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Editorial: present and future prospects

John Bynner
Executive Editor

The second conference of the *Society for Longitudinal and Life Course Studies (SLLS)* took place in Bielefeld, Germany, from 25-28th September 2011, attracting 209 Longitudinal and Life Course researchers from 20 countries across every continent, and was of much historical significance for Longitudinal and Life Course Studies (LLCS). At the Society's AGM, it was agreed that following the end of development funding from the Nuffield Foundation, by the end of September, SLLS should take over responsibility for running LLCS. This change signals exciting opportunities for the journal, offering a communication and dissemination platform for the research projects and programmes in which the society's members are engaged. The Society's annual conference and growing programme of associated activities are where the publication outcomes crystallize in the form of individual presentations and symposia devoted to particular topics - ensuring a steady flow of papers, including special Issues, for the journal.

A journal's reputation, on which indexing and impact ratings are judged, is critically dependent on the more senior and well-known readers using the journal as the outlet for their own work, as well as advising their more junior colleagues to select it as the publication outlet of choice. As we know, career advancement, not to mention research funding, follow in the wake of indexation and impact ratings for the journals in which researchers publish. The vitally needed funding for 'payment to publish' in Open Access journals can also rely on it. This is why LLCS needs the help of everybody engaged in longitudinal and life course study by making sure their next paper or proposal for a symposium-based Special Journal Issue goes to LLCS!

The development of the Society, (with membership now over 240 and just below 1000 registered readers of the journal) is a central part of the strategy for assuring the journal's future. We have set a target of 100 additional SLLS members per annum, to achieve a membership of over 600 by 2015. Safeguarding the journal's future, while holding onto, as far we are able, the principle of world-wide Open Access, now lies in the Society's hands. So please join the Society if you have yet to do so, and persuade at least one other colleague to become a member with you – go to:- www.longstudies.longviewuk.com/pages/membership.shtml

Corporate membership brings special benefits so please get your institution to apply for it and advantage more of your colleagues, including a reduced annual conference fee – also remind them to advertise in the journal. The society's bimonthly Newsletter (restricted to members), which replaces the journal's original section *News, Events and Resources,* will supply more up-to-date information of much interest to journal readers.

2011 SLLS Conference

The Society's second annual conference took place in a beautifully converted Victorian linen factory, now serving as an adult education facility and conference centre in parkland close to the centre of Bielefeld. Sponsorship came from the German Research Council, the British Academy, the European Science Council, through EUCCONET and from the University of Bielefeld who serviced the conference. The delegates heard over 120 papers presented, in 8 symposia and 24 other themed sessions, and took part in four round tables, one panel and one poster session (26 posters). They also heard keynote lectures from Professor Hans-Peter Blossfeld (University of Bamberg, Germany) on the *National Education Panel study: idea, theoretical frame, design and research potential*; Professor Marjo-Riitta Jarvelin (Imperial College London, UK) on *Health from an Early Life Perspective – the Roles of Genes and Environment* ; Professor Jutta Heckhausen (University of California, Irvine, California, USA) on *A Motivational theory of Life Span Development*. Topics ranged from early child development to divorce and ageing, and from methodology through youth and the great recession to psychological well-being and biobanks. The final session was devoted to four major European longitudinal studies: Understanding Society UK, the German Socio-Economic Panel Study (SOEP), the British Cohort

Studies and the German Family Panel (PARFAM) as preparation for the *Data Discovery* training workshops, held the following day. The conference abstracts will be published as a special supplement of the January 2012 Issue of LLCS.

The next conference will be in France in September 2012 (possibly Paris) with sponsorship from ESF/EUCCONET. The 2013 conference is likely to be in Amsterdam and the 2014 conference in Copenhagen.

This Issue

This seventh LLCS issue comprises some novel features. Seven individual papers span a wide range of the journal's and now the Society's interests, including our first example of a paper on qualitative longitudinal research findings - *Middle income families in the economic downturn: challenges and management strategies over time* (Iversen, Napolitano, Furstenberg). We also have our first *Study Profile,* a reflective account of the design of the new longitudinal study, *The German National Educational Panel study: a wealth of potential for research in school to work transitions* (Leuze, Ludwig-Mayerhofer, Solga). Finally we have a new book review format, *Review Symposium,* comprising three reviews, from contrasting disciplinary perspectives (Goldthorpe, Sociology; Murray, Health Sciences; Maughan, Developmental Psychology) of the new book *A Companion to Life Course Studies.*

Health sciences are well represented in three of the individual papers, each concerning an aspect of obesity. The first, *Developmental trajectories of body mass index (BMI) throughout the life course an application of latent class growth (mixture)modelling* (Hoekstra, Barbarosa-Leiker, Koppes, Twisk), uses data collected over the period 13 to 42 years in the Amsterdam Growth and Health longitudinal study, to identify three trajectories relating BM trajectories to cardio-vascular risk; the second, uses data from the Australian, diabetes, obesity and lifestyle (AusDiab) cohort study in an analysis of *Incidence of cardio vascular risk factors by education level* (Beauchamp, Wolfe, Magliano,Turrell) across a five years follow–up interval; the third, *BMI and hearing ability at 45 years* (Ecob, Russ, Davis), using UK National Child Development Study data (NCDS), focuses on the changing relationship between BMI and hearing from age 7 to age 45.

The other papers are social science fare concerning education, employment, family, abilities and gender. *Cross cohort changes in gender pay difference in Britain over the period 1972 to 2004 accounting for selection into employment using wage imputation* (Neuberger, Kuh, Joshi) compares male and female earnings at comparable ages in the three British Birth cohort studies starting in 1946, 1958 and 1970 respectively; *Family caring and children's reading and maths skills* (Michael) takes an economics perspective on the relationships between various indicators of 'family caring', using NCDS data to investigate the inter-generational relationship of caring, with child test scores from parent to child, from grandparent to parent and from grandparent to child.

If you find the content of a paper particularly interesting and thought provoking do not hesitate to write to the author through the journal or submit papers of your own on the same or related themes. We also welcome alternative interpretations of findings or short reports of new findings for the journal sections, *Notes, Comment and Debate* and *Research Notes.* More suggestions for discussion symposia based on a book or paper or special issue will also be well received as will ideas for other formats we have yet to think of.

Most importantly, next January marks the opportunity to participate in the next stage of a great publishing venture, which the Editors are confident that the journal, now linked to the Society, will continue to be.

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BMI over the life course and hearing ability at age 45 years: a population-based cohort study

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Abstract

Previous research on anthropometric factors and adult hearing loss has found relationships, in separate studies, to birthweight and contemporary BMI. However no study has examined data on BMI over the life course. This paper uses data from the 1958 British Birth Cohort to examine relationships between BMI (both in childhood and adulthood), changes in BMI between adjacent age waves, and hearing thresholds at 1 kHz and 4 kHz obtained by audiometric examination at age 45 yrs. Body Mass Index (BMI) in adulthood, but not in childhood, was associated with increased hearing threshold levels at both 1 kHz and 4 kHz at age 45yrs. Two further models examine the effect of changes in BMI between successive waves and adult hearing thresholds, firstly adjusting for childhood hearing loss and a range of further childhood factors (including birthweight, family history of hearing loss, mother's weight, childhood social class) and secondly adjusting in addition for noise, current social class, current systolic blood pressure and diabetes, current smoking and drinking. In the first model, increases in BMI at age intervals throughout the life course, over both childhood and adulthood, were independently associated with increased hearing threshold levels at both frequencies in mid-life, largest relationships being shown at both frequencies to increasing BMI in adolescence and in early adulthood. These relationships generally persisted in the second model, though were reduced more at earlier ages (pre 23 yrs). Noise at work attenuates the relationship between BMI change and mid-life hearing threshold, more so at 4 kHz than at 1 kHz and for BMI change at older ages. The relationship between 1 standard deviation of BMI change between 11 and 16 years, and mid-life hearing threshold was close to one-third that of noise at work (>5yrs vs. none). Future studies should be carried out to determine the mechanisms underlying these relationships and whether these relationships strengthen as the cohort ages further.

Keywords: Hearing loss, hearing impairment, hearing threshold level, Body Mass Index, noise duration, health inequalities, birth cohort, longitudinal, first differences, thrifty phenotype, life course

Introduction

Hearing impairment is the most common sensory deficit in developed countries (Steel 2000). The prevalence of hearing impairment rises throughout the life course, affecting approximately 1-2 per thousand newborns (Russ et al 2003; Fortnum et al 2001; Van Naarden et al 1999), 30% of adults over the age of 65yrs (Gates et al 1990) and 50% of adults over the age of 75 yrs (Davis 1995). Age-related hearing impairment undoubtedly has a genetic component, but environmental factors are also important. Occupational noise exposure is a well documented risk (Kurmis 2007) but there is growing evidence also for recreational noise exposure (Clark 1991). Social class at birth and in adulthood also contribute (Power et al 2007). Smoking has been associated in several studies (Nomura et al 2005), with the notable exception of the Framingham cohort (Gates et al 1993). Although chronic alcohol abuse has also been implicated as a risk (Rosenhall et al 1993), moderate alcohol intake may actually be protective (Fransen, et al 2008). These findings taken together indicate that hearing impairment in mid-life and old age may not be an "inevitable" consequence of ageing, but is associated with a range of lifestyle factors, many of which are amenable to change with potential hearing health benefits.

Recent studies have suggested a relationship between anthropometric factors and hearing ability. Fransen et al, using pooled data from nine European centres, demonstrated an association between high body mass index (BMI) and hearing threshold levels at both low and high frequencies in adults between the ages of 53 and 67yrs (Fransen et al 2008). High body weight was associated with hearing threshold levels at low frequencies only. Fransen also found that taller people had, on average, better hearing, replicating a previous finding by Barrenas (Barrenas et al 2003, 2005a). In a separate study, Barrenas found an association between being born short or light for gestational age and higher hearing threshold levels at age 17-24yrs among Swedish male conscripts (Barrenas et al 2005b). Barrenas also demonstrated an association between overweight and obesity and sensori-neural hearing impairment (SNHI) especially if born light for gestational age. These results were broadly consistent with SNHI resulting from mechanisms suggested by the thrifty phenotype hypothesis, with SNHI as a possible clinical feature of the metabolic syndrome (Barrenas et al 2005b).

Even a modest association between BMI and hearing ability has potentially important clinical implications. The prevalence of overweight and obesity in adults, as measured by BMI, is high, affecting 65% of the US population (Hedley et al 2004). These individuals are not currently recognized as being at increased risk of poorer hearing, so do not receive targeted hearing surveillance or screening. At the population level, an association between BMI and hearing has implications for the likely prevalence of age-related hearing impairment among the "baby boomer" generation. The association also raises the question of whether weight reduction could decrease the risk of hearing impairment in middle and old age. Consequently, it is important to determine whether this association can be confirmed. In addition neither Fransen's study, limited to cross-sectional data, nor Barrenas' study, which analyzed birthweight together with height and weight at the time of conscription, could address the important question of whether changes in BMI at key ages in the life course predict later hearing thresholds sufficiently well to warrant targeted preventive interventions at individual or population level.

Montgomery et al (2010) have examined possible associations between hearing impairment and BMI from a different perspective. They demonstrated that hearing impairment in childhood was associated with BMI in both childhood and adulthood in female, but not male members of the 1970 British Cohort Study (BCS70). Osika and Montgomery (2008) also found that greater clumsiness at age 7 and 11 years was associated with later obesity. They suggested that childhood hearing loss could be a marker of impaired neurologic function, and a possible component of a "pre-obesity syndrome."

This study analyzes data from the British 1958 Birth Cohort (NCDS), a longitudinal study of all children born in England, Scotland and Wales during one week in March 1958 (Power and Elliott 2006). The British 1958 Birth Cohort contains data on birthweight, BMI (constructed from measured or self-reported height and weight at seven points in the life course, measured at ages 7, 11, 16, 33, 45yrs, self-reported at 23 and 42yrs), and hearing threshold levels (HTL) at age 45yrs at low (1 kHz)and high (4 kHz) frequencies. The dataset incorporates a

wide range of associated risk factors including social class, smoking, alcohol, occupational noise exposure, family history of hearing impairment and full audiometric examination in childhood at ages 7, 11, 16yrs, as well as a proxy measure for conductive hearing impairment (impairment resulting from disorders in the external or middle ear) in childhood. We aimed to examine the relationship between (a) BMIs throughout the life course and (b) changes in BMI at age intervals throughout the life course, and hearing threshold at age 45yrs both in a marginal model and after adjusting for a range of risk factors in this large population sample. We hypothesized that increasing BMI would be associated with worse hearing at low and high frequencies in mid-life, and that increases in BMI particularly earlier in the life course would be independently associated with worse hearing in mid life.

Methods

Study sample

Participants were originally enrolled in the Perinatal Mortality Survey (PMS) of all those born in England, Scotland and Wales during one week in March 1958 (Power 1992) and followed up throughout childhood and adulthood by interview, at ages 7, 11, 16, 23, 33yrs and most recently at 44-45yrs (Biomedical Wave). A total of 17,415 individuals participated in the PMS from an eligible sample of 17,638. Immigrants with the same birth dates were recruited up to age 16yrs (n = 920), giving 18,558 eligible study participants (Total Cohort Sample). At 44 - 45yrs, 12,069 participants, still in contact with the study, and who at 42yrs had not required a proxy interview (of family member or carer due to learning disability for example), were invited to a clinical examination undertaken in their home by a trained nurse. Of these, 9,377 participants were seen between September 2002 and March 2004, 8894 of these having a valid hearing measure at both 1 and 4 kHz. The 45yr sample remains broadly representative of the surviving cohort (Power et al 2006).

Variables used in the analysis

Dependent variable: pure tone audiometry at age 44-45yrs

Pure tone audiometry was performed by air conduction in each ear, at frequencies of 1 kHz and 4 kHz according to the British Society of Audiology recommended procedure (British Society of Audiology 1981). In the analysis, Hearing Threshold Level (HTL) in the better ear at age 45yrs is used throughout. Log scores (logged after addition of a term chosen to minimise skewness in the logged distribution) were used, both for the dependent variable and for childhood hearing threshold measures. For adult hearing the transformation was log (y+16.6) for 1 kHz and log (y+20.6) for 4 kHz.

Using this transformation the residuals were found to be reasonably normally distributed in contrast to a pronounced skewness using raw scores (Ecob 2008b).

Exposures

1. Anthropometric variables

Heights and weights were measured by trained medical personnel at ages of 7, 11, 16, and 45yrs and at age 33 by trained interviewer, but were self-reported at 23 and 42yrs.

At 7, 11, and 16yrs, the heights were measured by stadiometer to the nearest inch, and subjects were weighed in their underclothes to the nearest pound. At age 33yrs, height was measured without shoes, using a stadiometer reading to the nearest centimetre, and weight was measured in their underclothes to the nearest pound, using Salter portable scales. These agreed with measured heights in a contemporary national sample (Power et al 1997). Standing height at age 45yr was measured to the nearest millimetre, using a Leicester portable stadiometer placed on a hard floor. Weight was measured to the nearest 0.1 kg in light clothing with shoes removed. Height at 45yrs, when coded as being deemed unreliable by rater, was treated as missing.

Data at all waves on both height and weight, were examined for outlying observations which may be indicative of errors of measurement or transcription. In practice, few obvious errors were found. However, the self-reported heights at age 42yrs, when compared with height measures from adjacent waves, contained a number of errors. For this reason and because the measure was close in time to that at 45 yrs, the study team elected not to include measures derived from heights and weights at age 42 yrs in further analyses.

Body Mass Index (BMI) at each of ages 7, 11, 16, 23, 33, 45yrs was constructed from heights and weights according to the usual conventions (BMI= weight (kg)/height (metres^2).

2. Noise exposure

Duration of occupational noise was assessed at age 45yrs by the following, self-completed, retrospective question "Have you ever worked in a place that was so noisy that you had to shout to be heard?" This was classified as (i) no, never, (ii) yes, for less than 1 yr, (iii) yes, for 1-5yrs, (iv) yes, for over 5yrs. Level (iv) was associated with about 90 dBA (Lutman et al 2008). NCDS has no data on exposure to non-occupational noise in adulthood or childhood.

3. Tobacco and alcohol exposure

The drinking measure used is the number of standard units of alcohol consumed in a typical day at age 45yrs ("how many standard drinks do you have on a typical day"), coded into 4 categories ('>= 7 drinks per day', '3 to 6 drinks per day', '<3 drinks per day', 'non-/ex-drinker/non response'). These categories are based on the distribution of alcohol consumption in the cohort. Non- and ex drinkers were not coded separately due the small numbers in these categories. Smoking ('current' in contrast to 'ex-smoker', 'never smoked') is measured at age 42yrs. For current smokers the following categorisation is used; number of cigarettes smoked per day in three categories (1-9, 10-20, 20+) and for ex-smokers, a combination of years since quitting and number smoked (<1 cigarette/day, >1 cigarette/day - last > 5yrs ago, >1 cigarette/day - last <= 5yrs ago).

4. Adult socio-economic position

Adult socio-economic position (referred to as current social class) is based on the participant's current or most recent occupation at 42yrs (or at 33yrs if data were unavailable at 42yrs; n = 1558). Six Registrar General's occupational groups were used: professional (I), managerial/technical (II), other non-manual (IIInm), skilled manual (IIIm), partly skilled (IV) and unskilled manual (V).

Further control variables

1. Childhood HTL and conductive hearing impairment in childhood

Childhood HTL (Hearing Threshold Level) was assessed by Pure Tone audiometry (performed by air conduction) in each ear, at frequencies 0.25, 0.5, 1, 2, 4, 8 kHz, at three ages (7, 11, 16yrs). These were combined into an optimal measure for prediction of adult hearing threshold levels at 1 and 4 kHz separately. This constituted a weighted combination of hearing ability at each age and frequency, comprising the polynomial relation to an independently determined 'base' frequency (2 kHz for 1 kHz outcome, 4 kHz for 4 kHz outcome, being that frequency with the highest correlation with outcome) and the contrasts with other frequencies at a given age. The final model includes 10 terms over the 3 yrs in childhood HTL for each outcome (Ecob 2008a,b). The consistent relationships between adult HTL and childhood HTL at corresponding frequencies at each age (adjusted), provide some reassurance as to the reliability and validity of the childhood measures.

Two variables, at ages 7 and 11yrs, provided proxy measures of present or past middle ear dysfunction. At 7yrs the variable used was "signs of past, present otitis media" from nurse observation at school ('yes' versus 'no' and 'don't know') and, at 11yrs, otoscopic examination of each ear**,** ('inflamed', 'scarred', 'abnormal-other' versus 'normal', 'obscured by wax' and 'not examined'). On this basis, prevalence of middle ear dysfunction was 7.2% and 6.6% at ages 7 and 11yrs respectively. The retrospective element of the 7 yr measure allows some adjustment for conductive hearing impairment up to this age.

3. Socio-economic position in childhood

Socio-economic position in childhood (referred to as social class of origin) is based on father's occupation at birth in 1958, (or at age 7yrs if data were unavailable at birth; n = 422). The same coding is used as for adult social class (above) but here, those with no male head of household in childhood were grouped with class V.

4. Family history of hearing impairment

This is measured by a question on the biomedical wave (age 45yrs). "Did any of your parents, children, brothers or sisters have great difficulty in hearing before age 55?" ('yes' versus 'no' or 'don't know').

5. Birthweight

Birth weight was recorded in pounds and ounces by the midwife in charge of the delivery, and has been converted to kilograms. Birthweight was adjusted for gestational age by sex and expressed in percentiles (<10, 10-24, 25-50, 51-75, 76-90, >90%). Where this information was incomplete (13.1% given valid adult hearing measures) this was treated as missing and so imputed.

6. Further variables

Mother's weight at child's birth was measured in stones and converted to kilograms. Diabetes was

response (self-assessment) as to whether ever had diabetes (yes/no) at age 42yrs. Noise at test was a binary variable with the following values; 'Background noise at acceptable level for test',' Background noise distracting'. Systolic blood pressure was the mean taken over three readings at age 45yrs**.** Details of all measurement processes for the current biomedical wave are given in the Technical Report for this wave (Fuller et al 2006).

Further possible explanatory variables not included in the models

We examined, in relation to adult HTL, childhood illnesses, accidents, and hospital admissions, but found no relation after adjustment for childhood HTL. We therefore excluded these variables from the final model. We also examined possible confounding effects of pregnancy on mother's weight and found only marginal effects.

Statistical Analyses

We assessed the relationship between (a) BMI and (b) rates of change (per year) in BMI at age intervals throughout the life course (7yrs, 7-11yrs, 11-16yrs, 16-23yrs, 23-33yrs, 33-45yrs) and log hearing threshold at age 45yrs by multiple regression.

Two regression models were constructed to estimate effects of changes in BMI on log hearing threshold at age 45yrs.

The main model (1) adjusted for early life variables that were potential confounders i.e. gender, family history of hearing impairment, mother's weight at birth, social class at birth, childhood hearing impairment, middle ear dysfunction in childhood, as well as noise at time of adult test (binary). Additional adjustment was made for birthweight in order to allow for possible 'thrifty phenotype' effects (Barrenas et al 2003, 2005a).

An additional, and subsidiary, model (2) adjusted in addition for factors, measured in adulthood, which may play a mediating role: current social class, noise exposure at work, current smoking, drinking, diabetes and systolic blood pressure. All models were implemented in Stata 9.2 (StataCorp 2005).

In each of the models, simple BMI at age 7yrs was included, together with terms for differences in BMI between subsequent ages. This approach to the treatment of repeated measures has been used widely in life course research, to cope primarily with the multi-collinearity of repeated measures giving easily interpretable estimates (de Stavola et al 2006). Another application to BMI over age is found in Schienkowitz et al (2006).

A substantial amount of missing data occurs both for audiometric data in childhood and for BMI throughout the life course: where there were valid hearing data at 4 kHz at age 45yrs, data were missing for hearing threshold for 4 kHz in childhood for 30%, 22%, and 28% of cases at 7, 11 and 16yrs respectively, and for data on BMI for 8%, 18%, 20%, 37%, 15%, and 3% of cases at ages 7, 11, 16, 23, 33, 45yrs respectively.

All analyses were run on a dataset with missing data on all variables multiply imputed having 20 cycles (Sterne et al 2009; Kenward and Carpenter 2007). This is implemented in Stata 9.2 by the procedures *ice* and *Micombine* (Royston 2005).

The imputation scheme used was as follows:

For each of the childhood ages, the HTL at each frequency (2, 4 kHz) was imputed using the HTL at other childhood ages, together with other hearing related variables (conductive hearing loss etc) at that age. All polynomial terms in the base frequency at any age were imputed using polynomial terms of lower degree at that age. All polynomial contrasts at a given age were imputed using lower degree polynomial contrasts at that age and all terms in base frequency in that age.

Noise at work and social class at birth were imputed using the linear term in one of the base frequencies (4 kHz) at each childhood age together with sex, current social class and respectively, social class at birth and noise at work. Current social class was imputed using the linear term in one of the base frequencies (4 kHz) at each childhood age together with sex, social class at birth, noise, current smoking. Smoking was

imputed using sex, social class of origin, current social class, noise and current drinking. Height and weight at each age were imputed separately, and BMI constructed from the imputed values: variables used were birthweight, current height, heights and weights at all other ages and the current age (height for weight, weight for height), current drinking and smoking and other current variables (fibrinogen, blood pressure, diabetes etc). These variables, and in addition height and weight at all ages, were used to impute adult hearing loss. Only those data with a productive assessment of hearing at age 45yrs at both frequencies were used. Mother's weight at birth was imputed using sex and social class at birth. Birthweight was imputed using heights and weights at each age, family history of hearing loss, sex, social class at birth, and adult hearing loss at both frequencies (1, 4 kHz). By the nature of the construction of the current drinking measure, this has full data so no imputation was necessary.

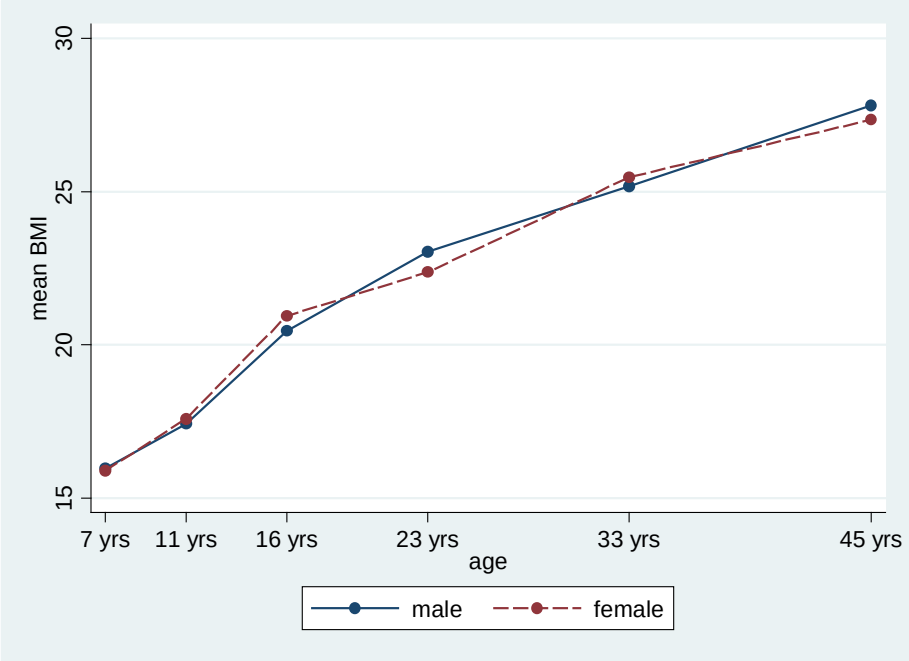
Analyses were weighted for estimated probability of response, defined as productive interview for those issued and eligible, as predicted by sex, childhood hearing loss, social class at birth and heights and weights at both 7 and 33 yrs.

Before imputation only 46% of the sample with valid data at 45yrs for 4 kHz had complete HTL data at all childhood ages, and 33% had full anthropometric data. Sensitivity examination to a range of multiply imputed models with varying model complexity and number of replications was examined, and found very similar results in all models. Nominal sample size, which includes imputed values, is 8,894.

Results

Figures 1a and 1b show the relationship of mean and standard deviation of BMI to age, separately by gender. Males and females show broadly similar relationships at each age (Figure 1a). The variability at the population level shows a continual increase over the life course up to age 33 yrs, with females showing larger standard deviations than males at later ages (Figure 1b).

