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Review Paper

After 50 years and 200 papers, what can the Midspan cohort studies tell us about our mortality?

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ABSTRACT

Objective: To distil the main findings from published papers on mortality in three cohorts involving over 27,000 adults, recruited in Scotland between 1965 and 1976 and followed up ever since.

Method: We read and summarized 48 peer-reviewed papers about all-cause and cause-specific mortality in these cohorts, published between 1978 and 2013.

Results: Mortality rates were substantially higher among cigarette smokers in all social classes and both genders. Exposure to second-hand smoke was also damaging. Exposure to higher levels of black smoke pollution was associated with higher mortality. After smoking, diminished lung function was the risk factor most strongly related to higher mortality, even among never-smokers. On average, female mortality rates were much lower than male but the same risk factors were predictors of mortality.

Mortality rates were highest among men whose paternal, own first and most recent jobs were manual. Specific causes of death were associated with different life stages. Upward and downward social mobility conferred intermediate mortality rates. Low childhood cognitive ability was strongly associated with low social class in adulthood and higher mortality before age 65 years. There was no evidence that daily stress contributed to higher mortality among people in lower social positions.

Men in manual occupations with fathers in manual occupations, who smoked and drank >14 units of alcohol a week had cardiovascular disease mortality rates 4.5 times higher than non-manual men with non-manual fathers, who neither smoked nor drank >14 units. Men who were obese and drank >14 units of alcohol per day had a mortality rate due to liver disease 19 times that of normal or underweight non-drinkers. Among women who never smoked, mortality rates were highest in severely obese women in the lowest occupational classes.

Conclusion: These studies highlight the cumulative effect of adverse exposures throughout life, the complex interplay between social circumstances, culture and individual capabilities, and the damaging effects of smoking, air pollution, alcohol and obesity.

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Some key findings from the studies.

1989 Never-smokers had higher mortality rates from lung cancer and cardiovascular disease if they lived with a smoker.
1996 Lung function was inversely associated with all-cause mortality risk in both smokers and never-smokers.
1998 There was a cumulative effect on mortality from factors associated with social position throughout life.
2003 Lower cognitive ability scores in childhood predicted lower social position in adulthood and higher mortality rates.
2006 When smoking and pre-existing disease were adjusted for, being overweight was associated with important increases in all-cause and cardiovascular disease mortality.
2009 Smoking itself was a greater source of health inequality than social position and nullified women's survival advantage over men.
2010 Compared with normal or underweight non-drinkers, men drinking more than 14 units of alcohol a week were three times more likely to die from liver disease if their weight was normal but 19 times if they were obese.
2011 Women who had never smoked and were not obese had the lowest mortality rates, regardless of their social position.

Introduction

Between 1965 and 1976, the medical epidemiologist Victor Hawthorne (1921–2014) and his colleagues recruited three cohorts of mainly middle-aged people living in west and central Scotland: the Main & Tiree Study (1965–68), the Collaborative Study (1970–73) and the Renfrew & Paisley Study (1972–76). A fourth cohort was established in 1996 with offspring of married couples in the Renfrew & Paisley Study. Collectively, they are known as the Midspan studies.

Whilst the first two cohorts were mainly men recruited from workplaces, the Renfrew & Paisley cohort included about 78% of all the 45–64 year olds in an area with high levels of socio-economic deprivation. It was also the first in the United Kingdom to include large numbers of middle-aged women.

The initial aim of the Midspan studies was to improve understanding of cardiorespiratory risks and diseases in the population. By linking data from the participants with details of their subsequent deaths, hospitalisations, cancer registrations and other datasets, they have provided a unique source of information about the health of people living in this part of Scotland. By combining and comparing data from these and other cohorts such as the Whitehall study, further useful findings have been generated.

Since 1965, results from the Midspan studies have been published in around 200 papers in 78 biomedical journals. A full listing is provided on the Midspan website at: www.gla.ac.uk/midspan. With so many publications, scattered over time and journal space, it is difficult to form a coherent picture of what has been learnt. The present paper distils the findings from 48 papers that focused on all-cause and cause-specific mortality in the first three cohorts. Our aim is to highlight what they have revealed about patterns of mortality and the possible underlying causes and contributors and to consider their relevance for improving health and reducing health inequalities.

