⇒Unemp[h]	22138	1.41[1.14, 1.76]‡	1.25(0.20)‡	1.46[1.14, 1.87]‡	0.79[0.53, 1.17]	0.77[0.41, 1.42]	2.90[1.87, 4.51]‡	1.63[1.04, 2.57]†	1.79 [1.1, 2.92]†	1.61[1.07, 2.45]†	1.87(0.35)‡	0.29
	⇒ Inactiv		2.87[2.35, 3.50]‡	0.68(0.18)‡	3.14[2.48, 3.97]‡	1.44[0.82, 2.54]	4.38[2.06, 9.30]‡	1.10[0.69, 1.76]	0.8[0.48, 1.33]	1.64[0.97, 2.75]*	1.07[0.7, 1.66]	1.32(0.40)‡	
Unemp	⇒ Emp	1335	0.86[0.66, 1.12]	0.66(0.15)‡	0.82[0.54, 1.25]	1.88[0.93, 3.78]*	2.09[0.73, 5.93]	0.16[0.06, 0.43]‡	0.53[0.19, 1.52]	0.84[0.27, 2.61]	0.95[0.34, 2.63]	3.72(0.82)‡	0.08
	⇒ Inactiv		2.66[1.97, 3.59]‡	0.45(0.19)‡	3.02[1.88, 4.84]‡	5.23[2.05, 13.4]‡	6.49[1.66, 25.4]‡	1.55[0.28, 8.54]	2.95[0.74, 11.8]	1.88[0.38, 9.22]	3.57[0.89, 14.3]	3.12(0.94)‡	
Inactiv	⇒ Emp	2747	0.40[0.28, 0.58]‡	1.15(0.21)‡	0.28[0.15, 0.53]‡	0.6[0.17, 2.13]	0.52[0.11, 2.47]	0.17[0.04, 0.82]‡	0.26[0.05, 1.26]	0.47[0.1, 2.29]	0.54[0.13, 2.17]	8.44(2.31)‡	0.78‡
	⇒Unemp		0.83[0.57, 1.20]	0.50(0.09)‡	0.53[0.29, 0.97]†	0.48[0.15, 1.55]	0.17[0.03, 0.88]†	2.57[0.33, 20.3]	2.08[0.24, 18.4]	0.5[0.05, 5.47]	1.24[0.15, 10.4]	6.52(1.65)‡	

a. For variance, coefficients (standard error) are given.

b. Model I fits only with health variable, while model II fits along with other covariates.

c. Model II is adjusted for period and cohort effects as well as covariates listed in the table.

d. No qualification (I), GCE O levels or less (II), GCE A levels (III), Vocational qualification (IV), and Higher degree (V).

e. The random effect appears for every transition, as a transition specific random effect is assumed.

f. N denotes observations for each origin.

g. The correlation is calculated from the values in covariance matrix between random effects

h. emp = employment, unemp = unemployment, inactiv = inactivity

*Statistically significant <0.1, †Statistically significant <0.05, ‡Statistically significant <0.01

Table 7-6 presents the estimated ORs and coefficients of health and other covariates on transitions between employment statuses. The multilevel multinomial modelling is built for each origin status separately, and the risk of every transition is compared to that of staying in the same status (e.g., transition from employment to employment) as a reference category. The effects estimated show how much each transition is influenced by the level of independent variables observed in the previous year. Model I fits only with the health variable as an independent variable, while model II fits it along with other covariates.

The results from the fixed part show that the transitions from employment to either unemployment (OR=1.46) or inactivity (OR=3.14) are strongly affected by health status. These effects of health are identified as statistically significant. This indicates that inidividuals who had poor health in previous year are more likely to move to unemployment and inactivity than those with good health. This is particularly true for the pathway to inactivity because this transition is more strongly associated with health status compared to the transition to unemployment. In the second model which treats the transition from unemployment to employment and inactivity, poor health appears to facilitate the transition to inactivity (OR=3.02) and to obstruct transition to employment (OR=0.86), but only the former transition appears to be statistically significant. The transition from inactivity to employment suggests that returning to employment is very unlikely for those with poor health (OR=0.28). On the transition from inactivity to unemployment, the effect of poor health involves a lower probability of becoming unemployed (OR=0.53), but less statistically significant level compared with the former transition.

Findings from this table also show that younger age and higher educational level are also positively related to staying employed and negatively related to leaving employment. This relationship between age and labour market transitions supports the idea that old age is a barrier to maintaining employment. This is particularly true for those in their 50s and 60s. The probability of a transition into employment generally increases as the level of education rises, and the opposite principle is applied to the risk of moving out of employment. The effect of education is substantially significant when a comparison is made between a person having no qualifications and one having a higher degree (i.e., I vs V).

All individual-level variances are highly significant, implying that there are considerable individual level differences. An estimated correlation coefficient from covariance matrix demonstrates that the random effect for transition from inactivity to employment is positively correlated with the random effect for transition from inactivity to unemployment. This signifies that men with a high tendency of transition from inactivity to employment have a high tendency to become unemployed at the same time. This suggests that the two transitions tend to be closer at the modest level. However, when considering a correlation coefficient in transitions from employment both to inactivity and to unemployment, they do not appear to share similar characteristics.

The difference between model I and model II denotes only small changes in the ORs for the health variable, as outcomes before and after adjustment of other covariates are similar. This implies that there is an independent effect of health even after the adjustment of age, education, cohort, and period effects.

To illustrate the link between health and transitions between employment statuses in women, the estimated effect of independent variables is presented in table 7-7.

Table 7-7 The estimated odds ratio and 95% confidence interval[a] from two mutilevel multinomial models[b] with transitions from each employment status having repeated measurements in women

Transitions		N[f]	Model I		Model II[c]								
			Fixed effect	Random effect	Fixed effect							Random effect	
			Poor health vs good health	Variance	Poor health vs good health	Age 40s vs 30s	50s vs 30s	Education[d] I vs V	II vs V	III vs V	IV vs V	Variance[e]	Correlation
Emp[h]	⇒Unemp[h]	18991	1.52[1.19, 1.94]‡	0.51(0.23)‡	1.5[1.15, 1.96]‡	1.04[0.68, 1.58]	1.19[0.63, 2.25]	2.28[1.34, 3.86]‡	1.68[1.01, 2.81]†	1.66[0.91, 3.04]	1.17[0.7, 1.96]	1.22(0.38)‡	0.47‡
	⇒ Inactiv		1.70[1.47, 1.95]‡	1.23(0.10)‡	1.78[1.49, 2.13]‡	0.48[0.35, 0.64]‡	0.95[0.61, 1.48]	2.81[1.91, 4.15]‡	1.7[1.17, 2.47]‡	1.42[0.89, 2.27]	1.37[0.96, 1.98]*	2.84(0.37)‡	
Unemp	⇒ Emp	616	0.49[0.35, 0.69]‡	0.71(0.18)‡	0.44[0.30, 0.71]‡	1.47[0.25, 8.53]	6.34[0.44, 90.62]	0.3[0.03, 2.82]	0.98[0.12, 8.21]	3.76[0.23, 62.59]	2.61[0.31, 21.71]	1.53(0.25)‡	-0.18
	⇒ Inactiv		1.27[0.91, 1.78]	0.45(0.12)‡	1.82[0.82, 4.06]	1.16[0.37, 3.69]	1.06[0.19, 5.8]	1.24[0.29, 5.32]	1.29[0.29, 5.65]	1.14[0.16, 8.07]	0.78[0.17, 3.55]	0.98(0.19)‡	
Inactiv	⇒ Emp	6038	0.53[0.45, 0.62]‡	0.69(0.09)‡	0.59[0.47, 0.73]‡	0.73[0.52, 1.04]*	0.33[0.19, 0.59]‡	0.43[0.25, 0.71]‡	0.64[0.39, 1.04]*	1.0[0.56,1.79]	0.85[0.51, 1.41]	2.29(0.34)‡	0.20
	⇒Unemp		1.56[1.10, 2.19]‡	1.18(0.33)‡	1.73[1.12, 2.69]‡	0.86[0.39, 1.9]	0.42[0.13, 1.32]	1.31[0.46, 3.74]	0.79[0.27, 2.33]	0.42[0.08, 2.1]	1.67[0.58, 4.84]	4.16(0.94)‡	

a. For variance, coefficients (standard error) are given.

b. Model I fits only with health variable, while model II fits along with other covariates.

c. Model II is adjusted for period and cohort effects as well as covariates listed in the table.

d. No qualification (I), GCE O levels or less (II), GCE A levels (III), Vocational qualification (IV), and Higher degree (V).

e. The random effect appears for every transition, as a transition specific random effect is assumed.

f. N denotes observations for each origin.

g. The correlation is calculated from the values in covariance matrix between random effects

h. emp = employment, unemp = unemployment, inactiv = inactivity

*Statistically significant <0.1, †Statistically significant <0.05, ‡Statistically significant <0.01

For women, poor health increases the risk of leaving employment, as the both transitions from employment to unemployment (OR=1.50) and from employment to inactivity (OR=1.65) are significantly affected by poor health. When it comes to transitions to employment either from unemployment (OR=0.44) or from inactivity (OR=0.59), women in poor health are more likely to remain unemployed and economically inactive in the next year than those in good health. Conversely, transitions between unemployment and inactivity show that poor health may not play a major role in these movements. The effect of health on the risk of the transition from inactivity to unemployment is contrary to expectations, as poor health increases the risk of the transition rather than the other way round. This finding roughly corresponds with the previous table 7-5, in which the proportion in poor health in the transition from inactivity to unemployment is higher than that in the transition from unemployment to unemployment. In general, older age tends to be associated with worse employment status, though the effects are less pronounced in women than those in men. A higher educational level leads to a decrease of transition out of employment and an increase of transition into employment.

Random effects (variances across individuals) in all transitions turn out to be highly significant. This evidence suggests that variability across individuals is large for every transition. An estimated correlations support the suggestion that there is considerable unobserved heterogeneity, in particular for the transitions from employment. The transitions from employment to unemployment and inactivity seem to be strongly correlated each other (correlation coefficient=0.47). Certainly, the positive correlation implies that those two transitions tend to be closer to each other.Although it is not statistically significant, there is a negative correlation (coefficient=-0.17) between the transition from unemployment to employment and the transition from unemployment to inactivity.

7.6 Discussion

7.6.1 Main findings

In this chapter, an overview of the effect of health on labour market transition was provided. Using longitudinal data, health was set to precede the labour market transitions to test whether poor health leads to deterioration in labour market position. Labour market status was categorized as employed, unemployed, or economically inactive. Nine possible transitions across three categories of labour market status were modelled separately for each of the three origin statuses. Results supported the previous findings that those with poor health are more likely to exit from employment and less likely to find new employment. Moreover, poor health was outlined here as one of important factors in understanding the gender differences in labour market participation.

Multilevel multinomial modelling was used to estimate the effect of health on each transition, because this model is able to account for the structure of pooled data having repeated measurements from the same individual. The effects of health on the transitions from employment to both unemployment and inactivity and reverse transitions were continuously significant. The weakest relationship between health and the transition arose around the transitions out of/into unemployment, especially among men. Older age increased the risk of exiting the labour force among both men and women. Higher education lowered the probability of leaving employment, although the impact of education on inactivity and unemployment was relatively small. Health appeared to have a different effect on the pattern of transitions between men and women. When men left employment, the effects of health on the risk of economic inactivity (OR=3.14) were much larger than the effects on the risk of unemployment (OR=1.46). In contrast, among women, the effects of poor health on both transitions tended to be about the same degree (OR=1.50 for the former transition and OR=1.78 for the latter transition). Subsequently, poor health lowered the probability of reemployment from unemployment for women, but this was not the case for men.

7.6.2 The effect of health on various transitions

There is longstanding evidence that poor health leads to a decrease in labour force participation [Little, 2007; Laplagne *et al*, 2007; Cai and Kalb, 2006; van de Mheen *et al*, 1999; Jime´nez-Martı´n, 1999]. This topic has been frequently visited by a wide spectrum of disciplines from health economics studies [Little, 2007; Laplagne *et al*, 2007; Cai and Kalb, 2006; Haardt, 2006] to gerontology studies paying special attention to early retirement [Disney *et al*, 2006; Flippen and Tienda, 2000; Dwyer and Mitchell, 1999]. The relationship between health and subsequent labour market transitions has been examined across various health measures such as mental illness [Ojeda *et al*, 2009; Salkever *et al*, 2007; Qin *et al*, 2003] and physical disability [Choi *et al*, 2001; Baldwin and Jhonson, 2000; Baldwin and Jhonson, 1995; Loprest *et al*, 1995]. Overall, the current study supports the finding that poor health is negatively connected with labour market transitions for both men and women.

A unique strength of this study is that it incorporates all the transitions out of and into three crucial employment statuses. To date, only a few studies in the health selection framework (i.e., when the causal direction runs from health to the transitions) have considered the disaggregation of non-employment into specific dimensions. To investigate the causal link between chronic disease and labour market exclusion, Lindholm *et al* [2001] distinguished three non-employment statuses: unemployment, long-term unemployment, and economically inactive. Although those with chronic illness had an increased the risk of adverse labour market consequences, the effect of health was uneven across each type of transition. When it was measured with age- and sex-adjusted OR, the effect of health was more influential on the risks of becoming economically inactive and unemployed, but was less influential on the risk of becoming long-term unemployed.

Using the Turin Longitudinal study, Cardano *et al* [2004] evaluated the influence of health on various types of exit from employment. Movement out of employment was described by a discrete variable distinguishing unemployment, early retirement, and (for women) becoming a housewife. They found that health status had a substantial effect on taking early retirement but had a less substantial effect on the exit towards unemployment or becoming a housewife. Using the European Community Household

Panel, Schuring *et al* [2007] analysed the influence of poor health as a predictor of various destinations: entering employment, becoming unemployed, retirement, and leaving the workforce to take care of the household. They reported that in most European countries poor health led to an increased risk of each of those transitions. Thanks to the advantages over the traditional division of employment structure into employment and non-employment, the above studies could observe that not only that health can affect employment career, but also that different dimensions of non-employment are linked with health status in different ways. Despite this advantage, these studies were limited to deliver the diversity in patterns of labour market transition in accordance with health, as they focused on some of selected transitions rather than on all possible transitions. The current study unravels some important details and gross flows across labour market statuses by taking into account both the heterogeneous nature of non-employment groups and the exit and entry simultaneously, as suggested by previous studies [Pollock *et al*, 2002; Jarvis and Jenkins, 1997]. The transitions between employment and inactivity are most affected by health status. In contrast, the smallest effect of health was observed around the transitions out of/into unemployment. The effect of poor health on the probability of re-employment from unemployment was not statistically significant among men and the effect of poor health on the transition from unemployment to inactivity was not significant among women.

To uncover the variation of the effect of health, the presence of health selection is sometimes tested in conjunction with other factors. It has been generally accepted that the effect of health selection is differentiated by socioeconomic groups: gender [Schuring, 2007; McDonough and Amick, 2001], social class [Bartley, 1996], nationality [Arrow, 1996], ethnicity, education [McDonough and Amick, 2001], various forms of benefit [Haardt, 2006], and previous employment history [Agerbo, 2005; Siebert, 2001]. For instance, Arrow [1996] examined the negative health selection hypothesis separately for male and female workers from Germany and foreign countries using the German Socio-Economic Panel (1984-1991). Although none of the health variables were significant for German males, the effects of health were significant for other working groups (German females, foreign males, and foreign females). From Panel Study of Income Dynamics data (1984-1990), McDonough and Amick [2001] showed no statistical significance of health effect for older men and women, but a slight significance for a younger cohort. Both studies suggested a differential selection effect according to gender, ethnicity, education, and nationality.

Therefore, it seems obvious that health selection takes place in the context of social influences. In such circumstances where multiple factors are involved, a few studies have argued that the relative effect of health is entirely conditional on other socioeconomic factors, saying 'poor health does not constitute a risk to employment. It only does so, when it concurs with other factors' [Arrow, 1996]. However, evidence suggests that health might be one of the primary factors for leaving the workforce [Disney *et al*, 2006; Haardt, 2006; Elstad and Krokstad, 2003; Faggio, 2003, p41]. The current study noticed that the effect of health decreases after controlling for other variables (age and education), but at a rate that does not radically alter the effect. The scale of change estimated by odds ratio supported the notion that the independent role of health is operating on a number of transitions between employment statuses. This indicates that health itself seems to have an independent effect on labour market transitions separately from other conditions, although the realization of health selection is developed through many facets.

7.6.3 Different health selection between men and women

There may be a difference in how men and women respond to poor health. However, studies have demonstrated comparable differences in health-related transitions between men and women. Most previous studies have found that poor health was a more important risk factor among men [Ojeda *et al*, 2009; Cardano *et al*, 2004; McDonough and Amick, 2001; van de Mheen *et al*, 1999], particularly when employment status was dichotomized into two groups (i.e., employment and non-employment) [Ojeda *et al*, 2009; McDonough and Amick, 2001; van de Mheen *et al*, 1999]. However, the current study arrived at a different result, suggesting that the influence of health on labour market transitions depends on gender, but varied differently according to the type of transitions. In the current study, poor health appeared to involve a gender difference in labour market experience. First of all, although general health status was worse among women than among men, poor health rate among inactive men was higher than that in women. The second difference between men and women is highlighted in the light of subtypes of inactivity. Men who exit into inactivity tend to move to retirement or long-term sickness, while women tend to leave the labour force to meet the demands of family care. Thirdly, the influence of health on transitions between employment and inactive status were more pronounced among men than among women, whereas when it comes to the transitions between employment and unemployment, women were more likely than men to be influenced by health. Subsequently, the fourth difference arose when returning to employment from unemployment. Poor health lowered the probability of reemployment from unemployment for women, but this was not the case for men. Similar to the current study, other studies also reported that women were more vulnerable to poor health in the labour market [Haardt, 2006; Cai and Kalb, 2006; Arrow, 1996], suggesting that women with poor health experienced more disadvantage in their working experience than men with the same condition [Burström *et al*, 2003]. Besides these studies, based on more detailed categories of employment status, Schuring *et al* [2007] reported that the effect of health on the chance of entering paid employment from unemployment was stronger for women than for men.

The difference in results may be partly attributed to the application of how to define the categories of employment status. It is notable that when studies were based on a simple dichotomy, most studies demonstrated that the influence of poor health is larger among men than among women. This may be explained by the fact that gender differences in the labour market transition are not well-reflected in the traditional classification of two categories of employment status (i.e., employment and non-employment), because subtypes of non-employment are too diverse to be simplified into a single entity. Similarly, the finding that the transitions between employment and inactivity are more significantly affected by health status among men than among women needs to be interpreted with caution. This may be related to the fact that the main reason for inactivity among women is family care, while the prime reason for inactivity among men is long-term sickness. If inactivity is separated into several subtypes, the varied transitions may respond differently to poor health by men and women. This may be worthy of further investigation.

7.6.4 Strengths and limitations

Including categories of unemployment and inactivity separately in the analysis offered the special ability to show the diversity of transitions in the labour market. Without resorting to predefined transitions, a full range of movements across three domains of employment status were considered simultaneously. In connecting health and other covariates with the occurrence of different types of transitions, the use of multinomial multilevel modelling was appropriate for this purpose.

Another strength of the study was its longitudinal application. In the assessment of transition processes, tracing individuals in longitudinal data is essential, as all transitions are considered to resume the process constantly over 13 years without ending up in an absorbing state, which has often been regarded as a limitation in other longitudinal approaches [McDonough and Amick, 2001; Jime´nez-Martı´n, 1999; Arrow, 1996]. This study was able to address this issue by taking advantage of recent advances in multilevel modelling.

Despite the strengths noted above, the current study suffered from a potential limitation that should be considered in future research. The limitation is related to the ability to comprehend inactivity subtypes. Although this approach could reliably identify three major employment statuses, inactivity was observed by pooling several categories into one. In the BHPS data, economically inactive people contain six possible destinations: retirement, family care, full-time student, long-term sickness/disability, maternity leave, and government training schemes. The pattern of transitions with three inactive groups (i.e., retirement, family care, and long-term sickness/disability) in the current study suggested a substantial difference from one type to another. Since the current approach combined these different subtypes into a single category, it was unable to separately identify the health impacts on various subtypes, which themselves might show important distinctions between different paths [Marzano, 2006; Atkinson and Micklewright, 1991]. To get a clear idea of how the effects of health vary in different types of transitions, therefore, it would be better to keep the separate groups instead of collapsing them into a single category.

Chapter 8: A way of linking between health selection, social mobility, and social inequalities in health

8.1 Introduction

In Chapter 2, approaches to explain social inequalities in health in relation to health selection were discussed, including the application of population-level data. In the last three chapters, however, empirical accounts of health-related social mobility with three different socioeconomic indices were provided from the perspective of analysis of individual-level effects (type I study). Unlike the previous chapters, this chapter offers a view of the association between health selection and social inequalities in health at the population-level concepts. It is important to note that the topic of this chapter concerns the contribution of social mobility to social inequalities in health (type II study). This chapter is structured as follows; firstly, an overview of population-level approach is presented, followed by the aims of this chapter. Then, based on two different methods, separate sections present related methods and results together. A discussion of both sets of results follows at the end of the current chapter.

8.2 Literature review

The central concepts of the type II study is related to the link between social mobility, health selection, and social inequalities in health. For example, to indicate an increase or decrease in the degree of social inequalities in health, it is necessary to make a comparison between social inequalities in health at two time points, before and after both changes in social position (social mobility) and health take place. Then, the unit of comparison becomes a specific population over two time points. Social mobility represents the concept of the scale of social mobility (i.e., the proportion of people who were mobile among a population). The current chapter explores how health selection, social mobility, and social inequalities in health are defined at the population-level, and how they are related to each other.

A few studies [Elstad, 2001; Stern, 1983] have tried to estimate whether or not class inequalities in health are increased by social mobility, by demonstrating the change in the proportion in poor health in social classes before and after mobility. These studies made an example of 'the distribution of health post-mobility' compared to 'the distribution of health pre-mobility' using hypothetical examples. Together, these studies demonstrated the net effect of mobility on social inequalities in health as a consequence of exits from and entries to each social class and the new proportion in poor health brought by these movements.

Inference in the gradient constraint hypothesis follows in a similar manner. The explanation uses concepts such as movements between classes comparing the proportion in poor health in the mobile and non-mobile groups. Using this approach, it described the change in social inequalities in health. For instance, the upwardly mobile groups are less healthy than the group that they join and healthier than the group from which they move [Claussen *et al*, 2005]. In this approach, all elements of mobility are combined and the contribution of social mobility to social inequalities in health is evaluated [Cardano *et al*, 2004; Adams *et al*, 2004; Elstad, 2001; Blane *et al*, 1999a; Hart *et al*, 1998; Bartley and Plewis, 1997]. The current study adopts the same approach. By assessing the movements of every exit and entry, and by measuring what impact those movements make on each social class, the resulting change in social inequalities in health is evaluated.

The studies reviewed above share an approach that indices used in the analysis are collected from individual-level aggregation in the form of a proportion in poor health. In this chapter as an extension of previous studies, an attempt is made to account for all exits and entries in the mobility process. The present study measures a pair of pre- and post-mobility social inequalities in health using participants who gave complete information over year *t*-1 and year *t.* The detailed reproduction process of social inequalities in health is traced by mapping movements in individuals' SEP over two years. To identify factors involved in the social mobility process (and health selection as a part of it), mathematical formulae and simulations are manipulated[17].

[17] Throughout this chapter, social mobility is distinguished from health selection. In fact, health selection is defined as one component of social mobility and there are many causes of social mobility other than health reasons (non-health related social mobility). Keeping this distinction as a basis, in this chapter, social mobility is linked to social inequalities health. By separating the social mobility processes into parts, this study tries to explore both health

8.3 Specific aims of this chapter

The three main aims for this chapter are to:

1) understand the basic mechanism and the underlying structure in which the effects of health selection influence social inequalities in health at the population-level,

2) assess whether and how non-health related social mobility and health selection lead to changes in social inequalities in health,

3) investigate how social class inequalities in health are connected with the health selection process of leaving and entering employment as well as health selection processes between classes, and

selection and non-health related social mobility.

8.4 Tabulation for the description of changes in social inequalities in health

8.4.1 Method

All participants are pooled across 13 waves of the BHPS collected from 1991 to 2003 as long as they participated in two consecutive years. The numbers of individuals aged 21 to 65 are 25,611 excluding some categories of the economically inactive: full time students, those on maternity leave, and those on governmental schemes. This is the same sample used in Chapter 5, but restricted to men only. A more detailed description of the sample was given in Chapter 4.

In epidemiological studies, two distinctive populations can be distinguished: the closed population and the open population [Rothman and Greenland, 1998, p32-34]. Since this sample recruits only those who are in economically active age, the sample is open to gain new members and to lose members over time. However, the sample is closed in the sense that the same group of people is followed for at least two years[18]. Therefore, this study design implicitly demands a closed sample across the mobility period[19]. A similar approach is found in other studies [Crimmins, 2006; Norman *et al*, 2005; Boyle *et al*, 2004] which monitor trends in social inequalities in health over different time periods.

The diagram below shows the basic redistribution of poor health in two social groups in a simplified mobility process, following participants' social location at year *t*-1 and year *t*. All possible types of entries and exits in the mobility processes between social groups and into/out of employment are shown.

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[18] In a general sense, a closed sample contributes equal person-time as the entire population is followed from the start to finish, but in a broader usage, the definition of closed sample is applied when the follow-up of individuals continues until the death or onset of disease, or sometimes births without allowing any subject to enter the sample [Rothman and Greenland, 1998, pp32-34].

[19] Since this approach is based on a closed sample with complete information on health and class measures over two years, a descriptive analysis is available for social mobility and health inequality in year *t*-1 and year *t*. In other words, it is outside the scope of the current study to yield coefficient which addresses the expected probability of a risk factor on the basis of statistical approach.

