Intelligence, health and death

WHETHER you live to collect your old-age pension depends in part on your IQ at age 11. You just can't keep a good predictor down.

Scores on psychometric intelligence tests (IQ for short) are unrivalled as predictors of job performance (Schmidt & Hunter, 1998). IQ is the strongest predictor of educational performance (Ones *et al*., 2005). That does not mean that intelligence differences account for all, or even the majority, of the variance in these life outcomes. It means that, among the predictors we know and use, intelligence tests do better than anything else.

But, apart from within older age groups (e.g. Korten *et al*., 1999) we've tended not to think so much about IQ as contributing to the prediction of death and disease. Health psychology and epidemiology have preferred personality traits as correlates of illness outcomes. For example, traits like hostility and the Type A behaviour pattern feature as health-related independent variables more prominently than do cognitive differences (e.g. Smith & Ruiz, 2002). In health studies, cognitive test scores were more likely to be outcome variables than antecedents, whether those studies involve birth weight or heart surgery. Here, I shall describe how childhood IQ scores are becoming established as associates of longevity.

Childhood IQ and mortality – Finding the association

Our own first finding of an association between IQ and death used data from the Scottish Mental Survey of 1932 (SMS1932: Scottish Council for Research in Education, 1933). The survey took place on Wednesday 1 June, with almost everyone born in 1921 tested. Its purposes were to record the distribution of mental ability in the nation, to understand the numbers of people with 'mental deficiency', and to help in the planning

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of educational provision. In total, 87,498 schoolchildren sat a version of the Moray House Test No.12, one of Godfrey Thomson's tests that were being used for primary to secondary school selection in England. The majority of the questions are verbal reasoning, but there are some numerical, spatial and other items too. Teachers read the instructions and did the scoring of the tests.

The Scottish Council for Research in Education (SCRE) published a report and then securely and confidentially retained the data. In 1997 my close colleague Lawrence Whalley (Professor of Mental Health at the University of Aberdeen) and I discovered that these data still existed. If we could trace and re-test some of these people, we thought, we could study cognitive changes between age 11 and old age: probably a unique set of data.

As part of the tracing process we obtained permission to use Scotland's Community Health Index – the database that lists Scottish residents and the GP with whom they are registered. One day, when Professor Whalley and I met to plan this research, we realised that because this showed whether these people were alive or dead, we could find out if IQ at age 11 is related to being alive at age 77.

We had aimed to study cognitive ageing, but this was epidemiology: cognitive differences as antecedents rather than outcomes. There were already published associations between cognitive test scores and survival in older adults (e.g. Korten *et al*., 1999). Education and socio-economic position – for example, based on a person's job, or even on their father's – are related to mortality and morbidity (for more up-to-date references than we had at the time, see Davey Smith *et al.*, 1998; Galobardes *et al*., 2004). And both are related strongly to IQ (Neisser *et al.*, 1996). So why had no one mentioned early life IQ as a possible correlate of mortality?

We decided to try to find out whether the 2792 children who took the SMS1932 test in Aberdeen were alive or dead on 1 January 1997. We chose Aberdeen because it was manageable in size, we had a research base there, and because it had a relatively low migration rate. Finding people on the Community Health Index was quick and easy. We found the vital status of about half the sample (recall that the only available data were a name and date of birth), but analyses between IQ and survival on half of the population might contain biases – we were concerned that the people we found might be different in some important way to those we couldn't find.

So we started hand searches of the death records in Scotland from 1932 onwards. Tracing the girls was a special problem. Registrations of death and details on the Community Health Index would often be married names. So, for untraced women, we had to begin searches of marriage records from 1937 (when they would be 16 years of age) onwards. When we found a marriage we would then search the death records from that date to try to trace the woman. Some people leave Scotland, so we conducted computerised and hand searches for people living in England and Wales using the NHS Central Register.

By the year 2000 we had traced 79.9 per cent (2230) of the Aberdeen children who took part in the SMS1932. It would be harder to argue then that the untraced 20.1 per cent might seriously bias the results.