Methods

The cohorts

A summary of the cohorts is given in Table 1. More details are available on the Midspan website and in an earlier paper.[1] Most of the studies reviewed here used data from the Collaborative and Renfrew & Paisley studies.

Information at recruitment

At recruitment, participants completed a questionnaire, underwent various measurements and tests and gave a blood sample. Full details are provided on the Midspan website. Around half the participants were rescreened after one to seven years but these data have been little used in the publications we reviewed.

Table 1 – The Midspan cohorts.

Cohort	Recruited	Sampling frame	Location	Number	Age (y)
Main	1965–67	13 Factories	Central Scotland	3930 3411 m 519 f	15–70
Tiree	1967–68	General population	Isle of Tiree & Glasgow	762 336 m 426 f	14–92
Collaborative	1970–73	27 Workplaces	Glasgow Clydebank Grangemouth	7028 6022 m 1006 f	21–75
Renfrew and Paisley	1972–76	General population (78% response)	To the west of Glasgow	15,402 7049 m 8353 f	45–64

Linkage to other datasets

Linkage to the National Health Service (NHS) Central Register provided information on dates and causes of any participant's death occurring in the United Kingdom. Data on general hospital discharges, mental health hospital discharges and cancers were obtained through linkage with the Scottish Morbidity Records data held by the Information Services Division, Scotland.

On 1st June 1932, almost all children in Scotland born in 1921 and attending school completed a validated cognitive ability test, the Moray House Test. Scotland is the only country in the world to have undertaken such a survey. In the Collaborative and Renfrew & Paisley cohorts, 1251 participants were born in 1921 and 938 (75%) were matched to their test score. Full details of the test and matching procedures have been reported elsewhere.[2]

Daily black smoke measurements at 181 monitoring sites were obtained from the UK National Air Quality Archive. Short- and long-term exposure concentrations between 1970 and 1979 were estimated for 15,331 Renfrew & Paisley participants and 3818 Collaborative participants using their residential postcodes.

Statistical methods

Full details of the statistical methods used have been published in the papers themselves.

Selecting and reviewing the papers

All the papers focussing on the mortality of participants of the three original Midspan cohorts were identified from the publication list on the Midspan website. Forty-eight relevant papers were published during a 35 -year period from 1978 to 2013. They were read in full by LG and the accuracy of the summarized data verified by CH. The papers were sorted chronologically and thematically, finally being grouped under the following themes (number of papers in brackets): smoking (9); other cardiorespiratory risk factors (10); air pollution (2); social position (9); cognitive ability (5); stress and sleep (5); interactions between alcohol, smoking and obesity (8). All authors agreed on the findings from each paper used in the review and their interpretation.

Results

Smoking

Three of the earliest papers focused on smoking. The mortality rate of current smokers across all three cohorts was twice that of never-smokers, with no differences between the rates of smokers of plain and filter cigarettes.[3] Compared to UK male doctors and two American cohorts, smokers in the West of Scotland had much higher absolute lung cancer mortality rates at all levels of cigarette consumption but the difference in relative risks compared to never-smokers was somewhat less in the West of Scotland than in the other two cohorts.[4] This suggested some additional factor in the West of Scotland was raising lung cancer rates among both smokers and never-smokers.

Hole and colleagues showed that, compared with never-smokers living with another never-smoker, never-smokers living with a smoker had higher age- and sex-adjusted mortality rates from lung cancer and cardiovascular disease.[5] This was one of the clearest demonstrations to date that 'exposure to other people's tobacco smoke cannot be regarded as a safe involuntary practice'.

In the Collaborative and Renfrew & Paisley cohorts, lung cancer mortality rates were at least ten times higher among both male and female smokers than never-smokers.[6] Higher rates among never-smokers were related to poorer lung function and lower social class, with higher exposure to second-hand smoke and environmental air pollution, and poor socio-economic conditions throughout life being possible explanations. In comparisons between smokers and never-smokers, mortality rate ratios were similar for non-manual and manual social classes[7] and for men and women,[8] suggesting that neither social class nor gender had much influence on the adverse effects of smoking. There was a dose response relationship between blood carboxyhaemoglobin concentration (a measure of smoking intensity) and mortality due to all causes, stroke, coronary heart disease, chronic obstructive pulmonary disease and lung cancer, even after adjusting for self-reported smoking.[9] This suggested that carboxyhaemoglobin levels capture more of the risk of smoking than does self-reported smoking alone.