Figure 1a. Relation of mean BMI (kg/metres^2) to age, separately by sex



1b. Relation of standard deviation BMI (kg/metres^2) to age, separately by sex

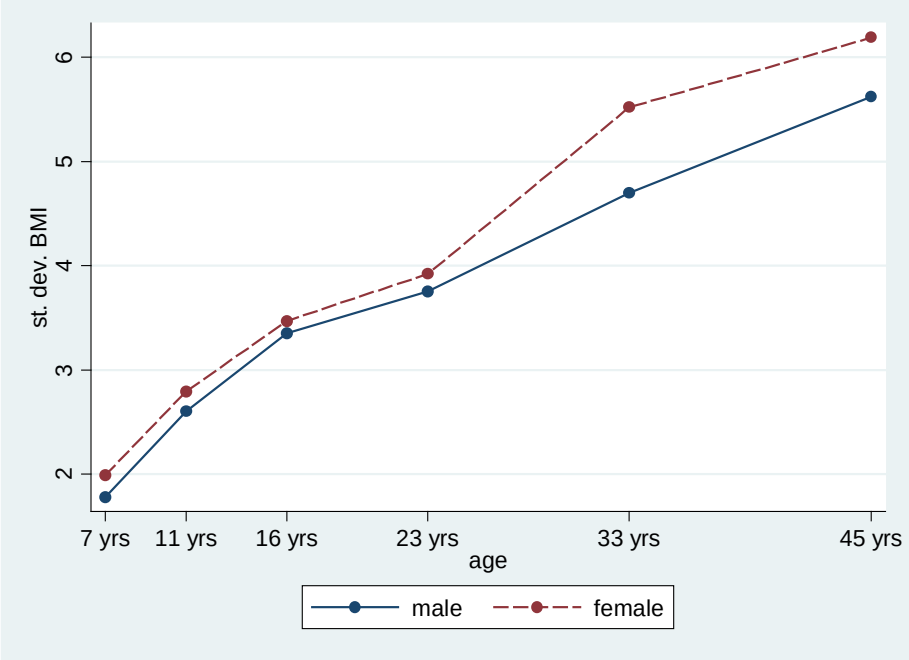


Figure 2 shows changes in BMI (mean, sd) at different ages. Age intervals are centred at the mid-range for interpretability. The change of BMI is positive at all ages, with some tendency to decrease at all ages after puberty (Figure 2a). The standard deviation of change of BMI (Figure 2b) shows a continual increase with age. We use these estimates of standard deviation of change later in this paper, to estimate the effect of one standard deviation of change in BMI on hearing impairment

Figure 2. Relation of mean and standard deviation of change of BMI (kg/metres^2) to age

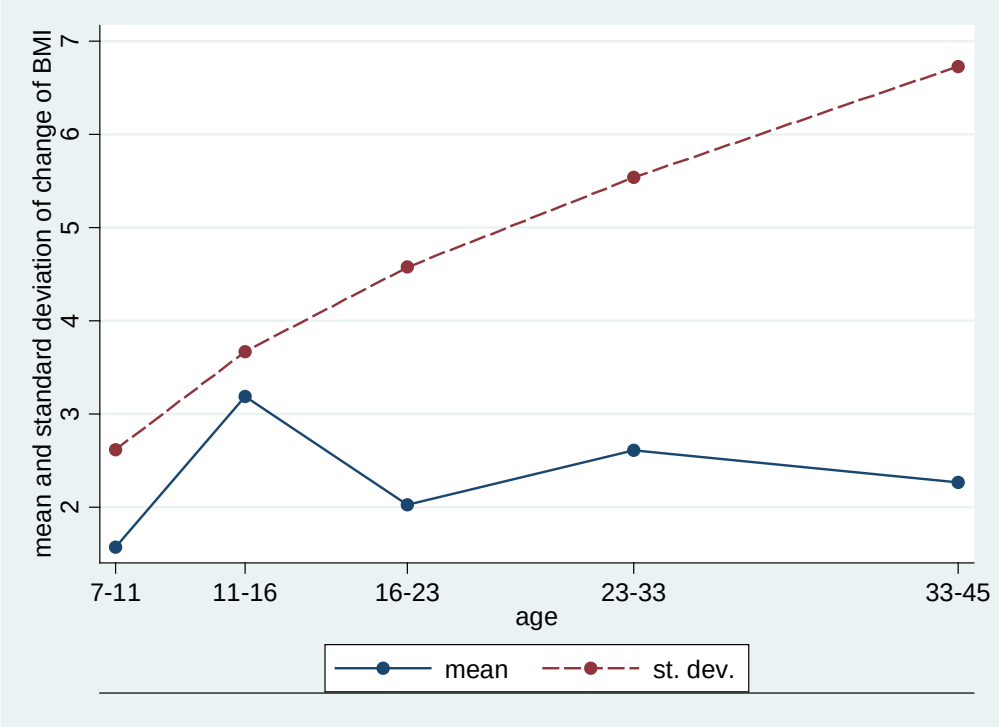


Table 1 shows the relationship between BMI separately at each age and hearing threshold at 1 kHz and 4 kHz. This preliminary model adjusts for noise at test and gender only. Coefficients are back-transformed, for ease of interpretability, to relationships of BMI to raw (not logged) hearing threshold. Higher BMI at age 16yrs and above (4 kHz) and at age 23yrs and above (1 kHz), is associated with higher (worse) log hearing threshold. Effects at 4 kHz are between around 2 and 4 times those at 1 kHz, over the ages considered. Coefficients show a tendency to increase with age with maximum relationship at the age of the hearing measurements (45 yrs).

Table 1. Regression coefficient (95% CI) of hearing threshold (dBHL) at 45yrs on BMI (kg/metres^2) at separate ages.

	1 kHz	4 kHz
BMI, 7yrs	-0.005 (-0.095, 0.084)	0.086 (-0.078, 0.249)
BMI, 11yrs	0.001 (-0.061, 0.063)	0.081 (-0.035, 0.198)
BMI, 16yrs	0.040 (-0.008, 0.088)	0.126 (0.030, 0.223)
BMI, 23yrs	0.081 (0.035, 0.126)	0.200 (0.119, 0.282)
BMI, 33yrs	0.094 (0.062, 0.125)	0.171 (0.113, 0.229)
BMI, 45yrs	0.114 (0.090, 0.138)	0.201 (0.155, 0.248)

Tables 2a and 2b show the regression of log hearing threshold in adulthood on BMI at 7yrs, and subsequent changes in BMI between successive waves, in the two models described above. Table 2a shows this relationship at 1 kHz and Table 2b at 4 kHz.

Model 1, which adjusts for birthweight, noise at test and early life factors (family history of hearing impairment, conductive hearing loss in childhood, hearing thresholds in childhood, mother's weight at child's birth, and social class at birth) and noise at test, shows a positive and statistically significant relationship between change (increase) in BMI at ages 11-16 and above (both frequencies) and higher log hearing threshold (worse hearing) at 45yrs of age with the strongest relationships (shown earlier at 4 kHz than at 1 kHz) with change in adolescence (4 kHz) and in early adulthood, up to age 33) (1 kHz). These relationships of BMI change to hearing threshold continue to be found at both frequencies in Model 2, which also adjusts for all remaining variables (occupational noise exposure and current social class, smoking and alcohol intake, diabetes and systolic blood pressure).

Current smoking is related to hearing loss at both frequencies while drinking (at >=7 units per day only) is related to hearing impairment at 4 kHz only. In addition (not shown), relationships are found with social class of origin (for 4 kHz only) and current social class (for both frequencies). Hearing impairment is greater for males than females in both models at 4 kHz but less in males at 1 kHz. Noise at work (> 5 yrs) is positively related to hearing impairment at 4 kHz but not at 1 kHz. Increase in blood pressure (systolic) leads to an increase in hearing impairment at 1 kHz but not at 4 kHz. Diabetes is positively related to hearing impairment at both frequencies. No relation was found to birthweight in either model at either frequency. Neither was birthweight related to adult hearing in models without other explanatory variables (models not shown).

Table 2a. Regression coefficients of Log hearing threshold at 1 kHz on BMI (*10^4) in the 2 models

	Model 1		Model 2	
	Estimate	**Standard error**	**Estimate**	**Standard error**
BMI, 7yrs	5.51	21.88	-10.23	22.30
Change BMI, 7-11yrs	27.02	19.49	10.42	19.46
Change BMI, 11 -16yrs	65.74	16.77	50.06	17.24
Change BMI, 16-23yrs	70.14	13.42	55.44	14.00
Change BMI, 23-33yrs	72.48	10.64	68.88	10.91
Change BMI, 33-45yrs	56.99	10.24	58.39	10.43
Male (v female)	-0.012	0.007	-0.018	0.008
Blood pressure (systolic)	-	-	0.520	0.233
Diabetes	-	-	0.078	0.025
Drink; ex/none	-	-	0.024	0.014
Drink; 3-6 units per day	-	-	0.004	0.008
Drink; >=7 units per day	-	-	0.019	0.012
Smoking; ex- for <1yr	-	-	0.030	0.014
Smoking; ex– for 1-5yrs	-	-	-0.011	0.010
Smoking; ex- for >5yrs	-	-	0.020	0.016
Current smoker; 1-9 cigs per day	-	-	0.026	0.013
Current smoker;10-20cigs per day	-	-	0.049	0.012
Current smoker;>20cigs per day	-	-	0.074	0.012
Noise at work; <1yr	-	-	-0.024	0.012
Noise at work; <1-5yrs	-	-	0.003	0.013
Noise at work; >5yrs	-	-	0.023	0.012
Constant	1.687	0.170	1.648	0.172

Notes. All Change BMI measures are divided by 10^4 in order that coefficients are easily readable

Table 2b. Regression coefficients of Log hearing threshold at 4 kHz on BMI (*10^4) in the two models.

	Model 1		Model 2	
	Estimate	**Standard error**	**Estimate**	**Standard error**
BMI, 7yrs	40.57	25.60	27.74	25.92
Change BMI, 7-11yrs	49.84	24.34	34.80	25.03
Change BMI, 11 -16yrs	77.81	19.57	58.19	20.03
Change BMI, 16-23yrs	70.96	16.45	54.79	17.38
Change BMI, 23-33yrs	55.95	12.48	52.78	13.04
Change BMI, 33-45yrs	45.71	10.81	49.94	11.24
Male (v female)	0.17	0.01	0.14	0.01
Blood pressure (systolic)	-	-	-0.034	0.279
Diabetes	-	-	0.075	0.033
Drink; ex/none	-	-	-0.005	0.016
Drink; 3-6 units per day	-	-	0.012	0.009
Drink; >=7 units per day	-	-	0.041	0.016
Smoking; ex- for <1yr	-	-	0.008	0.018
Smoking; ex– for 1-5yrs	-	-	-0.001	0.012
Smoking; ex- for>5yrs	-	-	0.036	0.020
Current smoker; 1-9 cigs per day	-	-	0.042	0.016
Current smoker;10-20cigs per day	-	-	0.057	0.014
Current smoker;>20cigs per day	-	-	0.067	0.014
Noise at work; <1yr	-	-	0.015	0.015
Noise at work; <1-5yrs	-	-	0.036	0.017
Noise at work; >5yrs	-	-	0.076	0.014
Constant	2.571	0.207	2.542	0.203

Notes. All Change BMI measures are divided by 10^4 in order that coefficients are easily readable

When transformed back to original scale, at 1 kHz the largest effect, of 0.039 dB in model 1 (reducing to 0.036 dB in model 2) occurs at age 23-33 yrs. At 4 kHz the largest effect, of 0.102 dB in model 1 (reducing to 0.074 dB in model 2) occurs at age 23-33 yrs.

In terms of the increase per 1 standard deviation of the change scale, at 1 kHz this corresponds to, at age 23-33 yrs, 0.222 dB in model 1 (reducing to 0.203 dB in model 2). At 4 kHz the largest effect, of 0.378 dB in model 1 (reducing to 0.274 dB in model 2) occurs at age 23-33 yrs. For comparison, the effect of noise at work (>= 5 yrs versus none) is 1.00 dB.

The contribution of noise at work to the difference between model 1 and model 2 is examined by repeating model 2 but without adjustment for noise at work to form Model 2a (Table 3). Coefficients in models 1, 2, 2a are given in cols 1-3 (1 kHz) and 6-8 (4 kHz). Cols 4, 8 show the coefficient of BMI change between ages in model 2 as a % of model 1. Columns 5, 10 show (for 1, 4 kHz respectively) the change in coefficient of BMI change between ages between models 2a and 2, as a % of that between models 1 and 2 (note that for BMI change between 33-45 yrs, all models exclude smoking, as the inclusion of smoking leads to an increase in the coefficient of BMI 33-45 yrs).

Table 3. Contribution of noise at work to difference between the two models.

	1 kHz					4 kHz				
	Model 1 (M1)	Model 2 (M2)	Model 2 without adjustment for noise (M2a)	M2 as % of M1	M2a-M2 as % of M1 – M2	Model 1 (M1)	Model 2 (M2)	Model 2 without adjustment for noise (M2a)	M2 as % of M1	M2a-M2 as % of M1 –M2
BMI 7-11yrs	27.01	10.42	11.96	39	9.2	49.84	34.80	37.74	70	19.6
BMI 11-16yrs	65.74	50.06	51.86	76	11.5	77.81	58.19	63.43	75	26.7
BMI 16-23yrs	70.14	55.44	56.94	79	10.2	70.96	54.79	58.94	77	25.7
BMI 23-33yrs	72.48	68.88	69.48	95	16.6	55.95	52.78	55.12	94	74.1
BMI 33-45yrs	56.98	51.84	52.43	91	11.5	45.71	44.09	45.71	96	100

Notes. All coefficients are divided by 10^4 in order that they are easily readable. All models exclude smoking.

The effect of adjustment for noise (cols 5, 10 of Table 3) is seen to be greater for 4 kHz than for 1 kHz at all ages, and shows a tendency to be greater at higher ages. Noise at work is responsible for the majority of the difference between models 1 and 2 for effect of BMI change 23-33 yrs on hearing threshold at 4 kHz.

Finally, separate models tested for an interaction between changes in BMI between successive ages and, separately, both noise at work (>5yrs versus <= 5yrs) and gender, and found no interactions with any of the BMI changes for either hearing outcome frequency with either noise at work or gender.

Discussion

Higher BMIs in adulthood, at ages 23, 33, and 45 yrs, in univariate analyses, were associated with higher hearing thresholds (worse hearing) at both 1 kHz and 4 kHz at age 45 yrs. Change (increase) in BMI in successive age waves from 11 yrs upwards, after adjustment for confounding early life factors (Model 1), was also associated with worse hearing at age 45yrs for both sexes at both frequencies**.** At both 1 and 4 kHz, changes in unit BMI between ages 11 and 33 yrs showed the strongest partial relationships to hearing in adulthood.

These relationships largely persisted, though were attenuated after taking into account, in Model 2, the effects of further variables - occupational noise exposure, current social class, current drinking, smoking, diabetes and systolic blood pressure. These variables, being generally more recent in time than the BMI change variables, are potential candidates for a mediating role.

The inclusion of smoking, drinking and noise at work in model 2, was to aid in the search for mechanisms behind the BMI change/ hearing loss relationship, and to determine the extent to which these may or may not overlap with variables which are causes, correlates or sequelea of these. We however make no claim of a biological pathway between these variables.

We examined the effect of adjustment for noise per se, by comparing coefficients in model 2 re-run without the adjustment for noise, with model 2, expressed as the percentage of the difference between model 1 and model 2. The effect of noise at work on the coefficient of BMI change 23-33 yrs on hearing threshold at 4 kHz, is responsible for the majority of the difference between models 1 and 2.

The increase in the partial relationships to BMI at later ages (post 33yrs) in model 2 is due principally to the adjustment for current smoking. Smoking is inversely related to BMI (particularly at later ages) and positively related to hearing impairment. These findings suggest that increases in BMI peri-pubertally and beyond, have relatively long-term influences on hearing ability in mid-life.

In order to check for any bias in results due to any errors of measurement in the self-assessed weight and height at age 23, we re-ran analyses without this measure, now using the change in BMI from age 16 to age 33 to replace those from age 16 to age 23 and from age 23 to age 33, and found very comparable results, the maximum relationships occurring, as before, between ages 16 and 33 (models 1,2) for 1 kHz outcome and between ages 11 and 16 (models 1,2) for 4 kHz outcome.

In a comparable model (model 2), a 1 standard deviation change in BMI from 11 to 16 yrs has 27% of the effect (transformed back to raw, dB, scale) of exposure to noise for greater than 5yrs, compared with the effect of no work-based exposure on hearing threshold levels at 4 kHz. Effects of current smoking and drinking, occupational noise exposure, and current social class are found, even after controlling for BMI over the life course.

Strengths and limitations

To our knowledge, this is the first analysis to examine the effects of increases in BMI throughout the life course on hearing ability in mid-life. The findings are based on a large, probably unique, cohort with extensive pure-tone audiometry results, together with a wide range of anthropometric, early childhood, social and environmental variables (Ecob et al, 2008a). The British 1958 Birth Cohort is population-based, consisting of all births during one week in March 1958, so findings should have a high degree of generalizability to the mid-life British population.

As with all longitudinal cohort studies, there has been significant attrition from the cohort over time. Recent analyses suggest that fewer participants who were still in contact with the study at age 45yrs had

unskilled manual class (IV or V) compared with the original sample. However, the difference was small (Power et al 2007; Atherton et al 2008). Missing data and attrition, however, represent a significant study limitation, which we have addressed as far as possible through use of multiple imputation and weighting.

Lack of a measure of recreational noise exposure was a further limitation. Changing patterns of social and environmental noise exposure e.g. use of MP3 players and iPods across generations, could limit the generalizability of our findings to later birth cohorts.

Comparison with other studies

The finding of a relationship between BMI and hearing thresholds is consistent with that from a cross-sectional study using an amalgamated dataset from nine European audiological centres (Fransen et al 2008). This study had a comparable number of subjects to the British 1958 Birth Cohort (4.083 vs 9.023), with an older and wider age range (53-67yrs vs 45-46yrs) but relied on a mix of population-based and clinic-based samples.

The European dataset included measures of both air and bone conduction, allowing exclusion of cases with probable conductive hearing impairment, and a measure of recreational noise exposure (gunshot noise). However, they lacked data on social class, family history of hearing impairment, and early childhood risks, and were unable to examine relationships with BMI across the life course.

Barrenas's large prospective longitudinal register study of 245,000 Swedish conscripts aged 17-24yrs, also demonstrated an association between current overweight/obesity and sensorineural hearing threshold (Barrenas et al 2005b) although no data were available on potential social and environmental confounders. Unlike Barrenas, we found no association between being light for gestational age at birth and hearing impairment in early adulthood. It would be of interest to analyze the British 1958 Birth Cohort to determine whether a subgroup of infants who were light for gestational age at birth, but subsequently overweight or obese in adulthood (as suggested by thrifty phenotype hypothesis (Barrenas et al 2003)), showed increased risk of hearing impairment. Hearing threshold in the Swedish conscripts was also associated with short stature (Barrenas et al 2005a), a finding consistent with other reports (e.g. Burr et al 2008). We found a similar association, but only for males, at 1 kHz (but not at 4 kHz).

Comparisons between the present study, and that of Montgomery et al (2010), are challenging, as the studies examine different relationships. Montgomery demonstrated relationships between childhood BMI and childhood hearing impairment, and between adult BMI and childhood hearing impairment, even when childhood BMI and social factors were controlled for. They proposed that certain exposures might impact both neurological development and the risk of adult obesity, but also acknowledge that it is plausible that early hearing impairment could itself predispose in some way to the subsequent development of obesity. Similarly, Osika and Montgomery's (2008) finding of an association between poor coordination in childhood and subsequent obesity, could be explained by clumsiness discouraging participation in sports and exercise, resulting in increased risk of obesity.

The present study examines relationships between adult hearing ability and BMI while controlling for childhood hearing impairment. We found no evidence of a difference in pattern of relationship between BMI and hearing threshold by gender. We demonstrated a relationship between adult hearing threshold and BMI in adulthood even when controlling for childhood hearing impairment, however additional analyses beyond the scope of the present study are needed to determine if childhood hearing impairment was associated with adult BMI in our study cohort.

Our findings raise the important question of the nature of a biologically plausible pathway between increasing BMI in adolescence, and adult BMI and later hearing ability. Hearing impairment is common in adult diabetics (Bainbridge et al 2008) possibly resulting from effects on the vasculature and neural system of the inner ear; however the relevance of these mechanisms for individuals with high BMIs in the absence of diabetes is unknown. Montgomery et al (2010) have suggested that hormones such as oestrogen could influence hearing ability through action on inner-ear oestrogen receptors (Stenberg et al 2001). Obesity has been associated with the unopposed action of endogenous oestrogens (Williams 2010; Hulcrantz 2006). There is also

evidence for menstrual fluctuations in auditory perception (Haggard and Gaston 1978) that could point to a hormonal effect on hearing ability. Our finding of increasing BMI in adolescence, in association with poorer adult hearing ability, could also implicate a hormonal mechanism.

Prolonged psychological stress has been demonstrated to result in chronic activation of glucocorticoid receptors, potentially damaging hearing through detrimental effects on the central nervous system (Montgomery et al 2010). Canlon et al (2007) demonstrated the influence of the hypothalamic-pituitary-adrenal (HPA) axis on the auditory system, so a "stress effect" on hearing appears biologically plausible. Psychological stress is also known to be associated with childhood obesity (Dockray et al 2009) and weight gain. Maternal stress, depression and insecure parent attachment styles have also been associated with overweight in young children, and could conceivably have a negative impact on the young child's neurological stimulation and function (Montgomery et al 2010). In this model, poor maternal health is a common antecedent of both obesity in the child (and subsequent adult) as well as poorer hearing ability. Obesity is also known to be associated with oxidative stress (Henderson et al 2006; Le Prell et al 2011) and development of chronic inflammation (Fernandez-Sanchez et al 2011). These factors may in turn influence CSF pressure, changing CO2 / pH values that impact along the cochlear aqueduct and have an effect primarily in the high frequency turn of the cochlea, where the aqueduct enters the cochlea. Ferguson et al (1998) have shown that CSF pressure affects OAE function independently of middle ear pressure changes, at least over the short term. More studies are needed to confirm that these changes occur in the medium to long term, consistent with these results.

There is increasing understanding that much hearing loss has a genetic basis. Certain genes could predispose to both obesity and hearing loss, and some genes could be selective for high frequency loss. It is also possible that the efficiency of the cochlear mechanism is attenuated in the presence of high BMI, and that effects could differ between frequencies at different periods of development. Different biological mechanisms underly relationships at the two different hearing frequencies. Future studies should address some of these hypotheses.

In his recent review "Fair Society, Healthy Lives" (2010), Sir Michael Marmot suggests that "giving children the best start in life" be the first recommendation for reducing health inequalities. Our findings support this life course view of health development, suggesting that greater attention to early life factors may be needed to improve mid-life hearing ability. The same report calls for a strengthening of the role and impact of ill health prevention, including improving programmes that address the causes of obesity across the social gradient. (Department of Health and Department for Children, Schools and Families (2010). At present, only 4% of NHS funding is spent on prevention. Studies such as ours, that demonstrate associations between earlier life risks and later health impacts, support the policy argument that inaction on early life risks is no longer affordable. Our study also highlights the importance of addressing rising BMI in adolescence. Although recent data suggest that obesity prevalence rates in children under 10 yrs are levelling off, prevalence rates in 11-15 year olds remain high and have actually risen in boys (Health Survey for England 2008). Our findings strengthen the importance of maintaining a focus on health promotion as children enter the teenage years (Department of Health 2010). In addition, 2008 data show that 61% adults in England are now overweight or obese, a trend that is likely to impact hearing ability at population level (Health Survey for England 2008). To explore the full extent of health associations with common conditions such as obesity, we also need more research, such as this study, that crosses disciplines, linking a range of risks with mid-life health attributes.

Conclusions

Data from a large population-based prospective birth cohort study, provide evidence for an association between increases in BMI in adolescence and throughout adulthood, and worse hearing in mid-life. Lower social class, smoking and alcohol consumption, and occupational noise exposure, are also associated. Most of these factors are amenable to prevention. Greater policy investment in public

health preventive strategies could pay dividends in improved hearing ability in mid-life. Future research should focus on the impact of earlier life risk prevention strategies on mid-life hearing ability, elucidating possible mechanisms for observed relationships and on the strength of these relationships as the NCDS population continues to age.

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Cross-cohort changes in gender pay differences in Britain: accounting for selection into employment using wage imputation, 1972-2004

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Abstract

This paper examines trends in the labour market position of British women and men from 1972 to 2004, using micro data from three British Birth Cohort Studies, of 1946, 1958 and 1970. Women's rates of employment and hourly pay have been lower than men's over this period, but generally increasing. Because employment decisions are influenced by the level of pay on offer, changes in women's relative pay may not be representative of changes in their labour market position. We accounted for selection into employment by imputing missing hourly wages for non-employees using observed wages of employees of the same sex and age with similar work and family histories, matched on their propensity score. At each survey, women's median hourly pay was lower than men's. Although relative pay increased across the cohorts, it decreased with age within each cohort. Accounting for selection into employment gave a lower estimate of young women's potential pay relative to men's in the two earlier cohorts. This evidence supports the view that the improvement in young women's labour market position since the 1970s has been substantial, and is underestimated in pay trends for the working population.

Keywords: Wages, gender gaps, employment, British Birth Cohorts, sample selection, imputation, propensity score matching

1. Introduction

A broad measure of women's and men's relative power and status in the workforce is the ratio of their average hourly pay. Not only does this measure the differences in pay for the same types of work, but also reflects the level of skill and responsibility involved in the jobs that they do. Thus, it is a measure of inequality in the structure of the workforce. However, it is a potentially biased measure because it excludes the non-working population, who may be out of work precisely because the wages on offer are too low. In particular, pay comparisons within the workforce tend to exclude a higher fraction of women than of men with low potential pay. The importance of such selection biases in wage comparisons was raised in the labour economics literature by Gronau (1974) and Heckman (1977) and has been the subject of more recent studies (Blau and Kahn 2006; Blundell et al 2007; Olivetti and Petrongolo 2008).

We focus on gender pay ratios, without making any adjustment for factors such as education and employment experience, although such adjustment is often done in the literature on gender pay discrimination (for example by Wright and Ermisch

1991; Joshi et al 2007). From a life-cycle perspective, this unadjusted ratio can be seen as a measure of the cumulative effects of pay inequality, since different rates of pay for women and men may affect investment in education and the gender division of domestic work, with cumulative impacts on productivity as well as pay. From a historical perspective, the broad ratio reflects changing institutional arrangements and employment opportunities. It is particularly pertinent to look at the overall gender ratio across the period studied, when the introduction of equal opportunities legislation in the 1970s had a major impact. To reveal its full effect, it is necessary to account for selection biases in unadjusted gender pay ratios. The estimation of adjusted gaps addresses a different question (i.e. differential pay conditional on education and experience) and is the subject of a separate investigation (Neuburger 2010) which relies on the findings in this paper.

Accounting for selection biases in wages is important for the period of British history we focus on, which saw major changes in women's and men's employment and pay. The implementation of the Equal Pay Act in 1975 led to increases in women's relative pay, following decades of no change (Zabalza and Tzannatos 1985; Manning 1996). The introduction and extensions of maternity leave after 1975 also contributed to an increase in mothers' employment across the wage distribution, apart from the lowest paid (Gregg et al 2007). Increases in women's relative wages in turn contributed to a decline in births and an increase in female employment in the 1970s, whilst rising pay was both a cause and effect of rising relative female education (Joshi et al 1985; Ermisch 1988). For men, decreases in economic activity in the 1980s and 1990s were concentrated amongst unskilled groups facing a drop in relative wages (Disney and Webb 1991; Faggio and Nickell 2003). Whereas women's employment rate increased from 56% to 70% of the working-age population between 1971 and 2008, men's employment rate decreased from 91% to 80% (Labour Force Survey 1971-2008).

Age comparisons of gender pay differentials may also suffer from selection biases, owing to more continuous life-cycle employment of higher-waged women around childbearing years. Wage-age profiles estimated for quasi-cohorts in the New Earnings Survey (supplementary analysis in Manning and Swaffield 2008) and General Household Survey (Harkness 2005) show a decrease in women's average pay relative to men's up to the age of 40, alongside cross-cohort increases. However, some of the decrease in women's earning power immediately after having children may not be measured in pay trends, owing to positive selection back into employment.