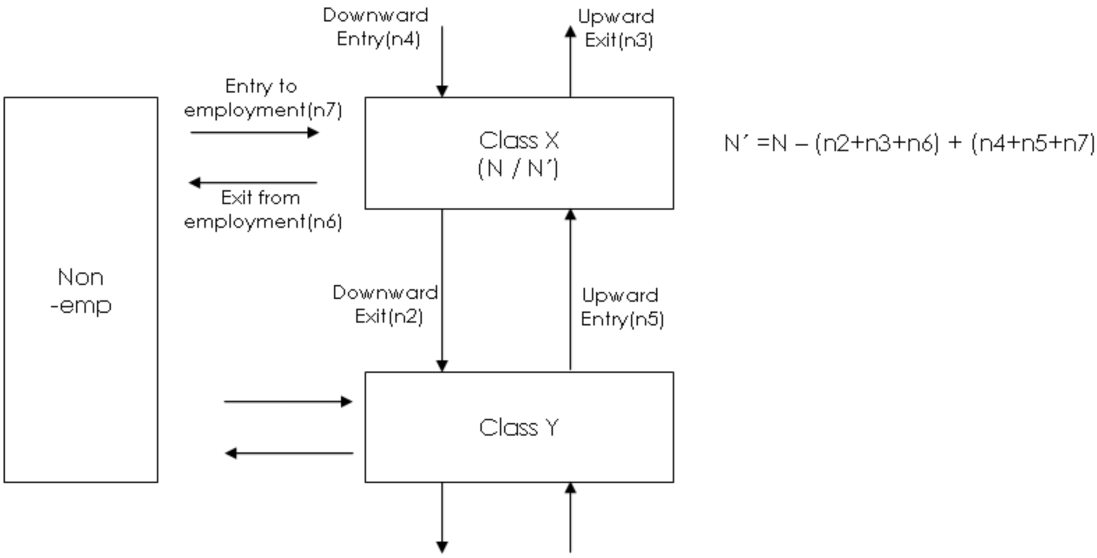

Figure 8-1 The flow diagram identifying redistribution of people with poor health

Note; Symbol N and N′ indicate the number of participants with poor health in a given class in year *t*-1 and year *t* respectively; n2, n3 and n6 are the number of downward exit, upward exit, and exit from class X whereas n4, n5, and n7 are the number of downward entry, upward entry, and entry to class X.

The model described in figure 8-1 is a depiction of a simplified social mobility process. Flows presented as arrows (e.g., n2) are movements of those with poor health from one state to another. The flows are terms used in the equation on the right hand side. The changes in the distribution of poor health is equated as a result of these flows: N´=N-(n2+n3+n6)+(n4+n5+n7).

Figure 8-1 illustrates how social mobility could alter social inequalities in health. Since all participants have completed two consecutive years, the total number of participants is preserved over these two years, and it is possible to identify all movements from one socioeconomic position in year *t*-1 to another in year *t*. The intermediate data converting processes are provided in Appendix 8-1.

8.4.2 Results

Results are presented in two parts: i) the process from 'social inequalities in health in year *t*-1' to 'post-mobility social inequalities in health' as in table 8-1, and ii) the process from 'social inequalities in health in year *t*-1' to 'social inequalities in health in year *t*', as in table 8-2 and 8-3.

8.4.2.1 Measuring post-mobility social inequalities in health

The path from pre-mobility social inequalities in health to post-mobility social inequalities in health has been explained by tabulating mobility against health status. Two processes of social mobility (i.e., social mobility between social classes and social mobility between employment and non-employment) are involved in the producing social inequalities in health. At the same time, two health selective movements are defined. Health selection between classes is conceptualized to reflect health-related social mobility contained in class redistribution, whereas the healthy worker effect[20] measures the effect of health on the transition between each class and non-employment.

[20] As defined in the glossary section (section 1.1.2), the healthy worker effect is used to refer to health selective movement in both entry into and exit from the labour market. To distinguish between the two sources of the healthy worker effect, some prefer to use the term 'healthy worker hire effect' for the former and 'healthy worker survival effect' for the latter [Kim *et al*, 2004; Siebert *et al*, 2001].

Table 8-1 Intervening effect of health selection between classes and healthy worker effect in the linkage between pre- and post-mobility class inequalities in health and pre-and post-mobility social inequalities in health by employment status by tracing those with poor health [Frequency (proportion)*]

	Health inequalities in Year *t*-1† (N)	Staying (n1)	Health selection within employment				Healthy worker effect		Total exit (n8)	Total entry (n9)	Post-mobility health inequalities (N′)
			Downward exit(n2)	Upward exit(n3)	Downward entry(n4)	Upward entry(n5)	Exit from employment(n6)	Entry to employment(n7)			
Changes in class inequalities in health following both health selection between classes and healthy worker effect											
I/II	1529(15.5)	1280(14.8)	170(22.0)	-	-	174(17.1)	79(27.4)	37(24.5)	249(20.2)	211(18.1)	1491(15.2)
III NM	429(18.9)	289(19.0)	50(23.9)	69(14.6)	72(17.3)	51(23.5)	21(28.4)	16(23.5)	140(18.5)	139(19.9)	428(19.3)
III M	1396(21.1)	1076(20.1)	121(25.2)	108(20.5)	98(20.5)	106(21.4)	91(34.5)	48(29.8)	320(25.1)	252(23.9)	1328(20.4)
IV/V	713(25.4)	488(25.6)	-	154(21.2)	171(23.4)	-	71(42.3)	65(39.4)	225(25.1)	236(26.4)	724(25.8)
Absolute Diff¶	9.9										10.6
Relative Diff¶	1.64										1.70
Changes in inequalities in health by employment status following healthy worker effect											
Employed	4067(18.9)	3805(18.3)	-	-	-	-	-	-	262(33.0) ‡	166(30.5‡	3971(18.6)
Non-employed	2221(54.9)	2055(58.7)	-	-	-	-	-	-	166(30.5)	262(33.0)	2317(61.5)
Absolute Diff¶	36.0										42.9
Relative Diff¶	2.90										3.31

* The frequency of this table is the number of individuals with poor health. Values in parentheses are the proportion of the individuals with poor health, where the denominator is the count of the entire membership of each category including those with good health.

† Symbol N represents the number of individuals with poor health in a given class in year *t*-1; and N′ represents the number of poor health in year *t*-1 after class mobility occurs over year *t*-1 and year *t*. n1 is the number of stayers; n2, n3 and n6 which are the number of downward exits, upward exits, and exits from each social origin, whereas n4, n5, and n7 are the number of downward entries upward entries, and entries to each social destination: n8 and n9 are the total of exits (n8=n2+n3+n6) and entries (n9=n4+n5+n7), respectively

‡ Exit from (166) and entry into (262) the non-employed are just the reverse of labour market exit (262) and entry (166).

¶ Health inequalities are evaluated by defining absolute difference and relative difference.

Although table 8-1 is unfamiliar in its layout, it is nothing but a transformation of the standard mobility table such as shown in table 5-5. This table aims to develop conceptualization of the formation of social inequalities in health, particularly highlighting the role of social mobility between social classes and between employment statuses (the employed and the non-employed). Findings show the change in the composition of poor health in each class and in the non-employed, and how these compositional changes alter social inequalities in health. The redistribution of individuals with poor health accords with the number of categories from n1 to n9 linking pre-mobility social inequalities in health (N) with post-mobility social inequalities in health (N′) in figure 8-1.

Noticeably, all of the movements appear to have a consistent pattern. For social mobility between social classes, those making an upward transition are healthier than the class they belonged to, but less healthy than the class they moved to. This occurs for every class origin and destination. Let's take an example of class III NM. Upward exits from class III NM included 14.6% in poor health, while upward entries to class III NM showed a less healthy composition of 23.5% in poor health. This is compared to 18.9% in poor health among those who stay in class III NM. On the other hand, the proportion in poor health among the downwardly mobile is greater than in the class which they leave behind, and smaller than in the class which they join. If we turn to the healthy worker effects, the proportion in poor health of those who exit and entry employment (33.0% and 30.5%), lie between the proportion in poor health of the employed and that of the non-employed.

To sum up, it is a solid fact that those with poor health are less likely to be upwardly mobile (or employed) and more likely to be downwardly mobile (or non-employed) whatever their socioeconomic position is. The same trends are repeated throughout all the transitions, suggesting that social mobility is affected by a selective process with respect to health. If such is the case, it might be said that social mobility is not a random movement with regard to health status, but the direction of social mobility is partly shaped by health.

Now, the question arises whether this selective effect causes differences in class inequalities in health. The answer is pursued by examining the initial social inequalities in health in year *t*-1 and post-mobility social inequalities in health. Class inequalities in health slightly increase as the difference in the proportion in poor health between classes I/II and IV/V widens. This is mirrored in the absolute difference (from 9.9 to 10.6) and relative difference (from 1.64 to 1.70). More remarkably, social inequalities in health by employment status become far wider, the absolute difference grows from 36.0 to 42.9, and an increase in relative difference from 2.90 to 3.31 is detected.

For the reproduction of class inequalities in health, not only heath-related social mobility between classes but also healthy worker effects are found to play an important role. The healthy worker effects seemingly have a negative effect on class inequalities in health, because it tends to take those with poor health away from their class of origin. This might be true if exits from employment are the only impact and if entries are health neutral. However, the proportion of 34.5% in poor health amongst those who exit from class III M together with that of 29.8% in poor health amongst those who enter class III M combines to give a net impact of the healthy worker effect that is neither simple nor obvious. While the proportion in poor health rises from 27.4% among those who exit classes I/II to 42.3% among those who exit classes IV/V, the proportion in poor health increases from 24.5% of those who enter classes I/II to 39.4% of those who enter classes IV/V. Rates of poor health among those who exit seem tied to rates of those who enter.

8.4.2.2 Reproduction of new social inequalities in health over two years

In table 8-1, to demonstrate the effect of health in relation to social mobility, only social class is allowed to change, while health status is assumed to be constant from year *t*-1 to *t*. Because health status is not necessarily fixed over the period, the above table therefore tells only half of the story. Apart from changes in SEP, changes in health status need to be applied simultaneously to enable the reproduction of social inequalities in health in year *t*. Table 8-2 shows the link between social inequalities in health in year *t*-1 and year *t*, by including the redistribution of health as well as SEP over two years.

Table 8-2 Reproduction of new class inequalities in health following both changes in socioeconomic position (social mobility) and health over two years [Frequency (proportion)[*]]

	Pre-mobility health inequalities in year *t*-1 (N[†])	Staying (n1)	Health selection within employment				Healthy worker effect		Total entry (n9)	Post-mobility health inequalities in year *t* (N′)	New poor health entry (n10)	Health inequalities in year *t* (N″)
			Downward exit (n2)	Upward exit (n3)	Downward entry (n4)	Upward entry (n5)	Exit from employment (n6)	Entry to employment (n7)				
Link between health inequalities in year t and post-mobility health inequalities												
I/II	1529(15.5)	1280(14.8)	170(22.0)	-	-	174(17.1)	79(27.4)	37(24.5)	211(18.1)	1491(15.2)	-	-
III NM	429(18.9)	289(19.0)	50(23.9)	69(14.6)	72(17.3)	51(23.5)	21(28.4)	16(23.5)	139(19.9)	428(19.3)	-	-
III M	1396(21.1)	1076(20.1)	121(25.2)	108(20.5)	98(20.5)	106(21.4)	91(34.5)	48(29.8)	252(23.9)	1328(20.4)	-	-
IV/V	713(25.4)	488(25.6)	-	154(21.2)	171(23.4)	-	71(42.3)	65(39.4)	236(26.4)	724(25.8)	-	-
AD/RD[¶]	9.9/1.64									10.6/1.70		
Link between health inequalities in year *t*-1 *and health inequalities in year t*												
I/II	-	650(51.0)	94(56.0)	-	-	99(56.9)	55(69.6)	18(48.7)	117(55.5)	767(51.6)	786(9.5)	1553(15.9)
III NM	-	177(61.5)	31(63.3)	42(60.9)	43(59.7)	27(52.9)	12(60.0)	9(56.3)	79(56.1)	256(60.0)	197(11.0)	453(20.5)
III M	-	589(55.0)	78(64.5)	59(54.6)	55(56.7)	51(48.6)	67(75.3)	23(47.9)	129(51.2)	718(54.4)	675(13.1)	1393(21.6)
IV/V	-	306(63.2)	-	76(49.7)	105(62,1)	-	59(83.1)	34(54.3)	139(58.9)	445(62.0)	281(13.6)	726(26.1)
AD/RD[¶]												10.2/1.64

[*] The frequency of this table is the number of individuals with poor health. Values in parentheses are the proportion of the individuals with poor, where the denominator is the count of the entire membership of each category including those with good health (e.g., In classes I/II = 15.5 = 1529/(1529+8333)x100). .

[†] The bottom panel indicates number of individuals with poor health in year *t* and their proportions (percentile) having denominator from top panel which is an observation for men with poor health in year *t*-1 (e.g., the proportion in poor health in staying classes I/II = 51.0 = 650/1280x100).

[‡] Symbol N, N′ and N″ represent the number of individuals with poor health in a given class in year *t*-1, post-mobility, and in year *t*, respectively and n1 stands for stayer; n2, n3 and n4 are the number of downward exit, upward exit, and exit from labour, whereas n4, n5, n7, and n9 are the number of downward entry, upward entry, labour entry and their total entry. n10 denotes new poor health entry from those who were with good health. The relationship among them can be expressed by deriving equations; at first row of each stratum, N′ = N – (n2+n3) + (n4+n5) – n6 + n7, N = n1 + (n2+n3) + n6, N′ = n1 + (n4+n5) +n7, and N′ = n1 + n9 and for second line, N″ = n1 + n4 + n5 + n7 + n10, N″ = n1 + n9 + n10, and N″ = N′ + n10.

[¶] Health inequalities are evaluated by defining absolute difference (AD) and relative difference (RD).

Table 8-2 is essentially a revision of table 8-1, with the addition of a new panel at the bottom. The lower panel shows the number of individuals with poor health in year *t* and their proportions (percentile) within each category. The last three columns show two channels for producing poor health, one source from those who were already unhealthy in year *t*-1 (N′), another from those who were healthy in year *t*-1 (n10), giving the number of individuals with poor health in year *t* (N″ = N′ + n10). For instance, for class IIIM, the total number of individuals with poor health in year *t* (N″ = 1393) is an aggregation of those who already had poor health who stayed in class III M (n1); those who moved downward (n4); those who moved upward (n5); those who moved into employment (n7); and those new entries to poor health who were in good health in the last year *t*-1 (n10); 1393 = 589 + 55 + 51 + 23 + 675.

Both class inequalities in health in year *t*-1 and year *t* are similar, although they are slightly higher for the latter. In year *t*-1, the proportion in poor health varied from 15.5% for classes I/II to 25.4% for classes IV/V but, in year *t*, it varied from 15.9% to 26.1%. Note that N″ can be obtained by the formula; N″ = N′ + n10 (1393 = 718 + 675). The total number of individuals with poor health in year *t* (N″) is result from the syntheses of those who stayed in poor health from year *t*-1 to *t* (N′) with those whose health aggravates from good health to poor health (n10). It stands to reason that the rates of poor health among people with poor health in the previous year are much higher than the rates among people with good health in year *t*-1.

In table 8-2, the proportion in poor health among those who already had poor health in year *t*-1 (N′) is very high while the proportion among the new entry group to poor health (n10) is low. The recurrent rate of poor health is lower among the upwardly mobile than the downwardly mobile, with the highest proportion among those exiting employment and the lowest among those entering employment. The pattern whereby the stable group tends to be in the middle - between the upward entry and the downward entry, and between the downward exit and the upward exit is mostly maintained. This implies that their previous health status got worse or better according to their experience of socio-economic advantage by SEP in the next year.

Table 8-2 also shows that both changes in SEP (social mobility) and changes in health (health change) are responsible for producing social inequalities in health in year *t* and these two changes occur simultaneously. Post-mobility social inequalities in health are still informative in evaluating the isolated impact of social mobility on social inequalities in health, but it is not the same as social inequalities in health in year *t*. It is obvious that post-mobility social inequalities in health are intermediate to the final social inequalities in health in year *t*.

The following table illustrates the process of changes in both SEP and health in reforming social inequalities in health by employment status.

Table 8-3 Reproduction of new social inequalities in health by employment status following both changes in employment status and health over two years [Frequency (proportion)*]

	Pre-mobility health inequalities in year *t*-1 ($N^{\dagger}$)	Staying (n1)	Healthy worker effect				Post-mobility health inequalities in year *t* (N′)	New poor health entry (n10)	Health inequalities in year *t* (N″)
			Exit from employment (n2)	Entry to employment (n3)	Exit form the non-employed (n4)	Entry to the non-employed (n5)			
Link between health inequalities by employment status in year t-1 and post mobility health inequalities by employment status									
Employed	4067(18.9)	3805(18.3)	262(33.0)	166(30.5)	-	-	3971(18.6)	-	-
Non-employed	2221(54.9)	2055(58.7)	-	-	166(30.5)	262(33.0)	2317(61.5)	-	-
AD/RD¶	36.0/2.90						42.9/3.31		
Link between health inequalities by employment status in year t-1 and health inequalities by employment status in year t									
Employed		2102(55.5)	193(74.5)	84(50.6)	-	-	2186(55.3)	1939(11.2)	4125(19.5)
Non-employed		1761(86.2)	-	-	84(50.6)	193(74.5)	1954(84.9)	472(23.9)	2426(56.8)
AD/RD¶									37.3/2.91

* The frequency of this table is the number of individuals with poor health. Values in parentheses are the proportion of the individuals with poor, where the denominator is the count of the entire membership of each category including those with good health.

† The bottom panel indicates number of individuals with poor health in year *t* and their proportions (percentile) having denominator from top panel which is an observation for men with poor health in year *t*-1 (e.g., the proportion in poor health in staying employed = 55.5 = 2102/3805x100). .

‡ Symbol N, N′ and N″ represent the number of individuals with poor health in a given class in year *t*-1, post-mobility, and in year *t*, respectively and n1 stands for stayer; n2, n3, n4, and n5 are the number of exit from employment, entry to employment, exit from the non-employed, and entry to the non-employed. n10 denotes new poor health entry from those who were with good health. The relationship among them can be expressed by deriving equations; at the top panel, N′ = N – n2 + n3, N = n1 + n2, and N′ = n1 + n3 and at the bottom panel, N″ = n1 + n3 + n5 + n10 and N″ = N′ + n10.

¶ Health inequalities are evaluated by defining absolute difference (AD) and relative difference (RD).

Table 8-3 shows the process from social inequalities in health in year *t*-1 to social inequalities in health in year *t.* This table can be read as in the previous table 8-2, as health change as well as social mobility over two years is presented. Social inequalities in health are increased partly because the cohort has aged by one more year from *t*-1 to *t* in this closed data. Among those with poor health in the four mobility groups (staying employed, staying non-employed, entry to employment, and exit from employment) in year *t*-1, the recurrent rate of poor health is highest for those who remained non-employed (86.2%), while the lowest is for those who entered employment (50.6%). Among those who left employment, 74.5% reported poor health again, and of those individuals who remained employed, 55.5% reported poor health. On average, those with poor health in year *t*-1 are observed to be at high risk of poor health, 55.3% for the employed and 84.9% for the non-employed. In contrast, those with good health in year *t*-1 report a relatively low prevalence of poor health in year *t*, 11.2% for the employed and 23.9% for the non-employed.

Although changes in SEP and changes in health[21] are presented as if they occur in succession, they are simultaneous processes which occur at the same time at a given interval. Table 8-2 and 8-3 may help us to understand the function and the process of social mobility and health change over two years. These tables provide a valuable insight into how social mobility and health change combine in the reproduction of social inequalities in health in year *t.*

[21] Health change over two years in deciding new health inequality can be presented separately from social mobility by assuming that class status is constant over two years as in year *t*-1. This is shown in Appendix 8-3.

8.5 Simulation of modifying factors in deciding social inequalities in health

8.5.1 Method

In the previous section, the tabulation was used to describe the redistribution of health status as a result of subtraction/addition in a descriptive way. This approach was less able to track varying relationship between social mobility and social inequalities in health, as there was no variation in the single population. In the next section, a simulation is introduced to apply different values of components which reflect social mobility process.

The following figure explains how to break down the changes in social inequalities in health, in order to see the underlying components.

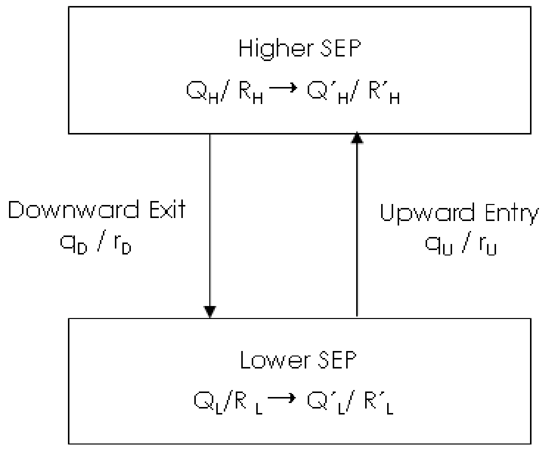

Figure 8-2 A general framework to identify the parameters by which the process of social mobility based on two socioeconomic groups is related to social inequalities in health

Note; For abbreviations used, H represents the higher SEP, L for the lower SEP. Q (Q′, q) is used to signify the size of population, and R (R′, r) for the proportion in poor health. U denotes upward social mobility, while D denotes downward social mobility. The symbol (′) signifies a new value after social mobility. As an example, q_U represents the number of population in upward social mobility, and R'_L indicates a new proportion in poor health in the lower SEP after social mobility.

In figure 8-2, identifiable factors bounded with the reproduction of social inequalities in health are characterized. Deriving such intervening factors is the first step for a simulation. For simplicity, only two SEP (Higher and Lower) are supposed. From the figure, four factors are derived to describe their influence on social inequalities in health. The four factors are:

Factor A) Level of health selection which is estimated from the rate difference between two proportions of poor health among the upward and downward mobile groups under the condition that the proportions in poor health among two mobility groups lies between those of the higher and lower SEP groups ($r_D - r_U \mid R_H < r_D, r_U < R_L$)
Factor B) Scale of social mobility which is expressed as a ratio between the number who are mobile and the total size of population ($q_U + q_D / Q_H + Q_L$)
Factor C) Relative difference between the magnitude of upward and downward mobility (q_D / q_U)
Factor D) Relative difference between the size of population in higher and lower SEP (Q_H / Q_L)

This approach identifies four factors embedded within the social mobility process. This follows Elstad's approach [2003; 2001], in which social inequalities in health were suggested to be products of several factors involved in the mobility process. Compared to Elstad's approach, the current study more systematically identifies the underlying mechanism of the relationship between social mobility (and health selection as a part of social mobility) and social inequalities in health. In this approach, social mobility is defined to vary depending on these four factors defined above. It is important to stress that not only are the four factors based on the notions of social mobility, but that they are also derived from the interrelationship of the eight parameters (Q_H, Q_L, q_U, q_D, r_D, r_U, R_H, and R_L), expressed in figure 8-2.

A simulation study is designed to assess the contribution of each of the four factors. It is based on a hypothetical population of 2000 that is maintained throughout two time points. This closed sample is assumed to have a poor health prevalence of 10% for the higher SEP and 40% for the lower SEP at the beginning of the mobility period. By varying the values of the four factors, this simulation detects how social mobility affects the proportion in poor health in both classes. This simulation essentially describes how social mobility characterized by four factors changes the degree of social inequalities in health.

In total, 24 situations are used to reflect different aspect of social mobility process. The level of health selection effect (factor A) is conceptualized by varying the proportion in poor health among the downward mobile group (r_D) from a1 (15%) to a5 (35%) while fixing the proportion of the upward mobile group (r_U) to 25%. Despite the variation in the proportion in poor health among the mobile groups, these rates lie between the proportion in poor health of the higher (R_H = 10%) and lower SEP groups (R_L = 40%). The scale of social mobility (factor B) is split into three degrees from small (b1) when the scale is 5% of the whole population to large (b3) when it is 20%. The ratio between the magnitude of downward and upward mobility (factor C) range from c1 (q_D:q_U =1:3) to c3 (q_D:q_U =3:1). The relative difference between the populations in higher and lower SEP groups (factor D) takes values d1 (Q_H:Q_L=1:3), d2 (Q_H:Q_L=1:1), and d3 (Q_H:Q_L=3:1). Table 8-4 is a description of the manipulation of the four factors.

Table 8-4 The manipulation of four factors

Factor	Simulated values	Model
A	a1(r_D=15%), a2 (r_D=20%), a3(r_D=25%), a4(r_D=30%), a5(r_D=35%) | r_U=25%, a6(r_D=10%) | r_U=40%, R_H =10%, R_L=40%	Model 1-6
B	b1 (q_U+q_D /Q_H+Q_L=0.05), b2 (q_U+q_D /Q_H+Q_L=0.1), b3 (q_U+q_D /Q_H+Q_L=0.2)	Model 7-12
C	c1 (q_D:q_U=1:3), c2 (q_D:q_U=1:1), c3 (q_D:q_U=3:1)	Model 13-18
D	d1(Q_H:Q_L=1:3), d2(Q_H:Q_L=1:1), d3 (Q_H:Q_L=3:1)	Model 19-24

The simulation assesses the effect of each factor keeping other factors invariant. While models 1-5 display various levels of health selection, model 6 simulates no health selection where social mobility is assumed to be independent of health. This situation is conceptualized as when there is an equal chance of downward and upward mobility between those with and without poor health (r_D= R_H =10%, and r_U=R_L=40%). Each set of models (e.g., model 7-9) relates to only one factor, whilst keeping the effect of other factors constant. The three possible values for each of B, C, and D (e.g., c1, c2, c3) are applied for two values of the effect of health selection (a2 and a4). One (a2) is the situation when the level of poor health among entries exceeds that of the exits ($r_D < r_U$) and the other (a4) is the opposite situation ($r_D > r_U$).