The effects of smoking in relation to social class and gender were further explored through the Renfrew & Paisley cohort after 28 years of follow-up.[10] The cohort was divided into 24 groups based on gender, smoking status at recruitment (never, current or former) and four social class groups. Among both women and men, never-smokers had much better survival rates than smokers in all social positions (Fig. 1). Female never-smokers had the best survival rates, with 56% of those in the lowest social class surviving after 28 years compared to 41% and 24% respectively of female and male smokers in the highest social class. The difference in survival rates between smokers of different social classes was small. Smoking itself was thus a greater source of health inequality than social position in this cohort and cancelled out women's otherwise large survival advantage over men.

Whilst quitting smoking resulted in lower long-term mortality rates, there was little evidence of benefit from reducing the number of cigarettes smoked.[11]

Other cardiorespiratory risk factors among men and women

Between 1989 and 1996, associations between various cardiorespiratory risk factors and all-cause and cause-specific mortality were studied. After cigarette smoking, FEV1 was the risk factor most strongly related to mortality rates among both men and women in the Renfrew & Paisley study.[12] Among never-smokers, there was a statistically significant trend between lower FEV1 and higher mortality rates due to all causes, ischaemic heart disease, respiratory diseases and other causes apart from cancer.

Death rates from coronary heart disease were found to be much higher among men than women at every age and every

Fig. 1 – Age-adjusted survival over 28 years of follow-up of women and men aged 45–64 years and who never smoked or currently smoked at recruitment in social classes I + II and IV + V.[10] Reproduced from the BMJ with permission.

level of smoking, blood pressure, plasma cholesterol, body mass index and social class.[13] After 10–14 years of follow-up, age-adjusted all-cause mortality rates were twice as high among men than women.[14] Sex-specific multiple logistic regression analysis showed that higher blood pressure was predictive of higher all-cause mortality rates among both men and women. Higher mortality due to coronary heart disease was significantly related to higher cholesterol levels among both men and women but to higher blood glucose only among women. The gender difference in cardiovascular mortality was maintained or even increased after adjustment for smoking and other cardiovascular disease risk factors, indicating that much of it was due to unmeasured factors.

Analysis of the Renfrew & Paisley data showed for the first time that evidence of heart disease at the time of recruitment was as good a predictor of subsequent death from heart disease among women as among men.[15] Unlike coronary heart disease, mortality rates due to stroke were similar among men and women as were the significant relationships between mortality after 20 years of follow-up and the following risk factors recorded at recruitment: respiratory function, height, blood pressure, smoking, pre-existing coronary heart disease and diabetes, and cardio-thoracic ratio. Blood cholesterol levels and body mass index were not related to stroke mortality in either sex.[16,17]

There were similar gradients in all-cause death rates for men and women related to height and social class.[18] The inverse relationship between height and mortality among men and women appeared largely related to the larger lung capacity of taller people.[19] However, while shorter people had higher mortality due to coronary heart disease, stroke, respiratory disease and stomach cancer, there was no relationship between height and smoking-related cancer and breast cancer; taller people had higher mortality due to prostate cancer, colorectal cancer and lymphoma. In a study of almost 1000 women in employment when recruited, a composite measure of lifetime socio-economic experience was a more powerful predictor of all-cause and cardiovascular disease mortality among women than any single measure, as had previously been shown in men.[20]

In an analysis comparing the Whitehall (London) cohort of male civil servants with men in the Collaborative and Renfrew & Paisley cohorts and a small cohort in Michigan, USA, breathlessness was consistently associated with significantly higher mortality from cardiovascular disease.[21] Chronic bronchitis and low FEV1 were associated with higher cardiovascular mortality in some but not all the cohorts.