Several studies have found evidence of substantial selection biases in gender wage comparisons across different time periods and countries, arising from differences in employment (Blau and Kahn 2006; Blundell et al 2007; Olivetti and Petrongolo 2008). Focusing on a similar question to ours, Blundell et al (2007) looked at changes in wage differentials in the UK between 1978 and 1998 using the Family Expenditure Survey (FES), with and without controlling for selection biases. They found that selection into employment masked some of the improvement in the position of women in work.

In this paper, we present newly compiled evidence from the British Birth Cohort Studies covering three decades at the end of the 20th Century. Our working hypothesis was that low wage opportunities for women in the earliest cohort in the 1970s were partly masked by low rates of employment, combined with positive selection into employment. Thus, changes in women's labour market position may not be fully represented in pay trends for the working population. We extend the analysis of Blundell et al (2007) in three main ways. First, we cover a longer period, starting in 1972, before the implementation of equal opportunities legislation, and ending after the Millennium (2004). Second, we are able to draw some distinctions between cohort and life-cycle effects by using large samples from three birth cohorts at three different ages. Third, we use detailed data on individual childhood, work and family histories in an alternative method of controlling for selection into employment.

Section 2 describes the dataset. Section 3 describes the wage imputation method used. Sections 4 and 5 present our results and conclusions.

2. Data

We compare three of the British Birth Cohort Studies. These are ongoing national multi-purpose studies of individuals born in March 1946, March 1958 and April 1970: the Medical Research Council

National Survey of Health and Development (NSHD); the National Child Development Study (NCDS); and the 1970 British Cohort Study (BCS70). Each of the studies took as its original sample all of the British births over a selected week. None of the three studies are fully representative of the adult population living and working in Britain, since each excludes some or all immigrants. For a profile of each study, see Wadsworth (2006) and Kuh et al (2011), Power and Elliott (2006) and Elliott and Shepherd (2006). For a comparison of the three cohorts, see the volume edited by Ferri et al (2003).

The three studies, taken together, offer important attractions for the analysis of employment and pay trends in Britain since the 1970s. A key advantage is that the 1946 cohort had a distinctly different history to the two later cohorts. Not only entering and anticipating the labour market before the Equal Pay Act, women in the 1946 cohort grew up in an era when girls did not equal male achievements in education and were typically not expected to combine parenthood with careers. Wage estimates for the 1946 cohort provide critical baseline estimates for cohort change.

A second major advantage is the detailed longitudinal information on childhood, education, employment and family histories. This makes possible the joint analysis of employment, family and wage data. A disadvantage is that earnings data were not collected frequently, not at the same ages nor in the same form for each cohort, in part owing to the somewhat different aims of the studies and in part owing to funding constraints and opportunities at different points in time. The data are not well suited to the longitudinal analysis of wage dynamics, unlike the British Household Panel Survey (BHPS), for example, but do allow the study of changes experienced by the whole cohort at different points over the life-cycle (Table 1).

Table 1. Description of surveys collecting wage data from the birth cohorts

Birth cohort	Survey year	Age	Survey method	Sample (men)	Sample (women)	Response rate *
1946	1972	26	home interview	1,897	1,853	85%
1946	1977	31	postal questionnaire	1,668	1,672	74%
1946	1989	43	home interview	1,635	1,627	80%
1958	1981/82	23	home interview	6,268	6,271	76%
1958	1991	33	home interview	5,630	5,836	72%
1958	1999/2000	42	home interview	5,627	5,794	73%
1970	1996	26	postal questionnaire	4,101	4,902	55%
1970	1999/2000	29/30	home interview	5,461	5,784	70%
1970	2004	34/35	home interview	4,625	5,039	61%

**The longitudinal response rate defined as the percentage of the target sample who participated at each survey, excluding individuals known to have died or emigrated. Permanent refusals were included in the denominator, giving slightly lower estimates than those presented in Wadsworth et al (2003) for the 1946 cohort. Figures for the 1958 and 1970 cohorts are estimates from Plewis et al (2004) and Ketende et al (2010).*

Derived variables

A major exercise was undertaken to derive comparable variables for the cohorts and to check and edit the data (see Neuburger 2010). Definitions are given in Appendix Table A1.

Employment status: Cohort members were asked to describe their current main activity at each survey. Measures of part-time work are based on self-defined part-time status, although questions were accompanied in most of the surveys by a prompt defining part-time work as working less than 30 hours a week.

Gross hourly earnings: Before-tax hourly earnings are used as the measure of pay in our analysis. Income from self-employment was excluded from our analysis, since it is organised, declared and measured differently from income from employment, and represents a return on assets and enterprise as well as labour. For employees, we calculated hourly earnings in two steps: first, weekly earnings were calculated from responses on before-tax pay and corresponding pay periods; second, hourly earnings were calculated by dividing the weekly figure by reported weekly hours of work. Overtime work was included in the numerator (pay) and denominator (hours). Measures were adjusted to January 2000 prices using the Office for National Statistics long-term indicator of prices.

Employment experience: Estimates were made of the number of years spent in employment and the number of years in full-time and part-time work. For the 1958 and 1970 cohorts, these figures were derived from retrospective data on job and unemployment histories collected from cohort members at each adult survey.

For the 1946 cohort, the job history data were not sufficiently complete for women to create full work histories. Instead, for women and men, estimates were made of number of years in work from the age of 25, rather than since leaving full-time education. This may affect the quality of wage imputations at age 26. Including an existing variable containing the total number of months spent out of work between the ages of 18 and 25 in our imputation models did not alter our results.

Social class of first job: For the 1958 and 1970 cohorts, information was included on the social class status of the first job held after leaving full-time education.

Highest educational qualification: Measures of the highest qualification held at each age include academic and vocational qualifications obtained in adult life. These were grouped using a classification devised by Makepeace et al (2003). We refer to the categories by the main academic exams taken in the English school system over this period: O-levels were basic academic qualifications, usually taken at age 16; A-levels were advanced academic qualifications, usually taken at age 18; diplomas were below-degree qualifications, including some teaching, nursing and lower-level professional qualifications; degrees cover undergraduate qualifications and higher.

Number and ages of children: Variables on the number and ages of children in the household were derived from retrospective birth histories for women and from information on household composition. Birth history data were used for ages up to 43 in the 1946 cohort, age 42 in the 1958 cohort and age 34 in the 1970 cohort.

Childhood mathematics scores: Scores from mathematics tests taken at age ten for the 1970 cohort and age 11 for the 1946 and 1958 cohorts were used as indicators of educational achievement at these ages. Standardised scores were calculated for the full sample (girls and boys) who took the tests.

Childhood variables: Variables containing information on cohort member's family size in childhood, their father's social class and mother's and father's ages and schooling were also included, also having been previously established as predictors of future earnings and employment in the birth cohorts (e.g. Kuh and Wadsworth 1991; Kuh et al 1997).

Individuals with missing items for highest qualification, employment experience or, for women only, numbers and ages of children, were excluded from our analysis. Cases with missing maths or childhood variables were included in the models. Missing maths scores were imputed from other childhood variables and dummy variables were included to indicate a missing item for maths scores and other childhood variables. Missing wages for employees were imputed using the full set of covariates, using the same methods as described below for imputing non-employee wages. The results were also robust to their exclusion from the samples and they were excluded from sample sizes on which standard errors were based (see below).

Effects of sample stratification and survey non-response

For the 1946 cohort, the sample followed up at age two included 5,632 children of the 13,687 births in the original maternity survey (91% of births in one week in March 1946 in England, Scotland and Wales). Babies born to unmarried mothers (N=672) and multiple births (N=180) were excluded from the study. All children born to fathers in non-manual and agricultural occupations were included in the age two survey, but only one in four born to fathers in urban, manual occupations, the aim being to preserve roughly equal numbers from the different social classes given funding constraints. We found that class origins were strongly associated with future earnings and that these effects differed by gender. A weighting variable is provided with the datasets, taking the value 4 for individual cases representing four cohort members and taking the value 1 otherwise. The variable was used as a covariate in the probit models used to estimate propensity scores (see below) and as a weight to estimate summary statistics.

Adult response rates decreased across the cohorts and also after their twenties within the two earlier cohorts (Table 1). Response rates to the 1996 postal survey (age 26) of the 1970 cohort were particularly low (55%), partly because of limited time and resource to trace cohort members (Plewis et al 2004). Studies of longitudinal non-response in the studies show that individuals who left the studies were more likely to be male and to have experienced disadvantage in childhood (Wadsworth et al 2003; Hawkes and Plewis 2006).

We undertook a supplementary analysis to characterise and quantify biases in our wage data arising from attrition and other survey non-response. We used the mathematics scores for cohort members from ages 10 or 11. Individual scores were strongly positively correlated with future earnings and with the probability of survey response in adulthood. As such, they are useful indicators of wage biases arising from non-response. We found that mean scores were generally higher amongst respondents than amongst non-respondents by roughly a third of a standard deviation (Appendix Table A2). These differences are comparable in size to those associated with selection into employment (Appendix Table A6).

We also compared wage ratios and employment rates in the cohort samples to those estimated from the Family Expenditure Survey (FES) for the same years (Table 2). Our FES cross-section samples were restricted to individuals either the same age or one year older or younger than cohort members. The broad pattern of cross-cohort and within-cohort trends in gender pay ratios was mirrored in the FES estimates and the confidence intervals on the estimates were overlapping in all cases. There was some evidence of upward bias in cohort ratios at age 43 in the 1946 cohort, at age 42 in the 1958 cohort and at age 26 in the 1970 cohort. However, the size of this bias is unclear since the FES estimates were based on comparatively small sample sizes and are imprecise i.e. with wide confidence intervals. There was also evidence that estimates of employment rates were slightly upward biased in the 1989 (age 43) survey of the 1946 cohort and in all three surveys of the 1970 cohort, compared to the FES samples. We consider the potential impact of these patterns of survey non-response on our conclusions.

Table 2. Median hourly wages and female-to-male ratios: comparison with FES

Survey year (age)	Sample size cohort	FES	Median wage, £ (95% CI) cohort	FES	Female-to-male ratio (95% CI) Cohort	FES
1946 cohort						
1972 (26)	2,396	592	5.4 (5.3, 5.5)	5.3 (5.1, 5.5)	0.68 (0.64, 0.72)	0.68 (0.63, 0.74)
1977 (31)	2,082	663	5.6 (5.5, 5.8)	5.6 (5.5, 5.8)	0.64 (0.61, 0.67)	0.65 (0.61, 0.69)
1989 (43)	2,291	605	7.0 (6.7, 7.2)	6.9 (6.4, 7.4)	0.60 (0.55, 0.64)	0.53 (0.48, 0.58)
1958 cohort						
1981 (23)	8,629	572	5.2 (5.1, 5.2)	5.2 (5.1, 5.4)	0.84 (0.82, 0.85)	0.79 (0.73, 0.85)
1991 (33)	7,726	535	7.6 (7.5, 7.7)	7.1 (6.8, 7.4)	0.69 (0.67, 0.72)	0.63 (0.56, 0.70)
2000 (42)	8,213	494	7.9 (7.8, 8.0)	8.2 (7.7, 8.8)	0.67 (0.65, 0.68)	0.58 (0.51, 0.65)
1970 cohort						
1996 (26)	6,521	450	6.7 (6.6, 6.8)	6.7 (6.4, 7.1)	0.89 (0.87, 0.91)	0.81 (0.73, 0.89)
2000 (30)	8,258	542	7.6 (7.5, 7.7)	7.8 (7.4, 8.3)	0.87 (0.84, 0.89)	0.81 (0.71, 0.92)
2004 (34)	7,048	533	8.7 (8.6, 8.8)	8.7 (8.2, 9.2)	0.80 (0.77, 0.82)	0.87 (0.77, 0.97)

Notes: Cohort samples include employees with observed wages and imputed missing wages. Samples from the Family Expenditure Survey (FES) include individuals either the same age, or one year older or younger than the birth cohort samples. 95% confidence intervals are shown in brackets.

3. Methods

For individuals who were not in paid work, the potential wage was defined as the wage that they could expect to earn if they entered work. We use the term "potential wage", rather than the traditional economic concept of the "wage offer", since it is not linked to one theoretical model of the labour market (Olivetti and Petrongolo 2008) and more naturally encompasses situations in which individuals are not seeking work, have been out of work for a long period and have only a vague expectation of what they could earn if they did get a job. Wages were not imputed for self-employed individuals, based on the assumption that their labour earnings were missing at random. This assumption was supported by a comparison of their characteristics, relative to those of employees. Our conclusions were also robust to their inclusion.

Since potential wages of non-workers are unobserved, statistical methods to estimate these inevitably draw on additional modelling assumptions, such as:

- *Selection on observables.* The potential wages of non-workers are, on average, the same as observed wages of workers with the same observed characteristics.
- *Selection on unobservables, plus exclusion restriction.* The potential wages of non-workers are the same as wages of similar workers, but that determinants of the employment decision, uncorrelated with potential wages, can be used to estimate the unobserved selectivity bias (Gronau 1974; Heckman 1979).

- *Positive selection.* Potential wages of non-workers are lower, on average, than observed wages of workers with the same characteristics (Blundell et al 2007).
- *Constancy of individual relative wage over time.* An individual's relative wage remains fairly constant over time and their potential wage is, on average, the same as their observed wage on a previous or future occasion when in work (Blau and Kahn 2006; Olivetti and Petrongolo 2008).

Which assumption is used depends on the data available, as well as on the theoretical stance taken on credibility of different assumptions. The assumptions can also be formulated in weaker terms (Manski 1989; Blundell et al 2007).

For women, employment participation tends to be positively correlated with their own wage prospects, based on own levels of education, age at having a first child, employment experience and past wages, but negatively correlated with their partner's income (Joshi 1986; Gregg et al 2007). Historically, partner's income and other family structure variables have been used as types of instrumental variable to quantify the likely size of unobserved selection biases in wages (Gronau 1974; Heckman 1977).

Using family structure and health variables as exclusion restrictions in Heckman's two-step model, unobserved selectivity biases in wages have previously been estimated to be small and non-significant for the 1946 and 1958 cohorts (Joshi and Paci 1998; Kuh et al 1997). Such instruments are less credible for later cohorts, such as the 1970 cohort, since there evidence of increasingly strong correlations between characteristics of spouses in their social origins and levels of education (Blossfield and Timm 2003). More credible exclusion restrictions are those based on administrative or structural arrangements that affect employment, such as out-of-work benefits entitlement (Blundell et al 2007), but this type of information was not collected in the birth cohorts.

Wage imputation method

We have used a wage imputation method which relies on the assumption of selection on observables. The detailed information on individual work and family histories available in our data was an important pre-condition for this assumption. We also exploited the longitudinal aspect of the wage data to test the sensitivity of our results to alternative assumptions (see below).

Imputation methods come from statistical work on methods to handle bias arising from missing data in surveys (see Little and Rubin 2002). These methods have been further developed for handling missing data in large-scale Government surveys. We have used a form of nearest-neighbour imputation based on propensity score matching (Rosenbaum and Rubin 1983).

Our method involved two steps. First, a propensity score was estimated using a probit model with a binary response, taking the value 1 for non-employees and 0 for employees (Appendix Tables A4 and A5). The second step was to match each non-employee to a potential wage donor, i.e. individuals in work despite a low probability of working, based on their propensity score. For each matched pair, the missing value was replaced with the value of the observed wage. The estimation of the probit model and the nearest-neighbour matching were carried out together using the psmatch2 program in Stata (Leuven and Sianesi 2003). We included a common support restriction which excluded individuals with a propensity score outside the range of scores for the opposite group.

A summary of differences in mean maths scores and other model statistics before and after matching are given in Appendix Table A6. The difference before matching gives an indication of the strength of biases arising from positive selection into employment, based on observed characteristics. The difference after matching reflects the degree of similarity between matched samples, and the accuracy of imputed values for non-workers. Sample sizes are given in Appendix Table A7.

Summary statistics and standard errors

The ratio of women's to men's median hourly wage is the summary statistic used as the measure of relative pay. The ratio of women's to men's median potential hourly wage, including imputed values for non-workers, is the measure of relative pay opportunities. Methodologically, comparing medians places less reliance on the goodness of individual imputations. Substantively, cross-cohort comparisons of relative median wages, rather than relative mean wages, places less weight on the differential effects on women and men of rising wage inequality.

Standard errors on these ratios were estimated using bootstrap methods, rather than analytically, since there is no formula for ratios of medians. The size of samples used in the bootstrap replications was restricted to the size of the original non-imputed sample with observed wages.

Sensitivity analysis

We exploited availability of longitudinal wage data to test the robustness of our results to the assumption of "selection on observables". Separately for women and men who were not in work, we assigned their missing wage above or below the observed median wage, based on the position of their last or next observed wage. These assignments capture fixed, unobserved selectivity biases, but assume that individuals experience a limited amount of individual life-cycle wage mobility. The results of this exercise were used as the basis for a sensitivity analysis; applying the fractions of below-median wages, estimated from the sample of non-working individuals with observed wages at a previous or later survey, to the whole non-working population and re-estimating gender pay ratios.

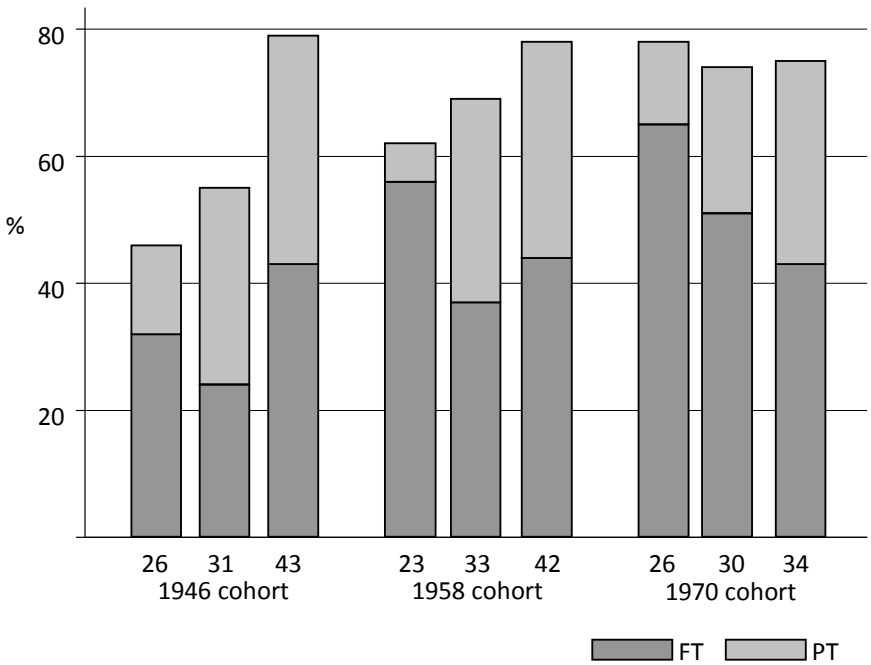
4. Results

Overview of trends

For women and men in the 1958 and 1970 cohorts, the expansion of basic and higher educational opportunities delayed the start of work and changed patterns of earnings and employment. More than 60% of the 1946 cohort left school at ages 15 (then the minimum school leaving age) or 16 and more than half of the cohort had either no or very low formal qualifications i.e. not having either a General Certificate of Education (GCE) `O'-level, a Certificate of Secondary Education (CSE) grade 1, a Scottish Standard grade 1 or a vocational equivalent, which are exams usually taken at 16. Around 60% of the 1958 cohort left at age 16 (by then the minimum leaving age), and around a quarter of the 1958 cohort and a fifth of the 1970 cohort had no or very low formal qualifications.

The change in women's employment across the cohorts at younger ages is equally striking (Figure 1, Appendix Table A3). Just under half of women in the 1946 cohort were in paid work at age 26 in 1972, compared to nearly 80% in the 1970 cohort at the same age quarter of a century later (1996). The fraction of women in full-time work also increased across the cohorts at younger ages, but by their mid-thirties, at least 40% of employed women were working part-time in all three cohorts.

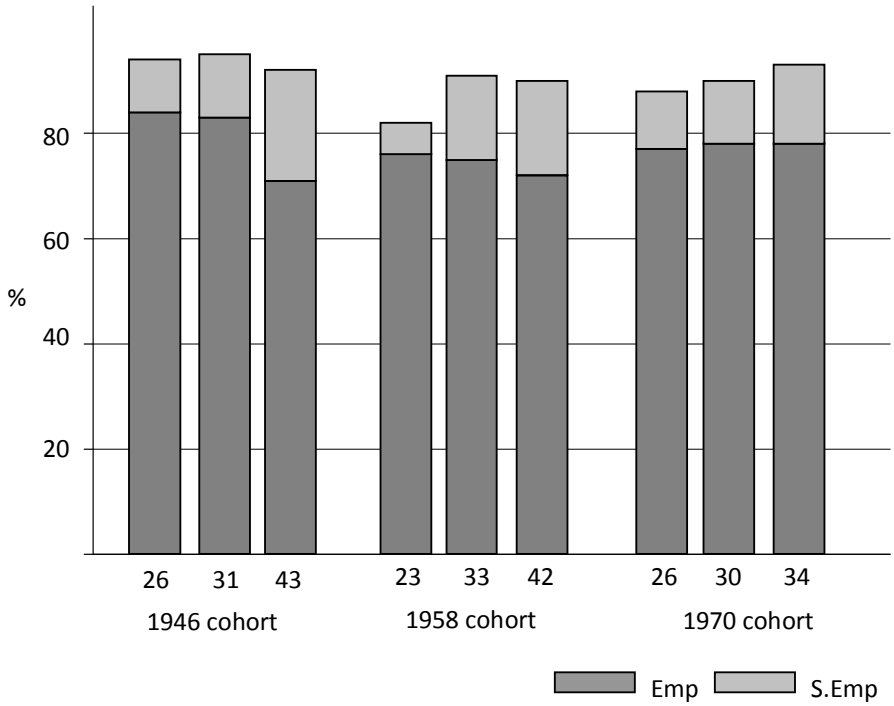
Figure 1. % of women in full-time or part-time work, by age and cohort



Full-time and part-time work here includes self-employed.

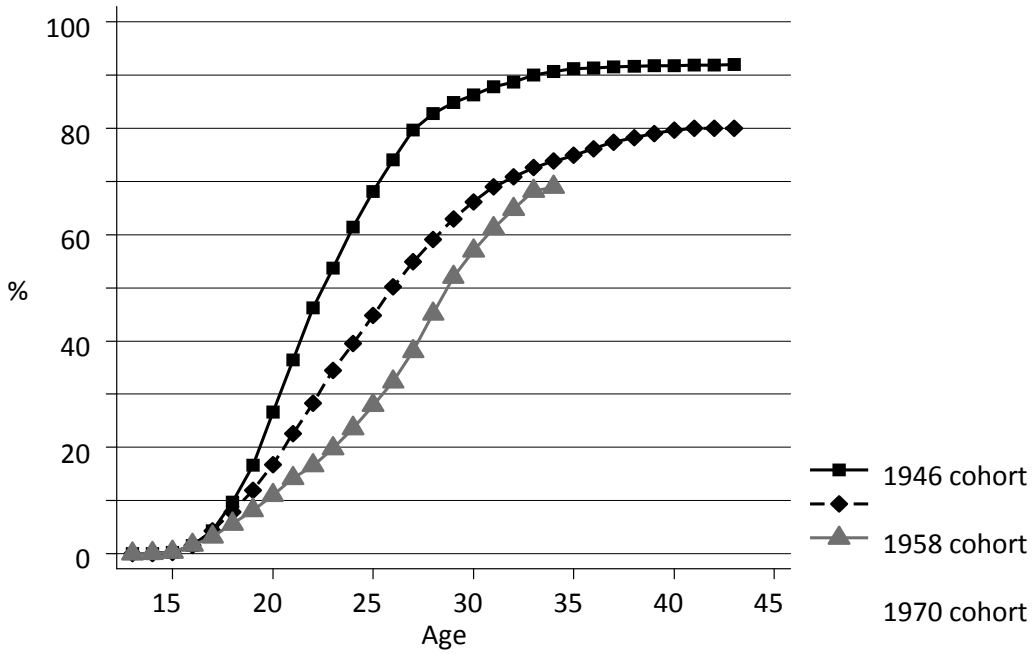
In contrast to women, men's rates of employment decreased slightly across the cohorts at young ages, although they remained high (Figure 2, Appendix Table A3). The decrease was largest between the 1946 and later cohorts when in their twenties and thirties, with the two later cohorts affected by recessions at the start of their careers. Moreover, the employment rate for the age 26 sample of the 1970 cohort is likely to be an overestimate, owing to the low response to the postal survey.

Figure 2. % of men in employment and self-employment, by age and cohort



The cross-cohort increase in women's rate of employment was composed both of an increase in the proportion of women without children and an increase in rates of maternal employment. Years of childbearing became more spread out and, on average, later for women in the 1958 and 1970 cohorts (Figure 3), with effects on the composition of female workforce at different ages. The proportion of mothers working a year after a first birth also increased from a fifth in the 1946 cohort to nearly two-fifths in the 1958 cohort and close to 60 per cent in the 1970 cohort.

Figure 3. % of women who were mothers by each age, by cohort (live births only)



The timing of childbirth differed by social and educational status in all three cohorts. More educated women were likely to have had their children later in life. For the 1946 cohort, there were strong social and educational differences in the timing of childbirth over a relatively small range of ages; from the early-twenties to the early-thirties. By age thirty-one, most women in the 1946 cohort had become mothers and there were few systematic differences between the groups in and out of employment at this age. For the two later cohorts, the compositional effects of delays in childbirth amongst more highly qualified women were mostly offset by their more rapid return to work.

Across the cohorts, women's median pay increased relative to men's at all ages (Figure 4). In their twenties, the ratios for the 1946, 1958 and 1970 cohorts were 0.68, 0.84 and 0.90 respectively. In their thirties, the respective ratios were 0.62, 0.70 and 0.86/0.80. In their early forties, the change across the 1946 and 1958 cohorts was less, with a ratio of 0.60 (95% CI 0.57, 0.63) for the 1946 cohort in 1989 and 0.67 (0.65, 0.69) for the 1958 cohort in 1999/2000 (Table 3). These patterns are also consistent with evidence of decreases in women's relative pay with age (Manning and Swaffield 2008), here including the impact of moves into lower paid part-time work (Connolly and Gregory 2009).

Changes in the relationship between wages and non-employment

Nearest-neighbour imputation provides a pseudo distribution of wages for non-employees, which can be used to understand where in the wage distribution non-employment is occurring for women and men at different ages and how this has changed across the cohorts.

For women, median imputed wages for non-employed women were systematically lower than observed wages of employed women (Appendix Table A8). Those out of work were also consistently over-represented in the bottom quartile of the observed wage distribution (Appendix Table A9). At age 26, over 70% of non-employed women in the 1946 cohort had imputed wages lower than the observed median wage. However, this pattern changed with age, and by age 43, the imputed wage distribution was bimodal; non-employed women were slightly over-represented in the top quartile of the observed wage distribution, as well as in the bottom quartile. For the 1958 and 1970 cohorts, women's wages were consistently over-represented in the lower part of the observed wage distribution and under-represented in the upper part (Appendix Table A9).