To appreciate how the manipulation of values for the four factors changes social inequalities in health, absolute and relative differences between the proportions in poor heath in the higher and lower SEP are compared. The calculation of absolute and relative differences of poor health from time t_1 and time t_2 is expressed according to the parameters illustrated in figure 8-2. A change in social inequalities in health before and after mobility is indicated by comparing the two absolute differences before and after mobility.

$$[\text{Absoulte Difference}] \sim [\text{Absolute Difference}'] = [R_L - R_H] \sim [R'_L - R'_H]$$

Within this mathematical framework, the change in social inequalities in health is seen to be dependent on the parameters illustrated in figure 8-2.

$$[R_L - R_H] \sim \left[\frac{Q_L R_L + q_D r_D - q_U r_U}{Q_L + q_D - q_U} - \frac{Q_H R_H - q_D r_D + q_U r_U}{Q_H - q_D + q_U} \right]$$

To obtain the number of individuals who reported poor health among the lower SEP in year *t*, the number of those with poor health who entered the lower SEP ($q_D r_D$) is added to the initial number in poor health in year *t*-1 ($Q_L R_L$) and the number of those with poor health who exited ($q_U r_U$) is subtracted from it ($Q'_L R'_L = Q_L R_L + q_D r_D - q_U r_U$). The new total number of people who were in the lower SEP in year *t* (Q'_L) is obtained by adding the number of entry (q_D) to the initial total in year *t*-1 (Q_L) and subtracting the number of exit (q_U) from it ($Q'_L = Q_L + q_D - q_U$). Thus, the new rate of poor health in year *t* among the lower SEP (R'_L) can be gained by the simple division of the number of those with poor health ($Q'_L R'_L$) by the new population size (Q'_L).

The new proportion in poor health in year *t* among the higher SEP (R'_H) is calculated following the same logic. As is explicit in the equation, changes in the eight parameters (Q_H, Q_L, q_U, q_D, r_D, r_U, R_H, and R_L) affect both in the numerator and denominator, resulting in a new absolute difference ($R'_L - R'_H$). In a similar way, changes in social inequalities in health can be measured by monitoring the relative difference before and after mobility. Relative differences are defined as the rate ratio between the proportion in poor health in the higher and lower SEP groups.

$$[\text{Relative Difference}] \sim [\text{Relative Difference}'] = R_L/R_H \sim R'_L/R'_H$$

The comparison of the two relative differences is a function of eight parameters as follows:

$$R_L/R_H \sim \frac{Q_L R_L + q_D r_D - q_U r_U}{Q_L + q_D - q_U} \Bigg/ \frac{Q_H R_H - q_D r_D + q_U r_U}{Q_L - q_D + q_U}$$

It is important to note that changes in both the mobility process (four factors) and in social inequalities in health (absolute and relative difference) are described based on the same eight parameters. In this way, the parameters represent the key concepts in the definition of both social mobility and social inequalities in health. In other words, the conceptual description of the process from social mobility to social inequalities in health is obtained through numerical description of a finite set of parameters (Q_H, Q_L, q_U, q_D, r_D, r_U, R_H, and R_L).

It needs to be emphasized that social inequalities in health in year *t*-1 are compared with post-mobility social inequalities in health, rather than with social inequalities in health in year *t.* Post-mobility social inequalities in health are based on the unrealistic assumption that health is persistent during the mobility period while allowing changes in socioeconomic position. This has been the approach in previous studies in explaining the isolated effect of social mobility on social inequalities in health [Claussen *et al*, 2005; Cardano *et al*, 2004; Adams *et al*, 2004; Elstad, 2001; Stern, 1983] [22]. This is probably because this measure (post-mobility social inequalities in health) effectively evaluates the isolated effect of social mobility in the generation of social inequalities in health. Thus, post-mobility social inequalities in health are used for the evaluation in the current study.

[22] The difference between post-mobility health inequality and actual health inequality after mobility has never been discussed before, although many studies have investigated whether social mobility increases health inequality depending on the assessment of the former measure.

8.5.2 Results

In the previous section, it was outlined that the processes of both changes in health and SEP lead to new social inequalities in health. The broad description of the process, however, did not identify how levels of health selection and the scale of social mobility interrelate to provide new social inequalities in health. In the following table, the influence of the four factors defined in section 8.5.1 is examined by systematically manipulating their values. Insights are provided into the operation of these factors and changes in social inequalities in health.

Table 8-5 Hypothetical simulation[*] to assess changes in social mobility and resulting social inequalities in health based on two socioeconomic positions

Model[†]	Situation	Pre-mobility health inequalities in year *t*-1	Social mobility		Post-mobility health inequalities in year t	AD(%)/RD[‡]	Evaluation
			Downward exit	Upward entry			
1	A=a1, B=b2, C=c2, D=d1	100/1000 (10.0%)	15/100(15%)		110/1000(11.0%)	28/3.5	−−
		400/1000 (40.0%)		25/100(25%)	390/1000(39.0%)		
2	A=a2, B=b2, C=c2, D=d1	100/1000 (10.0%)	20/100(20%)		105/1000(10.5%)	29/3.8	−
		400/1000 (40.0%)		25/100(25%)	395/1000(39.5%)		
3	A=a3, B=b2, C=c2, D=d1	100/1000 (10.0%)	25/100(25%)		100/1000(10%)	30/4.0	0
		400/1000 (40.0%)		25/100(25%)	400/1000(40%)		
4	A=a4, B=b2, C=c2, D=d1	100/1000 (10.0%)	30/100(30%)		95/1000(9.5%)	31/4.3	+
		400/1000 (40.0%)		25/100(25%)	405/1000(40.5%)		
5	A=a5, B=b2, C=c2, D=d1	100/1000 (10.0%)	35/100(35%)		90/1000(9.0%)	32/4.6	++
		400/1000 (40.0%)		25/100(25%)	410/1000(41.0%)		
6	A=a6, B=b2, C=c2, D=d1	100/1000 (10.0%)	10/100(10%)		130/1000(13.0%)	24/2.9	−−−
		400/1000 (40.0%)		40/100(40%)	370/1000(37.0%)		
7	A=a2, B=b1, C=c2, D=d2	100/1000 (10.0%)	10/50(20%)		105/1000(10.5%)	29/3.8	−
		400/1000 (40.0%)		15/50(30%)	395/1000(39.5%)		
8	A=a2, B=b2, C=c2, D=d2	100/1000 (10.0%)	20/100(20%)		110/1000(11.0%)	28/3.5	−−
		400/1000 (40.0%)		30/100(30%)	390/1000(39.0%)		
9	A=a2, B=b3, C=c2, D=d2	100/1000 (10.0%)	40/200(20%)		120/1000(12.0%)	26/3.2	−−−
		400/1000 (40.0%)		60/200(30%)	380/1000(38.0%)		
10	A=a4, B=b1, C=c2, D=d2	100/1000 (10.0%)	15/50(30%)		95/1000(9.5%)	31/4.3	+
		400/1000 (40.0%)		10/50(20%)	405/1000(40.5%)		
11	A=a4, B=b2, C=c2, D=d2	100/1000 (10.0%)	30/100(30%)		90/1000(9.0%)	32/4.6	++
		400/1000 (40.0%)		20/100(20%)	410/1000(41.0%)		
12	A=a4, B=b3, C=c2, D=d2	100/1000 (10.0%)	60/200(30%)		80/1000(8.0%)	34/5.3	+++
		400/1000 (40.0%)		40/200(20%)	120/1000(42.0%)		
13	A=a2, B=b2, C=c1, D=d2	100/1000 (10.0%)	10/50(20%)		135/1100(12.3%)	28.3/3.3	−−−
		400/1000 (40.0%)		45/150(30%)	365/900(40.6%)		
14	A=a2, B=b2, C=c2, D=d2	100/1000 (10.0%)	20/100(20%)		110/1000(11.0%)	28/3.5	−−
		400/1000 (40.0%)		30/100(30%)	390/1000(39.0%)		
15	A=a2, B=b2, C=c3, D=d2	100/1000 (10.0%)	30/150(20%)		85/900(9.4%)	28.3/4.0	−
		400/1000 (40.0%)		15/50(30%)	415/1100(37.7%)		
16	A=a4, B=b2, C=c1, D=d2	100/1000 (10.0%)	15/50(30%)		115/1100(10.5%)	32.3/4.1	+
		400/1000 (40.0%)		30/150(20%)	385/900(42.8%)		
17	A=a4, B=b2, C=c2, D=d2	100/1000 (10.0%)	30/100(30%)		90/1000(9.0%)	32/4.6	++
		400/1000 (40.0%)		20/100(20%)	410/1000(41.0%)		
18	A=a4, B=b2, C=c3, D=d2	100/1000 (10.0%)	45/150(30%)		65/900(7.2%)	32.3/5.5	+++
		400/1000 (40.0%)		10/50(20%)	435/1100(39.5%)		
19	A=a2, B=b2, C=c2, D=d1	50/500 (10.0%)	20/100(20%)		60/500 (12.0%)	27.3/3.3	−−
		600/1500 (40.0%)		30/100(30%)	590/1500 (39.3%)		
20	A=a2, B=b2, C=c2, D=d2	100/1000 (10.0%)	20/100(20%)		110/1000(11.0%)	28/3.5	−
		400/1000 (40.0%)		30/100(30%)	390/1000(39.0%)		
21	A=a2, B=b2, C=c2, D=d3	150/1500 (10.0%)	20/100(20%)		160/1500 (10.7%)	27.3/3.6	−−
		200/500 (40.0%)		30/100(30%)	190/500 (38.0%)		
22	A=a4, B=b2, C=c2, D=d1	50/500 (10.0%)	30/100(30%)		40/500 (8.0%)	32.7/5.1	++
		600/1500 (40.0%)		20/100(20%)	610/1500 (40.7%)		
23	A=a4, B=b2, C=c2, D=d2	100/1000 (10.0%)	30/100(30%)		90/1000(9.0%)	32/4.6	+
		400/1000 (40.0%)		20/100(20%)	410/1000(41.0%)		
24	A=a4, B=b2, C=c2, D=d3	150/1500 (10.0%)	30/100(30%)		140/1500 (9.3%)	32.7/4.5	++
		200/500 (40.0%)		20/100(20%)	210/500 (42.0%)		

[*] A denotes difference in the level of health selection, B the scale of social mobility, C the ratio between two mobility, and D the difference between the size of population in higher and lower SEP.

[†] Numerous situations have been created by the combination of four factors. Four panels simulating different conditions are divided by the dotted line. In models 1-6, only A varies from a1 to a6, B for models 7-12, C for models 13-18, and D works on change in models 19-24.

[‡] Health inequalities are evaluated by defining absolute difference (AD) and relative difference (RD) between the two poor health rates from the higher and the lower SEP. The reference values (e.g., pre-mobility inequalities) for these measures are 30 for the absolute difference and 4.0 for the relative difference. Unlike the relative difference which is a ratio, absolute difference is based on the difference between two percentages, and therefore, the unit for absolute difference is percentage (%).

Table 8-5 displays the combination of different levels of the four factors A, B, C, and D. As an example of how post-mobility social inequalities in health are calculated, model 1 is reviewed. There were 100 people with poor health among 1000 in the higher SEP (R_H=10%), and 15 of them move downward (r_D=15%). In the lower SEP, 400 people had poor health among the total of 1000 (R_L=40%), and 25 of them move upward (r_U=25%). Consequently, we see a small increase in the proportion in poor health to 11% in the higher SEP and a small decrease in the proportion in poor health to 39% in the lower SEP, and thereby social inequalities in health are narrowed.

8.5.2.1 The influence of the four factors

Factor A: the net effect of health selection ($r_D - r_U$ | $R_H < r_D$, $r_U < R_L$)

To examine health selection effects, different values are applied in models 1-6. For models 1-2, the proportions in poor health among the downwardly mobile, 15% and 20%, are lower than the reference proportion of 25% among the upwardly mobile ($r_D < r_U$). In the middle, model 3, the two mobile groups have the same proportion of 25% ($r_D = r_U$). In models 4-5, the levels for the downwardly mobile are 30% and 35%, above the reference value of 25% ($r_D > r_U$). These five levels of health selection span the distance between the rate of poor health in the higher and the lower SEP groups in percentage terms. However, model 6 is given different values to evaluate the situation where no health selection occurs ($r_D = R_H$ =10%, and $r_U = R_L$=40%).

In models 1 and 2, post-mobility social inequalities in health are reduced. In model 3, where the downward and upward mobile groups are assumed to have the same risk of poor health, the gross effect of health selection amounts to nothing. Once the proportion in poor health among the downward group exceeds that of the upward group as in models 4-5, the effect of health selection appears to increase post-mobility social inequalities in health. When the downward and upward group have the same proportions in poor health as those of higher and lower SEP groups (i.e., no health selection), a marked decrease in social inequalities in health is seen. Although this situation may not take place in reality, the findings suggest a linear association between the net effect of health selection (ranging from no health selection to strong health selection) and social inequalities in health.

In conclusion, the overall change in social inequalities in health seems to depend on the difference between the proportions in poor health in the downwardly and upwardly mobile groups. When the proportion in poor health in the downward group exceeds the proportion of the upward group, the proportion in poor health among the higher SEP starts to drop, while that of the lower SEP starts to rise. Accordingly, when the proportion in poor health of the downward group surpasses that of the upward group ($r_D > r_U$), this leads to an increase in social inequalities in health.

In a realistic situation, this excess of the proportion in poor health among the downward group may occur when those with poor health suffer more disadvantages in employment. This condition was previously described as a ‘strong health selection’ in section 2.3.1.1, and it may be found, for example, when poor health significantly increases the risk of downward mobility (or leaving employment), while the opportunity to move upward (or to be employed) becomes highly unlikely. Thus, strong health selection may reflect unfavourable circumstances for workers with poor health such as economic recession and detrimental policy changes in welfare provision.

Factor B: the scale of social mobility (q_U+q_D / Q_H+Q_L)

In models 7-12, different scales of social mobility are introduced, while other effects remain neutral. The scale of social mobility ranges from 5% (small) through 10% (medium) to 20%. These three scales of social mobility are applied to two clearly different net effects of health selection ($r_D < r_U$ in models 7-9 and $r_D > r_U$ in model 10-12). As the scale of social mobility increases, there is a greater impact on post-mobility social inequalities in health. In models 7-9, the increase in the scale of social mobility results in a decline in the relative differences in social inequalities in health from 3.8 when the scale is small to 3.2 when the scale is large. In models 10-12, however, changes in post-mobility social inequalities in health increase as the scale of social mobility increases. It seems evident that the larger the scale of social mobility is, the greater the impact on social inequalities in health, and that, conversely, the smaller the scale of social mobility is, the smaller the impact on social inequalities in health.

This suggests that either widening or narrowing of post-mobility social inequalities in health are fostered by increases in the scale of social mobility. At the same time, the scale of social mobility in itself is not a determinant of the direction (i.e., increase or decrease) of social inequalities in health, although it may be a determinant of the size of the change. Recently, studies have noticed a trend of decreasing social mobility has decreased [Nunn *et al*, 2007, pp13-19; Elstad, 2001], and this may imply that the contribution of the scale of social mobility to social inequalities in health may become less important.

Factor C: Relative difference between the magnitudes of the two mobile groups (q_D/q_U)

Changes in social inequalities in health seem to rely partly upon the relative difference between downward and upward mobility, although this trend is observed only in the relative difference in social inequalities in health and not in the absolute difference. In models 13-15, when the proportion in poor health among the upward group (30%) exceeds that of the downward group (20%), there is a widening of relative social inequalities in health from 3.3 to 4.0 as the ratio between the sizes of the two mobile groups increases from 1:3 to 3:1. Models 16-18 follow the same trend as the increase in the relative difference in magnitude between the two mobile groups leads to an increase in social inequalities in health. Thus, the findings suggest that the relative difference between the magnitude of downward and upward mobility groups makes a contribution to post-mobility social inequalities in health.

In summary, when the downward group is bigger than the upward group ($q_D/q_U>1$), a widening of post-mobility social inequalities in health occurs. On the other hand, if upward mobility is supposed to be more common ($q_D/q_U<1$), this results in a narrowing of social inequalities in health. To provide a clearer account of this manipulation, a more detailed breakdown of the relative difference between the magnitudes of the two mobility groups is presented in Appendix 8-4.

Factor D: relative difference in population size (Q_H:Q_L)

The relative difference between the size of the populations in the higher and lower SEP groups (Q_H:Q_L) are assessed in relation to the changes in post-mobility social inequalities in health. In models 19-21 where a small net effect of health selection is applied, a decline in social inequalities in health becomes apparent with the increase of asymmetry in the ratio of the population sizes. As the ratio moves from 1:1 to either 1:3 or to 3:1, post-mobility social inequalities in health further decreases. In models 22-24 where the net effect of health selection is large, the opposite situation arises. As the ratio 1:1 moves to either 1:3 or 3:1, an increase in social inequalities in health is seen. This result implies that an uneven distribution of the population across the class structure may magnify the change (either increase or decrease) in post-mobility social inequalities in health. A more distinctive trend from a more detailed manipulation is presented in Appendix 8-4.

8.5.2.2 Generalization of the findings

Although many other combinations of the four factors need to be studied, the four factors are found to be related to the process of social inequalities in health following social mobility. The following is a summary of the preliminary conclusion.

1) As the differences between health selection in the downwardly and upwardly mobile groups becomes larger, post-mobility social inequalities in health further increase.
2) An increase in the scale of social mobility (q_U+q_D /Q_H+Q_L) magnifies a change in social inequalities in health in either direction.
3) An increase in the relative difference between the magnitude of downward and upward mobility (q_D/q_U) widens social inequalities in health.
4) As the relative difference in the size of population becomes larger ($Q_H >> Q_L$ or $Q_H << Q_L$), social inequalities in health narrows.

It is important to note that the patterns expressed here are derived from hypothetical data which are confined to a set of allowed changes. To accommodate the full variation of the four factors and to improve generalization, future studies remain to be developed. Despite the limitation, it seems likely that changes in social inequalities in health are responding to social mobility at the population-level.

8.5.2.3 Interpretation of some empirical data using the four factors

In table 8-6, an actual example is evaluated based on the same factors as in the above simulation. The applicability of the four factors is reviewed in this particular case of changes in social inequalities in health by employment status.

Table 8-6 Applicability of four social mobility factors in assessing changes in social inequalities in health by employment status using actual data

		Pre-mobility health inequalities in year *t*-1	Social mobility: Exit from employment	Social mobility: Entry to employment	Post-mobility health inequalities in year t	Evaluation†
Employment status	Employed	4067/21563 (18.9%)	262/794(33.0%)		3971/21314(18.6%)	
	non-employed	2221/4048 (54.9%)		166/545(30.5%)	2317/3765(61.5%)	
AD(%)/RD†		36.0/2.9			42.9/3.3	++

* To evaluate applicability of the four factors with actual data in the current study, the change in social inequalities in health by employment status is introduced. For data construction process, see table 8-2, Appendix 8-1.
† Health inequalities are evaluated by defining absolute difference (AD) and relative difference (RD) between rates of poor health among the employed and the non-employed. Unlike the relative difference which is a ratio, the absolute difference is based on the difference between two percentages, and therefore, the unit for absolute difference is percentage (%).

As an empirical application, social inequalities in health by employment status in table 8-3 are rearranged to correspond to the four factors. These factors are possibly derived from the social mobility process. Pre- to post-mobility health inequalities show a widening both in the relative difference (from 2.9 to 3.3) and absolute difference (from 36.0 to 42.9). This outcome can be interpreted by means of the four components of the social mobility process.

There are 4067 people with poor health among 21563 (Q_H) employed people (R_H=18.9%) and 2221 people with poor health among 4048 (Q_L) non-employed people (R_L=54.9%) in year *t*-1. The proportion in poor health among those who exit from employment is 33.0% (r_D) as 262 people reported poor health among the whole exit group (q_D=794). The proportion in poor health in the exit group is higher than the 30.5% (r_U) in the entry group (q_U=545) who move into employment. This mobility process leads to changes in the proportion in poor health both among the employed (from 18.9% to 18.6%) and the non-employed (from 54.9% to 61.5%). Consequently, the mobility process results in a considerable widening of post-mobility social inequalities in health.

Let's examine how the four components of social mobility are associated with the changes in social inequalities in health. Firstly, since the proportion in poor health among the exit group (33.0%) exceeds that of the entry group (30.5%), health selection is expected to widen social inequalities in health ($r_D > r_U$). Secondly, the scale of social mobility is 5.2% (=$q_U + q_D / Q_H + Q_L$=1339/25611 X 100). If we consider this scale of social mobility to be small (like the 5% value in the simulation), then it may lead to a slight increase in social inequalities in health. Thirdly, the relative difference between the magnitude of the exit and entry groups ($q_D:q_U$ = 794:545 = 1.5:1) also intensifies the widening of social inequalities in health. Finally, the vast majority of the population is employed, and the relative difference in the size of two populations between the employed and the non-employed ($Q_H:Q_L$ = 21563:4048 = 5.3:1) is large enough to indicate an increase in social inequalities in health. Therefore, the widening social inequalities in health are expected given the values of all four factors. This implies that the four factors are reflected in the changes in social inequalities in real data as well as simulated data.

8.6 Discussion

The two previous sections were organized based on two different methods (a tabulation and a simulation method), which were followed by results. In the discussion, some issues refer to each result individually (Section 8.6.2 for the results from the tabulation method, and section 8.6.3 for the results from the simulation method). Other issues are drawn from the results of both methods (section 8.6.4), as the issues are common to the two results.

8.6.1 Main findings

This chapter has sought primary explanations for social mobility and the subsequent changes in social inequalities in health. A population-level approach was used by an aggregation of individual changes over two consecutive years. Two methods were developed to investigate the process of change in social inequalities in health from a health selection perspective. The first method provided an explicit and exact tabulation within which health selection, social mobility, and social inequalities in health were woven together. This numerical approach gave insights for the second method, identifying the components contributing to the change in social inequalities in health. In this analysis, a simple simulation based on four factors from the numerical model was developed, with some manipulation of these factors.

Social mobility partially mediated two inequalities in health, one pre-mobility and the other post-mobility. Every transition repeated the pattern that those who moved upwards were healthier than their counterparts who remained, and worse than the counterparts with whom they joined. This might be a permanent fixture of society and might be unlikely to disappear. Social inequalities in health were connected with both social mobility and health change. Once the social mobility process was completed, social inequalities in health in year t-1 became post-mobility social inequalities in health. When the process of health change was added, the model was extended to social inequalities in health in year t. The new social inequalities in health are defined as a result of both changes in health and changes in SEP. This observation suggested that social mobility and health change work together to produce social inequalities in health.

From a population-level framework, four components appeared to be key factors in the process of social mobility, and the pattern of change in social inequalities in health was described as a function of these factors. The factors were the net effect of health selection; the scale of social mobility; the relative difference between the magnitude of downward and upward mobility; and the relative difference between the size of populations in the higher and lower SEP. Various sets of simulations with these four factors revealed that no single factor is solely responsible for changes in social inequalities in health.

8.6.2 Healthy worker effects and class inequalities in health

The question of whether health selection between the employed and the non-employed (healthy worker effect) contributes to 'class' inequalities in health needs to be differentiated from a broader question of whether health selection contributes to social inequalities in health. The first question becomes clear after a distinction is made. It was noted in section 8.4.2.1 that health selection between classes only contributes to class inequalities in health, while the healthy worker effect is related, not only to health inequalities between the employed and the non-employed, but also to class inequalities in health [van de Mheen *et al*, 1999; Bartley and Owen, 1996]. For instance, the healthy worker effect may increase the health gradient between the employed and the non-employed, by accelerating the departure from employment of those with poor health, and by preventing them from (re)entering employment. At the same time, this process is also linked to class inequalities in health by health selection from each class.

A view has been expressed that the 'healthy worker effect' is partly responsible for class inequalities in health within employment, because of the differentiated selection from employment [Cardano *et al*, 2004, p1572; Manor *et al*, 2003; van de Mheen *et al*, 1999; Koskela, 1997, p9; Dahl, 1993a]. It has been suggested that the higher exit rate among the lower classes would weaken social inequalities in health [Manor *et al*, 2003, p2225; Dahl, 1993a, p1077]. The result from the current study, however, suggests a rather more complex situation. Once entry into employment was taken into account along with exit, the influence of the healthy worker effect on class inequalities in health came down to a contrast between movements (into and out of employment). The results showed that entries may dilute the impact of exits. Despite the better health of those entering than leaving, as long as the proportion in poor health across the exit and entry groups is about the same, the overall contribution of the healthy worker effect to class inequalities in health may be fairly minimal, due to the cancelling between two forms of health selections.

The view that the 'healthy worker effect' explains some of class inequalities in health needs to be understood in a more comprehensive context. There have been some studies indicating that health selection itself sometimes changes in favour of the lower class (e.g., in a period of economic expansion or low unemployment) but sometimes against them (e.g., in periods of economic recession or high unemployment) [Bartley and Ferrie, 2001; Lahelma *et al*, 2000; Bartley and Owen, 1996]. This suggests that health selection between employment statuses may lead to narrowing of class inequalities in health, not just because the lower class workers are more health selective, but also because they are more vulnerable to economic variation. Therefore, the relationship between the healthy worker effect and class inequalities in health needs to be elucidated from both perspectives. In the current study, the contribution of health selection between employment statuses to class inequalities in health was studied in the context of whether health selection influences the lower class more than upper class. However, this study has not examined how the healthy worker effect is related to class inequalities in health under different economic circumstances such as when unemployment rates are high. An answer to this question requires a future study with multiple mobility processes that could take place during different economic cycles such as periods of high and low unemployment rate.

8.6.3 Decomposition of the social mobility process

In the current study, social mobility was evaluated after decomposing its structure into four components. This viewpoint, which considers social mobility as a unitary structure composed of several major parts, also helps to clarify conceptual issues around the health selection debate. At the population-level, social mobility appears to contain plural components (e.g., the net effect of health selection and the scale of mobility), and one conclusion arising from the results is that each of the four factors depends on the others. A change in one factor may be accompanied by changes in the others, which might even result in a reversal of direction by other factors. Elstad [2001] saw this passage as conditional, so that it might result in either a widening or a narrowing of inequalities. He suggested that knowing the initial health difference and the magnitude of mobility was therefore essential to establish the specific effect of health-related social mobility. Consistent with his argument, these factors were found to account for social inequalities in health.

Additionally, social mobility should be differentiated from health selection. The two terms, health selection and social mobility, have been conceptually mixed, and rarely distinguished [Cardano *et al*, 2004; Manor *et al*, 2003]. In fact, social mobility contains diverse components which cannot be easily simplified, and health selection is defined as one of these. Health selection needs to be understood as one characteristic of social mobility that expresses the health-related aspect of social mobility. In a similar way, social mobility is not identical to the scale of social mobility which is only one of many defining characteristics of the social mobility process. Thus, when social mobility is defined at the population-level, it should be seen as diverse characteristics according to its components which cannot be summarized in a single measure.