Air pollution

In a nested case–control study, members of the Renfrew & Paisley and Collaborative cohorts who had died during the periods 1971–79, 1980–89 and 1990–99 were compared with up to nine controls of similar age from the same cohort who had not died. Air pollution levels in the participants' neighbourhoods in the periods 0–3, 0–6 and 0–30 days before the case's death were compared with levels during the same intervals before their controls reached the same age as the case had been when he or she had died. After adjusting for a range of potentially confounding factors, higher pollution levels were associated with significantly higher short-term mortality rates among the cases in the Renfrew & Paisley cohort particularly with the longest exposure interval. Exposure–mortality associations were generally smaller and non-significant in the Collaborative cohort, possibly due to the much smaller number and wider geographical distribution of the participants.[22]

A more detailed analysis of cause-specific mortality used three different models for estimating long-term exposure to air pollution.[23] Using the most detailed model, exposure to higher levels of air pollution was associated with significantly higher long-term mortality rates due to respiratory and

cardiovascular disease in the Renfrew & Paisley cohort, all of whom lived in a relatively small geographical area. These results suggest that air pollution can have a long-term adverse effect on health.

Social position and social mobility across the life-course

A series of papers from the Collaborative cohort were among the first to examine the relationship between mortality rates and indicators of socio-economic circumstances at different points in participants' lives. After adjusting for age and a range of other risk factors, there was a gradient of increasing mortality from men whose father's, first and current jobs were all non-manual to those whose father's, first and current jobs were all manual.[24] Each measure made an independent contribution to overall mortality rates. Having a father with a manual job was associated with higher rates of cardiovascular disease but not other causes, whereas a manual job at recruitment was more strongly associated with cancer and non-cardiovascular and non-cancer causes of death. Living in a more disadvantaged area[25] and not owning a car were associated with yet further increases in mortality rates.[24] Social class at the time of recruitment to the study was associated with a greater relative index of inequality than social class earlier in life, suggesting a cumulative effect on mortality from factors associated with social position throughout life.[26]

Adverse socio-economic circumstances in childhood had a specific influence on mortality from stroke and stomach cancer in adulthood.[27,28] Having a father with a manual occupation[27] and a larger number of siblings[29] were both strongly associated with stomach cancer, possibly due to higher risk of childhood infection with *Helicobacter pylori* in crowded households. Disadvantage in childhood also appeared to increase the risk of mortality from coronary heart disease and respiratory disease in adulthood. Mortality from lung cancer, other cancers, and accidents and violence was predominantly influenced by risk factors relating to behaviour and social circumstances in adulthood.[27]

The effect of social mobility on men was examined.[30] For social mobility between childhood and adulthood, mortality was highest for the stable manual group and lowest for the stable non-manual group, with upwardly and downwardly mobile men experiencing intermediate rates.

Both educational attainment and social class were associated with mortality in middle-aged men but social class was more strongly associated with non-cardiovascular non-cancer causes of death and education with cardiovascular causes.[31] Social class was more strongly associated with smoking than was education.

When compared with the Whitehall occupational cohort, the higher all-cause mortality rates among men in the Collaborative and Renfrew & Paisley cohorts were largely explained by differences in social class, the number of cigarettes smoked, lung function and pre-existing self-reported health problems.[32] However, the substantial excess mortality in the Midspan cohorts from stroke, alcohol-related causes, accidents and suicide remained unexplained by social class or the baseline risk factors.

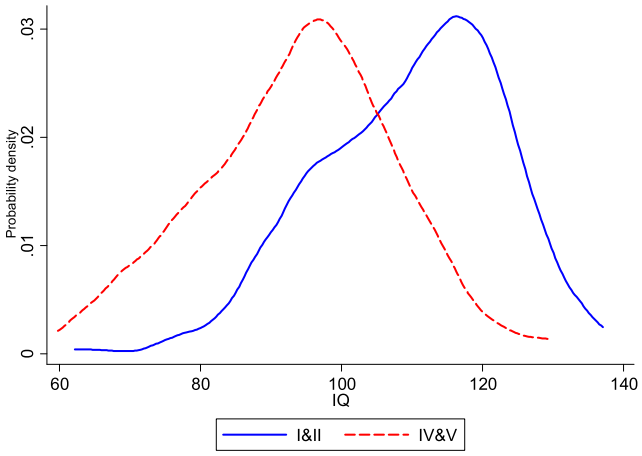

Fig. 2 – Distribution of mental ability scores (IQ) in social classes I & II and IV & V for Midspan participants born in 1921 (data from Hart et al. 2003[2]).

Cognitive ability

Among the 938 Midspan participants matched with the Mental Ability Test taken on 1 June 1932, cognitive ability at age 11 was strongly related to social class in adulthood.[2] Fig. 2 shows the strikingly different distributions of the scores in social classes I&II and IV&V, with 2.9% and 25.5% respectively having scores of below 85. The scores for social classes III non-manual and III manual were intermediate.