For men, median imputed wages for non-employed men were also systematically lower than median observed wages of employed men (Appendix Table A8). For men in the 1946 cohort, imputed wages for the non-employed were also over-represented in the lower part of the wage distribution, although they were also over-represented in the top quartile at age 26 (Appendix Table A9). In the two later cohorts, imputed wages of non-employed were also heavily concentrated in the lower part of the observed distribution, and appeared to become more so with age. An exception was at age 26 in the 1970 cohort, when non-employment seemed to occur more evenly throughout the wage distribution.

Population estimates of women's and men's median potential pay

For women, the inclusion of imputed wages of non-employees in population samples had the greatest quantitative impact on the population median for the 1946 cohort at age 26, since half of women were out of work. In all three cohorts, selection biases in women's wages occurred mainly around childbearing ages in each cohort; most strongly in evidence at age 26 in the 1946 cohort; at age 33 in the 1958 cohort; and at age 30 and 34 in the 1970 cohort. However, the impact of selection biases decreased across the three cohorts as the fraction of women out of work decreased from a half, to a third, to just under a quarter (Appendix Table A3).

For men, the inclusion of low imputed wages for non-employees in population samples did not have an impact on estimated median wages, since they comprised a small fraction of the population across the cohorts at all ages (Appendix Table A3).

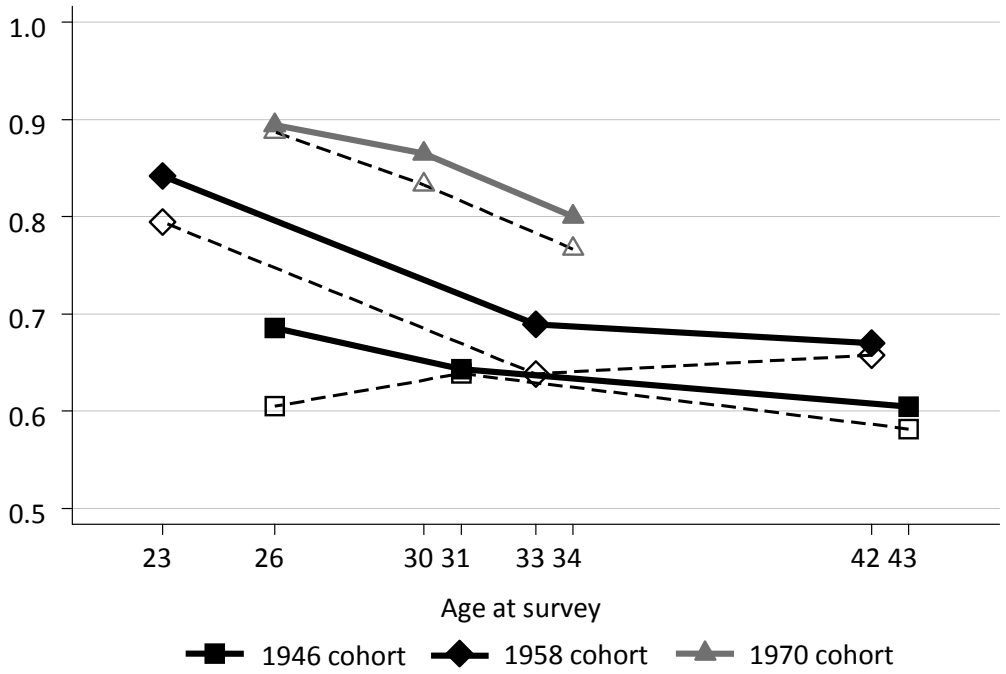
Putting these trends for women and men together, the aggregate picture is of a cross-cohort increase in women's median potential pay, relative to men's, that is understated in median pay ratios for employees (Figure 4). The 95% confidence intervals on estimated employee and population sample ratios are non-overlapping for the 1946 cohort at age 26, for the 1958 cohort at age 23 and for the 1970 cohort at age 30 (Table 3).

Table 3. Female-to-male ratios of medians, by survey

Birth cohort	Survey year	Age	Employee sample ratio (95% CI)	Population sample ratio (95% CI)
1946	1972	26	0.68 (0.64, 0.72)	0.61 (0.58, 0.61)
1946	1977	31	0.64 (0.61, 0.67)	0.64 (0.60, 0.67)
1946	1989	43	0.60 (0.55, 0.64)	0.58 (0.55, 0.61)
1958	1981/82	23	0.84 (0.82, 0.85)	0.79 (0.78, 0.81)
1958	1991	33	0.69 (0.67, 0.71)	0.64 (0.62, 0.66)
1958	1999/2000	42	0.67 (0.65, 0.68)	0.66 (0.64, 0.68)
1970	1996	26	0.89 (0.87, 0.91)	0.89 (0.87, 0.91)
1970	1999/2000	29/30	0.86 (0.84, 0.89)	0.83 (0.81, 0.85)
1970	2003	34/35	0.80 (0.77, 0.82)	0.77 (0.74, 0.79)

Notes: Employee samples include observed and imputed missing wages. Population samples include observed wages, plus imputed missing wages and imputed potential wages for non-employees.

Figure 4. Female-to-male ratios of median observed and potential pay, by survey



Notes: The solid thicker lines show the female:male ratio of median pay for employees. The dashed lines show the female:male ratio of median potential pay for the whole samples, including employees and non-employees.

Sensitivity analysis

We exploited the longitudinal aspect of the wage data to test the sensitivity of our estimates to alternative imputation methods. Our nearest-neighbour imputation method relied on the assumption of "selection on observables". An alternative assumption is that the position of an individual's wage or potential wage relative to the median remains the same over time, compared to those of the same sex and cohort. This assumption is supported by evidence for employees with repeat wage observations; around 70%-80% of individuals, both women and men, had wages in the same position relative to the median at consecutive surveys. We did not use this as a main imputation strategy because only between 30% and 60% of the non-employed samples had an observed wage at a subsequent or previous survey (see sample sizes in Appendix Table A10.)

Instead, for these restricted samples, we compared the fraction of imputed wages for non-employees that fell below the observed median wage using nearest-neighbour imputation with the fraction based their observed wage at another survey. There was evidence of position selection into work for women around childbearing ages from both methods (Appendix Table A10). However, for the 1946 cohort women, the fractions of below-median wages are lower when imputed from a future observed wage, rather than the nearest-neighbour wage. This may be owing to unobserved selectivity bias in the nearest-neighbour imputations, but may also be owing to a genuine recovery in the wage position of non-working mothers relative to women who had children at a later age. Applying this lower fraction of below-median wages to the complete non-employed female sample did not alter our conclusions.

5. Discussion

Summary and study limitations

Using newly assembled data from three British Birth Cohort Studies, we showed substantial cross-cohort increases in women's median pay, relative to men's, alongside decreases with age within each cohort. These findings confirm estimated trends for quasi-cohorts derived from cross-sections of the General Household Survey and New Earnings Survey (Harkness 2005; Manning and Swaffield 2008).

Accounting for selection into employment, we found evidence that the unequal position of young women in the labour market in the early 1970s was underestimated in the relative pay of those who were employed. Around half of women in the 1972 sample were not in work, and their estimated potential wages tended to be lower than those of women in work. However, as female employment rates increased across the cohorts, wage biases associated with positive selection into employment decreased. Taken together, these results suggest that the cross-cohort improvement in women's labour market position is underestimated in changes in relative pay for the working population. This is consistent with estimates for 1978-1998 based on the Family Expenditure Survey (Blundell et al 2007).

Over the life-cycle, selection biases occur around childbearing for women: in their 20s for the 1946 cohort and in the early 30s for the two later cohorts. In general, the decline in the relative potential pay of women around childbearing years appears to be partly masked by positive selection into employment. However, in the 1946 cohort, our wage observations do not go back far enough to say whether decreases occurred after childbirth or whether similarly low pay was a feature of women's work before having children. Although the wage position of non-employed women, relative to employed women, appeared to deteriorate in the two later cohorts, selection effects had decreasing impacts on the population median because a decreasing fraction of women were out of work at any one point in time.

Our main method of accounting for selection into employment was based on the assumption that non-working women and men could, on average, expect to earn a similar wage to working women and men who had similar levels of qualifications, employment experience and numbers of children. This is a simplifying assumption and, in reality, the reasons for working or not working are complex, depending on own wage prospects, employment sector, family circumstances, childcare costs and individual preferences. Systematic differences in the wages of those in and out of work may arise from differences in individual or employer characteristics, which are either not measurable (such as individual motivation) or not measured in our dataset (such as employment sector). As a check on the robustness of our results, we used longitudinal data to assign non-working individuals a potential wage above or below the median based on any observed wage at a previous or future survey. This alternative method also indicated positive selection into employment at younger ages and our conclusions were not changed.

A limitation of our data is that survey samples are not all representative of the cohort, owing to refusals to participate, or, more often, cohort members not being traced at the time of the survey. We found some evidence of bias in wage estimates arising from non-random non-response. Comparing female-male pay ratios in the cohort data to those based on small comparable cross-sections from the Family Expenditure Survey (FES), the general pattern of cross-cohort increases, and within-cohort decreases, was the same. There was some evidence that the ratio was upward biased at the age 43 survey of the 1946 cohort, at the age 42 survey of the 1958 cohort and at the age 26 survey of the 1970 cohort. As a consequence, we may slightly underestimate within-cohort decreases in women's relative pay in the two earlier cohorts into their forties, and overestimate cross-cohort increase for the 1970 cohort at age 26. We may also slightly underestimate the impact of selection bias in the 1970 cohort at this age, since the survey may have had lower response rates among the non-employed.

Conclusions

Debate continues about the causes of, and justification for, women's lower rates of hourly pay, compared to men's. There is a large literature focusing on individual causes, and separating the effects of gender on pay from the effects of having children, working part-time, spending periods out of work, and variations in education, to which this material is now placed to contribute. However, a broad measure of inequality in the structure of the labour market is important in its own right for historical comparisons, since individual decisions are shaped and constrained by institutional arrangements.

For women born in 1946, three decades before the implementation of the Equal Pay Act, relatively low rates of pay and long periods out of work to raise children remained the social norm into the 1970s. There is strong evidence of positive selection into the workforce. Arguably, low rates of pay may have created disincentives to education or

employment, but it is hard to establish the direction of causation. Also, the overrepresentation of non-employed women at the bottom and top of the female wage distribution at age 42 in this cohort, suggests that the wife not working may have been a desirable option if the family could afford it. For this earliest cohort we study, accounting for selection into employment in wage comparisons reveals the hidden extent of gender inequalities in the labour market.

A major transition in women's employment and pay occurred after the 1970s, with the introduction of equal opportunities legislation and maternity leave. There was also increased scope for family planning as the contraceptive pill became more available. This historical shift weakens the argument that women's lower rates of pay, compared to men, are the natural and inevitable consequence of caring for children, and instead demonstrates the possibility for change in social and institutional arrangements. To assess and quantify the full impact of such changes on the position of women and men in work, it is important to use unbiased population-level indicators, as we have done. Our evidence is consistent with the view that improved labour market opportunities for women had an impact both on their pay and employment, and that we understate their impact if we do not account for selectivity biases in wage comparisons.

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Appendix - Additional Tables

Table A1. Variable definitions

Gross hourly wage	Derived gross wage per hour worked (including overtime) (£, 2000)
Part-time worker	Dummy = 1 if self-defined part-time worker (<30 hours a week)
Work experience	Years in paid employment up to time of survey since age 16 for the 1958 and 1970 cohorts and since age 25 for the 1946 cohort
Full-time experience	Years in full-time paid employment since age 16 (1958 and 1970 cohorts) or 25 (1946 cohort). Full-time work is self-defined
Part-time experience	Years in part-time paid employment since age 16 (1958 and 1970 cohorts) or 25 (1946 cohort). Part-time work is self-defined
Job tenure	Years working for current employer at time of survey
O-level or equivalent	Dummy = 1 if highest qualification = O-level or equivalent at time of survey
A-level or equivalent	Dummy = 1 if highest qualification = A-level or equivalent at time of survey
Diploma	Dummy = 1 if highest qualification = diploma from non-degree higher education at time of survey
Degree or higher	Dummy = 1 if highest qualification = Bachelors degree, equivalent or higher at time of survey
Maths score at age 11	Standardised score (z score) from maths test taken at age 10 (1970 cohort) or 11 (1946 and 1958 cohorts)
Missing maths score	Dummy = 1 if maths test not taken or score from test missing
London or SE	Dummy = 1 if living in London or the South East at time of survey.
Children in hhld	Dummy = 1 if own or other children living in household at time of survey
Young child	Dummy = 1 if child under 5 years of age living in household at time of survey
More than one child	Dummy = 1 if more than one child living in household at time of survey
Social class of first job	
I	Dummy=1 if first job in RG Class I
II	Dummy=1 if first job in RG Class II
III	Dummy=1 if first job in RG Class III
IV	Dummy=1 if first job in RG Class IV
V	Reference category (first job in RG Class V)
VI	Dummy=1 if first job in RG Class VI
Missing	Dummy=1 if information of occupation of 1st job missing

Table A1 (continued). Variable definitions (childhood information)

CM father in non-manual job (1946 cohort)	Dummy = 1 if cohort member (CM) born to father in non-manual occupation
I	Dummy=1 if first job in RG Class I
II	Dummy=1 if first job in RG Class II
III	Dummy=1 if first job in RG Class III
IV	Dummy=1 if first job in RG Class IV
V	Reference category (first job in RG Class V)
CM Mother's age:	
Youngest quartile	Reference category
Second quartile	Dummy = 1 if cohort member born to mother in second
Third quartile	Dummy = 1 if mother's age in third quartile of age distribution
Oldest quartile	Dummy = 1 if mother's age in top quartile of age distribution
Missing	Dummy = 1 if information on mother's age at birth missing
CM mother's education:	
Left before 16	Reference category
Left at 17	Dummy = 1 if mother of cohort member left school at age 17
Left at 18	Dummy = 1 if mother left school at age 18 or older
Missing	Dummy = 1 if information on mother's schooling missing
CM father's education:	
Left before 16	Reference category
Left at 17	Dummy = 1 if father of cohort member left school at age 17
Left at 18	Dummy = 1 if father left school at age 18 or older
Missing	Dummy = 1 if information on father's schooling missing
Number of siblings at age 16	
Only child	Dummy = 1 if cohort member had no siblings at age 16
One sibling	Dummy = 1 if one sibling at age 16
Two or three siblings	Dummy = 1 if two or three siblings at age 16
Four or more siblings	Reference category

Table A2. Difference in mean (age 10/11) maths scores by response at each survey

Birth cohort	Survey (Age)	Women	Men
1946	1972 (26)	+0.42 (0.32, 0.54)	+0.32 (0.22, 0.42)
1946	1977 (31)	+0.37 (0.27, 0.47)	+0.26 (0.16, 0.35)
1946	1989 (43)	+0.23 (0.14, 0.33)	+0.28 (0.19, 0.38)
1958	1981 (23)	+0.26 (0.21, 0.32)	+0.30 (0.25, 0.35)
1958	1991 (33)	+0.31 (0.27, 0.36)	+0.32 (0.27, 0.37)
1958	1999 (42)	+0.31 (0.27, 0.36)	+0.36 (0.32, 0.41)
1970	1996 (26)	+0.35 (0.30, 0.39)	+0.27 (0.23, 0.32)
1970	1999 (30)	+0.26 (0.21, 0.31)	+0.20 (0.15, 0.25)
1970	2003 (34)	+0.34 (0.29, 0.39)	+0.41 (0.36, 0.46)

Notes: The figures shown are mean standardised maths scores (standard deviation = 1) for non-respondents deducted from mean scores for respondents. 95 % confidence intervals are shown in brackets. Non-respondents include refusals and non-contacts, but exclude emigrants and those who had died. Missing maths scores were estimated using previous childhood variables.

Table A3. Self-reported main economic activity, by gender, age at survey and cohort

	1946 cohort			1958 cohort			1970 cohort		
	26	31	43	23	33	42	26	30	34
Women									
Full-time employee	31	21	37	56	33	40	62	48	40
Part-time employee	13	29	34	6	29	31	12	21	29
FT self-employed	1	3	6	-	4	4	3	3	3
PT self-employed	1	2	2	-	3	3	1	2	3
Housewife / carer	51	45	11	24	27	13	14	20	19
Unemployed	1	1	4	7	2	2	2	2	2
Other not in work	-	-	3	-	1	1	2	1	1
Full-time student	1	1	1	2	1	1	2	1	2
Other	-	-	-	2	1	1	2	1	2
Sample size	1,852	1,649	1,618	6,256	5,785	5,777	4,835	5,766	5,025
Men									
Full-time employee	84	83	70	75	74	71	75	77	77
Part-time employee	-	-	1	1	1	1	2	1	1
FT self-employed	10	12	21	6	16	17	10	11	14
PT self-employed	-	-	-	-	-	1	1	1	1
Housewife / carer	-	-	-	-	-	1	-	1	1
Unemployed	3	4	2	12	6	3	7	5	3
Other not in work	1	-	4	-	2	5	2	3	3
Full-time student	1	1	-	3	-	-	4	1	1
Other	-	-	-	2	1	1	1	1	1
Sample size	1,897	1,661	1,607	6,249	5,582	5,605	4,063	5,436	4,609

Notes: Percentages are rounded to the nearest integer and are not reported when less than half a percent of the sample fell into the specified category. Percentages for the 1946 cohort are weighted to given population estimates.

Table A4. Regression parameters (std. errors) from probit models used to estimate propensity scores for women, DV = 1 for non-employee

	1946 cohort			1958 cohort			1970 cohort		
Age at survey	*26*	*31*	*43*	*23*	*33*	*42*	*26*	*30*	*34*
1946 cohort weight	-0.09 (0.09)	+0.21 (0.10)	-0.21 (0.13)	-	-	-	-	-	-
CM mother's age									
Youngest quartile	reference	reference	reference	reference	reference	reference	reference	reference	reference
2nd quartile	+0.06 (0.19)	+0.15 (0.11)	+0.05 (0.16)	-0.06 (0.07)	+0.01 (0.06)	-0.07 (0.05)	-0.02 (0.10)	+0.09 (0.06)	+0.11 (0.06)
3rd quartile	+0.14 (0.12)	+0.03 (0.11)	-0.01 (0.15)	-0.09 (0.07)	+0.02 (0.06)	-0.01 (0.06)	+0.03 (0.10)	+0.09 (0.06)	+0.11 (0.06)
Oldest quartile	+0.13 (0.13)	+0.04 (0.12)	+0.06 (0.16)	-0.02 (0.07)	+0.04 (0.06)	-0.08 (0.06)	+0.17 (0.09)	+0.03 (0.07)	+0.12 (0.07)
Missing age	-0.22 (0.18)	+0.04 (0.20)	0.00 (0.26)	-0.39 (0.12)	-0.03 (0.11)	-0.22 (0.11)	-0.50 (0.41)	+0.56 (0.07)	-0.29 (0.46)
CM father's social class									
I	+0.22 (0.23)	-0.21 (0.22)	-0.18 (0.30)	+0.08 (0.13)	-0.11 (0.11)	+0.11 (0.10)	-0.39 (0.16)	+0.12 (0.11)	+0.13 (0.11)
II	+0.25 (0.14)	0.00 (0.14)	-0.22 (0.19)	-0.06 (0.09)	-0.07 (0.08)	+0.09 (0.07)	-0.38 (0.13)	+0.07 (0.08)	+0.01 (0.08)
III	+0.34 (0.13)	-0.20 (0.13)	+0.06 (0.18)	-0.05 (0.10)	-0.03 (0.08)	-0.05 (0.08)	-0.23 (0.13)	+0.12 (0.10)	+0.07 (0.09)
IV	0.00 (0.11)	-0.05 (0.11)	-0.18 (0.15)	+0.02 (0.06)	-0.19 (0.06)	-0.08 (0.05)	-0.28 (0.10)	+0.11 (0.07)	0.00 (0.06)
V & VI	reference	reference	reference	reference	reference	reference	reference	reference	reference
Missing social class	0.00 (0.18)	-0.57 (0.20)	+0.07 (0.25)	+0.02 (0.09)	-0.16 (0.07)	+0.05 (0.08)	-0.31 (0.26)	-0.08 (0.18)	-0.02 (0.17)
CM mother's schooling									
Left at 16 or younger	reference	reference	reference	reference	reference	reference	reference	reference	reference
Left at 17	-0.08 (0.21)	-0.10 (0.21)	+0.09 (0.30)	-0.01 (0.13)	+0.04 (0.12)	-0.10 (0.13)	-0.06 (0.10)	-0.17 (0.09)	+0.05 (0.08)
Left at 18	0.00 (0.28)	+0.12 (0.26)	+0.57 (0.31)	-0.08 (0.13)	0.00 (0.11)	+0.01 (0.10)	0.00 (0.11)	-0.02 (0.10)	-0.10 (0.09)
Schooling missing	+0.51 (0.29)	+0.72 (0.37)	+0.19 (0.40)	0.00 (0.18)	-0.01 (0.17)	-0.10 (0.18)	+0.68 (0.40)	+0.54 (0.37)	+0.16 (0.42)
CM father's schooling									
Left at 16 or younger	reference	reference	reference	reference	reference	reference	reference	reference	reference
Left at 17	+0.30 (0.20)	0.00 (0.19)	-0.02 (0.27)	-0.16 (0.14)	+0.09 (0.11)	-0.01 (0.14)	+0.04 (0.11)	-0.11 (0.10)	+0.04 (0.09)
Left at 18	-0.29 (0.23)	-0.08 (0.20)	0.00 (0.21)	+0.13 (0.11)	+0.01 (0.09)	0.00 (0.09)	+0.17 (0.10)	+0.10 (0.09)	+0.04 (0.09)
Schooling missing	-0.39 (0.29)	-0.76 (0.36)	+0.15 (0.38)	-0.12 (0.14)	-0.26 (0.12)	+0.12 (0.12)	+0.04 (0.28)	+0.26 (0.17)	-0.03 (0.17)
CM siblings, at age 16									
Only child	-0.12 (0.18)	+0.07 (0.15)	+0.07 (0.22)	-0.15 (0.13)	+0.04 (0.11)	-0.04 (0.10)	-0.25 (0.16)	-0.14 (0.13)	+0.12 (0.13)
One sibling	+0.05 (0.18)	+0.07 (0.14)	+0.10 (0.18)	+0.02 (0.13)	+0.12 (0.11)	+0.09 (0.08)	-0.22 (0.14)	-0.14 (0.11)	+0.15 (0.11)

Table A4 (continued). Regression parameters (std. errors) from probit models used to estimate propensity scores for women

	1946 cohort			1958 cohort			1970 cohort		
Age at survey	*26*	*31*	*43*	*23*	*33*	*42*	*26*	*30*	*34*
Two or three siblings	+0.08 (0.12)	+0.05 (0.12)	+0.09 (0.16)	+0.02 (0.07)	+0.12 (0.07)	+0.07 (0.06)	-0.22 (0.14)	-0.23 (0.10)	+0.10 (0.10)
Four or more siblings	reference	reference	reference	reference	reference	reference	reference	reference	reference
Siblings missing	-0.08 (0.23)	+0.32 (0.24)	-0.39 (0.28)	+0.07 (0.18)	+0.32 (0.17)	+0.07 (0.18)	-0.18 (0.15)	-0.10 (0.12)	+0.19 (0.13)
Maths score, age 10/11	-0.12 (0.05)	-0.03 (0.05)	-0.03 (0.07)	-0.09 (0.03)	-0.06 (0.03)	-0.02 (0.03)	-0.01 (0.03)	-0.06 (0.03)	-0.03 (0.03)
Missing score	+0.31 (0.16)	+0.05 (0.17)	+0.50 (0.22)	-0.02 (0.07)	-0.10 (0.06)	-0.01 (0.06)	-0.05 (0.07)	+0.02 (0.05)	+0.04 (0.05)
Highest qualification									
No qualifications	reference	reference	reference	reference	reference	reference	reference	reference	reference
O-level or equivalent	+0.11 (0.11)	+0.05 (0.11)	-0.15 (0.15)	-0.31 (0.06)	-0.01 (0.06)	+0.01 (0.06)	-0.18 (0.07)	-0.12 (0.06)	-0.10 (0.07)
A-level or equivalent	-0.18 (0.14)	+0.22 (0.14)	-0.12 (0.18)	-0.76 (0.10)	-0.11 (0.08)	-0.09 (0.11)	-0.21 (0.11)	+0.04 (0.07)	-0.12 (0.08)
Diploma	+0.23 (0.17)	+0.47 (0.16)	-0.45 (0.24)	-0.81 (0.10)	-0.29 (0.08)	-0.20 (0.08)	-0.45 (0.12)	-0.28 (0.28)	-0.46 (0.08)
Degree or higher	+0.05 (0.22)	+0.19 (0.23)	-0.04 (0.22)	-1.24 (0.13)	-0.73 (0.10)	-0.31 (0.09)	-0.09 (0.11)	-0.91 (0.09)	-0.84 (0.09)
Years in full-time work	-0.07 (0.01)	-0.25 (0.02)	-0.17 (0.01)	-0.34 (0.02)	-0.15 (0.01)	-0.11 (0.00)	-0.08 (0.01)	-0.18 (0.01)	-0.15 (0.01)
Years in part-time work	-	-0.20 (0.03)	-0.22 (0.02)	-0.86 (0.05)	-0.26 (0.01)	-0.16 (0.01)	-0.14 (0.02)	-0.26 (0.01)	-0.20 (0.01)
Children in hhld	+0.35 (0.17)	+0.98 (0.13)	-0.14 (0.16)	+0.58 (0.16)	+0.22 (0.08)	-0.09 (0.07)	+1.02 (0.11)	+0.41 (0.07)	+0.17 (0.08)
Children under five	+1.29 (0.15)	-	+1.31 (0.25)	+1.36 (0.15)	+0.92 (0.05)	+0.87 (0.07)	+0.31 (0.11)	+0.75 (0.07)	+0.77 (0.06)
More than 1 child	-0.15 (0.10)	-	-0.33 (0.14)	-0.19 (0.09)	-0.12 (0.06)	-0.18 (0.06)	+0.30 (0.10)	+0.01 (0.06)	+0.11 (0.06)
Living in London/SE	-0.10 (0.08)	+0.27 (0.09)	-0.02 (0.11)	-0.06 (0.13)	+0.08 (0.05)	+0.02 (0.05)	-	+0.12 (0.05)	+0.14 (0.05)
Social class of 1st job									
I	-	-	-	-0.96 (0.26)	+0.57 (0.17)	+0.12 (0.21)	-0.57 (0.21)	-0.88 (0.21)	-0.44 (0.18)
II	-	-	-	-0.39 (0.10)	-0.04 (0.07)	-0.21 (0.09)	-0.45 (0.08)	-0.37 (0.08)	-0.20 (0.08)
III	-	-	-	+0.08 (0.10)	+0.01 (0.05)	+0.02 (0.06)	-0.19 (0.07)	-0.18 (0.06)	-0.08 (0.06)
IV	-	-	-	+0.21 (0.07)	+0.12 (0.20)	-0.21 (0.08)	+0.02 (0.09)	-0.04 (0.08)	-0.11 (0.09)
V	-	-	-	reference	reference	reference	reference	reference	reference
VI	-	-	-	+0.14 (0.26)	-0.07 (0.23)	-0.05 (0.23)	+0.01 (0.18)	-0.32 (0.16)	-0.43 (0.17)
SC missing	-	-	-	+1.61 (0.22)	+0.18 (0.11)	-0.50 (0.09)	+0.18 (0.12)	+0.47 (0.16)	-0.15 (0.11)
Constant term	-0.61 (0.18)	-0.29 (0.20)	+1.41 (0.28)	+1.03 (0.14)	+0.88 (0.12)	+1.34 (0.12)	-0.55 (0.19)	+0.77 (0.15)	+0.79 (0.17)
Sample size	1,660	1,340	1,079	5,626	5,301	5,339	3,684	5,473	4,714