There was a sizeable association between IQ at age 11 and survival to age 76 (Whalley & Deary, 2001). Women with a standard deviation (15 point) disadvantage in IQ relative to others at age 11 were only 71 per cent as likely to live to age 76. For men, the figure was 83 per cent. The reason for the smaller effect in men seemed to be the high mean IQ scores of men who died in active service in World

War II, thus temporarily reversing the 'lower-IQ-more-likely-to-die' association.

Replicating the association

We were not the first to report the childhood/youth cognitive ability–death association. A report based on data collected across boroughs of New York in the 1930s found lower death rates in neighbourhoods with higher mean IQ scores (Maller, 1933). Much later, studies looked at individual differences in IQ. There were reports of an association between cognitive ability test scores and mortality in a study of Australian Vietnam veterans (O'Toole *et al.*, 1988; O'Toole & Stankov, 1992), though they were still quite young when their vital status was assessed and they were all men. The famous Nun Study had reported an association between 'idea density' of hand-written biographies (a surrogate for cognitive ability) at about age 22 and death during a surveillance period between 1991 and 1998 (Snowdon *et al.*, 1999). Of course, the nuns were all women and the follow-up was just a limited epoch. And there was an obscure Swedish report of the impressive Malmo study, which examined people born between 1925 to 1929 and found, after 41 years of follow-up, that scores on the Hallgren test were inversely associated with mortality (Furu *et al.*, 1985). This was the earliest publication we know of in the field at the level of the individual.

We tried, using the SMS1932 data again, to replicate the association in another area of Scotland. We knew about the famous Midspan studies of health in the West of Scotland carried out by clinical epidemiologists at Glasgow University, the first of their kind in the UK. They had conducted medical interviews and examinations on thousands of people in the 1970s and had followed their medical progress via linkages to health databases in Scotland. Having this Scandinavian-like system of routinely collected data is unusual for UK. The age distribution of the Midspan participants made it clear that some were born in 1921 and participated in the SMS1932.

We combined with the Midspan investigators to form a joint research team. We found 938 people from the SMS1932 who later took part in the Midspan studies (Hart, Deary *et al.*, 2003). There were data on who was alive and who had died in the 25 years since the Midspan medical tests in the 1970s. We found that the risk of dying

in these 25 years was 17 per cent higher for each standard deviation disadvantage in IQ at age 11 (Hart, Taylor *et al.*, 2003). IQ and death were associated in the West of Scotland as well as Aberdeen, and the effect sizes were similar.

Since our original report the Aberdeen Children of the 1950s Study (Batty *et al.*, 2002) and the Danish Metropolit Study (Osler *et al.*, 2003) both found inverse associations between childhood IQ and mortality. The 1946 British Birth Cohort Study found a similar effect in men but not in women, though they had few female deaths (Kuh *et al.*, 2004). And we have found similar findings in analyses of people who took part in the later Scottish Mental Survey of 1947 (Deary *et al.*, 2004).

In summary, there are replications of the association between mortality and cognitive ability in childhood or young adulthood in Australia, Denmark, Great Britain, Scotland (thrice), Sweden, and the US. The samples cover birth years from the 1920s to the 1950s. These reports pretty

well establish it as a new finding, and the new field has been called cognitive epidemiology. The strength of the IQ–mortality association is similar to that for traditional physiological risk factors measured in early adulthood, such as obesity, high blood pressure and smoking.

Extending the association

The above-mentioned results refer to the association between childhood cognition and mortality by any cause. Some studies have examined associations between IQ and specific causes of death and disease.

In analyses of the SMS1932 in Aberdeen there were lower IQs at age 11 for people who died of lung and stomach cancer, although the number of people with these malignancies was low (Deary *et al.*, 2003). Lung cancer was associated with lower IQ at age 11 in the study that linked the SMS1932 and the Midspan databases

(Hart, Taylor *et al*, 2003). In the SMS1932 and the Danish Metropolit studies, lower IQ at age 11 is associated with mortality from, or hospital admission for, all cardiovascular disease and coronary heart disease, especially when disease occurs before age 65 (Hart *et al.*, 2004; Batty, Mortensen, Nybo *et al.*, in press).