8.6.4 Limitations of the study

Social mobility was disentangled into four factors (e.g., the net effect of health selection), and it is seen to be connected directly to post-mobility social inequalities in health, and indirectly to social inequalities in health in year *t*. Social inequalities in health in year *t* was determined after taking into account both changes in SEP (social mobility) and health (health change). Various combinations of the four factors were manipulated to identify population-level associations between social mobility and change in post-mobility social inequalities in health. However, one limitation of the study is apparent as the simulation approach does not allow the full range of variation of population-level parameters. This approach uses only artificial spectra of variability, and this suggests a need for further study in a real world situation.

A second limitation is related to the narrowness in defining social dynamics. In the current thesis, the numerical approach with parameters which accommodate both the social mobility process and changes in social inequalities in health are supposed to be static and deterministic, in the same way as many models in classical physics and mathematics. Though the underlying process is described through four factors within the process, it is unlikely that other factors are exogenous to this numerical association. This approach is too simplistic to link other factors with social inequalities in health in multiple ways. Therefore, more advanced model for the individual-level transitions is required to expain the complexity in this study area.

Thirdly, to assess the contribution of social mobility to social inequalities in health, post-mobility social inequalities in health are used as the main outcome measure. The applicability of this measure seems to be reliable because post-mobility social inequalities in health reveal the direct effect of social mobility on social inequalities in health more clearly than social inequalities in health in year *t*. Despite the effectiveness of this measure, it is still important to note its limitations. The major drawback to this measure is its unrealistic assumption that health is taken from year *t*-1 while SEP is taken from year *t*. Thus, the evaluation with post-mobility social inequalities in health should not be interpreted as exact estimates of the effects of social mobility on actual social inequalities in health. Rather, the estimation should be viewed as an indication of potential magnitude and sign of the effects of social mobility.

Chapter 9: Discussion

In this final chapter, linked to the study hypotheses, section 9.1 provides a summary of the conclusions from each chapter to provide an overview of the current thesis. In sections, 9.2, 9.3, and 9.4, some major issues arising from the current study are further discussed. Section 9.5 addresses the strengths and limitations of this study, followed by suggestions for future research in section 9.6. Lastly, implications for public policy are discussed in section 9.7.

9.1 Summary of main conclusions

Social inequalities in health remain a major social issue globally. One of the possible explanations of health inequality is health selection: in other words people with poor health move down the social hierarchy. This study examines the role of health selection on social inequalities in health in a large representative sample of British adults. A general typology of health selection study is developed. One type of study concerns the presence of health selection, and asks whether the impact of health could be attributed as the source of the socio-economic advantage or disadvantage (type I health selection study). The other type of study concerns the contribution of health selection to social inequalities in health by examining whether social inequalities in health increase or decrease as a result of health selection.

With this as a basis, an application of empirical and theoretical investigation is carried out. For the type I health selection study, multilevel multinomial modelling was used to assess the impact of health on social mobility defined by social class, income, and employment status, which represent different aspect of socioeconomic position. For the type II health selection study, a set of factors describing a social mobility process are put forward to trace the changes in social inequalities in health. In the following section, principal conclusions are given below and related hypotheses are shown in parentheses. A table follows to present a brief summary of the conclusions presented and implied in the currrent thesis in comparison with previous studies.

The different impact of health on social mobility was found to depend on the socioeconomic measures used (hypothesis 1). As to the impact of health on class mobility:

• The effects of health operated when exiting and entering each occupational class, but the effects were mostly negligible for the mobility across classes among both men and women.

• The effects of health on class mobility were not randomly distributed across all class strata; instead, manual classes were more vulnerable to health selection. When it comes to mobility into/out of the labour force, manual classes with poor health were more closely linked to the probability of being non-employed than those with poor health from other classes. Moreover, when entering employment, those with poor health tended to be confined generally to manual classes (hypothesis 3).

• Different predictors for social mobility showed different influences on particular transitions. Health and age played a substantial role in moving into/out of employment, whereas the effect of education was prominent for higher classes, in particular classes I/II.

As to the impact of health on income mobility:

• Those with poor health status tended to show a decline in wages during the mobility process as well as lower wages at baseline, which was shown when wage grade was measured in percentile distribution in the bivariate analysis. However, this tendency became negligible when the influences of health on income mobility as measured with quintile income bands were modelled using multilevel multinomial analysis. This conflicting outcome raised alternative possibility that results may depend on which measure is used for the assessment of income change. Therefore, consideration of continuous nature of income measure is necessary in a future study.

The findings for the influence of health on employment transition include:

• The effects of health on the transition and reverse transition from employment to both unemployment and inactivity were continuously noticeable. The smallest effect of health on the transition arose around the transitions out of/into unemployment especially among men.

• Health appeared to affect the pattern of transitions between men and women differently. When people withdrew from employment, men with poor health tended to turn toward inactivity; in contrast, women with poor health tended to end up in both destinations of unemployment and inactivity to about the same degree. Subsequently, poor health lowered the probability of reemployment from unemployment for women, but it was not the case for men.

The findings drawn from three type I health selection studies (the presence of health selection) with each socioeconomic measure indicate:

• The negligible impact of health on mobility inside employment may reflect the presence of the substantial impact of health on mobility between employment and non-employment. This implies that the effect of health was not evenly spread over all social mobility, but rather tends to concentrate on some types of mobility, partly because of the benefit of social policy (hypothesis 4).

• Rather than a simplified mobility variable (e.g., upward, stable, and downward mobility), a full mobility trajectory between origin and destination is more effective in detailing the different effects of health on individual mobility route (hypothesis 2).

The outcomes from the type II health selection study (the contribution of health selection to social inequalities in health) provide some information:

• Changes in social inequalities in health at the population-level were given as a function of a set of elements extracted from a social mobility process including the net effect of health selection and the scale of social mobility.

• The difference between levels of health selection across mobility processes appeared to be associated with the different extent of change in social inequalities in health (hypothesis 5), although this finding needs to be considered provisional given the simple model described in Chapter 8.

• The connection between the healthy worker effect and class inequalities in health remains to be ascertained. The healthy worker effects both in entry into and exit from employment were substantial. Since the two healthy worker effects are in line with each other, the offsetting of one health selective movement relative to another might leave little effect on class inequalities in health. However, to trace changes in the relationship between the healthy worker effect and class inequalities in health, a long term approach is required, which could take into consideration different economic cycles, such as periods of high and low unemployment rate.

Table 9-1 highlights how this study found several concepts differently and similarly to other studies. By providing broader issues, it is attempted to expand the horizons of the health selection debate and to sharpen the current understanding of the conflict. Nevertheless, it is difficult to avoid simplification when describing the concepts in previous studies. If an issue contains some different arguments, this is described by indicating the sources beneath the table. Lastly, this summary table also guides where those concepts have already been dealt with in earlier chapters, and some related chapters are listed in the last column of the table.

Table 9-1 Summary of main conclusions from the current study compared to previous studies

Concepts	In previous studies	In the current study	Related chapters
Typology of health selection study			
Type of health selection study	- Two types / One is about health and subsequent social mobility and the other is the contribution of health-related social mobility in explaining social inequalities in health. But this distinction has been rarely made[1].	- Same / type I health selection study (the presence of health selection study), type II health selection study (the contribution of health selection study)	Chapter 1
Type I health selection study			
The effect of health on social mobility (type I study)	- Contested / In some studies, the effect of health on social mobility has appeared negligible, but more frequently it has appeared to be substantial[2].	- The effect is negligible within employment, but substantial in transitions between employment and non-employment.	Chapter 5, Chapter 6, Chapter 7
Social mobility	- Social mobility is usually defined by a social measure, usually social class over two time phases. - This is commonly expressed in terms of the mobility direction, such as upward and downward mobility.	- Same - Social mobility as mobility direction is applied to the type I study. - Social mobility which is used in the context of the scale of social mobility (e.g., absolute or relative mobility rate) is applied to the type II study.	Chapter 2, Chapter 8
The distinction between health selection and healthy worker effect	- Not clear	- Healthy worker effect is defined as a type of health selection which operates at the transition between employment and non-employment.	Chapter 1, Chapter 8
Type II health selection study			
The contribution of health selection on health inequality (type II study)	- Narrowing - Little contribution of health to health inequalities has been understood as a probable result because of strong social causation which is presumably supposed to form a contrary concept to health selection in explaining health inequalities.	- Varying - This result suggests that both social mobility and health change are necessary in the production of new health inequalities.	Chapter 2, Chapter 8

Post-mobility health inequality to indicate changes in health inequality	- Post-mobility health inequality has been used as an indictor among studies that adopted the approach of comparison between health inequalities before and after mobility.	- Post-mobility health inequality is merely a proxy for actual health inequalities, which requires consideration of changes in health as well as changes in SEP (social mobility).	Chapter 8
The relationship between health selection and social mobility	- Health selection is a part of social mobility, but this distinction has rarely been made [Manor *et al*, 2003].	- Same / Health selection is defined as a minor part of social mobility, while social causation is defined as a major part of health change.	Chapter 8
Health selection and Macroeconomics	- Rarely studied / Different healthy worker effect was defined as responding to economic ups and downs and social welfare change [Lahelma *et al*, 2000; Bartley and Owen, 1996].	- Same / One implication of this study is that health selection is supposed to be affected by macroeconomic factors, such as social policy and the economic situation, depending on whether the environment is favourable to those with poor health.	Chapter 2, Chapter 8

* Although this table contrasts different positions within the complex debate around the study of health selection, it is not true that all previous studies presented the concepts in the same way, as described in this table. To clarify the differences observed across previous studies, an additional explanation is provided to complement the major concept, if it is specified with superscript.

1. Studies following similar typology are found among Lundberg [1991], Blane [1999], and Chandola *et al* [2003].

2. Some [Chandola *et al*, 2003a; Lundberg, 1991] reported the minor effect of health on the subsequent SEP, whereas others found a substatial effect of health on social mobility [Manor *et al*, 2003; Power *et al*, 1996; Power *et al*, 1986; Wadsworth, 1986; Illsley, 1955].

3. There was an attempt to consider health selection in the sense of health discrimination [West, 1991].

9.2 Varying level of health selection

It was hypothesized that the effect of health on social mobility varies depending on the social indices used (hypothesis 1). Health selection was negligible when it is indicated by class (Chapter 5) and income measure (Chapter 6), although it was highly significant in the transition between employment statuses (Chapter 7). In Chapter 8, it was suggested that health selection may have diverse levels. When we amalgamate all findings, health selection is shown not to be a single value; it is diverse following settings and conditions. To understand how health selection can arise in many different ways, the influences of different contexts (i.e., social welfare) are discussed in the following section.

Health selection may show cross-national differences mainly according to welfare status. Government intervention affects the outcome of health impact by providing some kinds of welfare program, including maternal health care, childcare, health insurance, unemployment benefit, incapacity benefit, worker's compensation, disability discrimination act, general medical provisions, and other welfare policies. In a country where the protection for the less advantaged including those with poor health is available, health selection may be weak, because social protection can buffer the impact of poor health in various ways.

The net effect of health selection may be particularly large in developing countries where the opportunities for education and employment for people with disabilities are quite limited [Shaar *et al*, 2002, pp10-11]. In developing countries, because of reduced welfare provision, people who are disabled at a young age reach lower SEP in their educational, employment, and marriage opportunities, compared to developed countries [Shaar *et al*, 2002, p12-56, p57]. In contrast, in a highly-developed welfare state such as Sweden, people with disabilities at younger ages are steered toward non-manual jobs rather than manual jobs. They successfully proceed their aim by continuing their study which is freely provided up to the university level, and by increasing the chance of being employed with legal protection for them [Lundberg, 1991]. Similarly, in Norway, the high level of compensation for occupational asthma meant that there was no income loss in groups suffering from this condition [Leira *et al*, 2005].

The type of welfare protection also makes a difference in the rate of labour force participation among people with illness in developed countries. In the US, for example, insurance coverage is endowed within an employment contract, and those with illness tend to remain at work due to the increased access to health benefits, rather than exit the labour force [Bradley *et al*, 2002; Bhattacharya and Bundorf, 2005]. However, in the UK, long-term invalid benefit was implemented in 1977, which influenced the numbers of inactive to rise sharply [Bartley, 1988]. In a comparison between two countries, Britain (the less regulated labour market) and Sweden (the more regulated labour market), the beneficial effect of deregulation in the labour market was discussed in terms of employment opportunity [Burström *et al*, 2003]. For both sexes, the impact of having a chronic illness was much greater for less-skilled social groups in Britain than in Sweden.
Although this review is limited to a few studies, they show that the choice of an employee with poor health largely reflects the context of the welfare system. The decision of whether they continue to work or turn to unemployment is closely linked to social protection. Social protection therefore provides another mechanism by which health and social advantages or disadvantages interact over the life course [Blane *et al*, 1999c, pp 70-71].

Beside welfare policies at the national level, there are a variety of other elements that create differential effects of poor health on labour outcomes. To stay in employment, workers with poor health may consider a number of options to accommodate their health status, and workplace factors are associated with this decision [Habeck *et al*, 1998]. Several studies have indicated that workers with poor health may prefer jobs with more generous working conditions [Currie and Madrian, 1999, p3320]. If a workplace provides flexibility to adjust the working environment, including reduced working hours, generous sick leave, and assignment to a task with less physical requirement [Holland *et al*, 2006], then employees were less likely to be forced to leave employment on account of physical health problems. When working conditions are favourable to workers with poor health, this may lower the effects of health on transitions between employment and non-employment.

It was pointed out that the severity of health is not considered in the current study

(Section 6.6.3). Another aspect of health impact that must be taken into account is that illness may constitute a specific part of a job characteristic. If an occupation relies more on a specific physical ability, a specific part of the body is essential to continue the task or job. Even a minor finger injury would have a very different importance between a professional music player and a teacher. It has been reported that the type of disability plays an important role in the probability of employment [Kidd *et al*, 2000]. Therefore, the relationship between health severity and ability to work does not take a simple linear pattern. As health carries a plural meaning, other characteristics of health may also diversify the effect of health on social conditions.

The contrast between acute and chronic disease is described to provide a basic insight into disease specific limitation in labour market activity. Acute disease is characterized by its abrupt onset and limited duration, whereas chronic disease is characterized by its lasting condition over a long period of time [Ruhm, 2003; Cutler and Richardson, 1998; Cropper, 1981]. Most acute illness is confined to a finite period with total recovery (e.g., acute infection, light injury) and does not lead to a change in economic activity. A few acute conditions are severe and leave permanent sequelae (e.g., serious injury with permanent disability), and subsequently, they may result in dramatic change in labour market participation. However, once the health event is settled, some may again build up stable prospects, by getting the kind of job with which they can cope.

In contrast, workers with chronic disease may experience a decline in working ability with the gradual deterioration of disease, which further limits their ability to work (e.g., diabetic mellitus, cardiovascular disease) [Ruhm, 2003; Cutler and Richardson, 1998; Cropper, 1981]. Some may exclude themselves from the labour force, and others may make compromises to remain in employment by reducing working hours, by seeking more flexible working hours and physically light work [Currie and Madrian, 1999, p3320], although they frequently have to face further worse working condition [Sullivan and Wachter, 2006; Bartley, 1988].

This distinction between acute and chronic conditions implies that the onset of the health condition is related to changes in career. Those who experienced an acute condition a long time ago may not continuously experience a further downward trend at a later time because, in general, the conditions are not persistent over time, although the acute conditions may restrict daily activity and labour participation

[Ruhm, 2003; Cropper, 1981]. But for those suffering from the chronic disease, the change in employment status may occur at a later stage of disease progress. When the diseases is in a controllable state, they are not limited in their working activity; this is shown in the observation that around 50% of those with chronic disease marked their health as excellent or very good [Cott *et al*, 1999; Pijls *et al*, 1993].

There has been some evidence that the impact of health on the variation of SEP relies on the characteristics of the study population [Finkelstein *et al*, 2005; Dahl, 1996]. The current study shows that health selection was more apparent among unskilled and manual workers whose physical component accounts for a greater proportion of their work ability (Chapter 5 and Chapter 7). The degree of health selection is stratified as to social class, and the poor health rate among those leaving and entering employment shows a large difference between classes I/II and classes IV/V. This differential selection process demonstrates that the health issue is more deeply involved in transitions between manual class and non-employment than non-manual class. Thus, as Dahl said, manual occupations have been more health selective over the last decades [Dahl, 1996].

In a similar way, the effect of health on SEP has greater importance for certain groups. In the review of economic consequences of obesity, Finkelstein *et al* [2005] found that the effect of being overweight on wages differed by gender. While most studies found a negative correlation between women's wage and weight, this correlation was less evident among men. Regarding the economic effect of obesity between ethnicity, the negative effect of obesity on wages appears larger for whites than blacks [Bhattacharya and Bundorf, 2005; Averett and Korenman, 1999]. Therefore, the study of health selection may need to combine both a specific and a comprehensive view. Since health selection is not homogenous across different subgroups, it may be important to note which groups are more vulnerable to poor health by differentiating the population layer by layer. This intrusive approach focuses on a specific demographic and social group. However, health selection which is obtained from a specific group (e.g., those within employment) needs to be considered relative to the whole variation of health selection in the general population.

In the above, varying effect of health selection is assumed to differ country by country and depends on other factors reviewed above. It is also affected by economic situation such as recession and maybe varies between geographic regions. Therefore, the results from the current study should be viewed in a larger context with various angles, and it needs to be examined further by varying the arrangement of different settings and conditions. The distribution and shape of health selection presented in the current study needs to be seen in the context of socioeconomic environments and welfare policy in the UK. This is further discussed in section 9.7 policy implications.
Nevertheless, it needs to be emphasized that although health selection is minimal and not consistent among populations, health selection accounts for a disadvantage that stems primarily from the nature of health. Although this is a common premise for the realization of health selection, health selection occurs always in conjunction with other factors which may increase the effect of health selection or may cause it to disappear.

9.3 Expansion of health selection concept

The consequences of health may require a more comprehensive view beyond the health selection framework. There are a range of health impacts which cannot be featured in labour market indicator such as social class and employment status. Firstly, a disease which has a considerably high fatality rate may appear to be barely related to health selection. In occupational epidemiology, it has been recognized that lung cancer and accidental death are not preceded by a long symptomatic period, and thus show a less pronounced healthy worker effect than diseases with a long symptomatic history, such as cardiovascular disease [Chen and Seaton, 1996].

Secondly, on the other end of the spectrum, there are a great number of diseases which are relatively mild. Most of them may not lead to a change in labour market outcome. So, the impact of this majority of health conditions is unrecognized by health selection when it is indicated by conventional socioeconomic measures. For example, gastroesophageal reflux disease is a chronic condition, diagnosed typically with heartburn and regurgitation. This condition is adversely associated with well-being and daily activity and positively associated with emotional distress, but has little effect on employment status [Wiklund *et al*, 2006; Ronkainen *et al*, 2006]. However, since health is the basic prerequisite for the satisfaction in social participation, quality of life, level of leisure activities, and gourmet [Zweifel and Breyer, 1997, p37-38], there are a range of other consequences of health impact apart from more fundamental transitions in working life, which are surely also a part of health impact.

Thirdly, the indirect impact of poor health remains essentially unexplained in terms of the concept of health selection. Investigations into the effect of health typically focus on the individual's own socioeconomic outcome. However, family members may suffer from the other member's health status. Many studies have highlighted the burden of the care-giving experience and its negative impact on socioeconomic participation [Brittain and Shaw, 2007; Wimo *et al*, 2002]. It has been claimed that 'There are currently 2.5 million carers who are in work, yet one in five gives up work to care' [The Guardian, 2008; Wolfe, 1995]. Besides the fact that the presence of a sick family member affects other family member's labour market experiences, the loss of a family member because of health reason may cause devastating results. Needless to say, for example, the loss of a mother in childbirth leaves serious short- and long-term consequences for the baby [The Guadian, 2007].

As illustrated, the consequences of health are comprehensive and multidimensional, and health selection detects only a certain range of adversities caused by health problems. More comprehensive scope beyond health selection is needed to echo the underlying impact of health, which should be found and addressed. However, the contrary perspective that health selection decreases social inequalities in health, while social causation increases it may not be relevant for this. Because, from this perspective, the magnitude of health selection is expected to be small, the perspective may not facilitate the recognition that poor health may play a substantial role in structuring life chances.

9.4 Strengths and limitations

As specific limitations and strengths have been delivered in each chapter, some more common issues are discussed in this section. The current study tried to enrich this study field. Firstly, data pooling over 13 years may be a creative use of the longitudinal data rather than focusing on single or few waves[23]. Because of its ability to account for longitudinal data structure, multilevel modelling was used for analyzing multiple waves of panel data. In addition, the multinomial structure offers the opportunity to take into account more detailed mobility progression between origins and destinations without collapsing it into simple terms. Another strength of the study is the attempt to bridge knowledge between social epidemiology and other disciplines. By reviewing recent evidence in economics and sociology as well as epidemiology, the current study tried to communicate with other areas on the subjects of social mobility.

In the longitudinal setting, the data have a time dimension, where time is often measured discretely. For studying event occurrence, an ideal framework considering time dimension is required. This study adopted the setting to depict the impact of health on short-term mobility in SEP outcomes over two years. Transition probabilities in the present study were estimated using the number of events (frequency) instead of the transition interval (duration) [Cook and Lawless, 2002; Andersen and Keiding, 2002; Rothman and Greenland, 1998, p29-38]. In the next section, the limitations of this study setting are discussed in more detail.

Firstly, in this thesis, the applications of multilevel multinomial model have been made on the assumption that transitions between socioeconomic categories depend on conditions such as health status from the previous wave. The proposed model did not take into account the past conditions prior to the previous one. This is the first-order Markov assumption, in which the transition probability at one time is assumed to depend only on the most recent events [Yang et al, 2007; Albert and Follmann, 2003; Diggle et al, 2002, pp87-89]. When the model is based on the first-order Markov assumption, the limitation is evident because this approach is less able to capture a dynamic process that has evolved continuously over time. To relax this limitation,

[23] As the data were pooled from 13 years, they might be subject to a period effect. Appendix 9-1 provides an investigation to see whether a marked change is observed during the survey years.

some alternative approaches have been outlined as a direction for future work.
One way of avoiding this limitation is to incorporate more transitions than only the last one (higher-order Markov model). This approach is expected to provide a better fit when a model includes multiple time sequences simultaneously [Mosconi and Seri, 2006; Uhlendorff, 2006; Jackson et al, 2003; Diggle et al, 2002, pp194-196]. For example, Mosconi and Seri [2006] show that a second-order Markov model, in which transition probabilities are given as a function of the last two states, can yield a better prediction than a first-order Markov model. In a similar context, some researchers have shown the importance of specifying the initial condition to account for baseline difference [Uhlendorff, 2006; Jackson et al, 2003]. Another approach has emphasized the importance of specifying the duration of the previous state, to allow the relaxation of the Markov assumption where the association between the duration spent in the previous path and the progression to the next state (e.g., incubation period followed by infection) is generally ignored [Grassly et al, 2008; Kang and Lagakos, 2007; Vaseghi, 1995]. These studies demonstrated duration-dependent transition probabilities conditioned on the temporal progress.

Secondly, the limitation of the first-order Markov assumption is also related to the endogeneity issue. Endogeneity can arise when a relevant variable is omitted (unobserved heterogeneity). By modelling changes of states between two consecutive waves rather than states themselves, the current study was partly able to adjust for pre-existing differences. Although modelling changes over time periods offers advantages over states-only design, this model is limited because it did not reflect baseline difference [Cribbie and Jamieson, 2000]. In fact, the model used in the current study includes information only from two consecutive years (t-1 and t years), as if they are independent of past years (e.g., from t-2 onwards). As a consequence of the limited coverage of variables, the unobserved heterogeneity is inevitable, which is certainly one of important reasons for endogeneity.
Another source of endogeneity is linked to this type of study. The relationship between health and SEP in the study of health selection suggests simultaneous evaluation as both development processes are interdependent and share various contributing factors. This type of endogeneity is not examined in the current study and deserves for future study. In this regards, some statistical models need to be given

due consideration. One strength of structural equation modelling is in its applications, since this modelling allows joint modelling of two causal relationships simultaneously [Wooldridge, 2006, pp557-559]. Similarly, the multi-process model suggested by Steele and Curtis [2003] shows the assessment of correlated processes by exploring random effects when several processes share common variables.

Thirdly, this model did not consider duration from the onset of the health event. The implicit assumption behind this model is that the risk is constant, regardless of an individual's history of poor health, even if the health problem persists for a long period. In other words, this model cannot answer whether the social mobility could occur as a result of a health accident two years ago, or whether the different duration of illness leaves a different impact on mobility. A more effective model would consider how long an individual has been in their current health status, as current health is not independent of previous health status.

Regarding the duration after a new occurrence of illness, there are some contrasts between different domains of disease. Although early retirement due to chronic illness reflected only a late stage of overall impairment [Siebert *et al*, 2001], peak years for leaving employment after rheumatoid arthritis were in the early years after onset and the majority had left 1 year after diagnosis [Holland *et al*, 2006]. This implies that long-lasting poor health (e.g., chronic disease) may have a different impact from a health event with an immediate change in health status (e.g., acute disease), and when modelling the duration of disease, it would be necessary to distinguish between acute and chronic disease.

The fourth limitation concerns the ability to evaluate the effect of age with more precision. By adding period and cohort effects in assessing age effect, it becomes possible to get a better estimation of the effect of aging. Despite the adjustment, this may not be sufficient to argue that the analysis has been completely adjusted for period effect. As age effect may have varied depending on the period, it requires an interaction term between age and period effect to assess the differential ageing effect over the study period. For example, transition probabilities between employment statuses may differ, according to whether the participants were young or old in the early recession period. However, when the interaction term was included into the model, both SAS and MLwiN did not converge due to the increased number of parameterization. As such, to ease computational burden, the interaction term was not included. Therefore, the current analysis is limited as it relies on the assumption that age effect is constant regardless of time period.

9.5 Future study

The results from the current study suggest many areas which require further work. With regard to the study of health selection, the comparison of the extent of social inequalities in health in relation to the trends in social mobility and health selection can be assessed at the population-level. In a given time period, different places (e.g., countries) may show different scales of social mobility and different levels y of social inequalities in health. Following changes in those measures can provide an empirical answer to the question raised in Chapter 8 about how to define social inequalities in health as a function of social mobility. This may be done in various ways: intergenerational or intragenerational comparison over more than two time points, international comparison between countries, and comparison across local areas. In particular, this approach is applicable to trace the effect of health selection between employment statuses on class inequalities in health. It has been of keen interest whether class inequalities in health become smaller because of greater health selection into/out of employment when unemployment levels rise. The changes in health selection into/out of employment can be linked to changes in class inequalities in health across the long-term period including economic ups and downs.