Table A5. Regression parameters (std. errors) from probit models used to estimate propensity scores for men, DV = 1 if non-employee

	1946 cohort			1958 cohort			1970 cohort		
Age at survey	*26*	*31*	*43*	*23*	*33*	*42*	*26*	*30*	*34*
1946 cohort weight	0.00 (0.18)	+0.10 (0.09)	-0.37 (0.23)	-	-	-	-	-	-
CM mother's age									
Youngest quartile	reference	reference	reference	reference	reference	reference	reference	reference	reference
2nd quartile	+0.03 (0.21)	-0.12 (0.21)	+0.18 (0.29)	-0.04 (0.07)	-0.13 (0.08)	+0.12 (0.08)	+0.07 (0.07)	-0.03 (0.06)	+0.06 (0.11)
3rd quartile	+0.28 (0.19)	+0.06 (0.19)	+0.17 (0.29)	-0.18 (0.10)	-0.03 (0.08)	-0.11 (0.09)	+0.01 (0.08)	-0.01 (0.07)	+0.03 (0.11)
Oldest quartile	-0.12 (0.23)	-0.20 (0.21)	+0.48 (0.28)	-0.17 (0.10)	-0.06 (0.08)	-0.08 (0.09)	+0.18 (0.10)	-0.02 (0.07)	-0.06 (0.11)
Missing age	-0.48 (0.34)	+0.37 (0.31)	+0.46 (0.43)	-0.33 (0.12)	-0.04 (0.14)	-0.06 (0.15)	-0.50 (0.41)	-0.14 (0.31)	+0.33 (0.32)
CM father's social class									
I	-0.10 (0.37)	+0.31 (0.38)	-0.71 (0.70)	+0.19 (0.13)	-0.12 (0.11)	-0.23 (0.19)	-0.39 (0.16)	-0.01 (0.11)	+0.22 (0.11)
II	-0.20 (0.31)	+0.07 (0.26)	-0.03 (0.33)	+0.18 (0.10)	-0.13 (0.11)	-0.19 (0.07)	-0.38 (0.13)	+0.08 (0.08)	+0.22 (0.08)
III	-0.21 (0.28)	-0.25 (0.28)	+0.13 (0.32)	+0.17 (0.11)	-0.08 (0.12)	-0.30 (0.08)	-0.23 (0.15)	+0.05 (0.10)	-0.04 (0.10)
IV	+0.45 (0.19)	+0.19 (0.18)	-0.05 (0.11)	+0.05 (0.07)	+0.01 (0.08)	+0.02 (0.05)	-0.28 (0.10)	-0.12 (0.06)	+0.02 (0.07)
V & VI	reference	reference	reference	reference	reference	reference	reference	reference	reference
Missing social class	-0.14 (0.35)	-0.02 (0.37)	-0.18 (0.45)	-0.09 (0.09)	+0.11 (0.09)	+0.02 (0.07)	-0.31 (0.27)	-0.05 (0.16)	-0.03 (0.17)
CM mother's schooling									
Left at 16 or younger	reference	reference	reference	reference	reference	reference	reference	reference	reference
Left at 17	-0.22 (0.22)	-0.10 (0.38)	-0.35 (0.53)	-0.16 (0.15)	-0.03 (0.18)	+0.14 (0.11)	+0.04 (0.10)	+0.09 (0.30)	0.00 (0.09)
Left at 18	-0.26 (0.56)	+0.20 (0.45)	+0.27 (0.63)	-0.03 (0.13)	+0.03 (0.18)	+0.13 (0.11)	+0.05 (0.11)	+0.02 (0.09)	-0.08 (0.10)
Schooling missing	+0.23 (0.65)	+0.05 (0.57)	+0.70 (0.70)	-0.02 (0.19)	+0.28 (0.22)	+0.12 (0.15)	+0.08 (0.37)	+0.09 (0.30)	-0.21 (0.32)
CM father's schooling									
Left at 16 or younger	reference	reference	reference	reference	reference	reference	reference	reference	reference
Left at 17	+0.33 (0.32)	-0.13 (0.38)	-0.35 (0.53)	-0.05 (0.16)	+0.16 (0.19)	+0.14 (0.12)	+0.13 (0.11)	-0.13 (0.10)	-0.08 (0.10)
Left at 18	+0.32 (0.34)	+0.42 (0.34)	+0.26 (0.63)	+0.13 (0.12)	-0.16 (0.18)	-0.05 (0.09)	+0.13 (0.10)	-0.25 (0.10)	-0.06 (0.09)
Schooling missing	+0.03 (0.65)	-0.70 (0.56)	-0.59 (0.70)	+0.30 (0.14)	-0.17 (0.16)	+0.09 (0.12)	+0.20 (0.20)	+0.27 (0.16)	-0.02 (0.17)
CM siblings, at age 16									
Only child	-0.86 (0.36)	-0.33 (0.31)	-2.06 (1.69)	-0.11 (0.13)	-0.02 (0.11)	+0.10 (0.11)	-0.33 (0.17)	+0.12 (0.14)	+0.22 (0.14)
One sibling	-0.22 (0.22)	-0.02 (0.22)	+0.86 (0.36)	-0.12 (0.13)	0.00 (0.08)	+0.10 (0.08)	-0.32 (0.15)	0.00 (0.12)	+0.10 (0.12)

Table A5 (continued). Regression parameters (std. errors in brackets) from probit models used to estimate propensity scores for men

	1946 cohort			1958 cohort			1970 cohort		
Age at survey	*26*	*31*	*43*	*23*	*33*	*42*	*26*	*30*	*34*
Two or three siblings	-0.25 (0.20)	-0.07 (0.21)	+0.67 (0.36)	-0.04 (0.08)	+0.04 (0.06)	+0.03 (0.06)	-0.27 (0.14)	+0.04 (0.10)	+0.16 (0.11)
Four or more	reference	reference	reference	reference	reference	reference	reference	reference	reference
Siblings missing	+0.11 (0.36)	+0.51 (0.57)	+1.16 (0.55)	-0.32 (0.17)	-0.05 (0.22)	-0.02 (0.22)	-0.03 (0.18)	+0.04 (0.15)	+0.15 (0.20)
Maths score, age 10/11	-0.02 (0.08)	-0.31 (0.09)	+0.11 (0.11)	-0.01 (0.29)	-0.04 (0.03)	-0.05 (0.04)	-0.02 (0.04)	-0.02 (0.03)	-0.09 (0.04)
Missing score	-0.28 (0.29)	-1.15 (0.48)	-0.44 (0.54)	+0.01 (0.07)	-0.02 (0.05)	+0.04 (0.09)	-0.07 (0.08)	+0.11 (0.05)	+0.05 (0.09)
Highest qualification									
No qualifications	reference	reference	reference	reference	reference	reference	reference	reference	reference
O-level or equivalent	+0.05 (0.23)	+0.27 (0.22)	-0.25 (0.30)	-0.31 (0.07)	-0.13 (0.08)	+0.03 (0.08)	-0.21 (0.08)	-0.08 (0.08)	+0.15 (0.11)
A-level or equivalent	-0.07 (0.23)	-0.14 (0.26)	-0.51 (0.32)	-0.65 (0.08)	-0.42 (0.10)	-0.08 (0.10)	-0.35 (0.12)	-0.25 (0.09)	+0.05 (0.11)
Diploma	-0.29 (0.30)	-0.26 (0.31)	-0.10 (0.31)	-0.80 (0.11)	-0.52 (0.08)	-0.24 (0.11)	-0.30 (0.13)	-0.32 (0.11)	-0.02 (0.12)
Degree or higher	-0.29 (0.30)	-0.07 (0.32)	-0.69 (0.37)	-1.60 (0.12)	-1.03 (0.12)	-0.93 (0.13)	-0.02 (0.11)	-1.08 (0.12)	-0.45 (0.13)
Years in full-time work	-0.28 (0.02)	-0.41 (0.06)	-0.41 (0.04)	-0.45 (0.02)	-0.17 (0.01)	-0.14 (0.01)	-0.04 (0.01)	-0.21 (0.04)	-0.17 (0.01)
Years in part-time work	-	+0.13 (0.15)	-0.48 (0.12)	-0.65 (0.14)	-0.15 (0.04)	-0.19 (0.03)	-0.05 (0.05)	-0.24 (0.04)	-0.08 (0.03)
Children in hhld	+0.25 (0.40)	-	-0.51 (0.21)	+0.24 (0.24)	+0.20 (0.10)	-0.23 (0.09)	+0.24 (0.18)	-0.03 (0.12)	-0.23 (0.13)
Children under five	-0.37 (0.40)	-	-1.14 (0.54)	-0.17 (0.25)	-0.11 (0.08)	+0.15 (0.09)	-0.66 (0.19)	-0.10 (0.12)	-0.14 (0.11)
More than 1 child	+0.15 (0.23)	-	+0.12 (0.29)	+0.14 (0.13)	+0.10 (0.09)	-0.08 (0.09)	+0.19 (0.17)	+0.18 (0.10)	+0.27 (0.12)
Living in London/SE	-0.32 (0.18)	+0.02 (0.16)	-0.20 (0.23)	+0.16 (0.08)	+0.02 (0.08)	-0.13 (0.07)	-	-0.06 (0.07)	+0.07 (0.08)
Social class of 1st job									
I	-	-	-	-0.29 (0.10)	-0.36 (0.21)	-0.11 (0.21)	-0.59 (0.16)	-0.81 (0.21)	-0.48 (0.24)
II	-	-	-	-0.14 (0.06)	-0.25 (0.08)	-0.13 (0.14)	-0.57 (0.10)	-0.61 (0.11)	-0.19 (0.13)
III	-	-	-	-0.17 (0.06)	-0.15 (0.06)	-0.18 (0.11)	-0.36 (0.10)	-0.28 (0.10)	-0.09 (0.12)
IV	-	-	-	+0.09 (0.06)	-0.09 (0.05)	-0.07 (0.09)	-0.24 (0.09)	-0.04 (0.08)	+0.23 (0.10)
V	-	-	-	reference	reference	reference	reference	reference	reference
VI	-	-	-	+0.14 (0.10)	-0.15 (0.12)	0.00 (0.12)	+0.44 (0.14)	+0.19 (0.11)	+0.40 (0.14)
SC missing	-	-	-	+0.48 (0.12)	-0.26 (0.12)	-0.68 (0.12)	+0.13 (0.12)	+0.13 (0.13)	+0.13 (0.13)
Constant term	+1.32 (0.33)	+0.53 (0.38)	+5.10 (0.73)	+1.89 (0.14)	+1.04 (0.12)	+1.87 (0.17)	-0.19 (0.21)	+1.31 (0.19)	+0.45 (0.16)
Sample size	1,602	1,272	996	5,219	4,580	4,591	3,034	4,752	3,928

Table A6. Difference in mean maths scores and model fit before and after matching

Survey	**Women**		**Men**	
(Age)	Before matching	After matching	Before matching	After matching
(1) Mean maths scores				
1972 (26)	+0.26 (0.17, 0.35)	-0.04 (-0.07, 0.15)	+0.14 (-0.11, 0.39)	-0.14 (-0.52 0.24)
1977 (31)	+0.06 (-0.04, 0.16)	+0.01 (-0.11, 0.13)	+0.55 (0.29, 0.82)	-0.02 (-0.43, 0.38)
1989 (43)	+0.20 (0.05, 0.35)	-0.12 (-0.34, 0.10)	+0.19 (-0.14, 0.53)	+0.29 (-0.25, 0.83)
1981 (23)	+0.42 (0.36, 0.47)	-0.09 (-0.16, -0.02)	0.00 (-0.08, 0.08)	+0.05 (-0.07, 0.18)
1991 (33)	+0.22 (0.17, 0.27)	-0.03 (-0.11, 0.04)	+0.48 (0.39, 0.58)	+0.02 (-0.11, 0.15)
1999 (42)	+0.21 (0.15, 0.27)	-0.04 (-0.14, 0.05)	+0.48 (0.39, 0.58)	-0.11 (-0.24, 0.02)
1996 (26)	+0.23 (0.16, 0.30)	-0.05 (-0.16, 0.06)	+0.11 (0.01, 0.22)	-0.04 (-0.19, 0.11)
1999 (30)	+0.31 (0.25, 0.36)	+0.04 (-0.04, 0.12)	+0.25 (0.15, 0.35)	+0.13 (-0.01, 0.28)
2003 (34)	+0.19 (0.13, 0.26)	+0.04 (-0.05, 0.12)	+0.31 (0.20, 0.43)	-0.04 (-0.21, 0.13)
(2) Pseudo R2 from probit models				
1972 (26)	0.62	0.12	0.49	0.14
1977 (31)	0.25	0.03	0.23	0.10
1989 (43)	0.34	0.14	0.55	0.17
1981 (23)	0.52	0.06	0.29	0.04
1991 (33)	0.28	0.02	0.28	0.04
1999 (42)	0.27	0.02	0.33	0.04
1996 (26)	0.26	0.02	0.08	0.02
1999 (30)	0.35	0.02	0.31	0.03
2003 (34)	0.29	0.01	0.31	0.05
(3) Likelihood-Ratio test (p-value) of significance of variables				
1972 (26)	1233.4 (0.00)	152.2 (0.00)	332.2 (0.00)	24.0 (0.99)
1977 (31)	457.4 (0.00)	57.5 (0.00)	115.9 (0.00)	16.3 (0.95)
1989 (43)	355.3 (0.00)	76.5 (0.00)	270.8 (0.00)	17.4 (0.96)
1981 (23)	3824.2 (0.00)	296.5 (0.00)	1337.5 (0.00)	81.1 (0.00)
1991 (33)	1893.6 (0.00)	100.1 (0.00)	910.9 (0.00)	56.7 (0.02)
1999 (42)	1518.0 (0.00)	64.8 (0.00)	1066.0 (0.00)	53.1 (0.04)
1996 (26)	1012.7 (0.00)	45.4 (0.14)	178.5 (0.00)	22.1 (0.97)
1999 (30)	2250.0 (0.00)	92.5 (0.00)	1010.5 (0.00)	30.6 (0.76)
2003 (34)	1601.6 (0.00)	41.6 (0.28)	703.1 (0.00)	40.8 (0.31)

Notes: The figures shown are (1) mean standardised maths scores (95% confidence intervals) for non-employees deducted from mean scores for employees. (2) The pseudo R2 from a probit model regressing the propensity score on all the variables included in the model for the unmatched and matched (weighted) samples. (3) The likelihood ratio tests of the joint insignificance of these covariates before and after matching. These statistics were estimated using the pstest commands in Stata (Leuven and Sianesi 2003).

Table A7. Sample sizes for observed and imputed wages, by gender, age and cohort

	1946 cohort			1958 cohort			1970 cohort		
	26	31	43	23	33	42	26	30	34
Women									
Observed wage	739	621	1,129	3,657	3,185	4,000	3,237	3,903	3,005
Employed, missing wage	74	124	32	230	406	134	249	83	433
Not employed	884	679	193	1,901	1,761	1,205	811	1,453	1,277
No common support	2	5	16	132	6	5	1	52	3
Missing key covariates*	97	114	110	223	40	4	356	11	7
Sample size	1,796	1,543	1,480	6,143	5,398	5,348	4,654	5,502	4,725
Men									
Observed wage	1,463	1,181	1,105	4,375	3,754	3,958	2,779	4,183	3,291
Employed, missing wage	120	156	25	367	381	121	256	89	319
Not employed	68	60	38	788	517	509	387	444	321
No common support	20	2	29	69	12	7	0	81	11
Missing key covariates*	97	114	110	223	40	4	356	11	7
Sample size	1,715	1,441	1,240	5,837	4,696	4,607	3,652	4,824	3,950

**Missing wages were not imputed if items were missing for either highest qualification, employment experience or, for women only, number and ages of children.*

Table A8. Median observed and imputed potential wages (£, 2000 prices)

	1946 cohort			1958 cohort			1970 cohort		
	26	31	43	23	33	42	26	30	34
Women									
Observed wage	4.06	4.02	5.07	4.71	6.08	6.39	6.33	6.96	7.68
Employed, missing wage	4.17	4.42	5.07	4.63	5.62	5.85	5.94	6.83	7.12
Not employed	3.33	3.79	5.00	3.66	4.71	5.23	5.69	5.41	5.62
Men									
Observed wage	5.95	6.29	8.50	5.61	8.79	9.51	7.06	8.05	9.54
Employed, missing wage	6.14	6.72	9.36	5.65	7.75	10.43	6.90	7.06	9.45
Not employed	5.77	5.76	6.62	5.28	6.98	6.73	6.90	6.48	7.44

Notes: Medians for each 1946 cohort sample are weighted to give population estimates.

Table A9. % imputed wages below 25th, 50th and 75th percentile of employee wages

	Women			Men		
(Age)	25th	50th	75th	25th	50th	75th
1972 (26)	38.1%	70.4%	82.9%	36.1%	57.4%	69.0%
1977 (31)	37.3%	59.8%	77.8%	41.3%	60.0%	79.3%
1989 (43)	35.7%	50.1%	68.9%	34.7%	62.2%	78.6%
1981 (23)	54.1%	76.3%	89.1%	31.6%	58.1%	83.8%
1991 (33)	37.7%	67.5%	85.2%	44.3%	71.0%	87.6%
1999 (42)	40.5%	66.4%	82.7%	52.8%	74.5%	90.2%
1996 (26)	35.6%	59.2%	76.6%	26.8%	52.7%	78.6%
1999 (30)	46.3%	67.2%	83.0%	43.2%	63.2%	84.7%
2003 (34)	47.8%	69.8%	86.7%	46.1%	67.6%	85.4%

Notes: Imputed wages for non-employees. Weights used for 1946 cohort samples.

Table A10. % imputed wages below the median (1) nearest-neighbour (2) longitudinal

Survey		**Women**			**Men**	
(Age)	(1)	(2)	Sample (N)	(1)	(2)	Sample (N)
1972 (26)	71.4%	62.6%	560	54.9%	72.0%	37
1977 (31)	57.9%	52.6%	466	55.3%	65.8%	45
1989 (43)	50.0%	52.3%	97	63.9%	61.4%	32
1981 (23)	77.4%	70.6%	1,169	58.1%	56.5%	432
1991 (33)	64.4%	59.0%	1,194	65.9%	66.2%	293
1999 (42)	60.8%	53.6%	646	69.6%	67.8%	283
1996 (26)	57.5%	71.2%	472	51.3%	62.5%	269
1999 (30)	64.4%	65.1%	674	58.2%	68.2%	170
2003 (34)	64.4%	55.5%	735	58.1%	68.4%	136

Notes: The samples include non-employees at each survey with both (1) an imputed wage from propensity score matching and (2) an observed wage from another survey.
For this reason, percentages falling below the median are slightly different to those for the complete non-employed samples shown in Table A9. Weights used for 1946 cohort.

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Middle-income families in the economic downturn: challenges and management strategies over time

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Abstract

The "Great Recession" that began in 2007 has hurt many families across the United States, yet most research has examined its impact on those already considered poor or working poor. However, this recession has affected middle-income families, whose experiences with economic challenge have seldom been looked at in any detail. Such families have recently been called "the new poor," "the missing middle," and "families in the middle." One in seven American children under age 18 (10.5 million) has an unemployed parent as a result of this recession, and because economic mobility for children in the U.S. is affected by their parents' earning capacities, these children's educational and employment futures may be permanently constrained. The research presented here, which is informed by Weberian stratification theory and capital theories, is based on a small longitudinal subset of a larger, two-country, multi-city, mixed-methods study. Two waves of in-person interviews between spring 2008 and late fall 2009, revealed how families experienced the economic downturn, and the management strategies that parents used to try to counter its negative effects. Parents were moderately able to provide financially for their children's daily needs and support children's current school activities, despite income and job challenges and losses, but less able to continue to develop children's future-enhancing capital.

Keywords: recession; economic downturn; families; middle-income; children's education; management strategies; longitudinal; mixed methods; human, social and cultural capital

Introduction

The "Great Recession" that began in 2007 has hurt many families across the United States whose experiences with economic hardship have seldom been examined (Voydanoff 1990; Williams and Boushey 2010). Most research has examined the recession's impact on those already considered poor or near poor (Acs and Nichols 2010; U.S. Department of Labor 2010). Yet increasing numbers of middle-income families now contend with altered financial landscapes, so much so they have been recently defined as "the new poor" (Smeeding in Goodman 2010), "the missing middle" (Skocpol 2001; Williams and Boushey 2010), and "families in the middle" (Furstenberg and Gauthier 2007). By the end of 2009, an estimated one in seven American children under age 18 (10.5 million) lived in a family with an unemployed parent, nearly double the pre-recession number (Lovell and Isaacs 2010). Although the Great Recession is technically over, the U.S. Federal Reserve Chairman, Ben Bernanke, recently declared that "unemployment is likely to remain elevated for up to five more years" (Chan 2011). Other countries around

the globe report similar recession challenges (International Labour Organization 2011).

Our concern here stems from findings that the long-term effects of economic downturn among middle-skilled, middle-educated parents in particular, can negatively impact the educational and work outcomes of the next generation (Haveman, Heinrich and Smeeding 2011; Irons 2009; von Wachter 2011). Some have found that early economic disadvantage, including living in households with unemployed parents, effectively relegates children to lower economic productivity throughout their later life (Holzer 2010; Oreopoulous, Page and Stevens 2008; Stein 2010), although others urge caution about such conclusions (Mayer 2010). Similarly, "economic scarring" from recession-induced job loss and falling incomes may "force families to delay or forgo a college education for their children" (Irons 2009), which is concerning in the context of the current labor market pattern of rising educational requirements (Brand and Xie 2010; Danziger and Ratner 2010). Thus, the negative effects of economic downturn are not experienced solely by already-poor families; nor are the effects as short term as is often portrayed (Irons 2009). Indeed, Bernanke has attributed the slow pace of economic recovery to "the worst financial crisis....since the Great Depression" (Irwin, 2011). Accordingly, the ways in which such recessions may disadvantage middle-income families over time are what we begin to examine here.

Conceptually, this research follows classical theories on social stratification, that social class position is strongly influenced by unequal situations early in life that accumulate over time and affect children's odds of success (see, for example, Grusky 1994; and particularly Weber 1922/1978). Such situations are increasingly viewed from a life-course perspective whereby parents strategize and manage their living situations, including their income sources and allocations, toward family well-being in general and child well-being in particular (Furstenberg et al 1999), albeit with varying rates of success. In this paper, we analyze family management strategies and practices in terms of parents' inclinations and abilities to provide the basics and to develop children's human, social, and cultural capital (Coleman 1990; Lin 2001; Bourdieu 2001, respectively; also, Furstenberg 2005; Parcel, Durfur, and Zito 2010) in the context of economic downturn. Development of all forms of capital pertains to processes that occur over time, which makes even the short-term longitudinal analysis presented here potentially informative.

We first briefly examine selected past research on how families' financial situations affect their children, and then describe our research procedures before turning to the findings. The responses by parents to protect their children's opportunities, lead us to speculate in the final part of the paper about the longer-term effects of economic downturn on the economic and educational mobility of children in middle-income families.

Intergenerational effects of family income on children

A considerable body of research has been devoted to examining the *inter*generational effects of families' economic situations on children's educational and employment futures, beginning with Glen Elder's (1999) seminal finding that fathers' job loss during the Great Depression negatively affected the mobility of their sons. However, subsequent work focused more on whether the effects of parents' income-related actions and behaviors on children are direct or indirect, that is, on *intra*generational family processes. For example, one strand of research, based on what is often called the *family stress perspective* (McLoyd 1998; Mistry et al 2002; Strohschein 2005; Yeung, Linver, and Brooks-Gunn 2002), finds associations between families' economic situations, parenting behaviors, and child outcomes, such as school achievement or behavior. Most of these scholars suggest that the effects are indirect and are mediated through parents' mental health. That is, if the economic situation causes the parent great emotional distress, the distress tends to be passed on to the children, usually in the form of harsh or inconsistent parenting practices. These practices in turn negatively affect children's health or school performance and behavior. However, most family stress research has been conducted among families that live in inner cities rather than in the suburbs, which is our site and where economic distress has recently increased (Kneebone and Garr 2010).

From a somewhat different direction, Voydanoff (1990) suggests that a structural perspective on inter-

and intragenerational responses to economic challenge is also necessary (see also Haley-Lock and Shah 2007; Iversen and Armstrong 2006). Voydanoff identifies the role of the labor market as mediator between family distress and children's psychological and achievement outcomes. She highlights what she calls *economic deprivation*, which she defines as "the inability to meet current financial needs and the loss of financial resources and income over a period of time" (p. 1103), and as "the loss of income because of employment instability" (p. 1104), both of which are rife during a recession such as the latest one. Although her focus is on how the labor market affects family relations rather than on children's outcomes per se, her emphasis on the role of employment is relevant to our inquiry.

Finally, Furstenberg and colleagues (1999) integrate process (parenting practices) and structure (aspects of economic opportunity) when they examine education pathways of successful adolescents aged 11 to 14 in a mixed-income sample of Philadelphia families. In that research, parenting practices composed only a portion of the ingredients that produced successful development in early adolescence. More generally, Furstenberg and colleagues' focus on *family management* refers to how parents manage their family lives and the external world: in particular, whether and how parents engage in multiple and concurrent strategies on behalf of their children's current and future development. Of relevance to our study are the strategies that parents use to manage family life and children's futures and whether such strategies are able, in the context of economic downturn, to develop the human, social, and cultural capital that adolescents need for the futures the parents have in mind for them.

Moreover, with a few exceptions (Conger, Conger and Elder 1997; Furstenberg et al 1999; Land 2010), research on family income and child outcomes has focused on the experiences of children of preschool and elementary school age, rather than on adolescents, as ours does, and on children in poverty-level or near-poor families, rather than on those in families with middle incomes. Further, in contrast to most prior research, our study is longitudinal rather than cross-sectional in design. Uniquely, these data were collected at the beginning of the recession, when its full effects were not yet fully visible, and between twelve and eighteen months later when the recession was in full bloom. Accordingly, our aim is to explore the links between family income in the midst of a recession, and parental responses or management strategies that are commonly related to survival in the present as well as to longer-term social and economic mobility. We acknowledge that an eighteen-month time span is short for study of longitudinal processes, but we hope that the interview detail in the findings will augment earlier inquiries and foster future ones.

Research Procedures

When the Great Recession officially began in December 2007, we had already launched a comparative study of middle-income families in the United States and Canada. The study was designed to examine how national policies might buffer some of the hardship in families with moderate earnings[i] (Furstenberg and Gauthier 2007). The families in this report comprise a longitudinal subset, embedded in that larger cross-sectional, two-country, multi-site, mixed-methods study, with the attendant benefits of multiple modes of inquiry and of inquiry over time. The families live in a suburban town of nearly 100,000 in the greater Philadelphia area (Pennsylvania, U.S.).