Our studies of the SMS1932 and psychiatric outcomes showed an association between childhood IQ and late-onset but not early-onset dementia (Whalley *et al.*, 2000). Lower childhood IQ was also associated with greater risk of contact with psychiatric services in our Scottish study (Walker *et al.*, 2002), and of psychiatric disorder in Denmark (Batty, Mortensen & Osler, in press).

Some disease risk factors are related to IQ at age 11, such as high blood pressure in middle age (Starr *et al.*, 2004). People from the SMS1932-Midspan study who had lower childhood IQs were the least likely to give up smoking after the health risks became known (Taylor *et al.*, 2003).

Possible mechanisms

So we've established an association, but how do we understand it? Here are some possible and non-exclusive mechanisms.

Socio-economic position as a mediator Childhood IQ might be associated with survival because people with higher IQs obtain more education and then tend to enter more professional occupations. These occupations might offer safer environments and other, wider privileges that are linked to better health. It is well known that health outcomes are patterned according to education, social class and income. Indeed, I have put this possibility first because many people's first response to hearing about the childhood IQ–mortality association is to respond that it might all be caused by differences in socio-economic position.

To date we have found that adjusting for adult socio-economic position provides some attenuation, but still leaves a substantial effect of childhood IQ on mortality. And it's a moot point what this partial attenuation tells us. On the one hand, it might indicate that we can seek a proportion of the cause of IQ effects on mortality in socio-economic position as a mediating effect. On the other hand, because socio-economic position is correlated with IQ, adjusting for it might just be removing some truly cognitive

variance. The key will be to find and test some specific effects of socio-economic position *per se*, as have been suggested by Professor Sir Michael Marmot (2004) in his 'status syndrome' thesis, and in his notion that some socially patterned health inequalities are caused by 'exposure to adverse psychosocial environments during midlife and particularly at work' (Siegrist & Marmot, 2004). Briefly, Marmot suggests that one's position in a social hierarchy is associated with health via (among other psychosocial variables) the mediating construct of 'control', and that differences in control affect physiology.

Health behaviours and knowledge as mediators Occupation-based social class and deprivation indices like the Carstairs-Morris are group-based variables through which childhood IQ might act. But there are also some individual differences variables that might act as mediators of childhood IQ. Thus, childhood IQ might be associated with mortality because it is associated with individual differences in health knowledge and health behaviours, such as smoking, alcohol intake, diet, exercise, accident prevention, taking part in screening programmes, detecting and understanding the early signs of illness, and correctly adhering to medication regimens. There are probably many more factors that we might list and test.

The general theme of this set of possibilities is that managing health might be construed as a continuous cognitive task and that it is possible that intelligence differences might affect how well it is managed. The Australian veterans study showed that people with lower cognitive ability were more likely to die in motor vehicle accidents (O'Toole & Stankov, 1992). The authors thought this association might be explained by poorer risk perception in the lower-scoring IQ groups.

One of our empirical findings is also relevant here. We found that, among people born in 1921, there was no association between childhood IQ and taking up smoking (Taylor *et al.*, 2003). However, this cohort's members almost all began smoking at a time when the health dangers were not known. We found that IQ was related to their stopping smoking over the period (up to the mid-1970s) when health warnings about smoking were increasingly publicised. More studies are needed that examine health behaviours and knowledge as mediators of the IQ–mortality association. A proponent of the 'health management' explanation is Professor Linda Gottfredson (2004), who goes as far as to suggest that the social patterning of health outcomes, including mortality, might mostly be caused by cognitive differences.

The Marmot (group differences, 'control'-based) and Gottfredson (individual differences, 'cognitive'-based) accounts both have merit, are not mutually exclusive, and we are currently testing aspects of them empirically. To date, the best response to both of these suggestions is to remember that, as far as we know, far from all of the IQ effect on mortality is accounted for by socio-economic position, and IQ does not account for all of the effect of social class on mortality. These findings urge plural rather than singular hypotheses regarding causes.