With regard to longitudinal data management, an advanced models need to reveal long-term changes in health and SEP with multiple transitions. For instance, many risk factors can have effects both on changes in health and SEP, and it would be desirable to accommodate health transition and SEP transition into a model. In order to allow co-development of the two changes, instead of fitting two separate models, they can be modelled and analyzed simultaneously using multilevel multi-processes model [Steel *et al*, 2005a; Steele, 2005b]. Because the above approach generally needs a complex modelling, alternatively, trajectory analysis may construct a trend of development in both health and SEP with more than three transitions (e.g., employment-unemployment-inactivity) over a longer period. This may exhibit consecutive interaction between health and SEP on the long-term basis.

9.6 Policy implications

This thesis contributes to better understanding of the relationship between health selection and social inequalities in health. Some findings from this thesis are directly relevant to public health issues, and they shed new light on issues of interest important to policy makers.

Firstly, social mobility has been an emerging agenda in recent decades, because it is believed that as social mobility increases, social inequalities decrease [Giddens, 2007]. It is also hypothesized that an increase in social mobility dilutes social inequalities in health, as if an increase in social mobility renders health more equal. However, the current study suggests that there is no absolute direction for social mobility. Even if the scale of mobility increases, overall social inequalities in health may increase when health selection is strong. In other words, an increase in social mobility along with a reduction in the effect of health selection may indicate greater equality. This means that, in order to decrease social inequalities in health, policies should be driven to reduce health selection while increasing social mobility.

The second political implication alerts the difficulty in maintaining paid employment for those with poor health. Special attention needs to be paid to protection of those with poor health from turning to outside employment and to reduction of threshold for those with poor health who want to join employment. If the higher level of health selection into and out of employment is related to the lower level of health selection between social classes (among only those employed), the policy needs to be balanced to stimulate a desire to remain in employment among those with poor health. This may include a measure to intervene in the vicious cycle between non-employment and manual class in which all forms of deprivation seem to be assembled including poor health.

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Appendices

Appendix 2-1 Empirical example of reversing the mobility rate after simplification of the mobility table

Social mobility measures have been developed to reflect a dynamic structure of social movements. A transition matrix, a form of contingency table, provides a basic summary of social mobility, which displays the relationship between class of origin and destination, given row variable and column variable.

The following tables A, B, and C, which are all based on the same sample, show how the original transition matrix is collapsed into a brief summary of three mobility directions in order. Until table A2-1 and A2-2, a greater proportion of upward mobility among those with poor health is not observable at all across the transitions. However, a dramatic change is driven after converting table A2-2 to A2-3 when the reverse presents; there is now more upward mobility among those with poor health.

Table A2-1 Transition rate (row percentage) between social classes† with regard to health status‡ from 1991 to 2003 in Men

Social class in year *t*-1	Social class in year t				
	I/II	III NM	III M	IV/V	Total
Those with good health					
I/II	7352(90.5)	343(4.2)	299(3.7)	130(1.6)	8124(47.9)
III NM	403(22.5)	1230(68.6)	90(5.0)	69(3.9)	1792(10.6)
III M	333(6.6)	87(1.7)	4275(84.6)	360(7.1)	5055(29.8)
IV/V	105(5.3)	79(4.0)	390(19.6)	1419(71.2)	1993(11.8)
Total					16964(100.0)
Those with poor health					
I/II	1280(88.3)	72(5.0)	66(4.6)	32(2.2)	1450(38.1)
III NM	69(16.9)	289(70.8)	32(7.8)	18(4.4)	408(10.7)
III M	75(5.8)	33(2.5)	1076(82.4)	121(9.3)	1305(34.3)
IV/V	30(4.7)	18(2.8)	106(16.5)	488(76.0)	642(16.9)
Total					3805(100.0)

† Based on own occupation which are professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), and partially skilled and unskilled (IV/V)

‡ Health status in year *t*-1

This contingency table is an actual copy of this study from Table 5-5. The association between health and social mobility is evaluated through an array of cross tabulations between class of origin and destination. Note that the rate of any upward transitions (under diagonal) is larger among the healthy participants, without any exception. These data are rearranged from a 4X4 table to a 4X3 table in table A2-2 where transitions are grouped into three mobility directions.

Table A2-2 Rearrangement of Social mobility table by social classes and health status from 1991 to 2003 in Men

	Upward	Stable	Downward	Total
Those without health status				
I/II	0(0.0)	7352(90.5)	772(9.5)	8124(47.9)
III NM	403(22.5)	1230(68.6)	159(8.9)	1792(10.6)
III M	420(8.3)	4275(84.6)	360(7.1)	5055(29.8)
IV/V	574(28.8)	1419(71.2)	0(0.0)	1993(11.8)
Total				16964(100.0)
Those with poor health status				
I/II	0(0.0)	1280(88.3)	170(11.7)	1450(38.1)
III NM	69(16.9)	289(70.8)	50(12.3)	408(10.7)
III M	108(8.3)	1076(82.5)	121(9.3)	1305(34.3)
IV/V	154(24.0)	488(76.0)	0(0.0)	642(16.9)
Total				3805(100.0)

The rearrangement of the social mobility table by social classes and mobility direction presents that the healthy still remain in a more advantageous position to move upward. Two upward groups from each class of origin show that the healthy are more upwardly mobile, although the upward rate of the healthy from class III M equals to the rate of the unhealthy. This cross table can be categorized in another way. If the data are to have the simplest mobility categories, it can be arranged into a contingency table, shown below in table A2-3. The general approach of simplification is to treat the contingency table as a three way mobility direction with regard to poor and good health groups. The top and bottom panel of table A2-2 are merged to construct information on three mobility directions

Table A2-3 Collapsed mobile rate by general health status in men

	Upward	Stable	Downward	Total
Good	1397(8.2)	14276(84.2)	1291(7.6)	16964(81.7)
Poor	331(8.7)	3133(82.3)	341(9.0)	3805(18.3)
				20769(100.0)

This collapsed table A2-3 from the full transition shows an important change, as the unhealthy are seen to experience more upward mobility.

Appendix 4-1 Data converting to person year observations

The data merged from wave 1 and wave 13 contains an observation for each individual. To fit a multilevel multinomial model, it is necessary to convert these data to the person year format data with yearly observations for each individual. The following hypothetical tables present how to restructure data from four waves of the first two individuals into person year format (table B). The first individual, who quit the follow-up in the third year, gets three yearly observations, while the second who was traced for four years, gets four observations.

Table A4-1 First two cases of original individual observations over four waves

	Age				Social class				Health status				Sex			
	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Individual	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	28	29		31	III	III		IV	0	1		0	1	1		1
2	42	43	44	45	I	II	II	I	0	0	1	0	2	2	2	2

Table A4-2 Converted data with person year observations

Individual	Wave	Age	Social class					Health status	Sex
			I	II	III	IV	V		
1	1	28	0	0	1	0	0	0	1
1	2	29	0	0	1	0	0	1	1
1	4	31	0	0	0	1	0	0	1
2	1	42	1	0	0	0	0	0	2
2	2	43	0	1	0	0	0	0	2
2	3	44	0	1	0	0	0	1	2
2	4	45	1	0	0	0	0	0	2

In the original individual observation, each individual has a single record. On the other hand, in the person-year data set, each individual has multiple records. In table B, the class variable is treated with dummies.

Appendix 4-2 SAS array for converting of individual data to person year data

```
/*To convert horizontal data (one, one event to one case) to vertical data (many, many to one case),
we used SAS arrays*/
data hs.arrayb1;
set hs.arrayb;
array w{*} xdts1-xdts13;
array v{*} abrill1-abrill13;
array u{*} longill1-longill13;
array s{*} hldsbl1-hldsbl13;
array r{*} mlstat1-mlstat13;
array q{*} hlstat1-hlstat13;
mjbsec;1:13] ajbsec bjbsec cjbsec djbsec ejbsec fjbsec  gjbsec hjbsec ijbsec  jjbsec kjbsec ljbsec
array p[*] edu1-edu13;
array o[*] wave1-wave13;

do i= 1 to 13;
year = i;
accdt = w{i};
arptill =v{i};
illness = u{i};
class = t[i];
dsbl = s{i};
marge =r{i};
hlstat = q{i};
edu = p[i];
wave = o[i];
age = year + 1990 - byear;
output;
end;
run;

data hs.multib;

  merge arrayb2 (rename = (year=year1))
        arrayb2(firstobs=2 keep = class pid
             rename=(class=transit pid = nextpid)) ;
           if class^=transit then code =1;

costep =lag(code);
  dur + 1 ;
```

```
if pid ^=nextpid then
dur = 0;
else if pid=nextpid then do;
if costep=1 then do ;
            dur = 1 ;
   end;
   end;
run ;
```

Appendix 4-3 Data converting from individual observations (Top panel) to person year observations (Lower panel)

Original individual dataset

Obs	PID	sex	edu1	hlstat1	edu2	hlstat2	edu13	hlstat13
1	10007857	2	2	2	2	2	.	.
2	10014578	2	1	1	.	.	.	.
3	10014608	1	5	1	5	1	.	.
4	10016813	1	2	2	2	3	.	.
5	10016848	2	.	2	2	3	.	.
6	10016872	1	.	.	.	.	3	3
7	10017933	2	5	2	5	2	.	.
8	10017968	1	5	1	5	2	.	.
9	10017992	2	.	.	.	.	.	1
10	10020179	1	1	1	1	1	.	.
11	10020209	2	1	2	1	2	.	.
12	10020233	1	.	.	.	.	.	.
13	10023526	2	4	2	4	2	3	1
14	10023569	1	.	.	2	1	.	.
15	10024646	1	3	2	3	1	.	.
16	10025766	1	4	3	4	2	.	.
17	10025804	1	.	4	3	4	3	3
18	10028005	1	4	1	4	3	4	2
19	10028382	1	4	1	4	1	.	.
20	10028757	2	2	4	.	.	.	.
21	10029133	2	3	2	3	3	.	.
22	10029168	1	.	2	.	.	.	.
23	10040404	2	.	.	.	.	.	.
24	10048189	1	.	2	.	1	.	.
25	10048219	2	1	2	1	2	.	.
26	10048243	2	4	2	4	2	.	2
27	10048278	2	.	.	.	.	.	.
28	10049304	2	1	1	.	.	4	2
29	10049339	1	.	.	3	1	3	1
30	10049363	2	.	.	.	.	5	2

Converted person year dataset

Obs	PID	sex	byear	race	accdt	illness	class	transit	marge	edu	age	dur
1	10007857	2	1933	1	2	2	4	.	2	2	59	2
2	10014578	2	1937	2	2	2	3	.	1	1	54	1
3	10014608	1	1934	2	2	2	1	.	1	5	59	3
4	10014608	1	1934	2	2	2	1	2	1	5	61	1
5	10014608	1	1934	2	2	2	2	.	1	5	62	1
6	10014608	1	1934	2	2	2	1	.	1	5	64	1
7	10016813	1	1955	2	2	2	3	.	1	2	39	4

8	10016813	1	1955	2	2	1	3	4	2	2	42	1
9	10016813	1	1955	2	.	2	4	.	2	.	45	3
10	10016813	1	1955	2	.	2	4	.	2	.	47	1
11	10016848	2	1959	2	2	1	4	1	1	.	32	1
12	10016848	2	1959	2	2	2	1	5	1	2	33	1
13	10016848	2	1959	2	2	2	5	.	1	2	35	2
14	10017933	2	1942	2	2	1	1	.	2	5	54	6
15	10017933	2	1942	2	2	1	3	1	2	5	57	2
16	10017933	2	1942	2	2	1	1	3	2	5	58	1
17	10017933	2	1942	2	2	1	3	.	2	5	59	1
18	10017968	1	1945	2	.	1	1	.	1	.	50	5
19	10017992	2	1979	.	2	1	2	1	2	5	23	1
20	10020179	1	1939	2	2	2	3	.	2	1	54	3
21	10020209	2	1941	2	2	2	1	5	2	1	51	2
22	10020209	2	1941	2	2	2	5	1	2	1	52	1
23	10020209	2	1941	2	.	1	1	.	2	.	53	1
24	10020233	1	1972	.	1	2	4	.	1	2	21	1
25	10023526	2	1953	1	2	2	1	.	2	4	40	3
26	10023526	2	1953	1	.	2	1	2	2	.	42	1
27	10023526	2	1953	1	2	2	2	.	2	4	44	2
28	10023569	1	1956	.	2	2	2	.	1	2	36	1
29	10023569	1	1956	.	.	2	1	.	1	.	41	2
30	10024646	1	1965	2	2	1	4	.	2	3	28	3

. .

Appendix 4-4 The influence of the restriction on sample size

Table A4-3 presents the issue of sample loss by restriction criteria. By comparing data before and after restriction, the characteristic of respondents and non-respondents are examined. The restriction process assessed here is a criterion of 'two consecutive participation (response in class measure)' which results in a marked reduction, from 63599 (sample B) to 38689.

Table A4-3 The comparison of sample after restriction to participants with two consecutive waves over 13 years

Variables	Men		Women	
	excluded†	included†	excluded	Included
Number of observations [frequency(percentile)]	11091(34.8)	20769(65.2)	13819(43.5)	17920(56.5)
Number of individuals [frequency(percentile)]	1270(28.1)	3248(71.9)	1946(33.6)	2355(66.4)
Age [mean (±SD)]	48.5(±10.3)	43.9(±8.5)	44.9(±8.8)	43.0(±7.6)
Ethnicity (%)				
White people	95.9	96.9	94.7	96.4
Non-white people	4.1	3.1	5.3	3.6
Educational level (%)				
No qualification	30.3	16.0	31.4	17.1
GCE O levels or less	17.6	20.5	24.6	26.6
GCE A levels	9.8	12.1	7.3	8.9
Vocational qualification	31.5	35.5	28.0	33.9
Higher degree	10.8	15.9	8.7	13.5
Social classes‡ (%)				
I/II	40.4	46.1	34.6	38.3
III NM	9.9	26.0	31.0	35.0
III M	30.9	30.6	8.7	8.3
IV/V	18.8	12.7	25.7	18.3
Health status (%)				
Good	61.8	81.7	62.3	71.5
Poor	38.2	18.3	37.7	28.5

*Data are based on the sample removing those with missing on wage and health status variables. † Only those are 'included' when they were presented over two years in succession between year *t*-1 and year *t*, while the rest are 'excluded'. ‡ Professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), and partially skilled and unskilled (IV/V).

This result is a consequence of the sample restriction to participants with two consecutive waves. Disadvantaged groups, who are part of an ethnic minority, less educated, and from a lower social class are under-represented across all indices among those included in the sample. It is also evident that the distribution of health status is influenced by inclusion criteria; 38.2% of men who are excluded have poor health, in contrast to 18.3% of men who are included. This suggests that restriction criterion does not apply randomly, but rather leads to a cluster of the advantaged group. If health status is associated with high levels of turn-over rate and exclusion of more mobile individuals from employment, studying a sample which includes only the employed population may underestimate the occurrence of health-related downward mobility. Without a doubt, inclusion of the non-employed people would be necessary in order to fully demonstrate the impact of differential restriction on the degree of transitions.

Appendix 4-5 Application of sample weights

Brief description of general strategy in weighting

Attrition is a potential problem in characterizing longitudinal data, where individuals may leave the sample for one or more waves. Attrition may occur due to any condition such as follow-up loss, missing, drop-out, refusing to respond, deceased case, and, in general non-response [Lehtonen and Pahkinen, 1995, pp115-116; Little, 1988]. Most surveys assume that the study sample represents the underlying characteristic of the population by ensuring an adequate selection process, for example, randomization and selection probability. Selective attrition may lead to an unbalanced sample, when non-response cases are not at random.

Not only longitudinal study but also other situations, such as the case-control study and study with matching data in which representativeness over the entire population can not hold, face the same problem in inferring unbiased estimates. In a case-control study, 'intentionally biased selection distorts the frequency of disease in the study away from that in the source population' [Rothman and Greenland, 1998, pp103-104, p416]. Thus, estimates from an unrepresentative sample may risk biased inference as much as measurements from longitudinal study with severe non-response data.

In order to yield valid inferences, various techniques are developed to adjust for non-response errors. Three approaches are widely discussed: direct analysis ignoring non-response, imputation, and weighting [Lehtonen and Pahkinen, 1995, pp115-116; Little, 1988]. The first approach simply discards non-response cases, assuming data are completely missing at random. In an imputation approach, non-response values are replaced by estimates based on a variety of methods. The third approach uses sample weights to adjust for non-response [Fitzgerald *et al*, 1998; Pfeffermann, 1993]. Here a weighting scheme is considered in terms of its practical usage, along with the pros and cons of this approach.

Sample weights, under which condition?

It has been acknowledged that, for descriptive inferences such as population means and ratios, weighting should be used. For example, an unbiased mean can be calculated by dividing the weighted sum of a measurement by the weighted sample size.

$$X = \frac{\sum_{i-1}^{n} w_i x_i}{\sum_{i-1}^{n} w_i}$$

Similarly, the weighted ratio can be obtained as in the following equation [Groves, 2002, p290].

$$\frac{X}{Y} = \frac{\sum_{i-1}^{n} w_i x_i}{\sum_{i-1}^{n} w_i y_i}$$

However, for more complicated extensions of analytic inferences like regression coefficients, existing guidance varies [Groves *et al*, 2002, p290, Pfeffermann, 1993]. Generally, the primary interest of multivariate statistical modelling is to disclose regression coefficients from causal relations by involving a set of variables. A question may then arise about whether sample weights can account for all the multivariate relationships constructing a complex distribution across dependent and independent variables.

Some researchers, using maximum likelihood estimation (MLE), found the estimates of coefficients remain unbiased, although only the estimates for intercepts appeared biased under certain conditions [Pfeffermann, 1993, p324]. It has been acknowledged that sample weights are ignorable, as long as the model holds in a population despite the misspecification [Groves *et al*, 2002, p290]. Scott and Wild found that, even when a sample fails to hold characteristics of the target population, the coefficients may be close to the true value as the 'best approximate' [Scott and Wild, 1968, p194; Pfeffermann, 1993, p327].

Epidemiological studies have discussed the reliability of estimation from logistic regression with case-control data in which a supposed bias is inherent in the sampling scheme. The general consensus reached was that the population rate ratio is valid by modelling multivariate regression itself, and the model was only biased with intercept (and its standard error) [Prentice and Breslow, 1978, recited from Rothman and Greenland, 1998, pp416-417]. In the same context, selection bias induced by matching is proven to be 'controllable' by including a match factor on which matching is carried out into a model [Rothman and Greenland, 1998, p355].

The further discussion, about the exact conditions under which sampling weights for a complicated inference are ignorable is related to the sampling scheme. If X covariates include all variables used in weighting or study design (design variables) on which selection probability is based, any regressions lead to valid outcomes without sample weighting [Groves *et al*, 2002, p296]. Thus, inclusion of all the design variables, in other words conditioning on these variables is satisfactory to secure an unbiased estimation with the classical regression model. However, notably, incorporating such a complex model is a serious task, and sometimes not realistic [Pfeffermann, 1993, p326].

Sample weights were considered as an alternative or surrogate to the approach of conditioning on design variables [Pfeffermann, 1993]. Among several methods for incorporating sample weights, two favourable approaches, 'pseudo likelihood' and 'estimating equation', use weighting in the estimation stage to replace the likelihood estimation by a weighted value [Francesconi, 2005; Pfeffermann, 1993]. Pseudo likelihood facilitates the inference of maximum likelihood estimation that 'would have been obtained in the case of a census' [Pfeffermann, 1993, p331] by introducing sample weights. The weighted coefficient (β_w) is obtained from the equations, in the case of a census as a target population for inference, in which an unknown parameter vector (Θ) plays a key role in solving the likelihood equation [Pfeffermann, 1993; Scott and Wild, 1989]. The estimating equation follows a similar way that assumes 'optimal estimating equation' as if in the census, not the sample. The census estimating function is defined to be optimal when 'it minimizes the population quantity' [Pfeffermann, 1993, pp332-333]. Unlike the above two methods which modify the estimation, the 'weighted distribution' method includes sample weights in the inference stage as part of the model. However, this method seems still to be at the hypothetical stage and has not yet been demonstrated substantially [Groves *et al*, 2002, p297].

Sample weight in BHPS and its application

A sample weight reflects the inverse selection probability for each individual who is supposed to represent the distribution of the population. Weights are proportional to the inverse probability. Weighting adjustments in BHPS were based on external information, namely auxiliary variables at the population-level. These variables contributed to produce multiplicative weighting. A multiple logit model was fitted for this purpose. A rich set of auxiliary variables comprise the effects for region, housing tenure, an affluence measure, number of eligible individuals in household, marital status, employment status, age, and sex. Not only the main effects, but also all kinds of interaction effects from auxiliary variables are introduced to account for selective nature of attrition [Taylor *et al*, 2007].

In the BHPS, two types of weights are provided for longitudinal and cross-sectional analysis. Cross-sectional weights are appropriate for single wave analysis, whereas longitudinal analysis adopts the latest longitudinal weights which are obtained by multiplying across the previous cross-sectional wave weights.

Both respondent and enumerated weights are available for cross-sectional and longitudinal analysis. For the latter, an additional adjustment for household characteristics was made, which included consideration for proxy and telephone respondents [Lynn *et al*, 2006, pp50~54]. All sample weights are trimmed not to exceed a maximum of 2.5, and calibrated so that weighted and un-weighted sample sizes are an equal number.

Both cross-sectional respondent (wXRWGHT) and longitudinal respondent weights (wLRWGHT) are assigned to their corresponding sweeps from BHPS participants [Halpin, 2006]. Inferences such as mean and proportions that are based on single year data are calculated using cross-sectional weights of that year. On the other hand, longitudinal weights are used for analysis with transition matrix, as this sample lasts for longitudinal observational period (year t-1 to year t). By introducing longitudinal weights, the probability sample is derived based on individuals who are still present at the end observations.

Results from applying sample weight

The following outcomes are provided for the comparison of weighted results with the unweighted results in table 4-2 after applying cross-sectional sample weights. The sample weights are trimmed to have a maximum value of 2.5. In order to obtain weighted sample counts which equal the unweighted sample counts, weights are rescaled to have a mean of 1. Therefore, unweighted and weighted samples have the same size among those who received a weight value. The computed mean and variance are yielded by using an SAS statement of WEIGHT. If the value of interest is count, any non-integer values are truncated since the count must necessarily be integer.

Table A4-4 Weighted sample characteristics on demographic and social variables with four distinct sample*

Variables†	Men				Women			
	Wave1	Wave13	Sample A	Sample B	Wave1	Wave13	Sample A	Sample B
Range of sample weight [Min, Max]	0.25, 2.50	0.21, 2.50	0.21, 2.50	0.10, 2.50	0.25, 2.50	0.21, 2.50	0.21, 2.50	0.10, 2.50
Number of yearly observation		-	41512(50.3)	30894(50.9)	-	-	40970(49.7)	29816(49.1)
Number of individuals	3609(51.6)	2923(50.5)	5629(52.3)	4019(52.4)	3384(48.4)	2861(49.5)	5140(47.7)	3647(47.6)
Age [mean (±SD)]	40.7(±12.7)	42.3(±12.4)	41.4(±12.4)	46.2(±9.7)	38.6(±10.8)	40.8(±10.6)	39.6(±10.7)	44.3(±8.1)
Ethnicity								
White people	94.9	95.6	95.7	96.2	94.7	94.8	94.8	95.0
Non-white people	5.1	4.4	4.3	3.8	5.3	5.2	5.2	5.0
Educational level (%)								
No qualification	26.7	12.3	18.6	21.9	28.6	12.2	19.7	24.1
GCE O levels or less	22.6	19.2	21.5	19.2	29.7	21.5	26.8	25.2
GCE A levels	13.0	12.6	13.0	11.0	8.6	11.0	10.4	7.9
Vocational qualification	27.1	38.1	32.5	34.1	24.9	37.8	30.7	31.5
Higher degree	10.6	17.8	14.4	13.7	8.2	17.5	12.5	11.2
Social classes‡								
I/II	37.9	41.7	41.7	44.6	31.6	40.6	36.4	37.0
III NM	12.4	13.0	12.4	10.6	37.5	34.5	36.1	34.5
III M	34.4	29.9	30.8	30.7	9.3	7.3	8.5	8.3
IV/V	15.3	15.4	15.1	14.1	21.6	17.6	19.0	20.2
Health status								
Good	78.7	73.9	75.7	74.4	75.5	69.8	72.4	71.2
Poor	21.3	26.1	24.3	25.6	24.5	30.2	27.6	28.8

* While wave1 and wave13 data are obtained from person-oriented data, the rest data are based on yearly observation data. Wave 1 and wave 13 data represent wave 1 British Household Panel Survey (BHPS) and wave 13 BHPS, sample A after converting individual data, and Sample B with restriction on age (>30). † Estimates are presented in three ways; [frequency (percentile)], [mean (SD)], and [percentage]. ‡ Professional and managerial (I/II), skilled non-manual (III NM) skilled manual (III M), and partially skilled and unskilled (IV/V)

This table is an edition for corresponding table in 4-2, using weighting method. Cross-sectional weight has been applied for all four samples as they represent sectional dimensions. Sample weights are rescaled up to maximum of 2.5 with different minimum values. Because of the respondents who did not receive a weight value, the sample sizes are smaller compared to the unweighted samples apart from men in wave 1. In general, weighted samples tend to comprise more men with disadvantageous characteristics such as old age, belonging to an ethnic minority, lower educational levels, low class, and worse health status. However, differences between the weighted and unweighted samples are small (around 0.5%) in relation to every index under this survey.

The following table shows the application of longitudinal weights using the equivalent table 5-5. Longitudinal weights which range from 0.29 to 2.5 for every individual are used for the transition matrix.

