Morbidity and mortality in England, 1850-1950: testing the insult accumulation and constant 'frailty' hypotheses

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This paper examines the relationship between the amount and frequency of illness experienced by men and their subsequent longevity, using individual-level data from a sample of over 5,000 Englishmen living (mainly) between 1850 and 1950. In a well-known thesis, James Riley (1989; 1997) has argued that during this period age-specific morbidity rates increased as mortality declined. Alter and Riley (1989) examined two theoretical models of the relationship between morbidity and mortality: a constant 'frailty' model which predicted that sickness rates were likely to rise as mortality fell because an increasing number of 'frail' individuals were surviving the effects of infectious disease; and an *insult accumulation* model which theorised that survival from successive bouts of disease (or 'insults') left permanent marks on a person's health which gradually accumulated and rendered him or her less robust in later life, and thus more susceptible to further disease or death.

If it is true that the effect of morbidity on the body's ability to recover from disease is cumulative, then we might expect some relationship between a person's sickness history and his or her age at death. The effect of previous sickness on subsequent mortality has been examined empirically in a small number of studies, with inconsistent results. For example Costa (1993), using data relating to more than 300 Union Army veterans of the American Civil War, showed that men who had been discharged from the army for a reason other than being wounded had generally higher mortality at ages over 55 years than other men. On the other hand, both Lee (2003) and Scott Smith (2003), also using Union Army records, demonstrated that recruits originating from healthier environments**,** who might be expected to have been less intensely exposed to disease**,** were *more* likely to die from disease during their military service than those from less healthy places, results which contradict the insult accumulation hypothesis – at least in respect of the impact of insults on mortality. Murray (1997) analysed the effect of height at age 20 years (a proxy for living conditions in early life) among Amherst College students between 1834 and 1949 and their mortality, and could find no relationship.

All these studies used indirect measures of sickness experience. In this paper, we measure previous sickness in a more direct way by using individual sickness histories derived from records of past claims for sick pay. These records come from the Hampshire Friendly Society (HFS), which insured working men in a rural area of southern England against sickness during the nineteenth and twentieth centuries. The paper will build on an earlier study (Gorsky *et al*. 2006) using a small sample of just over 200 records from the HFS, which found that men who had made frequent claims for sick pay when they were aged under 50 years had higher mortality at ages over 50 years. Specifically, each separate year in which a man made a claim for sick pay when he was aged under 50 years increased his risk of dying at ages over 50 years by about five per cent. We suggested that this might have occurred either because of insult accumulation (people who are weakened by successive bouts of illness are more likely to die at younger ages) or differential 'frailty' ('frail' individuals are more likely both to fall ill and to die at younger ages than the rest of the population) (Vaupel *et al.* 1979), or a combination of both effects. However, the size of the sample meant that we were unable to distinguish empirically between these hypotheses.

In this paper we investigate the relationship between morbidity and mortality in much more detail using a much larger sample. We have collected sickness history data for 5,552 men who joined the Hampshire Friendly Society between 1825 and 1939, and whose dates of leaving the HFS range from 1855 to 1990. Of these men, we have dates of death for 1,667; for the remaining 3,885, we can ascertain a latest date at which they were known to be alive, and so we can treat their deaths as being right-censored and apply conventional survival analysis methods.

We begin by testing the insult accumulation hypothesis by taking a sub-sample of 1,608 men who were members of the HFS at age 50 years and estimating a survival model of duration until death including measures of the frequency of sickness claims at ages before 50 years on the right-hand side. We then examine the constant 'frailty' hypothesis by estimating a second model with the same data which does not include the sickness history variable but, instead, includes a random effect to capture constant 'frailty'. Third, we look at the relative influence of both sickness history and constant 'frailty' effects by estimating a third model which encompasses the first two.

The HFS data also include information about the locality from which a man came (in the form of the place where he was living when he joined the HFS). By linking this information to data on local mortality available from death registration data during the period 1851-1900 (Woods 1997), we can create a measure of the 'healthiness' of the places from which each man came and hence attempt to see if Scott Smith's (2003) results based on Union Army records carry across to southern England.

The analysis described so far has a certain conceptual simplicity. However it is restricted by the decision to condition on a man being a member of the HFS at age 50 years, a condition which limits the analysis to less than one third of the total number of men in our sample. In order to avoid this restriction we next analyse the data for all our records using a multistate competing risks model (Steele *et al,* 2004) in which falling sick and recovering from sickness are considered as simultaneous processes and both modelled as functions of the previous sickness experience of each man and a set of

covariates. Dying is modelled as a competing risk to both falling sick and recovering. The model comprises equations for the hazard of falling sick, for the hazard of recovery and for the hazard of dying. Each equation includes a man-specific random effect or residual which represents unobserved characteristics of the man. By allowing these residuals to be correlated across the processes of falling sick, recovery and dying we hope to be able to provide another assessment of the potential impact of constant 'frailty' – an unobserved characteristic which affects the hazards of falling sick and recovering and the risk of dying. Moreover, by modelling the risks of falling sick, recovering and dying as a function of previous sickness experience, we provide a more comprehensive test of the insult accumulation hypothesis.

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