In spring 2008, parents in 238 families who had been recruited through the town's public middle schools (grades 6–8) completed a short survey about how well they were doing economically. All families had at least one child in middle school. In spring and summer 2008, we randomly selected and personally interviewed at least one parent in 31 families from two middle-income categories (see description below), whom we call the *study parent*. To assess how the families were doing as the recession deepened, we re-interviewed 25 of the 31 families in summer 2009[ii] and interviewed five additional families in fall 2009 that we selected randomly from the original 238 survey responses[iii].

For the 2008 interviews, the families were selected according to reported earnings of either $45,000–$60,000 or $60,000–$75,000, which we designated as middle income. Although there is no consensus in the literature about how to define middle income (FinAid.org 2010), we used the range that other scholars employ, which is family income

that falls within 75% to 125% of the median family income (Birdsall, Graham, and Pettinato 2000; Pressman 2007). According to the 2008 American Community Survey/1-Year Estimates, median income was $63,366. Using the 75-125% metric, the range is $45,136 to $75,226. With adjustment for family size, the 75-125% range became $45,136 to $90,000 (Personal communication with Anne H. Gauthier, University of Calgary, August 19, 2010). Thus, in fall 2009, to more closely match the sample that had been recruited in the other U.S. site (Tacoma, Washington) and the equivalized 75-125% range, we randomly selected and interviewed five families who had reported incomes of $75,000 to $90,000 on the 2008 short survey. Overall, a broadened classification of families as "middle income", allowed us to examine sources of family financial security and insecurity in 2008 and how these led to strategies and prognostic possibilities over the eighteen-month time period.

In both years, interviewed parents also completed longer, semi-structured questionnaires. Income group data in this report derive from those questionnaires, but quantitative findings are reported elsewhere (e.g. Gauthier, Budd, Furstenberg and Pacholok 2010). The findings in this paper, consistent with our attention to family management strategies and practices in the context of shifting economic conditions, derive from qualitative interviews that reflect the experiences of 30 families[iv]. These interviews lasted from one to three hours and were conducted by the first author of this report (2009 only), the second author (2008 and 2009), and an additional researcher in 2008 only. The families received modest honoraria for interview participation, and study procedures were approved by the University of Pennsylvania Institutional Review Board. We digitally recorded, transcribed, and analyzed the interviews with the help of *Atlas.ti*, a qualitative analysis program, to ascertain similarities and differences across families' experiences and views. Given the small scale of this analysis and the short longitudinal time span, the results are merely suggestive.

Family Management Strategies and Practices

Typically, parents in the U.S. as elsewhere focus on providing for their families in two main areas: 1) financially, providing living space, food and clothing for the family's immediate needs, at a minimum; and 2) providing for their children's current and future education. Parents try to satisfy these provider goals through decisions and actions that we call family management strategies and practices. Such practices are aligned theoretically and often concurrently with concepts of financial, human, social and cultural capital. We present the results here in the form of parents' stories, that illustrate what happens with their provider goals in the context of economic downturn.

Providing financially for the family

Families' income and finances over the study period changed in multiple and often overlapping domains, such as employment status, employment conditions, and savings, emergency funds and debt, all of which impacted the amount of income available to parents toward their goals and practices. To compensate for financial losses, parent strategies included refinancing a home, thus using debt as a safety net, altering spending patterns, seeking a second job, and remarriage, as will be seen through the parents' stories. We focus on the plusses and minuses of two common compensatory strategies, refinancing and spending adjustments, at the end of this section.

***Employment Status*: *John and Alex's Story*[v]**

In 2008, all the parents who wanted paying jobs were employed. John and Alex, parents of two adopted children with special needs, were employed full time, but *both* parents lost their jobs in January 2009. John and Alex were architecture and real estate professionals respectively, in a 26-year gay relationship when they adopted their then (2009) 13-year-old son and 9-year old daughter in 2005. In spite of state adoption support of $12,000 annually, John reported a 2008 income of $45,000 to $60,000 in 2008, but his response may have been based solely on *his* income since the family was not eligible to file jointly. Alternatively, Alex's income may have been declining throughout 2008 as during the summer interview he had expressed concern that the real estate market would begin to falter, as was already the case nationally (MPIP 2010):

"The economy is in such a state of turmoil right now. My office, because we're a real estate

> office, we're running things very close to the vest right now as far as money coming in. Right now [summer 2008] things are fine, but we don't know what it's going to be like in November and December when nobody's buying houses. Am I going to have a job in three months"?

John, on the other hand, was confident that his architecture position was secure because the firm specialized in medical facilities, which he expected would always be needed.

Having waited for a long time to be parents, John and Alex were deeply dedicated to their children's physical and educational wellbeing. Despite the children's special learning and developmental needs, John and Alex's educational goals for them, that both children would finish high school and that their daughter might attend some college, remained constant over 2008-09. To these ends, in 2008 they used their adoption support money for the children's daily needs, and augmented basic sustenance actions with capital-building activities such as season theatre tickets and summer camp. By summer 2009, however, John and Alex reported family income in the same range as 2008, but now from Unemployment Insurance (UI). Their greatest single financial burden was health insurance. In 2008, before John and Alex were laid off, John's firm had provided health insurance coverage for domestic partners. This was very fortunate in that both men endured some serious illnesses during the period. Once John became unemployed, he was unable to cover Alex with his COBRA policy[vi], which meant that both men had to buy individual policies. As such, their health insurance costs more than tripled, going from $350 a month (coverage for both) to $800 a month for Alex and $400 a month for John: $1,200 a month total. As a result, Alex had not taken a required daily medicine for a couple of months.

In light of these financial strains, one of John and Alex's survival strategies in 2009 was to curtail the children's activities. As John said ruefully, "We did have them in the local YMCA summer program [last year], which we just can't afford to do this year." Fortunately, their daughter was just under twelve, which seemed to be the cutoff for state help for special needs children's summer activities; unfortunately, their son was 13 and no longer eligible for state-aided summer enrichment. Other financial strategies included turning "vegan out of necessity" to avoid spending money on meat, giving up theatre tickets, using private food banks, using credit cards sparingly, and buying in bulk. In effect, these strategies constrained the parents' ability to provide extra human and cultural capital for the children.

John and Alex's primary financial survival strategy, however, had been to religiously save money in their "rainy day fund" – a strategy that they had followed for virtually their entire life together and which had allowed them to weather earlier recessions. In 2008 they expressed complete faith that their fund would be sufficient for the future. In 2009, they were worried about the long-term financial effects of the recession, in part because their ages of 55 and 49 placed them in a demographic group that finds it increasingly hard to find new or financially satisfactory jobs, consistent with national patterns (Haveman, Heinrich and Smeeding 2011). While they energetically and optimistically sought new niches for their talents, including using the federal one-stop career centers, their anxiety and concern about their ability to adequately support their children was palpable in the 2009 interview. As John said, "We've been through this recession thing before, only this one's bad, not like the others, which were bad but not as bad as this one."

John's and Alex's UI money was scheduled to run out in January 2010. They expected that their substantial rainy day fund would be depleted about six months after that. Nationally, when UI benefits are exhausted, families' consumption falls, re-employment rates decrease, and the incidence of poverty rises (von Wachter 2011, p.1). The fact that in 2008 these parents' savings were one of the highest among the study parents, reminds us that sole reliance on savings is limited as a long-term strategy, especially when parents are in a hard-to-employ demographic, and particularly when policies, such as filing taxes jointly and accessing affordable health insurance coverage, exclude certain family forms.

Employment Conditions*: *Susan's Story

More commonly, employers reduced workers' hours or days at work (Lambert and Henly 2009), which lowered family incomes, or required employees who remained after layoffs to work more hours, which sometimes led to more income but also increased

parents' time stress, and generally did not compensate for the concurrent increases in everyday costs. As one parent bemoaned, "Everything's going up except my paycheck." Equally problematic for these families, many employers reduced or eliminated the possibility of working overtime. Overtime income had previously provided vacations for some families, religious-school tuition for others, and general subsistence for most, as Susan's story illustrates.

Susan is a 49-year old married mother of two children, aged 14 and 13 in 2008, who worked full time as a school secretary for $18,000 a year (in 2008) because of the school district's "great benefits." Her son had earlier been diagnosed as autistic, but was mostly mainstreamed by 2008, and her daughter's earlier ear surgery had resulted in some permanent hearing loss and special learning accommodations. Susan graduated from a community college in 2008 with her associate's degree in education and wanted to pursue her bachelor's degree to upgrade her career and income. Even with such a degree, a job in the school district would not be high paying, as her comments below inform us. Her husband David was a truck driver for a home materials supply company. They earned between $45,000 and $60,000 a year in both 2008 and 2009, so even in 2008 this family felt the results of rising costs, as Susan reported: "Since January, there's been no extra money...it's being eaten up by the cost of food and gas...it's just the economy; it's strictly the economy." As a result, Susan's daughter was not able to participate in her usual summer enrichment activities or take desired guitar lessons for $75, which reduced the human and cultural capital those activities could bring. Susan's daughter had, however, been part of the elementary and middle-school band for the past five years and Susan hoped she would be involved in the high school band in fall 2009, though it would be a class not an extracurricular activity, which may reduce its appeal to her daughter.

In both 2008 and 2009, Susan was adamant that her children would obtain four-year college degrees, even though Susan's own goal of earning a bachelor's degree was put on hold in 2009 because of the recession: "The recession kind of dictated that we're going to have to wait a little bit longer for me to go to that four-year [institution]". Her children's pathways had been stretched out as well, for by 2009 Susan anticipated that if the children did pursue four-year degrees, it would probably take them six years financially—largely a result of how the downturn had affected David's earnings, as she related:

> "It's been a rough year... I didn't realize how rough until we sat down with the accountant to do the 2008 taxes, and then it hit us right in the face. We knew that we were having difficulties. My husband had lost most, if not all, of his overtime, and when we sat down with the tax accountant, it was obvious, $8,000 less last year...90% of his overtime. So that was a really heavy hit.... We told our kids they were old enough, they weren't six years old anymore, this is the way it is... We don't go to the doctor's every time you have the sniffles....I actually went back to school to save my job, because of No Child Left Behind, and working in a school I needed to be certified and there was no certification at the time, so I decided to get the Associate so nobody could say this certification is no good. But as a teaching assistant in a local school district, you're making poverty... Even if I got my four-year degree and went into the public education system, I'm still in my local district only thinking about making $35,000 a year.... The biggest thing that I kept trying to remember coming into this was we lost $8,000 last year. That, to me, is the thing that if it's happening to me, it's happening to a whole lot of other people".

In addition, David was quite concerned about layoffs on his job, as there were rumors about branch closings and, for those who remained employed, no cost of living increases. David's company was particularly hurt by the downturn in the construction industry and related house building and repairs –a major industry sector that is not expected to rebound for years (O'Leary 2010). In fact, because David's employer reduced overtime possibilities so drastically, both parents were looking for second jobs, though unsuccessfully so far, in order to better manage the first aspect of parental provision – mortgage (shelter), clothing, and food.

Savings, Emergency Funds and Debt: *Mary's Story*

The ability to amass savings and emergency funds provides another lens on parents' financial challenges and strategies (Tufano and Schneider 2010) as well as on families' potential economic mobility more broadly (Cramer et al 2009). As Susan's experience illustrated,

most families in our study reported reductions or depletions in at least one area of savings between 2008 and 2009, such as bank savings accounts, Individual Retirement Accounts (IRAs), or emergency back-up funds, and often in more than one. Moreover, where possible, savings strategies had been oriented to both children's education and parents' retirements. In 2008 the children's future needs came first, but by 2009 parents were increasingly fearful that their retirement accounts would be lacking.

In addition to depleted savings over the 2008-09 period, virtually all the parents reported increased levels of debt, primarily from credit cards, which had become a largely unmanageable economic challenge for low- and middle-income households across the U.S. during the downturn (Garcia and Draut 2009; Pressman and Scott 2010), including many families in this study. Strategies such as adding a second income, either by a second job, which Susan's story revealed as quite difficult to attain, or marriage/partnering, helped some to decrease or avoid adding to their debt. However, marriage wasn't an automatic financial boon, as Mary's story illustrates. Her story details both the tenuousness of middle-income families' savings accounts and the tension parents experience between saving for their children's futures and their own.

In 2008, Mary was a single mother of two children, a 13-year-old daughter and a 2 ½-year-old son. Mary's mother, in her early 70s, lived with her, which helped considerably with Mary's daily hour-long work commute each way but was also a strain because the mother had some chronic health problems. Mary told us she had earned about $40,000 in 2008. Building on a couple of years of college after high school, Mary was currently taking one online course a semester toward her Associates degree in business administration, which her job paid for.

Mary was very focused on providing educational and neighborhood stability for her daughter and acknowledged the importance of extra-curricular activities for skill-building and enrichment (i.e. human and cultural capital) and, implicitly, as bridging social capital. She is the only parent in the study who verbalized the importance of "connections" for her children's futures: "I want her to know the same people [referring to good friends throughout her school grades] because I did not. It's a lot harder to get through your life when you don't have those resources." At this point, Mary's educational goals for her children were to "graduate college," either two-year or four-year.

Mary's situation was notable for the rather large educational fund she had already set up for her children's education, "a small secondary IRA of about $11,000," but even in 2008, Mary's contribution pattern was changing for financial reasons: "I have backed off on how much money I'm putting in there, because with the economy, gas, and energy crisis….I need the cash to live on, so I think there's $50 a month going into that IRA." Mary's strategy was that her daughter would "think about saving and working too," which recent research finds increases college attendance among children in families such as Mary's, regardless of family income or academic achievement (Elliott and Beverly 2010).

Mary also tried to save for her own retirement, which by 2009, despite the fact that she had remarried in the interim and the family income increased to between $75,000 and $90,000, had become more difficult. As Mary noted, "financially it has been a little rough since last year." She and her husband had two incomes but also two sets of expenses, and most of the debt and costs were pre-marriage: "So my husband and I now find ourselves in a position where every last penny that we have is going towards historical things." Strategies that Mary invoked to deal with persistent financial challenges included refinancing her house, which produced a higher rate of interest but some much-needed cash, and stopping her online education, partly as a job-saving maneuver because she didn't want to cost the company money and risk losing her job "when the economy hit rock bottom." Employees in Mary's firm did not receive a raise or a bonus in 2008/09, which meant a loss of between $2000 and $3000 dollars and correspondingly less to deposit in her retirement account.

As mentioned briefly in these stories, the families' strategies to contend with the financial impact of the economic downturn took two main forms: reducing debt through refinancing the home and reducing the financial outgo by spending less or differently. Typically these strategies took place concurrently, which we examine now in more detail.

Refinancing Strategy: *Stephanie's Story*

Refinancing a home mortgage with a lower interest rate was a common strategy parents used to manage their general financial challenges. As part of refinancing, families often borrowed an additional sum of money, such as $5,000 or $10,000, to use for household or other expenses. As such, refinancing can be a constructive short-term, safety-net strategy[vii], even though it generally lengthens the term of the mortgage. In the longer run, the volatility in employment and income that is typical during economic downturn (Dynan 2010) can lead to increased debt and a lower family credit rating. A related strategy was taking out a home equity loan whereby a family qualified for the loan by using the equity they hold in their home as collateral. Home equity loans can be either a lump sum or a revolving line of credit, but if they are not repaid on time, the creditor can require that the property be sold. In 2008 none of the families talked about foreclosure, but by 2009, many parents reported foreclosure sales in their neighborhoods, downward valuation of their properties, and fear of foreclosure for themselves.

Foreclosure notwithstanding, at least half the parents had recently used refinancing or home equity strategies to meet their family's expenses and children's needs. For example, Stephanie, a divorced mother of three daughters, ages 18, 16, and 12 in 2008, received no child support and also tended daily to her chronically ill father who lived in a nursing home. Stephanie has been a nurse in an area hospital for 30 years. In 2008, with an annual income between $45,000 and $60,000, she consolidated her mortgage, real estate taxes, and her credit card debt into a single $30,000 home equity loan that she pays monthly. Even in 2009 when her income increased to between $60,000 and $75,000, current and upcoming college costs for two of her daughters and her monthly loan payment ate up virtually all the increase. Stephanie's goal was to complete the loan payment by the time her youngest daughter goes to college, but she acknowledged that this strategy leaves little room for emergencies in the interim:

> "We'll see....I feel like if something happened to me and I got 80% of my pay or 70% on disability, I would probably sink, and that's the insecure part 'cause there's nobody out there that can help me".

Given that the home is these families' primary asset and that equity strategies are based on the assumption that house values will continue to rise, which has not been the case during this recession, many families like Stephanie's are thus gambling on their financial and their children's futures for short-term benefits.

Spending Strategies**:** *Amy's Story*

In 2008 only a few families found it hard to afford what their children needed, but in 2009 many more families – in fact virtually all – found such provision difficult, due mainly to the recession or the recession plus related management or budgeting problems. Given that annual child-rearing expense estimates nationally range from $8,330 to $23,530 (in 2009 dollars) for middle-income families like those in this study (Lino 2009), and that such expenses are highest for families in the urban Northeast, it is not surprising that almost all the families had curtailed or become even more strategic about spending by 2009. Families commonly limited or eliminated spending for entertainment, eating out, zoo membership, YMCA membership, clothes, or children's instrumental or dance lessons—notably, activities that bolster human, social and cultural capital. Amy's spending story is one of the most dramatic but also typical of the strain families reported in the recession climate.

In 2008, Amy and Marcus's daughters attended dance classes for "ballet, tap, jazz, modern, African," which they had gone to "all their lives." The parents valued this activity for the daughters' learning, for what it could lead to in their futures, and for the pride they felt in their children's accomplishments. Earning between $75,000 and $90,000 in both 2008 and 2009 from their full-time jobs plus Marcus's second part time job, the parents were still able in 2009 to engage in their usual summer vacation activity, which involved extended family, and take occasional weekend trips, but "with subtle differences...[because] we're not as comfortable [financially] as we were a year ago." The parents were down to one car from two in 2008 and by fall 2009, Marcus's hours were cut back at his second job. Overall, Amy found that expenses had risen but their incomes had not. As a result, Amy decided to eliminate the girls' dance classes. Amy had earlier reasoned that she expected that both daughters

would go to college, but because they didn't have any money saved for that, she thought that dancing might facilitate her older daughter's college entrée:

> "I just had visions of her going further with it [dancing]. And she said, 'I'm not going to be a dancer, you know, I do it, I'm good at it, but that's not what I want to do.' So I had to say, 'you know, this isn't what you're gonna do, we need to find what that is, because we don't have money'...To put it blankly, we need scholarships".

Countering Amy's reasoning, however, the tenth-grade daughter will not be able to show college admissions analysts her consistency and persistence in a demanding activity such as dance. Potentially worse for admission chances, neither daughter had substituted school- or community-based extracurricular activities for the dance classes. And in a challenge parallel to what other parents experienced, Amy wished she could return to complete her four-year college education, having returned for additional credits toward her bachelor's degree about five years earlier, but rued that furthering her education now wasn't financially feasible as her daughters were nearing college age:

> "It's like, it's something that I want to have, but is it practical when I have these girls like because their future is brighter than, you know, than mine at this point. It's, you know, it's just a, it's a trade-off and I have to work out within myself. I, I haven't come to a remedy for that yet".

Parents' spending strategies also included economizing and cutting back on consumption, including food, goods, and gas. They distinguished anew between "wants" and "needs," asked their children to contribute to their own purchases and develop their own savings accounts, and tried to learn or improve budgeting and money management practices. What little vacation was planned, typically involved family, such as staying at a grandparent's trailer at the shore, rather than the cultural capital-enhancing vacations of the past, such as a cruise won by one parent and out-of-state travel.

In a few instances, prior spending problems improved in 2009 over 2008. An inheritance eased previously frugal spending patterns for one family and also fostered their consumer spending and savings. Job promotions eased a few families' spending patterns, but were double-edged because promotion to management generally meant ineligibility for overtime. In addition, many parents' concern about their own financial futures meant that any extra money went into retirement accounts versus into children's college accounts. As one parent put it, "She can get a loan for her education. I can't get a loan for my retirement."

Overall, the parents' financial strategies can be considered only moderately effective. The strategies buttressed parents' ability to provide adequately for children's current needs, even as family incomes and employment conditions worsened, but they reduced parents' ability to build additional human, social and cultural capital for their children's futures.

Providing for children's education: strategies and practices

Providing for current and future education

Providing for children's education was a priority in all the families. Parents focused most strongly on their children's current education, even though their emphasis on extracurricular activities inadvertently might foster future possibilities. Strategic thinking about how to fund children's future education, however, remained generally underdeveloped. In the following stories, as in the earlier ones, aims and strategies are interwoven, but Maria's story at the end of the section describes one of the few positive funding situations.

Children's current education

In 2008, most of the families told stories about choosing their home and neighborhood at least partly, if not solely, on the basis of the reputation of the local schools. Some had even moved to the suburb from Philadelphia to enhance their children's school experience. In 2009, parents remained satisfied for the most part with their choice of neighborhood and, particularly, its local elementary school. Most also found the neighborhood middle school to be hospitable and adequate in quality. Many expressed concern about the size of the single high school, yet at the same time heralded its many opportunities as long as children didn't get "lost." Parents volunteered actively in the elementary schools if they were at-home mothers, or if their

work schedule allowed, and many mothers chose to work in the school district, even though the pay was extremely low (see Susan's story, earlier), in order to have the same schedules as their children. Few parents reported children's behavior or performance problems, although this could be an artifact of which parents agreed to participate in the interview portion of the research.

As a whole, parents focused intensively on sustaining children's participation in extracurricular activities. In 2008 most said that their children were involved in school-based and/or community-based extracurricular activities—predominantly sports but clubs, music, and drama activities as well. Most school activities were free or had only a small equipment fee, whereas costs for outside-of-school activities ranged from $150 a season to $8,500 a year for the two children in dance described earlier in Amy's story. Even in 2008, many families reported difficulty affording the cost of their children's activities, especially when two children were in high school or middle school at the same time. By 2009, limiting the number of activities was a relatively common strategy, as Elizabeth described: "There's just not enough money for extracurricular stuff...I want my daughter [age 10] to be in something, but we can't afford it." Elizabeth's 13-year-old son really wanted to learn golf, but attended a game club at the local library instead.

For the most part, even in 2009, parents chose to support at least some of their children's extracurricular activities, often sacrificing their own needs and wants in the process. Most valued these activities because they "keep kids out of trouble." Others felt that such activities taught children skills and provided entertainment and a sense of community for the parents. None of the families associated extracurricular activities with their child's grades, and none explicitly associated such activities with building social networks for their children's futures.

Children's educational futures: *Samantha's Story; Lola's and Martina's Observations*

Parents' views about and strategies toward their children's educational futures, were far more complicated than their thoughts about fostering current school experiences. At base, all the parents associated post-secondary education with the ability to get a good-paying job,[viii] as others also find (Danziger and Ratner 2010). Indeed, over the eighteen months, a growing number of parents said that they expected their adolescent child to go to college, and often all of their children. Although in 2008, two-year programs, trade schools and the military were mentioned quite frequently alongside ideas about college, in 2009 the focus was strongly on four-year colleges and bachelor's degrees. Parents attributed their upgraded schooling goals for their children, to experiencing greater fear of layoff because of their own perceived educational insufficiencies.

Samantha's comments were typical of this pattern. In 2008, Samantha's husband Dan was a strong proponent of college for their then 14-, 12-, and 5-year old children, but Samantha's opinions were quite opposite: "I'm not a huge advocate of college. To me it's the money issue. It's so much money to have your kids go to college. I just think it's ridiculous.... if they went to a trade school, that's fine." Neither Samantha nor Dan's parents went to college, though Samantha started at a community college and dropped out before the first semester ended. In 2008, she was an at-home mother with a $100/week child-sitting job.

By 2009, however, the family picture looked very different. Dan had developed an intestinal disorder that limited how much he could work. Because Dan had previously worked the equivalent of nearly another full-time job doing "side jobs," the family's annual income had increased from between $60,000 and $75,000 in 2008 to "about $79,000 a year" in 2009 before his health problems. Dan's now-chronic health concerns acted as a wake-up call for Samantha, in that she now wanted the children to have direction. She knew if something even more dire happened to her husband, she'd be in deep financial trouble, because she had no career direction or skills, and she did not want her children to ever be in the same predicament:

> "When Dan got sick I really, I mean... So initially [2008]....I wouldn't care if my kids went to college or not, because I still feel like you could get a good job, but now [2009] I really do want my kids to have some kind of a

degree...because nobody can take that away from them...I want them to be self-sufficient".

Paradoxically, in contrast to rising educational goals for their children, parents also felt that their hopes were less and less realistic. In 2008, most thought their goals were financially achievable but many fewer held that view in 2009, as Lola's comments suggest:

> "Yeah, I think financially it's too hard for me to say...Like we're maintaining. It's not possible at this point to be putting away money for that, so we'll see how things go as the time goes on. I mean I've got four years, four years. It will go quick". (*Lola, age 44, divorced, three children, ages 13, 13 and 10 in 2009, works full time. Family income $45,000 to $60,000 in both 2008 and 2009).*

Countering the rising educational goals and perhaps reflecting families' altered financial realities, by 2009 some parents expressed ambivalence about the financial benefits of a four-year college education, and a few lowered their expectations because they'd seen job loss among professionals, while they or their spouse had retained a trade job, as Martina noted:

> "I don't know if they'll end up in college or not. I'd like them to. I mean, with my two older kids it was like, you know, there was no talking about it, they had to go, but I've changed my mind that way... When a lot of people were getting laid off from some pretty big corporate jobs, my husband [a self-employed construction contractor] was still working. And a couple of the people who lived around here said they wished they could do what Jim did, because there was still demand for that". (*Martina, age 49, six children, ages 30, 28, 16, 14, 12, 10, worked part time at two nursing jobs, but had no post-secondary degree. Family income $45,000 to $60,000 in 2008; $90,000 to $105,000 in 2009 due to a doubled number of family earners).*

Martina's observations were echoed by national reports about the doubling of unemployment rates among college graduates between December 2007 and December 2009 (Hartmann, English and Hayes 2010). Finally, given the normative emphasis in these families on providing educational opportunities, savings strategies were severely underdeveloped. Only in rare cases, such as Maria's story illustrates, did children's college futures seem relatively financially secure.

Savings strategies toward children's educational futures*: *Maria's Story

In 2008, most parents expected to use general savings to pay for children's college costs, but by 2009, many fewer did. Some parents had not even thought about how they would finance their children's future education, although one parent hoped he'd hit the jackpot, another planned to use the children's piggy banks as a savings start, and one mother intended to return to work. The difficulty parents had in maintaining savings accounts described earlier in Mary's story, for example, was particularly relevant to children's accounts, which were often the first to be raided, though in some cases they were sacrosanct.

Even in families that struggled financially in 2009, grandparents' assets and wealth offered strategic help for children's futures. In Maria's family, for example, total earnings remained between $45,000 and $60,000 during the recession years despite the fact that she worked part time and her husband worked full time. In both 2008 and 2009, the parents struggled with the extra costs for dances, school trips, and other special events for their two children in middle school. Lessening the level of cultural capital available to the children had been one of the parents' financial strategies over the past year, as Maria reported: "Even the kids' activities, what they can do and when they can do it, it always comes that way because money is just not there." In the 2009 interview, Maria further described a roller-coaster of challenges over the past year and the implications of that for their family.