Table A4-5 Transition rate (row percentage) between social classes† with regard to health status‡ from 1991 to 2003 in Men

Social class in year *t*-1	Social class in year t				
	I/II	III NM	III M	IV/V	Total transitions
Those with good health					
I/II	90.4	4.4	3.6	1.6	6500(47.5)
III NM	22.7	68.5	5.0	3.8	1456(10.6)
III M	6.5	1.5	84.3	7.7	4098(29.9)
IV/V	4.8	3.8	19.3	72.1	1639(12.0)
Total					13693(100.0)
Those with poor health					
I/II	88.8	4.7	4.9	1.6	1173(37.3)
III NM	15.0	72.8	7.8	4.4	353(11.2)
III M	6.4	2.5	81.2	9.9	1063(33.8)
IV/V	3.8	2.5	18.3	75.4	556(17.7)
Total					3145(100.0)

† Based on own occupation which are professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), and partially skilled and unskilled (IV/V).

‡ Health status in year *t*-1

The longitudinal weights were only given for the original sample member (OSM) at

1st wave, which causes another big reduction in sample size, and so there are consequently 16838 (weighted sample) versus 20769 (unweighted sample) transitions in men, with a slight increase in classes IV/V compared to table 5-5. However, the transition trend throughout every cell shows exactly the same results as the results from the unweighted sample.

The following table illustrates the application of longitudinal weights among women as corresponding to table 5-6.

Table A4-6 Transition rate (row percentage) between social classes[†] with regard to health status[‡] from 1991 to 2003 in Women

Social class in year *t*-1	Social class in year t				
	I/II	III NM	III M	IV/V	Total transitions
Those without health status					
I/II	88.9	7.2	1.6	2.3	4126(37.9)
III NM	9.6	85.5	1.7	3.3	3893(35.8)
III M	8.9	8.1	67.2	15.9	856(7.9)
IV/V	5.3	6.4	7.3	81.0	2014(18.5)
Total					10888(100.0)
Those with poor health status					
I/II	85.1	9.8	2.0	3.1	999(33.2)
III NM	8.3	86.2	1.6	4.0	1030(34.2)
III M	11.2	7.2	70.1	11.5	295(9.8)
IV/V	5.6	7.3	8.3	78.7	685(22.8)
Total					3009(100.0)

[†] Based on own occupation which are professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), and partially skilled and unskilled (IV/V)

[‡] Health status in year *t*-1

As expected, there is a huge difference between the sizes of weighted (13897) and unweighted (17920) samples due to the lack of longitudinal weights for new entrants after the 2nd wave onwards in women. However, this difference has very little effect, and there is a resultant similar pattern in transition. The only contrasting result occurs in transit from III NM to III M, which is the opposite in the weighted result against the unweighted result.

In the previous study, it was found that, although the unweighted sample were more often from high class and better health, the bias caused by ignoring attrition was likely to be small [Jones *et al*, 2006]. Another examination of attrition among BHPS participants tests whether attrition causes a biased transition rate with regard to employment status. In comparing responding full-time respondents for all 13 waves with the few-time respondents, the result confirmed that attrition operates at random and that sample transitions are a good approximation [Marzano, 2006]. The current study also supports the idea that, in general, the unweighted analysis appears to be almost unaffected by attrition, as illustrated in the above tables.

Appendix 4-6 Sensitivity analysis regarding a health measure in wave 9

Introduction and method

BHPS did not collect the information about general health status in 1999 (wave 9). Instead, a similar question in SF 36 was asked for that year. In spite of the similar construction of question, the specific domains of health status changed in 1999. For the wave 1-8 and 10-13, five categories of 'excellent, good, fair, poor, or very poor' were used to identify a self-rated health status whereas, for the wave 9, 'excellent, very good, good, fair, or poor' were used to rate general health status. Because wave 9 is different from other waves in the construction of general health status variable, wave to wave consistency has been questioned.

Hernandez-Quevedo *et al* [2005] addressed this issue of measurement sensitivity. They asked whether the change in wording at wave 9 resulted in a substantial alteration in the relationship between socio-economic characteristics measured by income and self-assessed health. Using 11 waves of the BHPS between 1991 and 2001, the sensitivity of measurement was assessed by comparing two probit models; excluding and incorporating wave 9. It was concluded that the different versions of question did not induce the biased estimates over the relationship between socio-economic characteristics and self-assessed health. Full use of data without omitting wave 9 was advocated. As this approach was applied to income measure, the current study applies the similar approach to social indices (e.g., social class and employment status) other than income.

For the assessment of sensitivity of the health status measurement in wave 9, the current study uses logistic regression. Similar to the previous sensitivity analysis reviewed above, the first step is to construct the data including the wave 9 (sample A) and excluding the wave 9 (sample B). Secondly, after generating the probability of poor health for two samples, a proportion test is performed to test whether two probabilities from the two different samples have the different propensity. Thirdly, using logistic regressions, the relationship of social class, employment status, and age with health status are compared against two samples to see whether the results are unchanged. Health status is entered into the model as binary dependent variable. The effect of independent variables is presented by OR. By examining ORs from the two samples (including wave 9 and excluding wave 9), the divergence of wave 9 is examined.

Results and conclusion

The different distribution in health status in wave 9 compared to the other waves is illustrated in the following table.

Table A4-7 The comparison of health status across waves

	Men						Women					
	N	Exc†	Good	Fair	Poor	VP	N	Exc†	Good	Fair	Poor	VP
1991	3608	33.0	44.9	15.1	4.4	1.6	3622	29.0	46.5	16.5	6.5	1.5
1992	3486	31.3	45.3	16.6	5.3	1.5	3476	27.5	46.5	17.2	7.3	1.5
1993	3372	30.0	46.4	17.0	5.2	1.3	3455	24.7	48.5	18.6	6.7	1.6
1994	3341	28.5	47.7	16.7	5.9	1.2	3404	23.0	49.5	19.8	6.3	1.4
1995	3264	27.2	48.0	17.8	5.6	1.4	3301	22.4	50.4	19.2	6.6	1.5
1996	3359	27.2	47.8	17.4	6.2	1.4	3393	22.3	48.4	20.4	7.1	1.9
1997	3333	28.7	46.5	17.7	5.3	1.9	3378	23.7	47.1	20.2	6.9	2.1
1998	3268	27.1	48.0	17.2	6.1	1.6	3358	21.3	49.9	20.1	6.6	2.1
1999	3068	18.0	33.0	32.9	12.7	3.3	3266	15.1	34.3	33.4	13.6	3.6
2000	3169	25.5	49.2	18.2	5.4	1.7	3314	20.3	50.5	20.0	7.0	2.2
2001	3151	27.9	47.0	18.3	5.4	1.4	3292	22.3	48.3	20.2	7.4	1.9
2002	3102	27.0	47.1	19.0	5.5	1.4	3231	22.7	46.9	20.2	8.0	2.1
2003	3041	25.3	49.1	18.6	5.6	1.4	3149	22.1	48.6	20.6	6.9	1.8

† Health status was rated according five categories of ‘excellent (Exc), good, fair, poor, or very poor (VP)’, apart from wave 9 where it was assessed with different wording ‘excellent, very good, fair, or poor’.

The different distribution of health status in wave 9, due to the alteration of the question, is reflected in table A4-7. The result from 1999 is not consistent with results from other years. Two sets of logistic regressions were modeled separately by gender. Since the two logistic analyses with and without wave 9 use the same variables, interpretations of the output are attributed to the difference between the two samples. The following table presents the result for the change in the analysis.

Table A4-8 The comparison of odds ratio of poor health by social class, employment status, and age group between two different samples*

	Men		Women	
	Sample A (n=40427)	Sample B (n=37477)	Sample A (n=41334)	Sample B (n=38249)
Social class				
Classes I/II	1.00	1.00	1.00	1.00
Class IIIN	1.27[1.16, 1.39]	1.25[1.14, 1.37]	1.09[1.02, 1.17]	1.08[1.01, 1.16]
Class IIIM	1.45[1.36, 1.55]	1.43[.134, 1.53]	1.40[1.27, 1.55]	1.38[1.25, 1.53]
Classes IV/V	1.70[1.57, 1.84]	1.70[1.56, 1.84]	1.41[1.31, 1.52]	1.42[1.31, 1.53]
Non-employed	1.95[1.46, 2.60]	1.97[1.45, 2.67]	1.59[1.32, 1.93]	1.56[1.28, 1.91]
Employment status				
Employed	1.00	1.00	1.00	1.00
Unemployed	1.32[0.99, 1.76]	1.27[0.94, 1.72]	1.55[1.26, 1.91]	1.56[1.26, 1.94]
Inactive	4.96[3.72, 6.62]	4.81[3.55, 6.52]	1.87[1.56, 2.25]	1.86[1.54, 2.25]
Age group				
20s	1.00	1.00	1.00	1.00
30s	1.11[1.03, 1.19]	1.09[1.02, 1.17]	1.03[0.97, 1.10]	1.03[0.96, 1.09]
40s	1.22[1.14, 1.32]	1.21[1.12, 1.30]	1.27[1.19, 1.35]	1.25[1.17, 1.33]
50s	1.17[1.09, 1.26]	1.17[1.08, 1.26]	1.42[1.33, 1.52]	1.40[1.31, 1.50]

* Sample A includes wave 9, while sample B excludes wave 9.

In table A4-8, the first column lists the variables used in the logistic regressions. The second and third column highlights differences between results from sample A (includes wave 9) and sample B (excludes wave 9). Notably, lower social class, economic inactivity, and old age are strongly associated with the increased risk of poor health status in both men and women. In comparison to the results from sample B, the probability of having poor health in the sample A is higher. Although the effects of predictor variables on a dependent variable decrease in sample B with few exceptions, results from logistic regressions show that most pairs of odd ratios are similar.

Since the results are obtained from the pooled data, not from individual wave, nor from between waves, the sensitivity analysis also compares results from different sets of the pooled data. In sum, the focus of this study is on whether the effects from two samples are considerably different. Overall, repeating the same analysis using two different samples generates nearly the same ORs. As the influence of alteration in wording is not seriously reflected in the outcome on the relationship between health status and social indices, this may help to validate the full use of the BHPS data in this study setting.

Appendix 4-7 An investigation of period effect effect

Since BHPS data are taken from 13 separate years over a relatively long period, the analysis of this study estimates an average effect for the years combined. Notably, social mobility may undergo changes that correspond to the transitions in the occupational structure. In recent decades, upward social mobility has increased, as manual jobs have become less available whilst professional and managerial jobs have become more in demand [Eriksson and Goldthorpe, 2002].

Period effect is defined as when a shift in the probability of an event is observed during the survey years. A period effect would be suggested if any phenomena such as a war or a new treatment, which affects the risk of the event, occurred during the period of analysis [Szklo and Nieto, 2000, pp8-9]. In the current analysis, the risk of an event over 13 waves may not be the same, and time of occurrence needs to be taken into account. For example, the pattern of change in variables examined in this study may coincide with a time of social and political changes (e.g., 'New Labour' was elected in 1997, and Job Seekers Allowance was implemented in 1996) over this period. Therefore, it is necessary to test whether the change of variables is period specific[24]. This analysis is to see whether the trends are continuous over a period, or specific to a particular time within the period. If the trends are secular, then the average effect would be acceptable, but if the trends are period specific, then an adjustment would be necessary.

For the analysis, the sample A in figure 4-1 and table 4-2 is used, which was described in section 4.1.1. In the following table, trends of social class and employment status are described over the 13 years period.

[24] Regarding other variables of interest, the income increase over the 13 waves is discussed in another section (Appendix 6-3). About health measure, the inconsistency of outcome noticed in wave 9 is separately dealt with in the Appendix 4-6.

Table A4-9 Trends of proportion of categories in some indices over 13 years among men

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Number of individuals	3496	3399	3137	3254	3162	3279	3240	3204	3120	3082	3058	3023	2956
Age [Mean(±SD)]	40.3(±12.1)	40.1(±12.1)	40.2(±12.1)	40.0(±12.1)	40.0(±12.0)	39.8(±12.0)	40.0(±12.0)	40.3(±11.9)	40.6(±11.9)	40.9(±11.9)	40.9(±11.9)	41.2(±11.9)	41.4(±11.9)
Social class (%)													
Classes I/II	31.8	31.8	32.2	33.0	36.0	34.9	36.4	36.6	36.0	36.6	37.6	38.0	37.3
Class III NM	10.2	10.8	9.6	10.7	9.4	10.5	9.4	9.7	10.7	10.9	10.5	10.6	10.9
Class III M	28.7	26.8	23.8	25.3	24.8	25.5	26.0	25.7	25.2	25.9	25.4	25.3	25.6
Classes IV/V	13.0	12.3	15.8	12.6	13.0	13.0	13.6	13.8	14.4	13.6	13.7	13.4	13.2
Non-employed	16.3	18.2	18.7	18.4	16.8	16.1	14.6	14.1	13.7	13.0	12.8	12.7	13.1
Employment status (%)													
Employed	82.6	81.2	80.7	81.0	82.7	83.5	84.8	85.2	85.5	86.8	86.8	86.7	86.6
Unemployed	9.4	9.9	9.7	9.2	7.2	7.0	5.6	4.7	4.4	3.8	3.9	4.0	4.2
Inactive	8.0	8.9	9.6	9.8	10.1	9.5	9.6	10.1	10.1	9.4	9.3	9.3	9.2
Health status (%)													
Good	78.9	76.6	76.5	76.2	75.2	75.0	75.1	75.1	84.0	74.7	74.9	74.1	74.4
Poor	21.1	23.4	23.5	23.8	24.8	25.0	24.9	24.9	16.0	25.3	25.1	25.9	25.6

In table A4-9, age has remained almost constant over the time period. The ongoing structure of the BHPS data enables this characteristic of sample, as the new members enter and older members leave the sample according to the age criteria (age groups between 21 and 64 for men and between 21 and 59 for women). This finding suggests, if a specific change over a period is noticed, then this outcome may be attributed to a period effect, rather than to an age effect.

Over the 13 years, after reaching the lowest level of employment in 1993, as noted in elsewhere [Institute for Employment Research, 2007, pp32-40; Cook and Martin, 2005], constant increase in employment, in particular classes I/II, is observed. For example, classes I/II accounts for 37.3% in 2003, compared with 31.8% in 1991. In contrast, the size of the non-employed and inactive group has been gradually decreased through the period. This trend is featured in the following graphical presentation.

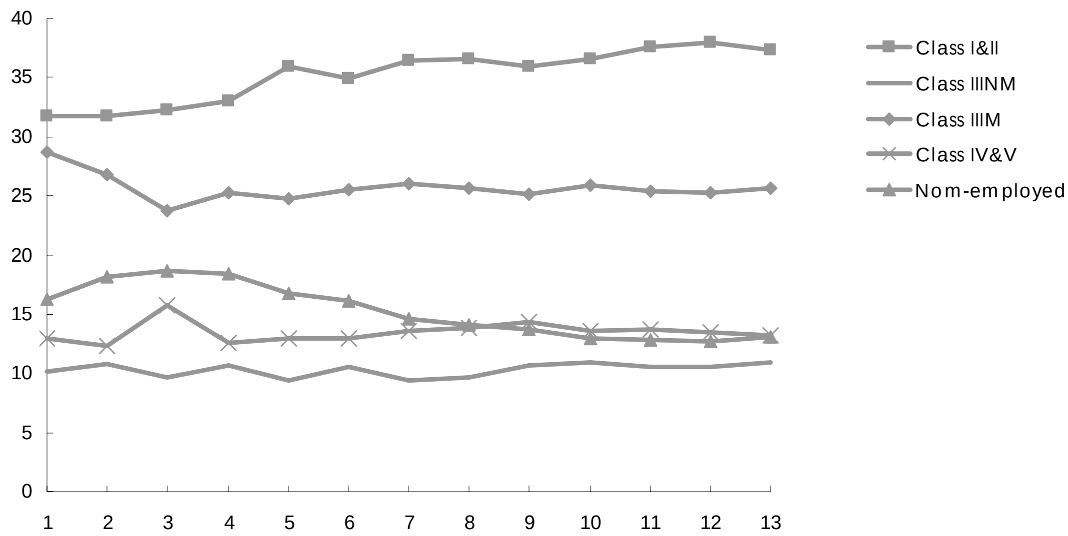

Figure A4-1 Graphical presentation of change in categories of social class and non-employed over 13 waves of the BHPS data in men

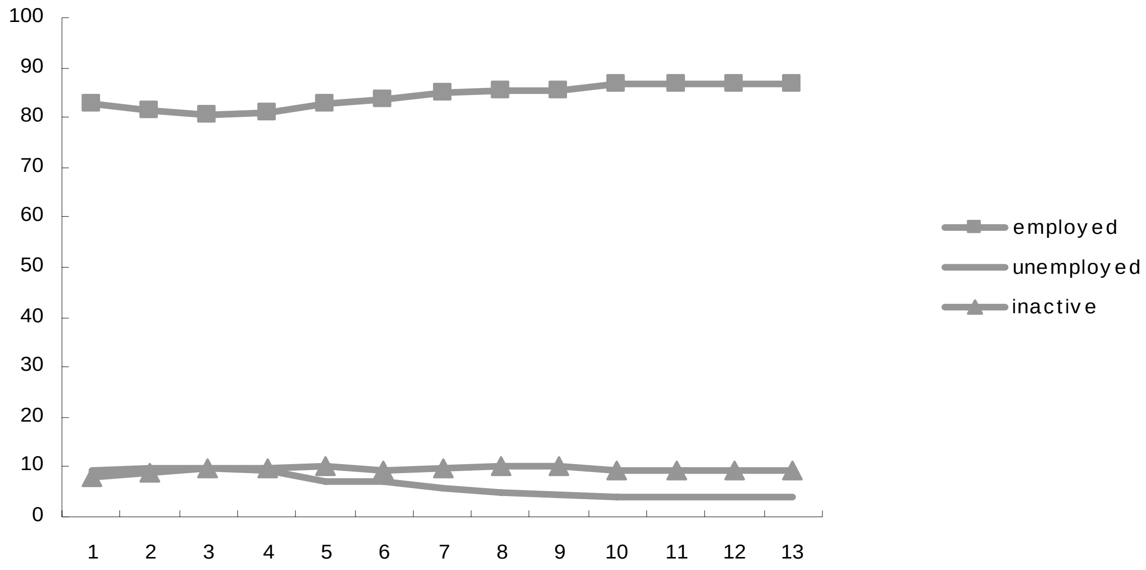

Figure A4-2 Graphical presentation of change in categories of employment status over 13 waves of the BHPS data in men

The proportion of employment fell throughout early 1990s and then has risen after 1993. As a result, unemployment rate continued to rise until 1993, although this trend was followed by a progressive increase afterwards. These results support a hypothesis to mark 1993 as a shift in socioecnomic trends. In the next table, the trends among women are tested to see whether a period effect is at work.

Table A4-10 Trends of proportion of categories in some indices over 13 years among women

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Number of individuals	3549	3397	3349	3325	3233	3314	3286	3281	3217	3225	3182	3145	3065
Age [Mean(±SD)]	38.4(±10.8)	38.2(±10.7)	38.4(±10.7)	38.4(±10.7)	38.6(±10.6)	38.6(±10.7)	38.7(±10.8)	38.8(±10.8)	38.0(±10.9)	39.2(±11.0)	39.3(±10.9)	39.5(±10.9)	39.8(±10.9)
Social class (%)													
Classes I/II	22.5	22.7	23.7	24.6	25.1	25.5	26.7	27.3	28.8	29.7	30.3	31.5	32.2
Class III NM	26.0	26.3	25.2	26.2	27.3	26.1	27.2	27.5	26.8	25.9	26.9	26.5	26.2
Class III M	6.6	6.3	5.4	6.2	6.1	6.7	5.9	6.9	6.8	6.7	6.5	5.6	5.6
Classes IV/V	15.3	14.5	18.8	15.4	14.6	14.6	14.1	14.0	13.9	13.3	13.2	13.4	12.8
Non-employed	29.6	30.3	26.9	27.6	26.9	27.1	26.1	24.3	23.7	24.4	23.1	23.1	23.2
Employment status (%)													
Employed	69.4	68.3	69.8	70.5	71.7	71.7	72.6	73.8	74.5	74.0	75.7	75.3	75.2
Unemployed	3.5	4.1	4.1	3.8	3.5	3.4	2.9	2.3	2.4	3.1	2.3	2.3	2.8
Inactive	27.1	27.7	26.1	25.7	24.8	24.9	24.5	23.9	23.1	22.9	22.0	22.4	22.0
Health status (%)													
Good	75.5	74.0	73.1	72.5	72.8	70.6	70.8	71.2	82.8	70.8	70.5	69.7	70.7
Poor	24.5	26.0	26.9	27.5	27.2	29.4	29.2	28.8	17.2	29.2	29.5	30.3	29.3

Table A10-2 presents the trend that women have tended to be more frequently employed in the high class since 1990s. The proportion of classes I/II for women have increased from 22.5% in 1991 to 32.2% in 2003. During the same period, however, the non-employed group fell from 29.6% to 23.2%. Over the 13 years, women have become a more integral part of workforce and have shown that a linear increase followed a decrease in early 1990s in employment levels. This trend is associated with a decline in the proportion of inactivity and unemployment rate over the same period, with the exception of short periods in early 1990s. There has been a much larger decline in the proportion of inactivity than in unemployment. This trend is graphically presented in the figures below.

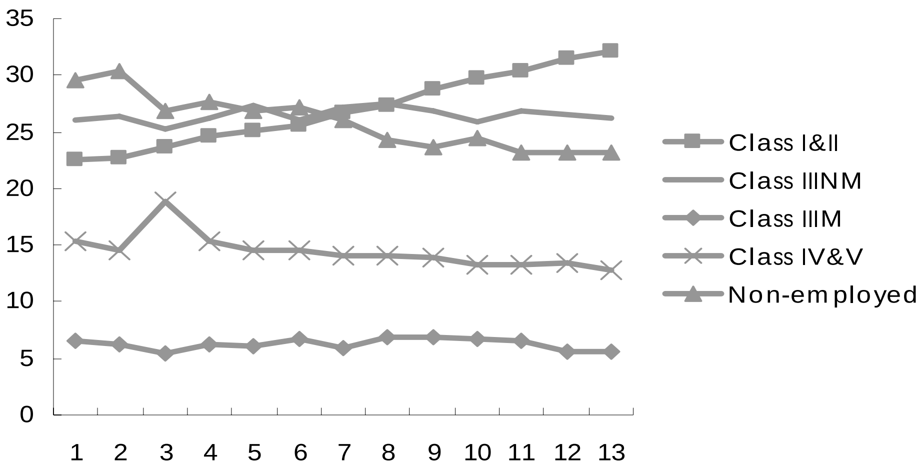

Figure A4-3 Graphical presentation of change in categories of social class over 13 waves of the BHPS data in women

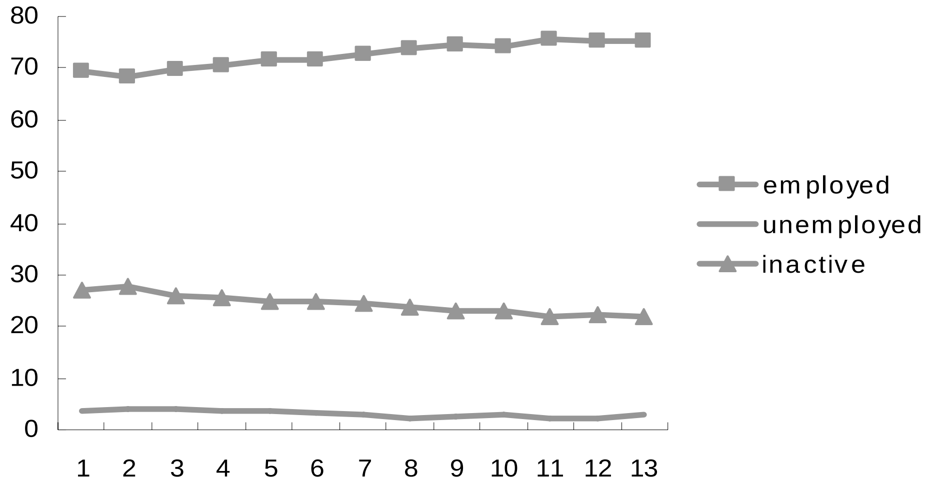

Figure A4-4 Graphical presentation of change in categories of employment status over 13 waves of the BHPS data in women

In summary, the major feature of occupational change has led to an increase and decrease in some domains of workforce across the survey years. Although the trends of these measures have changed over time, yearly differences have shown a steady change in proportional terms apart from the reverse trend in early 1990s. This suggests that the period covered in the current study is divided into two phases; early 1990s recession between 1991 and 1993, and the rest 10 years.

Appendix 4-8 Model comparison using goodness of fit statistic

A goodness of fit statistic has been used to compare one model relative to another model, when they are specified with different sets of variables while using the same dataset. There are various measures used to identify the goodness of fit statistic, some of which are specific to a particular statistical method. In the current study, the deviance statistic for SAS proc NLMIXED and Deviance Information Criterion (DIC) for MCMC are used. The deviance statistic is calculated from the difference in -2Log Likelihood from different models. The improvement in model fitting is possibly noticed as the deviance statistic follows chi-square distribution with degree of freedom (given by difference in number of parameters estimated). The SAS Proc NLMIXED allows the computation of -2Log Likelihood and number of parameters. In contrast, DIC is particularly suitable when parameter estimates are obtained from MCMC method. Dissimilar to the deviance statistics, DIC consists of two terms; the effective number of parameters and the average deviance. This enables DIC to make a direct comparison between two models and any decrease in DIC indicates a better model [Browne, 2005, pp25-30, Pettitt *et al*, 2006].

The following tables present set of goodness of fit statistics for three models. Model 1 includes only the health variable, Model 2 adds age and education variables to Model 1, and Model 3 includes all variables along with cohort and period effects. These are models with the same dataset but differing in variables, ranging from the simpler to the more complex model. These models are applied to three transitions, one from each social index. For transition from Class IIIM among men and transition from wage Grade II among women, the deviance test is used to examine which model fits the data better, whereas, for transition from inactivity among women, the DIC statistic is used.