A 15 point lower childhood cognitive ability score was associated with a 17% higher risk of dying in 25 years of follow-up. Adjustment for social class and deprivation category reduced this to 12%.[33] Most of the excess mortality was seen among participants in the lowest quartile of cognitive ability scores, among whom there was a 47% higher mortality rate than those in the highest quartile. Cause specific mortality and hospitalisation were significantly related to childhood cognitive ability for all cardiovascular disease, coronary heart disease and lung cancer, but the relationships became non-significant when adjusted for social class and area deprivation. Childhood cognitive ability was inversely related to all-cause mortality before 65 years but not after.[34] For deaths occurring before 65 years, a 15 point lower cognitive ability score was associated with a 36% higher risk of death, reduced to 29% after adjusting for social class and deprivation category. There was no relationship between starting to smoke and childhood cognitive ability but higher scores were associated with stopping smoking in adulthood[35] and, to a modest extent, to lower smoking-related mortality and morbidity.[36]

Stress and sleep

Levels of reported psychological distress as measured by the GHQ-30 at recruitment were higher among women than men.[37] More distress was associated with significantly raised 5-year all-cause mortality and coronary heart disease mortality in men after adjustment for socio-economic and

coronary heart disease risk factors but not after adjustment for baseline physical illness. There was no evidence that daily stress as measured by the Reeder Stress Inventory was the reason for the higher mortality among people in lower social positions.[38] Once other known risk factors had been adjusted for, there was little evidence that unstable employment history[39] or decreased job satisfaction over a period of 4–7 years[40] was associated with subsequent serious illness or mortality. Men and women who reported sleeping less than seven hours over a period of several years had a greater risk of dying from any cause than those who reported sleeping 7–8 h.[41]

Interactions between alcohol, smoking and obesity

After 21 years of follow-up of men in the Collaborative cohort, higher mortality rates were associated with heavier drinking and the manual social classes.[42] Unlike many other studies, no relationship was found between mortality from coronary heart disease and alcohol consumption, once adjustments were made for potential confounders. However, all-cause mortality was higher among men drinking more than 21 units of alcohol per week and mortality rates for stroke and alcohol-related causes were two and three times higher respectively among drinkers of over 35 units per week compared with non-drinkers. Father's occupation and own occupation at the time of screening were strongly related to tobacco and alcohol use.[43] Men whose father's and own occupation were manual and who smoked and drank more than 14 units of alcohol a week had a relative risk of cardiovascular death of 4.55 compared with men for whom all four factors were favourable. After a median of 29 years of follow-up, drinking more than 14 units per week was associated with increased mortality from most causes and an increased risk of hospital admissions from stroke, liver disease and respiratory diseases.[44]

Men in the Collaborative Study who both smoked and drank heavily had the highest all-cause mortality compared to never-smokers who did not drink. Heavy alcohol consumption and smoking were both strongly associated with lower educational attainment and low socio-economic position.[45]

As smoking is associated with lower body mass index, and pre-existing disease may result in weight loss, both could mask the long-term effects of overweight and obesity unless their effects are taken into account. In the Renfrew & Paisley and Collaborative cohorts, when smoking was controlled for and deaths in the first five years of follow-up excluded, overweight and obesity were associated with important increases in all-cause and cardiovascular disease mortality.[46]

Once the interaction between active smoking and social position is removed, does a socio-economic gradient in mortality rates still exist and if so what factors contribute to it? These questions were explored using data from 3613 women in the Renfrew & Paisley study who had never smoked.[47] Relative to the highest non-manual social classes, all-cause mortality rates were more than a third higher in the manual social classes. These differences were largely explained by differences in body mass index, systolic blood pressure, and lung function. Similar upward gradients were seen for mortality due to cardiovascular and respiratory diseases but not for cancer. Mortality rates were highest in severely obese women in the lowest social classes. Women who had never smoked and were not obese had the lowest mortality rates, regardless of their social position.