> "When we were here last time [2008], I had just started with a new job. Um, and it was an upswing for us because it was more money and it really was helping us out. And all through the summer it was a really good thing. We seemed to be on a little bit of an upswing because of that extra money. Once we got into the holidays and after the holidays in January (2009), it seemed to be...things were starting to hit the down, gas prices were up. Even though I was making more money...It really started to seem like I was back to where I was before I had this job.... and with

school activities, I mean, I just didn't realize how expensive with two kids in the middle school the activities were. And we leveled off and then we started hitting that little bit of a down, a down thing. My husband got some overtime. We came up a little bit like, probably February/March we went up again, and then his company started making cuts and the overtime stopped. And so now here we are back again, back on the down end of it. I think we've leveled off. I don't think we've really hit really down. I think we're a little above where we were at this point last year [[which is basically the tips of their noses above water]].... I mean, we did a lot of smart things. We paid off our debt, so we're in a really good position where, you know, we don't have credit cards...We have one credit card we use. We pay it off when we use it and we just have our bills, which has really helped us out a lot, so that's good".

Counterbalancing these struggles and rare among the study parents, Maria's father-in-law had established sizeable funds for the children's college needs, which may make the parents' current financial dilemmas less dire for the children's futures.

"My father-in-law has been very generous. He's set up funds for all three of them, um, that are pretty substantial, and probably by the time that Dominic (age 14 in 2009) goes to college...If Penn State doesn't go up significantly, what my father-in-law has put aside for him should pay for about a year and a half, which would be wonderful....And the same thing for Susan (age 13 in 2009). And then for June (age 8 in 2009), who knows what's gonna happen by the time that kid gets to school, you know.

Implications of economic downturn and parent strategies for children's educational futures

This research on "families in the middle" extends the recent findings of Irons (2009) and Lovell and Isaacs (2010) about recession-induced financial challenges on formerly non-poor children and their families, accounting for both structural (e.g. parents' income and employment) and process (e.g. parents' and children's management strategies) phenomena. All parents experienced resource restrictions in the economic downturn that touched their family members. In response, most families deliberately tried to sustain provision of basic needs and maintain their children's current educational opportunities and activities. Because of these adaptations, we found less evidence than might be expected that the Great Recession was reducing parental investment of time and resources in their children. Still, none of these middle-income families escaped the economic downturn unscathed. In most, future-oriented building of cultural capital, such as through travel, a full array of school-year extracurricular activities, and summer enrichment ventures, was constricted or eliminated by recession-induced financial challenges due mainly to income changes and employment conditions.

As the recession deepened, fewer parents believed that their expectations for their children's post-secondary activity would be realized, which is particularly concerning because of the growing link between education and later-life returns to employment. In addition, most study parents regretted that they had delayed or depleted savings, in general and for older children's post-secondary education, such that financial support for their younger children's educational futures was now uncertain. Still, most parents maintained or increased their valuation of a college education (generally four-year) for their children, even if they had few concrete ways or plans to finance it. They associated this heightened valuation with their own and others' experiences during the economic crisis, such as fear of layoff, job loss, and inability to seek a higher-paying job because they lacked a college credential. And although some technical and trade credentials are expected to yield moderate incomes in tomorrow's labor market, the highest incomes are still forecast for those with four-year degrees, especially "among individuals (such as many children in our study) with a low propensity for completing college" (Brand and Xie 2010, p. 293).

The full impact of the economic crisis on the study children's future educational attainment can only be surmised at this time, particularly from a small-scale study such as ours and because the recession's effects continue to be widely felt (McNichol, Oliff and Johnson 2011). The worst case is that the recession's constraints on full development of children's human,

social, and cultural capital will result in decreased economic attainment throughout adulthood. A more optimistic scenario, which could be examined by extended longitudinal inquiry, is that middle-income parents' vigorous attention to their children's futures overall, as evidenced by the study parents' management strategies, can provide at least basic capital for children's educational and economic futures. One caution, however, is that this recession leaves limited room for many parents to improve their own educational futures with new and more rewarding jobs, and for building financial support for their later years. Indeed, Susan and Mary and other parents in our study, acknowledged the painful dilemma between helping their children to succeed in school and protecting their own limited assets. The parents' need to choose between their children's educational futures and their own, may further limit younger children's educational futures by decreasing family mobility.

In times of major change, and particularly financial change, even a relatively short-term longitudinal panel study can reveal a rich range of family responses such that opportunities, costs and life chances are better understood. The next step is to ascertain with more certainty, what the long-term effects of recession-induced reductions or constraints are on children's capital development. At this point, our findings suggest that the American approach to off-loading much of the cost of higher education onto families who are economically stressed, which occurs in middle-income families more often than is generally recognized, is not viable if we hope to maximize the number of children who will receive mobility-enhancing post-secondary education.

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Endnotes

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[ii] We were unable to locate five families and did not re-contact the sixth family whose contact parent had been extremely ill at the 2008 interview.

[iii] Other than income, which was a selection criterion in both years, the 2008 and 2009 interview samples are substantively very similar and both samples are similar to the 238 respondents to the 2008 short survey.

[iv] Twenty-five families were interviewed in both 2008 and 2009, yielding prospective as well as retrospective data. Five additional families were interviewed in 2009 only, but had provided responses to the 2008 survey and retrospective commentary on their lives since then in the 2009 interview.

[v] All names are pseudonyms

[vi] COBRA (Consolidated Omnibus Budget Reconciliation Act of 1986 health benefit provisions) is a federal policy that "provides certain employees, retirees, spouses....the right to temporary continuation of health coverage at group rates" (Retrieved June 17, 2011, from http://dol.gov/ebsa/pdf/faq-consumer-cobra.pdf

[vii] Thanks to Daniel Meyer, University of Wisconsin-Madison, Institute for Research on Poverty, for urging us to also mention the positive aspect of refinancing.

[viii] The exception to this statement is that most parents of the children diagnosed as special needs expect that a high school diploma will probably be the highest level of education their children can reach.

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Family caring and children's reading and math skills

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Abstract

This paper investigates the influence of "family caring" on children's reading and mathematics test scores, controlling for the family's resources. Family caring is the parents' habits regarding nurturing their children; it is measured by the behavior of parents during the pregnancy and infancy of their child. Three hypotheses are developed and are empirically tested using three generations of data from the British NCDS. Controlling for family resources, family caring as measured here, is found to be strongly correlated with children's reading and math skills. There is evidence that particularly low levels of family resources or family caring can be compensated for by larger investments of the other. Since the data cover three generations of the same families, the study documents that the cross-generational correlations in family resources and in family caring behaviors are of approximately the same order of magnitude.

Keywords:

Investments in children, inter-generational transmission, longitudinal studies, cognitive skills

Introduction

The influence of family resources on children's cognitive capabilities has long been documented; it justifies much social policy effort to ameliorate the adverse effects of family economic deprivation on children's healthy development. This paper emphasizes that families differ not only in their level of resources but also differ in their inclination to use those resources in behalf of their children – called family caring. The nurturance of children begins at the earliest stages of life: behaviors of the mother during the pregnancy influence the healthy development of her child. From birth onward, the family plays a pivotal role in stimulating, nurturing, and facilitating the development of skills, knowledge, and habits that promote cognitive as well as socio-emotional development. While the family's resources are surely necessary, their sheer availability does not guarantee that they will be deployed in behalf of the child. This paper discusses the nature of "family caring" and frames the issue of its relevance to the production of skills in children. The concept is distinguished from two other related concepts, one in developmental psychology, "parenting styles," and one in economics, "interdependent preferences."

Analytic Framing

A simple framework for thinking about how skills are generated is a production function of the general nature

$$\text{Skill} = f(C, F, S),$$

where C is a vector of the child's own attributes and actions, F is a vector of family characteristics and behaviors, and S is a vector of school attributes. Various disciplines study effects of elements of S or F on skills but few studies have the data resource to investigate fully the influence of both S and F simultaneously. This paper follows that unfortunate tradition and focuses on the effects of F on children's skills, controlling for elements of C.

While some skills may be acquired without specific effort or investment, reading and math skills require effort in learning, in practice, and in usage to gain the facility assessed in any reasonable test of these skills. The family has much opportunity to influence these skills long before the child enters formal schooling. I assume that no parent would wish their child not to have the skills necessary for competent social intercourse, and these skills surely include both reading and mathematics. But families may differ in the extent to which they give priority to making the effort and sacrificing their time and resources toward this objective. So while all families are motivated to make investments in their children's skill development, subject to the limitations of their resources, the prices they face, and their understanding of how to enhance these skills, the hypothesis proposed here is that families differ in their inclinations and their behaviors regarding the nurturance of their children.

Family resources

The first set of inputs in the child's skill production that is explored empirically is very conventional: the level of parents' economic and personal resources. These include the family's financial resource, one parent's own reading and math ability, and the parents' levels of schooling. The evidence on the association of parental resources and children's cognitive skills is strong and broad: regarding the role of financial resources see e.g., Huston, et al (1994), Duncan and Brooks-Gunn (1997), Blau (1999), Mayer (2002), McCulloch and Joshi (2002), Aughinbaugh and Gittleman (2003), and Taylor et al (2004), among others. For a good summary reference on the "crucial role that parental cognitive stimulation plays in fostering the intellectual competence of young children" see Saltaris et al (2004); for evidence on the association of parents' education and child's cognitive skills, see e.g., Smith et al (1997), Feinstein (2003), and Michael (2004).

In addition to these three key resources, the structure of the family, its stability over time, and the number of and relationship among adults in the family are often hypothesized as having influence, but the evidence is mixed especially on cognitive attributes of children, see McLanahan (1997), Pierret (2001), DeLeire and Kalil (2002). The age of the mother at the birth of her child, birth order, and number of siblings also reflect relevant resources. Convincing evidence shows that resources affect the child's skill level through many mechanisms and are acknowledged to be influential in the literatures of many disciplines (illustratively, see Duncan and Brooks-Gunn, 1997, and Kalil and DeLeire, 2004).

Family caring: the concept

While family resources are often shown to influence the child's skills, they are not direct "inputs" in the skill production function. The evidence adduced is typically a reduced form relationship: families that have higher levels of these resources have children who score better on cognitive tests. The evidence usually does not tell us how the mechanism works that produces this association. The often-unstated argument is that a strong and robust statistical association must imply that having more resources means the child is given more. Few studies actually show the connection between the expenditures and the child's achievement; few document the mechanism by which the parent's income or ability or knowledge influences the child's skills. The point of this paper is that families differ in their willingness to expend their resources on their children, and that this difference is influential and is not random. "Family caring" is the term proposed to describe this parental behavior of allocating resources, energy, and attention to their children; it is a latent construct, there is no single measure of it, but there are many behavioral elements that can be identified and measured.

Most economic models assume that given the level of resources and prices, family differences in spending reflect preferences but these preferences are paid little attention because they are assumed to be distributed randomly. On average, families with higher levels of resources expend more on their children which results in more favorable child outcomes, tracked empirically. The contention in this paper is that family caring is a distinct and distinguishable factor and it too influences the resources devoted to the child. One can conceptualize the partial effect on some child outcome of a higher level of resources, holding family caring constant, and similarly, one can think of the partial effect on that outcome of a higher level of

family caring, holding family resources constant. More of either family resources or family caring is likely to result in more "input" into the child's skill production function and thus to generate more measured skill.

Hypothesis #1

The first of three hypotheses tested below is that *family caring differs substantially among families and does so at all levels of family resources*. One piece of evidence about the extent of variation across families in their inclination to expend resources on their children can be found in studies of intra-household allocation of total current consumption expenditures. As an example, Lazear and Michael (1988) estimate the share of household's expenditures made on behalf of the children and report that on average U.S. households spend about $40 per child per $100 spent per adult, but the variation across households is considerable: the 10%-90% quantile range among families with children indicates that ten percent of families spend as little as $17- or-less on each child per $100 spent on each adult, while another ten percent of families spend $60-or-more on each child per $100 spent per adult. Families differ in the use of their money resources in behalf of their children; they surely differ as well in their willingness to spend time with their children, and to focus their daily activities around their children.

In an inquiry that is somewhat related to this paper, Ermisch (2008) uses data from the Millennium Cohort Study to estimate production functions for pre-school child outcomes. He document that outcomes, both cognitive and behavioral, are strongly linked to family income group. He discusses "what parents do" in terms of educational activities and parenting style. The point here is different. One might expect that parent's education level is a key determinant of both the family's income and the educational activities and parenting style it uses with its children. That common determinant can explain a positive correlation between what parents have and "what they do." But their commitment to their children – family caring – may not be associated with their level of education or their level of resources. While this commitment is not easily or well measured in any data set, this paper uses several measures or indicators of family caring and investigates if it is distinct from family resources and whether it varies within as well as across family resource groups. If so, that fact may have relevance for policy consideration.

Hypothesis #2

The second hypothesis is that, while controlling for the level of family resources, *family caring is strongly, positively correlated with children's outcomes, measured as test scores in reading and mathematics*. The logic of the argument is that the level of the family input into the child's skill production function depends on both the availability of resources and the family's willingness to expend them on the child. A parent's wealth and own ability does not impact their children's skills automatically, genetics aside; the "inputs" into their children's skill production require the commitment to spend the money, the time, and the energy with their child.

To contrast the notion of family caring in this paper with related concepts in other literatures, consider the developmental psychology literature. There, "parenting" is an important focus and styles of parenting (authoritative or authoritarian, for example) are identified and assessed. Saltaris et al (2004) employ a direct measure of maternal teaching, from an observational study, and conclude that their "findings…suggest that within a high-risk sample, quality of parenting provided to young offspring represents an important predictor of their developing competence." (p.112) Parental "involvement" has been shown to be related to children's academic performance (e.g., Georgiou, 1999, Feinstein and Symons, 1999) and some studies have distinguished the involvement of mothers and fathers (see Peters et al, 2004). Flouri and Buchanan (2004) use the same data set as used in this paper and measure parental involvement at age 7 using some of the dimensions used here to measure family caring. In that literature the emphasis is on the description of the parenting styles. The focus is the parenting process and the associated child outcome. By contrast, I want to establish that there are differences in family's willingness to expend resources, differences in parents' habits of sacrificing their time, their convenience, their money for their children. Here, is it not the style of behavior or the tactic of parenting that is of interest.

"Caring" is a term that has also been also used in the economics literature for a very different concept from its use here. In his theory of marriage, Becker (1974, p.328) says "the natural way for an economist to measure 'caring' is through the utility function." In Browning et al (1994), for example, "caring" is the term of choice for describing a utility function in which the adults' utility includes the consumption or utility of the child. There, caring means a degree of altruism, here it means a degree of commitment or willingness to tradeoff some personal benefits in behalf of tending the needs and stimulating the interest of own children.

Hypothesis #3

The third hypothesis explored is that *family caring is a family habit that persists across generations*. The contention is that parents' values regarding family caring are systematically related to their own experiences in childhood and so these values persist within a family from one generation to the next. The experience of the parent when he or she was a child helped form habits and perceptions about how to be a parent, about how to nurture and train a child, and about what level of care-giving and attention and personal sacrifice is appropriate. Families have, and pass along from generation to generation, practices, customs, and behaviors as surely as they pass down recipes and heirlooms. For much the same reason that we see modestly strong correlations across generations in religious affiliation, in political party affiliation, and in occupational choice, the way parents raise children is influenced by the way they were raised. This notion of a habit or a commitment to caring for or investing in children is found in the literature of many social sciences, including economics, i.e., Becker (1991), Becker and Tomes (1986), and Sen (2001), and in psychology, i.e., *Developmental Psychology* (1998), Hauser (1999), Vandell (2000), Belsky (1984), and Chen and Kaplan (2001) among others.

Since the data set used here covers three successive generations, these data permit us to look across the generations of a family to see if there is consistency in the measures of family caring. If so, these family habits constitute the nature, the culture, of that family. In one extreme test of this notion, the test scores of grandchildren are regressed on the family caring behaviors of the grandparents, controlling for resources but not the behaviors of the intervening generation. A positive association between the grandparent's child caring behaviors and the grandchild's test score would support the hypothesis that these caring behaviors persist across generations.

There are parallel arguments in the literature to the contention that habits of parental behavior – family caring – are passed down from generation to generation. Discussions of "family dynasties" and family culture can be found in economics and in sociology while developmental psychology has often focused on the intergenerational transmission of parenting styles, as sketched in the literature review above. There is discussion, as well, of the heritability of parenting behaviors (e.g., Plomin et al, 1994) and the strategic functionality of parenting behaviors across social classes (Lareau, 2003).

Persistence of parenting styles across generations has been a feature of developmental psychology. As Belsky (1984) noted some years ago, much of the focus on intergenerational transmission of parenting was on abusive or unhealthy styles. Recent efforts focus on more supportive parenting styles. Regarding the transmission of constructive parenting, Chen and Kaplan (2001) describe their evidence from a longitudinal study in Houston as confirming the existence of "modest intergenerational continuity of constructive parenting" (p.27) but characterize the size of the effect they find as "at best moderate." (p.28) More recently, Belsky and colleagues (2005) used data from a longitudinal study of children in 1972-73, with follow-up measures of their parenting behaviors. They focused on what they call "warm-sensitive-stimulating" parenting behaviors. In a recent special section of Developmental Psychology several papers focus on the intergenerational transmission of parenting and in summarizing those papers, Belsky, Conger and Capaldi (2009, p.1203) conclude that two of those "studies provide new evidence of parenting in one generation being repeated in the second generation."

Perhaps the most compelling evidence that the behavior of one generation is closely linked to similar behavior by the mother is found in another species, where the evidence supports the conclusion that "variation in maternal care…is inherited; …[offspring]

that receive the minimum care from their mothers grow up to return the favor when they have their own offspring." (Robinson 2004, 398) This evidence pertains to the behavior of the Norway rat, studied by Michael Meaney and colleagues (Frances et al 1999) who show that pups raised by a "caring" (measured by specific acts) material care-giver produces a different level of the steroid hormone glucocorticoid. That hormone impacts the expression of a particular gene which in turn is closely associated with that same "caring" behavior when that pup becomes a mother. It is, Meaney and his team explain, an epigenetic modification of the gene which is then "stably maintained into adulthood" and affects adult behavior. So Meaney's study concludes that "our findings provide the first evidence that maternal behavior produces stable alterations of DNA methylation ….providing a mechanism for the long-term effects of maternal care on gene expression in the offspring." (Weaver et al, 2004, p.852) Moreover, by manipulating these rat-families for scientific study in ways no human subjects review would allow for humans, Meaney's team shows conclusively that it is the "custody" mom, not the "birth" (biological) mom, that determines this outcome. In their study of the Norway rat, there is no polymorphism in the gene, no inherited structural change; there is only an epigenetic modification in the gene, limited to that one generation. Without continued caring, the next generation does not inherit in its DNA a "caring" gene; the environment is the critical component.

We now turn to tests of these three hypotheses that family caring (1) differs among families and does so at high and low levels of family resources; (2) is positively correlated with children's test scores in reading and mathematics and is so when family resources are held constant; and (3) is correlated across generations thus constituting what one might characterize as the culture of the family. If these hypotheses are supported by evidence from the NCDS data set, that evidence should encourage families to engage in family caring in behalf of their children as an important investment in their well-being.

The data and research strategy

The data used in this study are part of the National Child Development Study (NCDS), the longitudinal study of a British birth cohort of 1958. Two data files are used. The first has information about the parent's resources and behaviors during the pregnancy that resulted in the 1958 birth and during that child's infancy and early childhood. There is a reading and a math test score for each of these children at age 11. With this data file we can study the relationship of the cohort member's test scores at age 11 to family resources and family caring.

The second data file exploits another feature of the NCDS, the "Child of the NCDS." In the 1991 interview, the biological children of a randomly selected one-third of the cohort members were given a series of tests including the PIAT reading recognition and mathematics tests administered to those age 5 and older. These 2,509 children constitute a third generation. The 1991 survey also asked the parent facts about parenting behavior. With this file we can study the relationship of these children's test scores to their family's resources and family caring.

To keep the generations straight, the parents of the child born in 1958 are called G1; the children born in 1958 – the NCDS cohort members – are called G2; and their children tested in 1991 are called G3. The empirical study focuses, separately, on the G1-G2 relationship and the G2-G3 relationship.

A feature of each of these two data files is important to note. The first file, the G1-G2 relationship, includes only those cohort members (G2) surveyed in 1991 who had a child included in the Child of the NCDS data file. Using this subset facilitates comparisons below. Since all these cohort members (G2) had at least one child by age 33, they are disproportionately female and somewhat less well-educated than the cohort overall. In the second file, the G2-G3 relationship, the sample of children in G3 is not a representative sample of British children. Verropoulou and Joshi (2009) discuss the nature of this sample of children as they use a similar subset of the "Child of the NCDS" in their study; also see Michael (2003) for comparisons with U.S. children. Because the second file can include more than one child per family, standard errors of estimated coefficients adjust for this clustering. The empirical investigation is a set of reduced-form OLS regressions that document the relationship of several measures of family resources and family caring to children's test

scores in reading and math. Subsequently linkages between the two files are exploited to address hypothesis #3.

Evidence of family influences: G1 behaviors, G2 test scores.

Considerable descriptive detail about the two data files can be found in Michael (2011); only the "family caring" variables are described here. The G1-G2 data file has 2,564 observations. As these G2 (cohort members) were identically the same age when the two cognitive test scores were administered, these tests have not been normed. The mean of each is about 16; the standard deviation is 9.4 for math and 5.5 for reading; the simple correlation of the two tests is 0.73. Measures of family resources include parent's SES at the time of the child's birth, home ownership, parents' education and age at the child's birth, and indicators of relative economic deprivation. The notion of family caring is a latent construct, so it is not directly observed; several behaviors are used here as the empirical measure "family caring" by G1 (see Table 1). Four are behaviors reported during the pregnancy: two dummy variables indicating that the mother did not smoke before or during that pregnancy; a dummy indicating that her first prenatal visit occurred within the first 16 weeks of the pregnancy; a dummy indicating that she had at least 16 prenatal medical visits. These four variables reflect the caring behavior by the mother during the fetal period.

Table 1. Family caring descriptive statistics, G1 parents, NCDS (1958-1969)

Variable description	Mean	Std. dev.	Min-max
G1 parent's child-nurturing behaviors: pregnancy (1958)			
G1-mom didn't smoke pre-preg	0.54	0.50	0-1
G1-mom stopped smoking in preg	0.08	0.27	0-1
First prenatal visit < 16 weeks	0.46	0.50	0-1
Freqency of prenat visit >16	0.25	0.43	0-1
G1 parent's child-nurturing behaviors: post-preg, pre-school age			
G1-mom breastfeed	0.59	0.49	0-1
G1-dad read to child	0.30	0.46	0-1
G1-mom outings w/ child	0.75	0.44	0-1
G1 parent's child-nurturing behaviors: during school years			
G1-mom big interest	0.32	0.47	0-1
G1-dad big interest	0.21	0.41	0-1
G1 parents' high aspirations	0.72	0.45	0-1
G1 parent's child-nurturing behaviors: composites			
G1care-preg	0.00	1.00	-1.77 – +0.81
G1care-post	0.00	1.00	-1.63 – +1.39
G1care-school	0.00	1.00	-2.06 – +1.50
G1-CARE	4.22	2.03	0-9
N=2,564			

The second set of three variables reflects the parents' caring behaviors during the child's pre-school years: a dummy indicating that the mother breastfed the child at least one month; a dummy indicating that the father read to the child frequently; a dummy indicating that the mother took the child "on outings" frequently. These too are behaviors that take time and effort, imply engagement with the child and thus "caring," but do not require a direct expenditure of money.

The third set of variables pertains to the child's early school years. In the data collected at ages 7 and 11 the child's school teachers were interviewed and asked about the involvement by each parent in the child's school life. Two composite indicators are included here that reflect that the teachers said the mother and the father, separately, showed a big interest in the child's school activities. Finally, the parents were asked in 1969 if they hoped their child would continue in schooling beyond the mandatory age of 16 and the final dummy variable indicates an affirmative response.

The measured family caring behaviors are used in three distinct statistical strategies. One strategy includes a set of separate dummy variables in the multivariate regressions on the child's test score. A second strategy uses the sum of nine behaviors as a single covariate. A third strategy performs factor analyses on subsets of the measures, including somewhat greater detail about them, in extracting the latent construct of family caring at different stages in the child's life (pregnancy, pre-school, and early school years), then uses those constructs as covariates in the regression. These factor analyses are described in Michael (2011). All three are defined such that a higher value implies greater family caring.

These several measures of the parent's behaviors with the child reflect family caring. We cannot hope to measure all the behaviors that constitute family caring and those measured serve as proxies for the efforts that distinguish families by their caring behavior. The hypothesis is that family caring is positively associated with the family inputs into the child's skill production function and therefore will be positively related to the child's reading and math test scores.

Table 2 reports OLS regression analyses for the G2 child's reading test score showing the unstandardized regression coefficients (and t-statistics). One sees the strong influence of the family's resources on the child's test score. Children have higher reading test scores in families with higher socioeconomic status, with parents who remained in school longer, in families that were relatively well-off as measured by their owning their home or by their ineligibility for subsidized school lunches. Children in families with a larger number of children have lower test scores. This regression clearly documents the importance of family resources in influencing the child's cognitive test score in reading. The same pattern of influence is seen for the mathematics test score in Table 3.

Of greater relevance to the key hypothesis in this paper, one also sees that several of the specific parental behaviors that reflect family caring are statistically significantly associated with both reading and math skills. When those specific behaviors are condensed through factor analyses, the three composite variables also show (Model #2) this same positive influence of caring behavior. When the simple composite sum of the "caring" variables is used instead in Model #3, it shows a very strong positive relationship with each of the test scores. Parental behaviors toward their child – caring behaviors – are statistically, strongly, positively associated with the child's reading and mathematics test scores, controlling for the family's level of resources. This evidence supports hypothesis #2.

To explore the implied magnitude of the associations of family resources and family caring on the child's test scores, the predictions from Model #3 are estimated. Holding all else in the regression model constant, as the resources of the family rise from the lowest SES class among those with subsidized housing and school meals, to the highest SES class with home ownership, the predicted test score rises by 5.5 points for reading and about 10 points for math – about one standard deviation in each case. Analogously, holding all else constant, as the parental caring index rises from a low value to its highest value, the reading test score rises by about 4.5 points and the math test score rises by about 7 points, also approaching a standard deviation increment in each case (see Michael 2011 for details). The regression shows that both family resources and parental caring, separately, are strongly related to these two test scores among the G2 children.