Table A4-11 The comparison of models based on goodness of fit statistic

	Model 1(Health only)	Model 2(Model 1 + Age and Education)	Model 3 (Model 2 + Cohort and Period effects)
Transition from Class IIIM among men			
-2 Log Likelihood (NP)	9013.7 (9)	8808.9 (33)	8764.7 (49)
Deviance test (d.f.)	Reference	204.8 (24) ‡	44.2 (16) ‡
Transition from wage grade II among women			
-2 Log Likelihood	6874.5 (9)	6675.7 (33)	6643.6 (49)
Deviance test	Reference	198.8 (24) ‡	32.1 (16) †
Transition from inactivity among women			
DIC	5233.45	5125.22	5095.80

*Statistically significant <0.1, †Statistically significant <0.05, ‡Statistically significant <0.01

The goodness of fit statistic is provided to compare three models by adding variables gradually. According to the deviance statistic for the transition model from Class IIIM and income grade II, Model 2 is significantly improved compared with Model 1. Then, the deviance statistics compared between Model 2 and Model 3 for these two transitions are 44.2 and 32.1 with 16 degrees of freedom, which suggests a better fit of the data in the model with cohort and period effects. This DIC diagnostic from the MCMC method for transitions from inactivity to other employment statuses is reduced by 108.23, when Model 3 is compared to Model 2. It can be therefore be seen that the inclusion of the age and education variables greatly increases overall fitting. When cohort and period effects are entered in Model 3, this fits the data better than Model 1.

Appendix 4-9 Comparison of results from SAS with MLwiN

1) Proc NLMIXED results comparison with MLwiN

$$\mathrm{resp}_{ijk} \sim \mathrm{Multinomial}(n_{jk}, \pi_{ijk})$$
$$\log(\pi_{1jk} / \pi_{5jk}) = -3.622(0.163)\mathrm{cons.one}_{ijk} + 0.204(0.341)\mathrm{sick.one}_{ijk} + h_{jk}$$
$$\log(\pi_{2jk} / \pi_{5jk}) = -2.794(0.110)\mathrm{cons.two}_{ijk} + 0.205(0.229)\mathrm{sick.two}_{ijk} + h_{jk}$$
$$\log(\pi_{3jk} / \pi_{5jk}) = -0.995(0.052)\mathrm{cons.three}_{ijk} + -0.027(0.115)\mathrm{sick.three}_{ijk} + h_{jk}$$
$$\log(\pi_{4jk} / \pi_{5jk}) = -1.221(0.056)\mathrm{cons.four}_{ijk} + -0.113(0.128)\mathrm{sick.four}_{ijk} + h_{jk}$$
$$h_{jk} = v_{10k}\mathrm{cons.1234}$$
$$\left[v_{10k}\right] \sim \mathrm{N}(0,\ \Omega_v) \ : \ \Omega_v = \left[0.234(0.037)\right]$$
$$\mathrm{cov}(y_{sjk}, y_{rjk}) = \pi_{sjk}\pi_{rjk}/n_{jk} \ : \ s \quad r; \quad \pi_{sjk}(1 - \pi_{rjk})/n_{jk} \ : \ s = r;$$

Parameter Estimates

Parameter	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower
beta11	0.2033	0.3698	1002	0.55	0.5826	0.05	-0.5224
beta21	0.2059	0.2523	1002	0.82	0.4147	0.05	-0.2892
beta31	-0.02556	0.1351	1002	-0.19	0.8500	0.05	-0.2907
beta41	-0.1142	0.1488	1002	-0.77	0.4429	0.05	-0.4063
s1	0.8889	0.07109	1002	12.50	<.0001	0.05	0.7494
alpha1	-3.6514	0.1783	1002	-20.47	<.0001	0.05	-4.0013
alpha2	-2.8210	0.1234	1002	-22.87	<.0001	0.05	-3.0631
alpha3	-0.9977	0.06683	1002	-14.93	<.0001	0.05	-1.1288
alpha4	-1.2297	0.07076	1002	-17.38	<.0001	0.05	-1.3685

Fixed effects from two results are largely comparable. ‘Cons.one’ from upper panel (MLwiN) and ‘alpha 1’ from lower panel (SAS) are nearly the same as are seen in the estimates fro ‘sick.one’ and ‘beta 11’. The values of the remaining pairs are all similar.

2) Proc MIXED results comparison with MLwiN

$$\text{dpcchg}_{ij} \sim \text{N}(XB,\ \Omega)$$

$$\text{dpcchg}_{ij} = 0.071(0.014)\text{age}_{ij} + \beta_{1i}\text{cons} + 0.239(0.277)\text{good}_{ij} + \text{-}0.403(0.411)\text{one}_{ij} + \text{-}0.232(0.378)\text{two}_{ij} + 0.035(0.430)\text{three}_{ij} + \text{-}0.246(0.340)\text{four}_{ij}$$

$$\beta_{1i} = \text{-}4.822(0.690) + e_{1ij}$$

$$\left[e_{1ij}\right] \sim \text{N}(0,\ \Omega_e)\ :\ \Omega_e = \left[198.158(2.262)\right]$$

*-2*loglikelihood(IGLS Deviance)* = 124699.900(15344 of 15444 cases in use)

```
The Mixed Procedure

Covariance Parameter Estimates

Cov Parm     Subject    Estimate

UN(1,1)      PID        1.42E-15
Residual                  198.25


Fit Statistics

-2 Res Log Likelihood        124711.4
AIC (smaller is better)      124713.4
AICC (smaller is better)     124713.4
BIC (smaller is better)      124719.3


Null Model Likelihood Ratio Test

DF     Chi-Square      Pr > ChiSq

 0           0.00          1.0000
```

Solution for Fixed Effects

Effect	edu	hlsta	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept			-4.8206	0.6897	2577	-6.99	<.0001
hlsta		0	0.2389	0.2773	13E3	0.86	0.3890
hlsta		1	0	.	.	.	.
edu	1		-0.4028	0.4108	13E3	-0.98	0.3268
edu	2		-0.2323	0.3779	13E3	-0.61	0.5388
edu	3		0.03486	0.4305	13E3	0.08	0.9355
edu	4		-0.2461	0.3399	13E3	-0.72	0.4690
edu	5		0	.	.	.	.
age			0.07099	0.01411	13E3	5.03	<.0001

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
hlsta	1	13E3	0.74	0.3890
edu	4	13E3	0.38	0.8206
age	1	13E3	25.33	<.0001

In the modelling of the continuous variable using SAS MIXED and MLwiN, the estimation on coefficients and standard error show almost identical results. For example, a variable of health status appears to have the same value with 0.2389 in SAS (hlsta) and 0.239 in MlwiN (good).

Appendix 4-10 SAS statement for multilevel analysis

1) Proc NLMIXED statement

```
proc nlmixed data=fourwgm;
parms beta11 = 0.18 beta21 = 0.19   beta31 = -0.04 beta41 =-0.12 s1 = 0.1;
/*code linear prdictors with assignment of random effect variables (u)*/
eta1 = alpha1 +hlsta*beta11+u ; /*u : intercept random effect - common random effect*/
eta2 = alpha2 +hlsta*beta21 +u;
eta3 = alpha3 +hlsta*beta31 +u;
eta4 = alpha4 +hlsta*beta41 +u;

/*Constructing probability of responses :
P(Y=j) = exp(eta{j})/[1+exp(eta{1}) +exp(eta{2})+...+ exp(eta{j})] */
if (nxtdec=1) then z = exp(eta1)/(1+exp(eta1) + exp(eta2) + exp(eta3) + exp(eta4));
else if (nxtdec=2) then z = exp(eta2)/(1+exp(eta1) + exp(eta2) + exp(eta3) + exp(eta4));
else if (nxtdec=3) then z = exp(eta3)/(1+exp(eta1) + exp(eta2) + exp(eta3) + exp(eta4));
else if (nxtdec=4) then z = exp(eta4)/(1+exp(eta1) + exp(eta2) + exp(eta3) + exp(eta4));
else if (nxtdec =5) then z = 1/(1+exp(eta1) + exp(eta2) + exp(eta3) + exp(eta4));

/*define log-likelihood : */
if(z>1e-8) then ll=log(z);
else ll=-1e100;
model nxtdec~general(ll);

/*specify random effect*/
random u~normal(0, s1*s1) subject=pid;
run;
```

2) Proc MIXED statement

```
Proc mixed data=change2;
class edu hlsta;
model dpccchg = hlsta edu /solution;
random intercept / sub=pid type=un;
```

Appendix 4-11 MLwiN macro for a multilevel multinomial analysis

```
MLwiN - [R:\ONEBMALE2_MAC.TXT]
File  Edit  Options  Model  Estimation  Data Manipulation  Basic Statistics  Graphs  Window  Help
Start  More  Stop  IGLS  Estimation control..

Note : 5 class categories
NOTE: macro to set up competing risks model in MLwiN
dinp c1-c10
r:\onebmale2.txt
name c1 'pid' c2 'sex' c3 'race' c4 'class' c5 'illness' c6 'hlstat' c7 'edu'
name c8 'transit' c9 'dur' c10 'agec'


NOTE: Calculate duration-squared variable
calc c11='dur'*'dur'
name c11 'dursq'

NOTE: Create level 1 ID (coded 1,2, . . . , 4823)
code 8749 1 1 c12
name c12 'lev1id'

NOTE: Create vector of ones - needed for estimation of intercept terms
put 8749 1 c13
name c13 'cons'

NOTE: Declare Episode as categorical then as a multinomial response, with category 0 the reference
NOTE: 2 new variables are created, the stacked binary responses for categories 1 and 2 and a response index
catn 1 'transit'  1 'frst' 2 'sec' 3 'thrd' 4 'four' 5 'fif'
mnom 0 'transit' c14 c15 1
name c14 'resp' c15 'resp_ind'

Note : denominator
put 34996 1 c17
name c17 'denom'

NOTE: Declare multilevel structure.  Level 1 used to define multivariate structure.
iden 1 'resp_ind' 2 'lev1id' 3 'pid'

Note : categorical data
catn 1 'class' 1 'first' 2 'sec' 3 'third' 4 'four' 5 'fif'
catn 1 'illness' 0 'no' 1 'sick'
catn 1 'abrlimit' 0 'no' 1 'sick'
catn 1 'agec' 1 'twenty' 2 'thirty' 3 'fourty' 4 'fifty'

NOTE: Add covariates
addt 'cons'
addt 'agec'
addt 'class'
addt 'illness'

Go to end   Find
Execute   Replace
```

Appendix 4-12 Interpretation of results from MLwiN

The following figure illustrates the way in which MLwiN presents an example of the result from multilevel multinomial analysis using MCMC method.

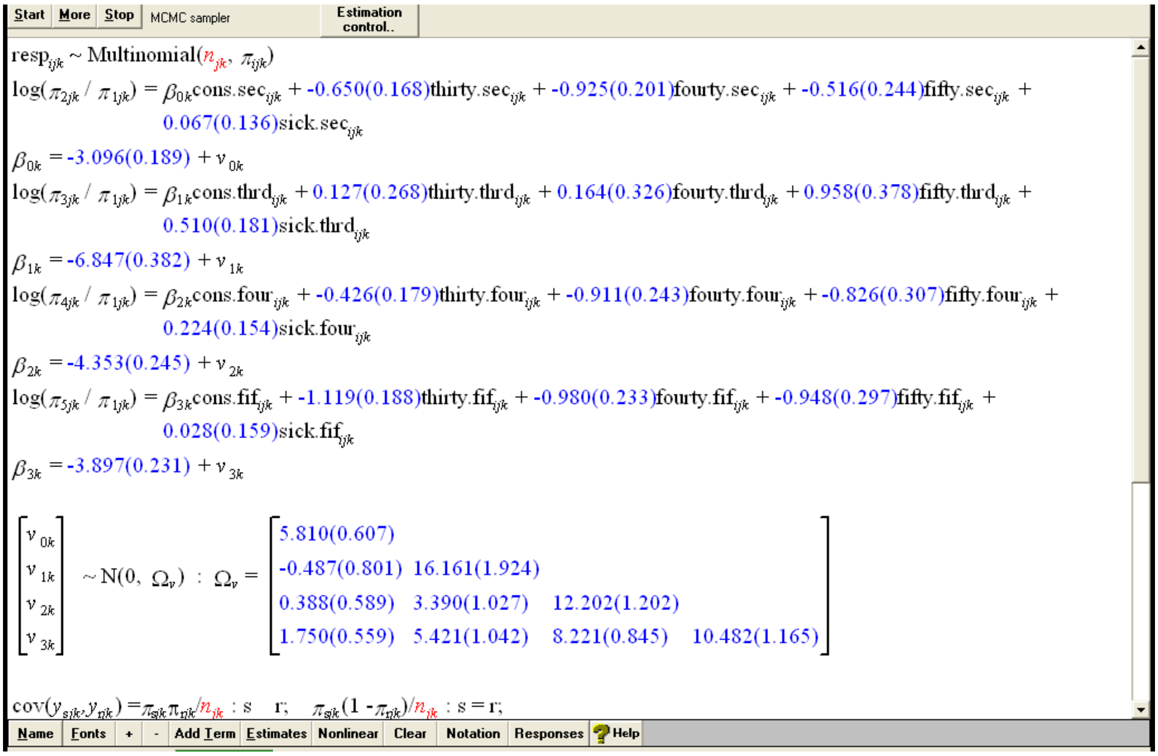

Figure A4-1 Result from multilevel multinomial analysis using MLwiN with MCMC method

Figure A4-1 shows the results from the multilevel multinomial analysis. In this model, transitions between social classes along with the non-employed fit the data for every origin. The significance of health status (name tag is 'sick') on the risk of transition from classes I/II for others is illustrated, referring to the transition from classes I/II to classes I/II as a reference. The only one covariate, 'age' is added with three dummies (thirty, forty, and fifty).

As a dependency between these competing transitions is assumed, the four equations specified in figure A4-1 are estimated simultaneously. In the upper panel, the four equations with different suffixes are the contrast between each type of transition and staying in classes I/II. For example, the first equation which includes variables with the suffix ‘.second’, is the contrast between transition from classes I/II to class III NM and staying in classes I/II.

This model allows the coefficients of the variables con.sec, cons.thrd, cons.four and cons.fif to vary randomly across individuals by adding random terms. Therefore, while the four equations in upper panel suggest the size of the effect with standard error for every coefficient (fixed effect), the lower panel gives information on random effects. Four between-individual variances are presented along diagonal line by involving the random effects for the risk of each transition. Unobserved factors in the form of covariance under diagonal line are also introduced, in order to represent correlation across different types of transition. For example, the between individual variance for transition from classes I/II to class III M is 16.161 with a standard error of 1.924, and for transition from classes I/II to classes IV/V is 12.202 with a standard error of 1.202. The covariance between two transitions is 3.390 with a standard error of 1.027. This means that individual level (level 2) variability is significant, but two transitions are correlated. This interpretation of figures is applied through Chapter 5 to Chapter 7, where multilevel multinomial analysis is used.

Appendix 6-1 Comparison of working hour with regard to health status

Table A6-1 shows simple test whether working hours differ with regard to health status.

Table A6-1 Comparison of working hour with regard to health status across every individual wave [Mean working hours per week, no=63599]

	Men		Women	
	Good heath	Poor health	Good health	Poor health
Wave 1	40.05	40.52	27.90	27.95
Wave 2	40.27	40.44	27.62	26.68
Wave 3	40.50	40.04	28.03	27.53
Wave 4	40.42	40.11	28.09	28.36
Wave 5	40.58	39.53	28.53	28.56
Wave 6	40.49	39.92	28.47	28.62
Wave 7	40.25	39.31	28.98	27.71
Wave 8	40.60	39.79	28.61	28.62
Wave 9	39.73	39.31	28.70	29.10
Wave 10	40.26	39.48	29.07	29.35
Wave 11	40.09	39.83	29.04	28.91
Wave 12	40.10	39.21	29.24	28.47
Wave 13	39.92	39.76	29.05	28.52

From brief overview on comparison between two health groups, it seems difficult to draw any firm pattern how health status is related to working hours. When this table is expressed as the number of statistical significance in the appendix 6-3, only one and three times were significant for men and women respectively.

Appendix 6-2 Comparison of main job related measures to second job related measures

As a preliminary examination, the reliability of economic measures is tested. After comparing the mean of set of measures as to health status year to year, the number of waves appears to be statistically significant are summarized together with total number of waves.

Table A6-2 The number of statistically significant[1)] waves in comparison of group mean between those with and without poor health for 13[2)] waves [Number of statistically significant waves/Number of total waves]

	Men	Women
Hourly payment from main job	12/13	9/13
Second job payment	0/13	0/13
Hourly payment from main and second job	6/13	5/13
Working hours in main job	1/13	3/13
Working hours in second job	0/13	0/13

1) ANOVA is used to compare group mean. Significance level is based on $p<0.05$.

2) All measures are surveyed through 13 waves, accordingly, denominator is 13.

The difference between two groups with and without poor health is distinctive when hourly payment from main job is used: Significant difference is presented over 12 times for men and 9 times for women among 13 waves. However, when payment in second job is used alone, no difference is detected. Expectedly, number of significant group difference on hourly payment from main job in combination with main second job is somewhere between hourly from main job and second job payment; six and five times among 13 waves for men and women respectively. With this finding, result from appendix 6-4 also aids to decide which measure to use to understand relationship between health and wage.

Appendix 6-3 Comparison of three wage measures on yearly mean

Following results show the mean of every measure for 13 waves as a simple way to overview the reliability of measurements.

1) Monthly wage

Wave	N	Mean	Std Dev	Minimum	Maximum
Male					
1	1644	1397.09	750.5585965	38.1666679	8666.67
2	1502	1474.63	814.5732860	82.3333359	8606.62
3	1407	1516.22	854.5020398	43.3333321	13010.01
4	1414	1582.43	952.7568235	18.0138569	16012.32
5	1421	1643.06	943.6427849	39.0000000	11008.47
6	1494	1716.74	1112.80	103.0792923	18859.12
7	1548	1749.46	1088.52	59.2822266	16012.32
8	1556	1860.02	2011.75	78.0600510	71058.95
9	1556	1884.15	1062.51	86.6666641	10007.70
10	1564	1948.35	1095.62	131.1008453	12009.24
11	1580	2042.13	1176.40	43.3333321	11008.47
12	1551	2142.39	1371.08	108.3333359	23888.38
13	1415	2214.57	1470.32	70.1367188	29794.92
Female					
1	1599	662.1609199	510.5547983	13.0000000	4583.33
2	1530	713.8830893	550.8244807	13.6190472	4469.83
3	1496	756.8176868	578.9441858	21.6666660	4653.58
4	1533	793.6669820	602.5062184	26.0000000	4003.08
5	1505	857.0102081	747.4996328	43.3333321	15439.88
6	1581	888.7763953	689.6780383	21.6666660	6254.81
7	1589	949.0844843	917.0239996	21.6666660	20558.57
8	1602	965.4507301	711.3349443	35.0269432	5468.03
9	1609	1026.53	750.1027931	17.3333340	5754.43
10	1609	1071.74	785.8450052	47.6666679	7000.00
11	1614	1139.22	845.4612546	41.8888893	8333.25
12	1596	1201.08	895.2636954	0.0833333	8093.58
13	1515	1239.16	919.8324277	21.6666660	8504.17

2) Hourly wage sum of main and 2^{nd} job

Wave	N	Mean	Std Dev	Minimum	Maximum
Men					
1	1658	8.5564421	7.7958668	0.5571087	199.9400000
2	1519	9.2696172	11.8306237	0.5000000	399.9600000
3	1418	11.2824872	79.7190449	0.2327372	3000.00
4	1423	9.4761732	5.8029010	0.0924499	88.0474962
5	1443	11.0164228	25.5083932	0.1818182	666.6000000
6	1520	10.8415873	11.9862669	0.1000000	300.0000000
7	1583	11.2554342	25.9321004	0.3911727	999.9000000
8	1570	11.2955151	12.9808457	0.1428571	350.0000000
9	1564	12.0014391	15.6835083	0.1010101	450.0000000
10	1576	12.3598722	21.2207052	0.5000000	750.0000000
11	1580	12.2210758	7.7877752	0.2566076	125.0000000
12	1550	13.0713354	9.3607705	0.8333333	150.0000000
13	1424	14.6985063	41.4738916	0.5000000	1500.00
Women					
1	1629	5.3829815	3.6219452	0.2166794	60.0000000
2	1543	6.1020074	8.6503096	0.2000000	300.0000000
3	1518	6.4823637	12.9007510	0.5956963	475.0000000
4	1563	6.3046273	4.0617855	0.5000000	43.4514407
5	1532	7.4290291	14.9017301	0.1315789	375.0000000
6	1607	6.9832647	5.3782180	0.2272727	110.0000000
7	1619	7.6855887	9.4150766	0.5000000	260.0000000
8	1622	7.7876138	7.1262121	0.4000000	187.5000000
9	1626	7.9944907	5.0956473	0.5003849	80.0000000
10	1620	8.5111847	7.7036724	0.6775493	200.0000000
11	1613	9.0972250	10.3405430	0.3333333	350.0000000
12	1597	9.3487775	6.7136393	0.000601424	140.0000000
13	1526	10.4521722	20.8343266	0.2501925	750.0000000

3) Hourly wage just from main job

Wave	N	Mean	Std Dev	Minimum	Maximum
Male					
1	1609	8.2131849	4.3515103	0.5571087	50.0384939
2	1464	8.7992636	5.2577073	1.3260201	66.7693485
3	1378	8.9626814	4.9239627	0.2327372	60.0924159
4	1384	9.3851213	5.5157128	0.0924499	88.0474962
5	1391	9.7423303	5.5517380	1.0958299	65.1890091
6	1462	10.2243302	7.5529194	1.2509623	170.6819644
7	1516	10.3505262	6.1720702	0.3911727	76.0070029
8	1527	10.8672308	8.1315147	0.5003849	234.4406281
9	1516	11.1673209	6.3399948	2.3494698	56.2195173
10	1536	11.5292144	6.3985512	0.9482038	74.9593564
11	1545	12.0566303	6.7348433	0.2566076	72.2264609
12	1521	12.7712145	7.9622318	1.9241129	137.9236569
13	1388	13.2213387	9.9125828	0.5399286	237.2773787
Female					
1	1572	5.2747622	2.9463919	0.2166794	25.6805197
2	1492	5.8764185	3.9681229	0.3335899	54.0415714
3	1464	6.0838161	3.6863426	0.5956963	35.0269444
4	1510	6.3001364	3.8726870	0.5942071	43.4514407
5	1473	6.6429120	4.3809858	0.3083768	89.1447877
6	1555	6.8382048	4.0452208	0.5003849	44.2840654
7	1564	7.3213689	5.7730176	0.6004619	118.6984450
8	1579	7.5317820	4.8048004	0.9382217	60.0000029
9	1581	7.9166978	4.5976137	0.5003849	45.0000008
10	1577	8.1940247	4.7515813	0.6775493	46.9479837
11	1585	8.8035865	5.2619114	0.5374505	52.8284961
12	1567	9.1515960	5.2710128	0.000601424	50.5185921
13	1488	9.6195404	5.7080752	0.2501925	76.5922493

This result presents that the hourly wage gained from the sum of main and second job went up and down in some years not fitting probable inflation, and large standard deviation of the measure indicates wider variation. This is not the case for both monthly and hourly wage derived just from main job. This fact probably stems from unstable measurements which are relatively common in second job related measures. Overall findings in appendix 6-3 and 6-4 suggest that second job related measures seem to be susceptible to measurement error.

Appendix 6-4 Constructing hourly wage variable

To create hourly wage variable, for example in 13th wave, the following formula has been used;

$$\text{Hourly wage (main and second job)}^{1)} = \frac{\text{mpaygu}^{a)} \times \left(\text{mjbhrs}^{b)} \times 4.3299999237^{c)}\right) + \text{mj2pay}^{d)} \times \text{mj2hrs}^{e)}}{\left(\text{mjbhrs} \times 4.3299999237\right) + \text{mj2hrs}}$$

$$\text{Hourly wage (main job)}^{2)} = \frac{\text{mpaygu}}{4.3299999237} \times \frac{1}{\text{mjbhrs}}$$

There are two kinds of hourly wage;

1) The first hourly wage is obtained from the sum of main and second job. To combine average values from two sources of payments, the weighted mean is used [Macfie and Nufrio, 2006, pp73-75].

$$X = \frac{\sum_{i=1}^{n} w_i \bullet x_i}{\sum_{i=1}^{n} w_i}$$

2) The second hourly wage is obtained just from main job.

In the formula, each parameter represents a particular concept as a BHPS terminology. They are;

a) mpaygu : This is a derived variable to measure usual monthly wage or salary payment from main job before tax and any deductions.

b) mjbhrs: This measures the number of hours that are expected to work in a week.

c) In BHPS data, one month is equal to 4.3299999237 weeks.

d) mj2pay : This is a monthly payment from 2nd job.

e) mj2hrs: This measures the number of hours worked per month for second job.

Appendix 6-5 Wage difference with regard to health status

Table A6-3 presents the comparison of wage between those with and without poor health over 13 waves.

Table A6-3 Wage difference with regard to health status for every individual waves measured in actual hourly wage (left panel) and percentile ranked wage (right panel) [Mean, no=63599]

	Actual hourly wage				Percentile ranked wage			
	Men		Women		Men		Women	
	Good	Poor	Good	Poor	Good	Poor	Good	Poor
Wave 1	8.38	7.45	5.35	4.96	51.94	44.07	51.17	47.95
Wave 2	8.93	8.26	6.01	5.31	51.34	47.39	51.46	46.78
Wave 3	9.19	7.97	6.18	5.74	51.21	43.13	51.29	47.76
Wave 4	9.69	8.02	6.49	5.59	52.39	42.11	51.62	46.57
Wave 5	10.03	8.48	6.81	6.05	52.20	43.18	51.83	45.74
Wave 6	10.26	10.07	6.96	6.46	51.25	47.64	51.76	46.68
Wave 7	10.78	8.60	7.51	6.69	52.63	42.01	52.15	45.11
Wave 8	11.19	9.55	7.68	7.11	52.03	44.31	52.40	45.00
Wave 9	11.39	9.41	8.04	7.08	51.68	41.54	51.39	44.56
Wave 10	11.81	10.49	8.38	7.65	51.98	45.16	51.37	47.97
Wave 11	12.41	10.83	8.93	8.42	52.55	43.65	51.77	46.86
Wave 12	13.35	10.95	9.46	8.26	53.04	42.51	52.35	45.19
Wave 13	13.93	10.56	9.92	8.97	53.64	39.65	52.11	45.91

Hourly payment (left panel) has been increased every year both men and women, while this trend disappear converting hourly wage into percentile wage (right panel) because this measure merely represents a rank in the wage distribution. However, both panels keep the consistency to show better wage status among those with good health. Actual wage of women remained in a degree of around two thirds of men although the gap had been gradually narrowed.