In a study using data from the Main, Collaborative and Renfrew & Paisley cohorts, mortality from liver disease was 50% and 400% higher in overweight and obese men respectively compared with men of normal weight. No such association was found in women. Whilst the data were adjusted for a number of possible confounding factors, these did not include alcohol consumption as data on alcohol consumption were not collected during the Renfrew & Paisley study.[48]

In the Main and Collaborative cohorts, compared to normal or underweight non-drinkers, drinkers of >14 units per week had adjusted relative rates for liver disease mortality of three for normal or under-weight men, seven for overweight, and 19 for obese men.[49] The relative rate for obese men who consumed 1–14 units of alcohol per week was five. The effect of the combination of high body mass index and alcohol was clearly greater than the additive effect of the two separately.

Discussion

Strengths and weaknesses

The Midspan cohorts have considerable strengths. The Renfrew & Paisley cohort, achieved almost 80% recruitment and a majority of the participants were women, providing a high level of population representativeness across a wide range of social circumstances and a rare opportunity for comparing genders in this age group. The Collaborative cohort collected social position data relevant to the whole life course. They offer unusually long periods of follow-up and high levels of completeness of data on death and hospitalisation. The unique linkages with childhood cognitive ability test results and air pollution measurements shine fresh light on aspects rarely addressed by cohort studies.

However, they have several limitations. The sampling frames of the Main and Collaborative cohorts were not clearly defined and the response rates not recorded, weakening their generalisability. Smoking and drinking alcohol were self-reported, leading to the possibility of some misclassification or under-reporting. Only about half of each cohort were re-visited, relatively soon after the initial interview, and the data from the second visit were rarely used. There is thus a likelihood of significant levels of misclassification, for example of participants whose smoking status, alcohol consumption or BMI changed during the follow-up period. The Renfrew & Paisley study did not ask about alcohol consumption, and social class was the main measure of social position rather than educational attainment. Social class is a relatively weak measure of social position for non-working women who were classified according to their husband's occupation. Few useful data were collected on diet or physical activity. Finally, a review such as this inevitably involves a selection process reflecting the authors' particular perspectives: others might have made different decisions and reached different conclusions.

Toxic air and lung function

The studies provide overwhelming evidence for the catastrophic lifetime consequences of breathing toxic air. Smoking tobacco is the number one cause, but breathing second-hand tobacco smoke and living in areas with higher levels of air pollution have also been damaging. Indeed, the effects of smoking have been underestimated in these studies. As only smoking status at recruitment was used in most of the analyses, the many participants who stopped smoking thereafter would still be classified as smokers although their risk of tobacco-related diseases would gradually have diminished.[50] Consequently, the real survival rates of lifelong smokers will be lower than we found.[10] As proportionately fewer smokers in lower social positions have given up in the last 30 years,[51] the already narrow differences in survival we found between smokers of different social classes will be even narrower in reality. A recent paper showed that where more data on smoking history were available and incorporated into regression models, social class differences in lung cancer rates disappeared.[52] The effects of second-hand smoke and air pollution may also have been underestimated as exposures at work or in other settings outside the home were not measured. Whilst the declines in tobacco smoking and inside and outside air pollution have made major contributions to health improvement in the United Kingdom over the last 60 years, they remain first, fifth and eighth respectively as causes of loss of disability adjusted life-years world-wide.[53] The evidence from Midspan sounds a loud warning to countries such as China where tobacco smoking and other forms of air pollution are not declining.

The Midspan studies were among the first to show that poorer lung function, as measured by FEV1, is associated with higher mortality from many causes, even among never-smokers. Peak lung capacity in adult life reflects the adequacy of development during pregnancy and childhood as evidenced by its association with height. Lung capacity that is lower than predicted and/or declines over time will largely reflect the effects of destructive insults from birth onwards.[54,55] The Midspan cohorts were born in and lived through a period during which under-nutrition, smoking, air pollution and serious lung infections were much more common than in contemporary Scotland. Further research is needed to establish whether FEV1 remains as important a risk factor for mortality in current and succeeding generations.