IQ as a mediator of developmental events The two previous sections conceptualise IQ as capturing variance associated with mortality, but the differences in IQ are mediated by some other, more directly relevant constructs. Here, the notion is that childhood IQ is an indicator or record of prior development, both from environmental and genetic influences. Especially, IQ might be an indicator of any problems in development which might be related to later health.

One example involves the hypothesis of the 'fetal origins of adult disease', sometimes called the 'fetal programming' or Barker (2004) hypothesis. This hypothesis suggests that events during intra-uterine development have an influence on adult diseases, such as hypertension, diabetes, cardiovascular disease and stroke. Birth weight is often used as an indicator of these developmental events. It is known that birth weight is associated with cognitive ability in childhood and with later disease. Even in the normal range of birth weights, lighter babies tend to have lower childhood IQs, though the effect is small (Shenkin *et al.*, 2004). In this view, then, IQ might be a mediator of earlier causes of health differences. In addition to birth weight, one could hypothesise that other intra-uterine, perinatal and early childhood influences might affect later health and survival and, along the way (we might say 'incidentally') influence childhood IQ scores.

IQ as an indicator of system integrity
In this view, the relation between IQ and mortality might hold because IQ acts as one of a number of indices of the body's efficiency or 'system integrity'. Thus, if IQ is an indicator of the brain's information-processing efficiency, it might be related to the efficiency of other aspects of the body, which are, in turn, associated with health and longevity. This possibility is not necessarily very different from the previous paragraph, but it has less focus on early development. Instead, it would state that IQ at any age might be an indicator of the body's general health. Certainly, in old age, this is now well established. The 'common cause' hypothesis of cognitive ageing recognises that cognitive function is related to bodily measures such as grip strength, sensory function, balance and lung function (e.g. Christensen *et al.*, 2001). Also, there is a precedent for suggesting that both health and cognitive ability are related to some aspect of bodily integrity, because fluctuating asymmetry is associated with IQ in young adults and might be a marker of 'fitness' (Furlow *et al.*, 1997).

Getting the critics on board
To reduce inequalities in health we first need to understand their associations, and then to explore the causes of these associations. To date, education and social class have been the social correlates given

most attention. In the past few years a venerable psychological variable (mental ability, the measurement of which is 100 years old this year) has been added. It is now becoming well established that childhood IQ is associated with mortality up to many decades later. Research from now on should examine various aspects of the association. The ages at which this effect is most pronounced are not fully understood. The specific causes of death that are most closely related to childhood IQ have only had occasional study. The possible mediators, confounders of the effect, and the health-related antecedents that also influence IQ, need further examination.

No one who conducts much research using IQ-type tests can be unaware of the feelings and opinions they evoke, and they should be aware of their history. Finding an association between IQ and mortality is bound to attract wide interest. Presenting IQ scores as health- and death-relevant predictor variables to epidemiologists, the majority of whom seem initially to have a bent toward social-environmental causes of the associations, has been an interesting experience; rather like parading a clever but noisily disobedient and mucky child before staid and suspicious relatives. But this is too important a finding to allow it to get lost in unhelpful controversy. Our own solution to developing an understanding of the IQ–mortality association was to include sceptical critics as collaborators. When the epidemiologist Professor George Davey Smith provided detailed and helpful criticism as a signed referee of our first report (Whalley & Deary, 2001), we involved him thereafter as a co-investigator and author (Hart, Deary *et al.*, 2003; Hart, Taylor *et al.*, 2003; Hart *et al.*, 2004; Starr, 2004; Taylor, 2003). Some of these reports dealt especially with the possibility that variables related to socio-economic position might account for the IQ–mortality association. Another sceptical epidemiologist, Dr David Batty, is now a member of our research team (Batty & Deary, 2004). On the other hand, I have also worked with Linda Gottfredson, whose ideas are valenced towards cognitive differences being the variable that accounts for socio-economic position associations with health (Gottfredson & Deary, 2004). My personal view is that most progress will be made in a situation where all hypotheses are considered and tested using a heterogeneous research team with a range of backgrounds and views about causes.

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