Appendix 6-6 Transition matrix with monthly wage

Table A6-4 provides transition rate between quintile wage grades measured in monthly wage for year *t*-1 and year *t* among men. Data from 13 waves from 1991 to 2003 in BHPS are used.

Table A6-4 Transition rate (row percentage) between quintile grade† of monthly wage with regard to health status‡ for year *t*-1 and year *t* based on 13 years BHPS data in men

Wage quintile in year *t*-1	Wage quintile in year t					
	I	II	III	IV	V	Total transitions
Those with good health						
I	85.5	11.5	1.6	0.7	0.7	2708(21.7)
II	15.0	64.7	16.1	2.8	1.4	2668(21.4)
III	2.1	19.8	57.8	17.4	2.9	2582(20.7)
IV	0.7	4.1	20.9	60.0	14.3	2392(19.2)
V(Bottom)	0.5	1.1	3.7	19.0	75.7	2126(17.0)
Total						12476(100.0)
Those with poor health						
I	84.5	10.9	2.5	1.1	1.1	367(12.9)
II	11.2	65.3	17.9	4.7	0.9	536(18.9)
III	1.1	18.9	55.4	20.0	4.6	560(19.7)
IV	0.5	3.3	16.9	60.4	18.9	657(23.1)
V(Bottom)	0.4	1.2	3.3	17.3	77.7	723(25.4)
Total						2843(100.0)

† Quintile ranking is based on the sample B (in table 4-2) before restricting the sample to participants with two consecutive waves. Therefore, the marginal distribution is not exactly 20% for every grade.

‡ Health status in year *t*-1

Apart from few exceptional cases (from I to II and from V to II), in general the trend that those with poor health record more downward and less upward has been kept.

Table A6-5 Transition rate (row percentage) between quintile grade† of monthly wage with regard to health status‡ for year *t*-1 and year *t* based on 13 years BHPS data in women

Wage quintile in year *t*-1	Wage quintile in year t					
	I	II	III	IV	V	Total transitions
Those with good health						
I	87.5	9.9	1.5	0.7	0.4	2691(21.6)
II	11.8	71.2	14.5	1.8	0.7	2592(20.8)
III	1.3	15.1	66.3	15.4	1.9	2528(20.3)
IV	0.7	3.0	15.0	70.3	11.1	2422(19.5)
V(Bottom)	0.3	1.2	3.4	14.8	80.3	2206(17.7)
Total						12439(100.0)
Those with poor health						
I	83.1	12.6	2.7	1.1	0.5	557(16.5)
II	10.2	72.8	14.4	1.3	1.3	688(20.4)
III	0.6	13.9	64.5	18.3	2.7	704(20.8)
IV	0.7	1.8	14.4	70.2	13.0	738(21.8)
V(Bottom)	0.3	1.2	3.5	12.1	83.0	693(20.5)
Total						3380(100.0)

† Quintile ranking is based on the sample B (in table 4-2) before restricting the sample to participants with two consecutive waves. Therefore, the marginal distribution is not exactly 20% for every grade.

‡ Health status in year *t*-1

Contingency mobility table in women (table A4-5) with monthly wage repeats the same trend as hourly wage that is less upward and more downward in those with poor health. Only two transitions from II to III and from V to III show the reverse direction with negligible difference.

Appendix 8-1 Rearrangement of mobility table in producing social inequalities in health

(1) Notation in the restructuring a mobility table

Number of individuals with poor health taken from any class (N′) in year *t* is given by the below formula after considering every movement.

Social class at t-1 year	Social class at t year					
	I & II	III NM	III M	IV & V	Unemployed	Total transitions
I & II	1280(83.7)	72(4.7)	66(4.3)	32(2.1)	79(5.2)	1529(24.3)
III NM	69(16.1)	289(67.4)	32(7.5)	18(4.2)	21(4.9)	429(6.8)
III M	75(5.4)	33(2.4)	1076(77.1)	121(8.7)	91(6.5)	1396(22.2)
IV & V	30(4.2)	18(2.5)	106(14.9)	488(68.4)	71(10.0)	713(11.3)
Unemployed	37(1.7)	16(0.7)	48(2.2)	65(2.9)	2055(92.5)	2221(35.3)
Total	1491(23.7)	428(6.8)	1328(21.1)	724(11.5)	2317(36.9)	6288(100.0)

$$N' = N - (n2+n3) + (n4+n5) - n6 + n7$$

Figure A8-1 Graphical representation of flows of individuals with poor health from class III M (N) to different domains of class positions and from them to final class III M (N′) during consecutive two years

† Symbol N and N′ indicate the number of individuals with poor health in a given class in year *t*-1 and year *t*, respectively; n2, n3 and n6 are the number of downward mobility, upward mobility, and exit from each class, whereas n4, n5, and n7 are the number of downward mobility, upward mobility, and entry to each class.

As shown in figure 8-1, above table can be converted to signify changes of poor health proportions at each class. For example, the number of cases with poor health of new class III M in year *t* (N′) is calculated from the initial size of individuals with poor health among class III M in year t-1 (N) by subtracting the number of exits, downward mobility (n2), upward mobility (n3), and exit from employment (n6) and by adding the number of entries, downward entry (n4), upward entry (n5), and entry to employment (n7). This equation yields the estimation of

1328 = 1396 – (121 + 108) + (98 + 106) – 91 + 48

(2) Construction of pre- and post-mobility social inequalities in health

The following table shows the link between pre-mobility social inequalities in health and post-mobility social inequalities in health. This table is merely replication of table 5-5 in Chapter 5, but delivers other message. Looking at the data in a different way, this new table focuses on health inequality over the mobility span.

Table A8-1 Frequency of each transition between social classes† and the non-employed and the proportion‡ of poor health [Lower panel] in each transition over year *t*-1 and year *t* in Men (n =25611)

Social class in year *t*-1	Social class in year t					
	I/II	III NM	III M	IV/V	Non-employed	Total transitions
Those with good health						
I/II	7352	343	299	130	209	8333
III NM	403	1230	90	69	53	1845
III M	333	87	4275	360	173	5228
IV/V	105	79	390	1419	97	2090
Non-employed	114	52	113	100	1448	1827
Total	8307	1791	5167	2078	1980	19323
Those with poor health						
I/II	1280(0.148)	72(0.173)	66(0.181)	32(0.198)	79(0.274)	1529(0.155)
III NM	69(0.146)	289(0.190)	32(0.262)	18(0.207)	21(0.284)	429(0.189)
III M	75(0.184)	33(0.275)	1076(0.201)	121(0.252)	91(0.345)	1396(0.211)
IV/V	30(0.222)	18(0.186)	106(0.214)	488(0.256)	71(0.423)	713(0.254)
Non-employed	37(0.245)	16(0.235)	48(0.298)	65(0.394)	2055(0.587)	2221(0.549)
Total	1491(0.152)	428(0.193)	1328(0.204)	724(0.258)	2317(0.539)	6288(0.246)

* Both ovals depict pre-mobility class inequalities in health in year *t*-1 and post-mobility one in year *t*, respectively.

† Based on own occupation which are professional and managerial (I/II), skilled non-manual (III NM), skilled manual (III M), partially skilled and unskilled (IV/V), and non-employed.

‡ Proportion in poor health = number of individuals with poor health in a given transition / total number of individuals in a given transition (e.g. proportion in poor health of transition from I/II to I/II = 0.148 = 1280 / (1280+7352)

Lower panel of this table expresses how much each of cells in table conceives poor health proportion. Mostly upward mobile group carries less poor health proportion compared to the reference group in last column with an exception (transition from III M to III NM). As a consequence of these movements, pre-mobility social inequalities in health (marked in oval at right hand side) are transformed into post-mobility social inequalities in health (marked in oval at table of bottom). Another aspect of this table notes continuum status of class domain as a consequence of moving and staying both outside and within employment.

(3) Process of modifying mobility table to health inequality table

Table A8-2 helps to understand the construction of social inequalities in health by employment status. This table is derived from table A8-1 by simply merging all classes into one category of employed with the other of non-employed. Even if the calculation is introduced using the measure of employment status because of its simplicity (i.e., two levels; the employed and the non-employed), the use of class measure follows much the same logic.

Table A8-2 Preparation for the calculation of mobility table using employment status over year *t*-1 and year *t* in Men (n=25611)

Employment status in year *t*-1	Employment status in year t		
	Employed	Non-employed	Total
Those with good health			
The employed	16964(a)	532(b)	17496(a+b)
The non-employed	379(c)	1448(d)	1827(c+d)
Total	17343(a+c)	1448(b+d)	19323(a+b+c+d)
Those with poor health			
The employed	3805(a´)	262(b´)	4067(a´+b´)
The non-employed	166(c´)	2055(d´)	2221(c´+d´)
Total	3971(a´+c´)	2317(b´+d´)	6288(a´+b´+c´+d´)

The entries in table A8-2 are number of individuals. Combining two panels of table A8-2 gives below result.

Table A8-3 Converting of the data format by changing the list of items according to social mobility between employment statuses

	Pre-mobility health inequality ($N^{\dagger}$)	Social mobility between employment statuses				Post-mobility health inequality (N′)
		Exit from employment	Entry to employment	Exit form the non-employed	Entry to the non-employed	
Employed	4067(18.9, A)	262(33.0, C)	166(30.5, D)			3971(18.6, E)
Non-employed	2221(54.9, B)			166(30.5, D)	262(33.0, C)	2317(53.9, F)

Table A8-3 is nothing but a rearrangement of numbers in the previous table A8-2. Cell entries are gained by the notation in table A8-2 and A8-3 with an application of the following formula;

The proportion in poor health among employed in year *t*-1, A = $\frac{a^{'}+b^{'}}{a^{'}+b^{'}+a+b}$

The proportion in poor health among non-employed in year *t*-1, B = $\frac{c^{'}+d^{'}}{c^{'}+d^{'}+c+d}$

The proportion in poor health among those exit from employment, C = $\frac{b^{'}}{b^{'}+b}$

The proportion in poor health among those entry to employment, D = $\frac{c^{'}}{c^{'}+c}$

The proportion in poor health among employed in year *t*, E = $\frac{a^{'}+c^{'}}{a^{'}+c^{'}+a+c}$

The proportion in poor health among non-employed in year *t*, F = $\frac{b^{'}+d^{'}}{b^{'}+d^{'}+b+d}$

Appendix 8-2 Construction of health inequality in year t

This table gives full expansion of the items of post-mobility social inequalities in health (N′), new poor health entry (n10), and health inequalities in year *t* (N″) in table 8-3 with different subheadings of those with poor health in year *t*-1 (N′), those with good health in year *t*-1 (n10), and subtotal in year *t* (N″).

Table A8-4 Presentation of total population with and without poor health

		Those with poor health in year *t*-1 (N′)	Those with good health in year *t*-1 (n10)	Sub total in *t* year (N″)
Classes I/II	*Those with good health in year t*	718(48.4)	7485(90.5)	8203(84.1)
	Those with poor health in year t	767(51.6)	786(9.5)	1553(15.9)
	Subtotal in year t-1	1485(100.0)	8271(100.0)	9756(100.0)
Class III NM	*Those with good health in year t*	171(40.0)	1590(89.0)	1761(79.5)
	Those with poor health in year t	256(60.0)	197(11.0)	453(20.5)
	Subtotal in year t-1	427(100.0)	1787(100.0)	2214(100.0)
Class III M	*Those with good health in year t*	603(45.6)	4461(86.9)	5064(78.4)
	Those with poor health in year t	718(54.4)	675(13.1)	1393(21.6)
	Subtotal in year t-1	1321(100.0)	5136(100.0)	6457(100.0)
Classes IV/V	*Those with good health in year t*	273(38.0)	1783(86.4)	2056(73.9)
	Those with poor health in year t	445(62.0)	281(13.6)	726(26.1)
	Subtotal in year t-1	718(100.0)	2064(100.0)	2782(100.0)

From table A8-4, the percentile of those with poor health at a given class marked with shade is provided in table 8-2. Another difference in number of individuals with poor health in year *t*-1 between table A8-4 and table 8-3 also needs to be noted. Although both tables appear numerically different, for classes I/II 1491/1485, class III NM 428/427, class III M 1328/1321, classes IV/V 724/718 due to the missing on health status variable in year *t*, the difference may be ignorable.

Appendix 8-3 Measuring health inequalities after health change

The following table is the exact opposite to table 8-2. Thus, health inequalities after health change are estimated assuming that class status is remained constant over two years and only health is subject to change.

Table A8-5 Assessment of the effect of health change supposing class status is constant over year *t*-1 and year *t* by employment status by comparing health inequalities before and after health change [Frequency (the proportion of individuals with poor health)*]

	Health inequalities in year *t*-1† (N)	Health change between year *t*-1 and year t: Exit from poor health (n1)	Staying in poor health (n2)	Entry to poor health (n3)	Health inequalities after health change (N′)	Health inequalities in year *t* (N″)
I/II	1521(15.5)	722(47.5)	799(52.5)	801(9.66)	1600(16.3)	1553(15.9)
III NM	426(18.8)	164(38.5)	262(61.5)	215(11.7)	477(21.1)	453(20.5)
III M	1389(21.1)	596(42.9)	793(57.1)	694(13.4)	1487(21.6)	1393(21.6)
IV/V	708(25.4)	267(37.7)	441(62.3)	311(14.9)	752(27.0)	726(26.1)
Absolute Diff¶	9.9				10.7	10.2
Relative Diff¶	1.64				1.66	1.64
Employed	4044(18.9)	1749(43.2)	2295(56.8)	2021(11.6)	4316(20.1)	4125(19.5)
Non-employed	2209(54.9)	364(16.5)	1845(83.5)	390(21.5)	2235(55.5)	2426(56.8)
Absolute Diff¶	36.0				35.4	37.3
Relative Diff¶	2.90				2.76	2.91

* The frequency of this table is the number of individuals with poor health. Values in parenthesis are the proportion which represents the proportion of the individuals with poor health. The denominator for the proportion of this fraction is obtained from entire member of each category including those with good health (e.g., In classes I/II, 15.5 = 1529/(1529+8333)x100) apart from n1 and n2 where the denominator is gained from the total number of poor health in year *t*-1 (e.g., In classes I/II, 47.5 = 722/1521x100).

† Symbol N and N″ represent the number of individuals with poor health in a given class in year *t*-1 and year *t* respectively; and N′ represent the number of poor health after health change occurs over year *t*-1 and year *t*. n1 and n2 stands for the number of exit from poor health and staying poor health among those with poor health in year *t*-1 after one year. n3 is the number of new poor health entry in year *t*. The relationship among them can be expressed by deriving equations: N = n1+n2 (the sum of proportion for n1 and n2 equals 100), N′ = n2+n3.

¶ Health inequalities are evaluated by defining absolute difference and relative difference which were described in the method part.

In table A8-5, a direct numerical link between health inequalities in year *t*-1 and health inequalities after health change is displayed along with health inequalities in year *t* as a reference. Health change in relation to the previous SEP is operating within a general mathematical framework, and it is supposed to be accountable for the development of new health inequalities.

This table provides a valuable insight into the idea that SEP predicts subsequent health change afterwards. As might be expected, all three groups, those who got out of poor health status, those who remained in poor health status, and those who newly developed poor health, are strongly associated with their previous SEP. Among those with poor health in year *t*-1, the proportion of people who exit from poor health in year *t* is largest among the highest classes I/II, while the proportion of people who stay in poor health is largest among the lowest classes IV/V. Among those with good health in year *t*-1, the occurrence of poor health shows a clear health gradient across both class strata and employment status.

In general, social inequalities in health measured across classes suggest an increase after health change. This increase is more profound when it is indicated by absolute difference (10.7). In contrast, the size of health inequalities by employment status shows an overall decrease in absolute and relative difference.

Appendix 8-4 The detailed manipulation in population size

The following two tables are an expansion of table 8-5 with more detailed intervals of relative difference between the magnitude of upward and downward mobility (Factor C) and population ratio (Factor D). Two factors are allowed to vary in each table, and they are applied to two different net effects of health selection: a2 (model 1-7) and a4 (model 8-14) as defined previously. In the following table, the ratio between downward upward mobility increases from c′1 (25:175=1:7) to c′7 (175:25=7: 1).

Table A8-6 Hypothetical simulation* to assess changes in relative difference between the magnitude of downward and upward mobility and resulting health inequalities

Model†	Situation	Pre-mobility health inequalities in year *t*-1	Social mobility: Downward exit	Social mobility: Upward entry	Post-mobility health inequalities in year t	AD/RD‡	Evaluation‡
1	A=a2, B=b2, C=c´1, D=d2	100/1000 (10.0%)	5/25(20%)		148/1150(12.9%)	28.5/3.2	−−−−−−
		400/1000 (40.0%)		53/175(30%)	352/850(41.4%)		
2	A=a2, B=b2, C=c´2, D=d2	100/1000 (10.0%)	10/50(20%)		135/1100(12.3%)	28.3/3.3	−−−−−
		400/1000 (40.0%)		45/150(30%)	365/900(40.6%)		
3	A=a2, B=b2, C=c´3, D=d2	100/1000 (10.0%)	15/75(20%)		123/1050(11.7%)	28/3.4	−−−−
		400/1000 (40.0%)		38/125(30%)	377/950(39.7%)		
4	A=a2, B=b2, C=c´4, D=d2	100/1000 (10.0%)	20/100(20%)		110/1000(11.0%)	28/3.5	−−−
		400/1000 (40.0%)		30/100(30%)	390/1000(39.0%)		
5	A=a2, B=b2, C=c´5, D=d2	100/1000 (10.0%)	25/125(20%)		97/950(10.2%)	28.2/3.8	−−
		400/1000 (40.0%)		22/75(30%)	403/1050(38.4%)		
6	A=a2, B=b2, C=c´6, D=d2	100/1000 (10.0%)	30/150(20%)		85/900(9.4%)	28.3/3.9	−
		400/1000 (40.0%)		15/50(30%)	415/1100(37.7%)		
7	A=a2, B=b2, C=c´7, D=d2	100/1000 (10.0%)	35/175(20%)		72/850(8.5%)	28.7/4.4	+
		400/1000 (40.0%)		7/25(30%)	428/1150(37.2%)		
8	A=a4, B=b2, C=c´1, D=d2	100/1000 (10.0%)	7/25(30%)		128/1150(11.1%)	32.7/3.9	−
		400/1000 (40.0%)		35/175(20%)	372/850(43.8%)		
9	A=a4, B=b2, C=c´2, D=d2	100/1000 (10.0%)	15/50(30%)		115/1100(10.5%)	32.3/4.1	+
		400/1000 (40.0%)		30/150(20%)	385/900(42.8%)		
10	A=a4, B=b2, C=c´3, D=d2	100/1000 (10.0%)	22/75(30%)		103/1050(9.8%)	32.1/4.3	++
		400/1000 (40.0%)		25/125(20%)	397/950(41.8%)		
11	A=a4, B=b2, C=c´4, D=d2	100/1000 (10.0%)	30/100(30%)		90/1000(9.0%)	32/4.6	+++
		400/1000 (40.0%)		20/100(20%)	410/1000(41.0%)		
12	A=a4, B=b2, C=c´5, D=d2	100/1000 (10.0%)	38/125(30%)		77/950(8.1%)	32.2/5.0	++++
		400/1000 (40.0%)		15/75(20%)	423/1050(40.3%)		
13	A=a4, B=b2, C=c´6, D=d2	100/1000 (10.0%)	45/150(30%)		65/900(7.2%)	32.3/5.5	+++++
		400/1000 (40.0%)		10/50(20%)	435/1100(39.5%)		
14	A=a4, B=b2, C=c´7, D=d2	100/1000 (10.0%)	53/175(30%)		52/850(6.1%)	32.9/6.4	++++++
		400/1000 (40.0%)		5/25(20%)	448/1150(39.0%)		

* A denotes difference in the level of health selection, B for scale of social mobility, C for ratio between two mobility, and D for difference in size of population between the higher and lower SEP.

† Two panels divided by dots line differ by the health selection level (a2 and a4). Numerous situations have been created by varying factor C. In each panel, the ratio between downward and upward mobility varies from c′1 to c′7.

‡Health inequalities are evaluated by defining absolute difference (AD) and relative difference (RD) between the two rates from the higher and the lower SEP. The reference values (e.g., pre-mobility inequalities) for these measures are 30 for absolute difference and 4.0 for relative difference.

Table A8-6 presents that changes in the relative difference between downward and upward mobility are associated with changes in post-mobility health inequality. The result suggests that the increase in the mobility ratio from 1:7 to 7:1 is connected with increase in health inequality. This trend can be seen by relative difference, although this trend is not noted by absolute difference. In the first set of manipulation (model 1-7), the decrease in health inequality is generally maintained throughout almost all models. However, as the mobility ratio rises from 1:7 (model 1) to 7:1 (model 7), the gradual increase in health inequality is accelerated. At last, the last model (model 7) shows the reversal of health inequality from decrease to increase. This suggests that the increase of health inequality created by the relative difference between two mobile groups seems to offset the decrease created by the level of health selection ($r_D<r_U$).

In model 8-14, the same trend as that above is observed. It seems to be obvious that increase in mobility ratio leads to increase in health inequality. The result also shows the possibility that the effect produced by the relative difference of mobile groups may outweigh the effect produced by the level of health selection. In model 8, an increasing tendency in health inequality turns toward a decrease due to the relative difference in mobile groups.

Table A8-7 introduces the variation of relative difference between the size of populations in the higher and lower SEP. A total of 2000 population ranges from d′1 (1:7) to d′7 (7:1) at regular interval.

Table A8-7 Hypothetical simulation* to assess changes in population size within social mobility and resulting health inequalities based on two socioeconomic position

Model†	Situation	Pre-mobility health inequalities in year *t*-1	Social mobility: Downward exit	Social mobility: Upward entry	Post-mobility health inequalities in year t	AD/RD‡	Evaluation‡
1	A=a2, B=b2, C=c2, D=d′1	25/250(10.0%)	20/100(20%)		35/250(14.0%)	25.4/2.9	−−−
		700/1750 (40.0%)		30/100(30%)	690/1750(39.4%)		
2	A=a2, B=b2, C=c2, D=d′2	50/500 (10.0%)	20/100(20%)		60/500 (12.0%)	27.3/3.3	−−
		600/1500 (40.0%)		30/100(30%)	590/1500 (39.3%)		
3	A=a2, B=b2, C=c2, D=d′3	75/750 (10.0%)	20/100(20%)		85/750(11.3%)	27.9/3.5	−
		500/1250 (40.0%)		30/100(30%)	490/1250(39.2%)		
4	A=a2, B=b2, C=c2, D=d′4	100/1000 (10.0%)	20/100(20%)		110/1000(11.0%)	28.0/3.5	−
		400/1000 (40.0%)		30/100(30%)	390/1000(39.0%)		
5	A=a2, B=b2, C=c2, D=d′5	125/1250 (10.0%)	20/100(20%)		135/1250(10.8%)	27.9/3.6	−
		300/750 (40.0%)		30/100(30%)	290/750(38.7%)		
6	A=a2, B=b2, C=c2, D=d′6	150/1500 (10.0%)	20/100(20%)		160/1500 (10.7%)	27.3/3.6	−
		200/500 (40.0%)		30/100(30%)	190/500 (38.0%)		
7	A=a2, B=b2, C=c2, D=d′7	175/1750 (10.0%)	20/100(20%)		185/1750(10.6%)	25.4/3.4	−−
		100/250 (40.0%)		30/100(30%)	90/250(36.0%)		
8	A=a4, B=b2, C=c2, D=d′1	25/250(10.0%)	30/100(30%)		15/250(6.0%)	34.6/6.8	++++
		700/1750 (40.0%)		20/100(20%)	710/1750(40.6%)		
9	A=a4, B=b2, C=c2, D=d′2	50/500 (10.0%)	30/100(30%)		40/500 (8.0%)	32.7/5.1	+++
		600/1500 (40.0%)		20/100(20%)	610/1500 (40.7%)		
10	A=a4, B=b2, C=c2, D=d′3	75/750 (10.0%)	30/100(30%)		65/750(8.7%)	32.1/4.7	++
		500/1250 (40.0%)		20/100(20%)	510/1250(40.8%)		
11	A=a4, B=b2, C=c2, D=d′4	100/1000 (10.0%)	30/100(30%)		90/1000(9.0%)	32/4.6	+
		400/1000 (40.0%)		20/100(20%)	410/1000(41.0%)		
12	A=a4, B=b2, C=c2, D=d′5	125/1250 (10.0%)	30/100(30%)		115/1250(9.2%)	32.1/4.5	+
		300/750 (40.0%)		20/100(20%)	310/750(41.3%)		
13	A=a4, B=b2, C=c2, D=d′6	150/1500 (10.0%)	30/100(30%)		140/1500 (9.3%)	32.7/4.5	+
		200/500 (40.0%)		20/100(20%)	210/500 (42.0%)		
14	A=a4, B=b2, C=c2, D=d′7	175/1750 (10.0%)	30/100(30%)		165/1750(9.4%)	34.6/4.7	++
		100/250 (40.0%)		20/100(20%)	110/250(44.0%)		

* A denotes difference in the level of health selection, B for scale of social mobility, C for ratio between two mobility, and D for difference in size of population between the higher and lower SEP.

† Two panels divided by dots line differ by the health selection level (a2 and a4). Numerous situations have been created by varying factor D. In each panel, the population ratio varies from d′1 to d′7.

‡ Health inequalities are evaluated by defining absolute difference (AD) and relative difference (RD) between the two rates from the higher and the lower SEP. The reference values (e.g., pre-mobility inequalities) for these measures are 30 for absolute difference and 4.0 for relative difference.

Table A8-7 displays the changes in health inequality in relation to the relative difference between higher and lower SEP. The changes in post-mobility health inequality assessed by absolute and relative difference vary depending on the population ratio. In the upper panel, the decrease in health inequality is pronounced, when the difference of population is large. Both ends of variation (d′1 and d′7) show more substantial decrease compared to the situation when population is similar in their size (d′3, d′4, and d′7). In the lower panel, the reverse tendency is found and a gradual increase in health inequality takes place towards both ends.

The overall pattern suggests that there is an association between the population ratio and changes in health inequality. It appears that if the difference in population size is large, this further reinforces the increase and decrease in health inequality. This tendency is more apparent with absolute difference than relative difference.