Social inequalities, cognitive ability and the lifecourse

The Midspan studies were among the first to show that an individual's lifespan and cause of death are influenced by many factors that operate differentially over the course of their lives. The studies add to the abundant evidence that people in jobs of lower status and skills, and those living in areas of social disadvantage have poorer health. However, once the effects of smoking, drinking excessive alcohol or being obese are accounted for, the socio-economic gradients in the Midspan cohorts are much reduced.[10,47] Indeed, lifelong smoking effectively negates other adverse factors associated with occupational group or area of residence. Continuing smokers thus cannot expect their health to benefit from improvements in socio-economic conditions: stopping smoking is their only option, and the sooner the better.[51]

In the field of health inequality research, there has been an understandable reluctance to explore the possible role of differences in cognitive ability, no doubt due to the controversies surrounding the use of IQ tests in relation to race, gender and education systems.[56–58] The vast majority of the Midspan cohort members were White British or Irish in origin[59] and will have received essentially the same local primary school education. Nevertheless, linkage between the Midspan cohorts and the 1932 Mental Ability Test showed a strong correlation between cognitive ability at age 11 and social position in later life, with most of those with the lowest scores in childhood being in manual social classes in adulthood. Those in the lowest quintile of cognitive ability had significantly higher mortality rates, mainly evident before the age of 65 years. The Midspan studies are thus among the few able to provide evidence that lower cognitive ability in childhood is associated with both lower social position and higher health risks and mortality in adulthood. Gottfredson has set out a well-argued case for the many ways in which cognitive ability might affect health and thus may be one of the 'fundamental causes' of social inequalities in health.[60] Recent influential reports acknowledge this implicitly, stressing the importance of promoting the cognitive and language development of children in disadvantaged circumstances as an essential component of strategies to reduce health inequalities.[61,62] Further research on this sensitive but important area is overdue.

Gender inequality, occupations and cultural values

The higher mortality rates among men than women are not often characterized as a health inequality. Yet, after smoking was taken into account, women in the lowest social positions in the Renfrew & Paisley cohort had lower mortality rates than men in the highest.[10] At least part of the inequalities between genders and occupational groups might be explained by greater occupational risk among men in manual occupations. A study by the Office of National Statistics shows certain manual occupational groups traditionally occupied by men had higher mortality rates from specific conditions.[63] These included asbestos-related diseases in various trades, pneumoconiosis in coal miners, silicosis in quarrymen and accidents involving motor vehicles, machinery and falling from buildings. Perhaps surprisingly, cause-specific mortality rates in particular types of occupations in the Midspan cohorts have not yet been investigated, but are planned. Gender and social class differences in smoking and drinking rates vary greatly between countries and ethnic groups in ways that may not reflect socio-economic status.[64,65] This points to the role of different group cultural values as another plausible contributor to the persistent differences between genders and social classes.[66]

Impact and future relevance

Many of the papers reviewed here have been frequently cited in scientific journals, suggesting significant academic impact. Academic and public meetings to discuss the findings were held in 2005 and 2014 and a number of the individual papers

received substantial positive national and international media coverage. The studies have influenced policy and practice. For example, the work on passive smoking contributed to the case for legislation banning smoking in public places in Scotland;[67] the studies of smoking and social position helped shape thinking on how to tackle social inequalities in health;[68] and Midspan data showed that NHS guidelines for identifying people at high risk of coronary heart disease (based on information from the Framingham Study in the United States), were much less effective in identifying people at high risk, who live in deprived areas.[69] However, perhaps because most of the studies were published in specialist academic journals, their importance has arguably been under-recognized by policy makers and practitioners.

How much of the Midspan cohorts' experience is relevant to today and tomorrow in Scotland and elsewhere? Where the Midspan cohorts lived during childhood and early adulthood, severe air pollution, inadequate sanitation and overcrowded, damp homes were common. These are now the exception in Scotland but common in many middle- and low-income countries, including the most populous, India and China. Working conditions in Scotland have also much improved, as has health care. Far fewer people now smoke, although the decline has been slowest among the most disadvantaged groups. All these changes will have contributed to the steadily improving average life expectancy in Scotland since these cohorts were established, albeit at a slower pace than in many other Western European countries.[70] Nevertheless, social inequalities in health stubbornly persist. It is often argued that unless there is a major transfer of power, influence and resources, newer hazards such as obesity and drug use will simply replace older ones such as infections and smoking.[61,71,72] The Midspan studies highlight the importance of tackling specific causes such as smoking, alcohol and drug misuse, and obesity within the context of the complex interplay between social circumstances, prevailing national and group cultures and individual capabilities.

Access to the Midspan data

The data are available to researchers whose specific research proposal has been approved by the Midspan Steering Committee. More information is provided at: http://www.gla.ac.uk/researchinstitutes/healthwellbeing/research/publichealth/midspan/research/access/.

Author statements

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