Table 2. Regressions on G2-child's reading test score at age 11 (1969)

	Model #1	Model #2	Model #3
Child is female	**-0.54 (-2.74)**	**-0.50 (-2.54)**	**-0.49 (-2.43)**
G1 parents' resources			
SES1 (highest)	**1.41 (2.47)**	**1.62 (2.84)**	**1.71 (2.96)**
SES2	**0.82 (2.38)**	**1.02 (2.99)**	**0.95 (2.75)**
SES4	**-0.78 (-2.47)**	**-0.72 (-2.30)**	**-0.82 (-2.59)**
SES5 (lowest)	**-1.49 (-4.22)**	**-1.46 (-4.14)**	**-1.64 (-4.58)**
Own home (buying)	**0.93 (3.83)**	**0.85 (3.48)**	**1.03 (4.20)**
Rent home	0.43 (1.26)	0.34 (1.00)	0.47 (1.36)
"free school lunch"	**-1.14 (-3.76)**	**-1.05 (-3.45)**	**-1.24 (-4.03)**
G1-mom's age at birth	0.01 (0.40)	0.01 (0.40)	0.02 (0.69)
G1-dad's age at birth	0.04 (1.61)	0.04 (1.53)	0.04 (1.58)
Biological G1-mom	-0.60 (-0.81)	-0.54 (-0.74)	-1.00 (-1.34)
Biological G1-dad	0.02 (0.03)	-0.04 (-0.08)	0.10 (0.22)
G1-mom's age leaving school	**0.30 (3.27)**	**0.33 (3.65)**	**0.33 (3.55)**
G1-dad's age leaving school	**0.36 (4.38)**	**0.33 (3.99)**	**0.37 (4.48)**
English spoken in home	-0.59 (-1.75)	-0.67 (-1.99)	-0.50 (-1.48)
Total number of children	**-0.43 (-3.73)**	**-0.47 (-4.12)**	**-0.48 (-4.12)**
G1 parents' child caring			
G1-mom didn't smoke pre-preg	0.07 (0.34)		
G1-mom stopped smoking in preg	0.12 (0.30)		
First prenat visit < 16 weeks	**0.73 (3.61)**		
Freq. prenatal visits >16	-0.15 (-0.64)		
G1-mom breastfeed	0.14 (0.64)		
G1-dad read to child	-0.03 (-0.15)		
G1-mom outings w/ child	0.03 (0.11)		
G1-mom big interest	**1.50 (5.10)**		
G1-dad big interest	**1.53 (4.59)**		
G1-pars' high aspirations	**0.86 (3.35)**		
Composites			
G1Care-Preg		0.05 (0.54)	
G1Care-Post		**0.24 (2.39)**	
G1Care-School		**1.31 (12.49)**	
G1-CARE			**0.55 (10.69)**
Intercept	**4.76 (2.83)**	**6.70 (4.00)**	**3.68 (2.18)**
N	2,564	2,564	2,564
R^2	0.20	0.20	0.18

Table 3. Regressions on G2-child's mathematics test score at age 11 (1969)

	Model #1	Model #2	Model #3
Child is female	**-0.99 (-2.89)**	**-0.93 (-2.72)**	**-0.93 (-2.68)**
G1 parents' resources			
SES1 (highest)	**2.26 (2.27)**	**2.56 (2.59)**	**2.83 (2.82)**
SES2	**2.63 (4.39)**	**2.93 (4.92)**	**2.88 (4.77)**
SES4	-0.39 (-0.72)	-0.28 (-0.51)	-0.45 (-0.82)
SES5 (lowest)	**-2.50 (-4.07)**	**-2.41 (-3.92)**	**-2.72 (-4.37)**
Own home (buying)	**2.05 (4.87)**	**1.90 (4.49)**	**2.28 (5.36)**
Rent home	1.03 (1.73)	0.87 (1.46)	1.07 (1.78)
"free school lunch"	**-1.73 (-3.27)**	**-1.58 (-2.98)**	**-1.86 (-3.47)**
G1-mom's age at birth	0.00 (0.04)	0.01 (0.13)	0.02 (0.44)
G1-dad's age at birth	0.06 (1.30)	0.05 (1.23)	0.05 (1.15)
Biological G1-mom	-0.12 (-0.09)	-0.15 (-0.12)	-0.81 (-0.63)
Biological G1-dad	0.23 (0.29)	0.22 (0.27)	0.30 (0.36)
G1-mom's age leaving school	0.24 (1.51)	0.29 (1.84)	0.29 (1.82)
G1-dad's age leaving school	**0.56 (3.92)**	**0.50 (3.51)**	**0.57 (3.93)**
English spoken in home	-0.61 (-1.04)	-0.78 (-1.34)	-0.48 (-0.81)
Total number of children	**-0.58 (-2.91)**	**-0.65 (-3.25)**	**-0.66 (-3.26)**
G1 parents' child caring			
G1-mom didn't smoke pre-preg	**0.87 (2.36)**		
G1-mom stopped smoking in preg	-0.08 (-0.11)		
First prenat visit < 16 weeks	**0.97 (2.75)**		
Freq prenatal visits>16	-0.24 (-0.61)		
G1-mom breastfeed	-0.06 (-0.16)		
G1-dad read to child	-0.27 (-0.68)		
G1-mom outings w/ child	-0.32 (-0.70)		
G1-mom big interest	**2.80 (5.49)**		
G1-dad big interest	**1.97 (3.41)**		
G1-pars' high aspirations	**1.79 (3.99)**		
Composites			
G1Care-Preg		**0.46 (2.69)**	
G1Care-Post		0.14 (0.79)	
G1Care-School		**2.18 (11.94)**	
G1-CARE			**0.87 (9.71)**
Intercept	1.19 (0.41)	4.67 (1.61)	-0.15 (-0.05)
N	2,564	2,564	2,564
R^2	0.18	0.18	0.16

Evidence of family influences: G2 behaviors, G3 test scores

A similar analysis of family influences on children's reading and math is undertaken with these same families a generation later, when the cohort member (G2) has become a parent interviewed at age 33 along with his or her biological children (G3). Here, the children vary in age so their scores on the PIAT-Reading Recognition and PIAT Mathematics tests are normed with mean 100 and standard deviation 15. The intercorrelation of the two tests is 0.57. Table 4 summarizes the information on the measures of family caring on these children who range in age from 5 to 18 (mean 8.7). Compared to the data file used in the previous section, this data file has relatively better information about the family's resources but less complete information about the family's caring behaviors. The G2-parent's reading and math test scores from age 11 (the dependent variables in the section above) measure one of the several resources available to the family in promoting the G3-child's skills. G2's education is measured by the level of qualifications earned by the cohort-member-parent, and by the age of school leaving for the partner-parent.

Table 4. Descriptive statistics, G2 parents and G3 children, NCDS (1991)

Variable description	Mean	Std. dev.	Min-max
G2 parents' child-nurturing behaviors			
Not Smoking (1=yes, didn't or stopped)	0.62	0.48	0-1
Pregnancy planning status (1=planned)	0.71	0.45	0-1
Prenatal Care in first trimester (1=yes)	0.60	0.49	0-1
Child breastfed (1=yes)	0.62	0.48	0-1
Breastfed 4+ weeks (1=yes)	0.30	0.46	0-1
Family takes holidays together (1=yes)	0.74	0.44	0-1
G2-CARE	3.60	1.42	0-6
N = 2,509			

In this data file family resources are measured by family income, education of each parent, and the reading and math skills of the CM-parent. There are six indicators that measure family caring by the G2 generation. Three pertain to the child's pregnancy, two that reflect behavior soon after the child's birth, and one other pre-school indicator; all are dummy variables and summarized in Table 4. In the analysis, the six are used as a set of separate indicators and also as a composite sum of the six. (A factor analysis was not undertaken for these measures of caring because the Cronbach Alpha value for the six is only 0.42.) While these few factors surely do not fully capture the parents' willingness to expend energy, time, and attention on their children, the contention is that there is signal content in these indicators. They are positively correlated with the degree of commitment to the child, so we expect to see a positive association between these indicators of family caring and the child's skills of reading and math.

Table 5 regression models show the strong influence of family resources on the child's test scores: parent's own abilities in reading and math, educational achievements of both parents and family's income level all have strong positive association with the child's reading and math test scores. (When the income measure is replaced in this regression by the log of annual gross income, its coefficient (and t-statistic) is: 0.89 (2.22).) The evidence here that family income influences these two test scores mirrors the findings reported by Aughinbaugh and Gittleman (2003), using the subset of children of female NCDS members. The family caring measures exhibit a weaker, but generally positive influence on the reading and math test scores in Table 5. The F-tests for this set of six variables are statistically significance and in Models

#2 and #4 when the six separate indicators are replaced by the index G2-CARE, it has a sizable and quite strong association with both test scores, again supporting hypothesis #2.

Considering the implied magnitude of these relationships, holding all other covariates at their means, as the family income index rises from a level of 2 to 7, the reading test score rises four points, or similarly, as the parent's education rises from lower-than-O-level to higher education, the reading test score rises three points. The magnitude of the index of family caring shows a comparable magnitude: a 5-point increase in the family caring index is associated with about a three-and-a-half point rise in the reading test score. So the family caring index has as its range of influence about the same magnitude as the education of the parent. It is well to caution that both the index for income and for caring are scaled arbitrarily as a simple sum of attributes. Within the range found in this sample of children, nonetheless, these magnitudes are substantial. Almost exactly the same magnitude of influence is calculated for the child's math test: as parents education, family income index, and family caring, separately, rises those same amounts, the math test score rises by 3.5 points, 4 points, and 4.5 points, respectively. Both the family's resources and the family's child caring behavior are strongly associated with the child's test scores.

Several qualifications and sensitivity checks have been undertaken and are reported in Michael 2011. Most importantly, to address concern about endogeneity of parent's behavior responding to a child inherently more inclined to be better at reading and math, the family caring composite variable in Models #2 and #4, Table 5, were replaced by one based on only behaviors pre-birth or breastfeeding. It is not credible to think these actions are influenced by the child's later interest in reading or math. This subset performed very similarly to the results shown in Table 5 – e.g., when the breastfeeding variable was included as the only "caring" variable its coefficient was 1.73 (t=2.71) for reading and 2.00 (t=2.98) for math. Similarly, when the sum of the four variables (smoking, prenatal medical care in the first trimester, breastfed and breastfed more than 4 weeks) was used, it was strong and statistically significant: 0.68 (2.38) for reading, 0.75 (2.53) for math. The reason for this robust association between the parent's behavior and the child's test scores several years later is not feedback from the child to the parent.

Interactions between resources and caring

One might be concerned that family caring is just another reflection of family resources which could explain why it is positively associated with the child's test scores. But the correlation between resources and caring is not high among either the G1 or the G2 parents: e.g., among the G1 parents, the simple correlation of father's age at leaving schooling and the composite measure of family caring is only 0.14 and among the G2 parents the correlation of family income and the composite measure of G2 family caring is 0.38. Looking at a large array of measures of family resources and measures of caring for each of the two generations (see Michael 2011), while there is a tendency for families with higher levels of resources to also exhibit higher levels of caring, there are substantial numbers of families with high-levels of resource who exhibit low levels of family caring and conversely. Having income or education does not automatically imply a large commitment to expending time and energy caring for the children. This should not be surprising since the attributes that generate income or that are associated with education are not necessarily those that reflect a strong commitment to children. Having sufficient resources to make a large investment does not necessarily imply that it will in fact be made. The relatively modest correlations between family resources and family caring in each generation suggests that the two concepts are not the same phenomenon and do not vary in lockstep. This evidence supports hypothesis #1 that family caring differs at all levels of family resources.

Table 5. Regressions on G3 child's reading and math test scores

	READING TEST SCORE		MATH TEST SCORE	
	Model #1	**Model #2**	**Model #3**	**Model #4**
Child's attributes				
age	**0.94 (6.60)**	**0.93 (6.59)**	**0.58 (3.86)**	**0.60 (4.12)**
girl	**1.75 (3.01)**	**1.71 (2.94)**	-0.94 (-1.63)	-0.93 (-1.62)
white	-2.80 (-1.01)	-2.91 (-1.05)	-3.51 (-1.14)	-3.52 (-1.15)
Parental controls				
mom is Cohort Member(CM)	0.37 (0.52)	0.45 (0.64)	0.53 (0.76)	0.58 (0.84)
age at first birth	0.30 (1.87)	**0.32 (2.00)**	-0.07 (-0.43)	-0.06 (-0.37)
attend religious serv. often	1.64 (1.91)	1.61 (1.88)	0.32 (0.36)	0.37 (0.42)
married	1.09 (1.61)	1.16 (1.75)	**2.13 (3.15)**	**2.09 (3.12)**
number of siblings	**-1.21 (-3.43)**	**-1.15 (-3.28)**	**-0.74 (-2.09)**	**-0.72 (-2.01)**
Parental resources				
CM's Reading test score	**0.33 (4.01)**	**0.34 (4.06)**	0.10 (1.11)	0.11 (1.25)
CM's Math test score	**0.16 (3.25)**	**0.17 (3.27)**	**0.29 (5.49)**	**0.29 (5.43)**
CM's Educ: No qualifications	0.45 (0.41)	0.50 (0.44)	1.49 (1.34)	1.60 (1.44)
O-level qualifications	**2.44 (2.45)**	**2.45 (2.49)**	1.63 (1.71)	1.75 (1.83)
A-level qualifications	**2.75 (2.19)**	**2.75 (2.20)**	1.68 (1.32)	1.76 (1.38)
Higher level education	**3.02 (2.40)**	**2.97 (2.37)**	**3.26 (2.63)**	**3.44 (2.78)**
Spouse's age leaving school	**0.37 (2.27)**	**0.36 (2.25)**	**0.56 (3.23)**	**0.57 (3.30)**
Income index	**0.80 (3.32)**	**0.77 (3.19)**	**0.72 (2.92)**	**0.77 (3.08)**
Parental child-caring behaviors				
Not Smoking	0.65 (0.98)		0.84 (1.25)	
Preg planned	**1.79 (2.59)**		0.60 (0.85)	
Prenat care 1st tri.	0.11 (0.18)		-0.04 (-0.06)	
Breast fed	**1.64 (2.28)**		1.45 (1.99)	
Breastfed 4+ weeks	0.11 (0.15)		1.19 (1.61)	
Family holidays	-0.11 (-0.15)		1.21 (1.70)	
G2-CARE		**0.73 (3.16)**		**0.90 (3.70)**
Intercept	**66.60 (11.01)**	**66.42 (11.06)**	**77.47 (12.03)**	**76.16 (12.00)**
N	2,509	2,509	2,490	2,490
R^2	0.141	0.138	0.128	0.126
F-Tests on sets of coefficients:				
8 Parental resources	**21.26**	**21.86**	**19.93**	**21.58**
6 or 1 Parental caring	**2.56**	**10.00**	**2.80**	**13.73**

Note. Standard errors are adjusted for the clustering of children within a family.

This dispersion in family caring among families at any given level of money resources, or in income among families at a given level of caring, offers an opportunity to re-estimate the basic model on the G2-G3 relationship interacting the levels of family resources and family caring. Table 6 summarizes the results of doing so. Subsets of families are selected either by family income (Panel A) or by family caring (Panel B). Each of these subsets provides much smaller range over which the other constraint might operate and many fewer observations. The table shows only one coefficient from each regression.

Table 6. Interacting resource and family caring

Panel A: Influence of family caring, controlling for family income

	Family income level		
	0 to 4.5	**4.5 to 5.5**	**5.5 to 7**
Reading	**1.13 (2.80)**	0.90 (1.76)	0.24 (0.70)
N, R^2	772, 0.15	555, 0.17	1182, 0.10
Math	**0.97 (2.26)**	0.56 (1.12)	**0.96 (2.69)**
N, R^2	765, 0.13	548, 0.15	1177, 0.09

Panel B: Influence of family resources, controlling for family caring

	Family caring level		
	0 to 2.5	**2.5 to 4.5**	**4.5 to 7**
Reading	**1.44 (3.49)**	**0.80 (2.36)**	-0.56 (-1.06)
N,R^2	562, 0.15	1231, 0.13	716, 0.10
Math	**1.09 (2.28)**	**0.87 (2.58)**	**0.27 (2.56)**
N,R^2	554, 0.10	1223, 0.11	713, 0.09

Note. Each G2-CARE (Panel A) or INCOME INDEX (Panel B) coefficient is from a separate regression, partitioned by either family income (Panel A) or Family Caring (Panel B). All regressions also include all other child attributes, parental controls, and parental resources from Table 5.

Partitioned by income (Panel A), the caring index exhibits a strong effect at low levels of income for both reading and math, no effect at mid-levels of income, and a significant effect on only the math score at the high level of income. Partitioning by the caring index (Panel B), income has a significant effect on both reading and math at the low level of caring, a smaller but still significant effect at the mid-level of caring, and no relationship with reading but a small, statistically significant relationship for the math score at the high level of caring. A suggested interpretation of this pattern is that at sufficiently high levels of either caring or income, the variation in the other is less important for the development of the child's skills, particularly in reading. At relatively low levels of either, however, variation in the other has a relatively strong compensatory influence on the child's skills. This point is mirrored in Bynner's (2001, p.287) synthesis essay on childhood risks and protective factors when he concludes "strong parental aspirations and emotional support in the context of sustained encouragement … may override the worst effects of poverty and disadvantage."

Cross-generational consistency in family resources and family caring

The previous section focused on the correlation between family resources and family caring within each of the two generations. Another important pair of correlations is across the two generations in family resources or in family caring, separately. The third hypothesis is specifically that family caring is correlated from one generation to the next. It is well-known that resources of a family are correlated from one generation to the next and it is so in these data as well. The correlation of high SES in G1 and the attainment of higher education by the cohort member in G2 is 0.15; the correlation of home-ownership by G1 and the Income Index in G2 is 0.18; the correlation of not being impoverished (not "Freelunch") in G1 and Income Index in G2 is 0.20. Modest stability of economic status from one generation to the next is a reality across these two generations. It is more novel to consider the pattern across the two generations in family caring: the correlation of the dummy variable for breastfeeding by G1 and G2 is 0.11; the index of family caring in G1 and in G2 is correlated 0.19, a very similar magnitude to the correlations of family resources. Families that are observed to have relatively high levels of family caring in Generation 1 also tend to do so in Generation 2. That fact supports hypothesis #3. One should note, however, that these cross-generational correlations are not dramatically high – modest stability in both family resources and family caring would seem an apt characterization. This finding is discussed in the concluding section below.

A more stringent test of the notion of carry-over from generation to generation in family caring is performed with these two files by re-estimating the relationships on the G3 children's test scores for reading and math, replacing the G2-parents' own caring behavior by the G1-grandparents' caring behavior. Doing so is not motivated by an argument that the grandparents actually care for the G3 child, although we cannot rule that out and if it occurs with much regularity that would undermine the test of hypothesis #3 reported here. Rather, the argument motivating the regressions reported in Table 7 is that habits of child caring carry over to their offspring, the G2-parent. Thus in these re-estimated regressions, the G1-caring variable is an instrument for the caring behavior of the G2 parent. The results do show a positive association between the G1-caring behavior and the G3 test scores: in terms of the reading test score, the grandparents' (not the parents') caring composite is positively and significantly associated with the child's reading test score. (It is debatable whether the middle-generation's (G2's) own test scores in reading and math should be held constant in this exercise, so both ways are shown here – models #1 and #3 include them while models #2 and #4 exclude them.) For the math test scores of the G3 children, the grandparents' caring variable is only significant when the parent's own test score in math is omitted from the regression. While subject to alternative interpretations, these regressions offer further suggestive evidence that family caring persists from one generation to the next.

Table 7. Regressions on G3 child's test scores, using G1 family caring

	READING TEST		MATH TEST	
	Model #1	**Model #2**	**Model #3**	**Model #4**
Child's attributes				
age	**0.90 (6.38)**	**0.91 (6.42)**	**0.56 (3.85)**	**0.58 (3.89)**
girl	**1.74 (2.99)**	**1.59 (2.72)**	-0.91 (-1.57)	-0.05 (-1.78)
white	-3.43 (-1.23)	-2.07 (-0.79)	-3.92 (-1.26)	-2.61 (-0.87)
Parental controls				
mom is Cohort Member(CM)	0.68 (0.97)	0.69 (0.98)	0.89 (1.29)	0.97 (1.39)
age at first birth	**0.34 (2.15)**	**0.40 (2.48)**	-0.02 (-0.14)	0.04 (0.23)
attend religious serv. often	**1.81 (2.12)**	**2.25 (2.58)**	0.61 (0.70)	1.01 (1.17)
married	1.24 (1.86)	0.87 (1.28)	**2.19 (3.28)**	**1.95 (2.83)**
number of siblings	**-1.22 (-3.51)**	**-1.28 (-3.68)**	**-0.80 (-2.23)**	**-0.83 (-2.33)**
Parental resources				
CM's Reading test score	**0.33 (3.94)**	--	0.10 (1.18)	--
CM's Math test score	**0.17 (3.35)**	--	**0.30 (5.60)**	--
CM's Educ: No qualifications	0.55 (0.49)	1.64 (1.47)	1.74 (1.57)	**2.74 (2.47)**
O-level qualifications	**2.54 (2.57)**	**4.96 (5.19)**	**1.97 (2.06)**	**4.38 (4.66)**
A-level qualifications	**2.89 (2.29)**	**6.45 (5.17)**	2.07 (1.63)	**5.56 (4.32)**
Higher level education	**3.11 (2.48)**	**7.06 (5.98)**	**3.76 (3.03)**	**7.65 (6.48)**
Spouse's age leaving school	**0.43 (2.65)**	**0.56 (3.38)**	**0.64 (3.64)**	**0.79 (4.36)**
Income index	**0.87 (3.65)**	**0.99 (3.99)**	**0.91 (3.59)**	**0.99 (3.82)**
G1 Parental child-caring behaviors				
G1-CARE	**0.36 (2.25)**	**0.56 (3.42)**	0.27 (1.61)	**0.48 (2.73)**
Intercept	**66.30 (11.04)**	**65.87 (10.96)**	**76.00 (11.90)**	**73.79 (11.40)**
N	2,509	2,509	2,490	2,490
R^2	0.137	0.109	0.122	0.092

Discussion and conclusions

This paper has emphasized that while having the resources to nurture and promote cognitive skills in children is an important family attribute, too often a second and independent attribute is overlooked: the inclination or willingness of families to expend parental energy, resources, and time in nurturing their children, called "family caring." The paper reports findings that support the three hypotheses that family caring: (1) differs among families and is discernibly distinct from having resources, (2) has influence on children's skill acquisition, and (3) exhibits cross-generational correlation of about the same magnitude as family resources since family caring is a habit experienced as a child and later expressed in adulthood. An additional suggestive finding in the pattern seen in Table 6 is that family caring is compensatory with family income in its relationship to children's cognitive test scores.

We rightly insist on relatively convincing evidence of a true causal connection before claiming to offer guidance to governmental policy makers. Yet, families must make decisions daily about how, and how intensively, to engage with their children. The evidence in this paper, as in other studies some of which have been cited above, show a clear association between engaged parental actions and better child outcomes measured as reading and math skills. While not yet meeting the standard of evidence sufficient to warrant claims of causation, I suggest there is sufficient indication of a connection

to justify advising parents to make efforts to engage with their children, to expend energy and devote attention to their children's interests and activities. Family caring, as measured here, does not "cost money" although it has obvious opportunity costs. Stopping smoking, attending to the pregnancy at an early stage, breastfeeding and going on outings with the children are not, of themselves, expensive efforts, however demanding and restricting they may be.

Doing most of these caring behaviors is within the grasp of nearly all parents! Unlike the observation that the parent's own ability in mathematics can contribute to the child's math skills – a fact that does not easily translate into an action which a parent without that ability can take – parental caring as measured in this paper can be modified relatively inexpensively. Since the evidence is that caring behaviors pays dividends in terms of the children's skills, it may be appropriate to try to persuade parents of the importance of providing that care and attention, especially since most parents have the capacity to act on this information. The human, unlike the Norway rat in the studies by Meaney and colleagues described earlier, may be persuadable by evidence that caring has attractive outcomes, so a mother's behavior might be modified by information, public education, and encouragement.

While the present study and many of the other social scientific studies cited above emphasize that there is a positive cross-generation correlation in parental behaviors toward their children, that correlation is far from the tight association found by Meaney and colleagues for their Norway rats. Indeed, one might as justifiably emphasize the discontinuity in parenting from one generation to the next. As emphasized above, neither family resources nor family caring exhibits an overwhelmingly strong cross-generation correlation. Moreover, even in data as fine as the NCDS, we have only information about the G1 behavior of one of the two sets of grandparents. While positive assortative mating may suggest that there will be positive association in the behaviors of the two sets of grandparents, the linkage is diluted and compromised and we cannot investigate both sets of G1 caring behaviors here. A similar point about discontinuity is found in Belsky, Conger and Capaldi's recent summary of developmental psychology evidence: "it remains indisputable that the parenting experienced in one generation is by no means inevitably repeated in the next" (2009, p.2102). As discussed above, Chen and Kaplan (2001) also describe the continuity of constructive parenting across generations as "moderate." So while the continuity across generations implies the existence of family culture, it is in the discontinuity that there are grounds for optimism and even activism, as parents can and do change their behavior and the evidence here and elsewhere should help persuade them of the usefulness of family caring.

The limitations of this work include the fact that "family caring" is measured in these data with measurement error and with some arbitrariness in the indicators that are included. Additional research is needed and, fortunately, these NCDS and other data sets capture additional and more detailed information about both what families *have* as resources and what families *do* in terms of their engagements with their children. We can hope to get closer to evidence that clearly indicates a causal relationship using two too seldom used aspects of these longitudinal data sets. One is the dynamics of parental actions and subsequent child outcomes and then subsequent parental actions: the NCDS, for example, has measures of the child's (G2) achievements and behaviors at ages 7, 11, and 16 as well as in adulthood while we also know something about the interactions with parents in these several intervals of time. From the sequencing of parental actions, child outcomes, and subsequent actions and outcomes we should be able to investigate whether there is in fact clear evidence of causal influence. A second underutilized element of these data is the within family, across sibling, comparisons that are feasible with the "Child-NCDS" (G3) data file since all the biological children of these cohort members were tested in 1991.

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Developmental trajectories of body mass index throughout the life course: an application of Latent Class Growth (Mixture) Modelling

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Abstract

The aims of this study are 1) to analyse developmental trajectories of body fatness from adolescence into adulthood, thereby determining the number and characteristics of distinct body fatness trajectories, and 2) to relate these distinct subgroups to indicators of cardiovascular disease risk, revealing subgroups specifically at risk. This paper will illustrate in more detail the application of Latent Class Growth (Mixture) Modelling (LCGMM) on longitudinal, observational data. Data were obtained from the Amsterdam Growth and Health Longitudinal Study, an ongoing observational study of apparently healthy participants (n=336). Participants were followed up from 13-42 years of age. Body Mass Index was used as a marker for body fatness and cardiovascular diseases (CVD)-risk factors included Mean Arterial Pressure and HDL-Cholesterol. LCGMM was used for the identification of developmental trajectories of body fatness, and linear regression analyses were used for the associations between the trajectories and CVD-risk. Analyses revealed three distinct trajectories; a "normative" trajectory (88.4%), a progressively overweight trajectory (4.5%) and a progressively overweight but stabilising trajectory (7.1%). Significant differences in CVD-risk between these trajectories appeared. These results show that body fatness development throughout life is heterogeneous, showing differences in CVD-risk. This paper also demonstrates that LCGMM is a promising technique to distinguish between subjects with different developmental trajectories.

Keywords

Life course epidemiology, Latent Class Growth (Mixture) Modelling, body fatness, cardiovascular disease risk

Introduction

Studying developmental patterns throughout the life course has gained interest over the recent years in the fields of epidemiology, psychology and beyond (Kuh and Ben-Shlomo 2004). More often, longitudinal studies take a life course approach when collecting and analysing data, which offers, through its interdisciplinary framework, (new) opportunities to understand the natural history of chronic disorders such as diabetes, depression or low back pain (Dunn 2010). Especially when studying disease aetiology, a life course approach offers valuable insights in the natural course of a risk factor and subsequent consequences for the chronic disease (Kuh and Ben-Shlomo 2004; Dunn 2010). Various statistical techniques are available when taking a life course approach (Singer and Willett 2003; Kuh and Ben-Shlomo 2004). Most techniques take a so-called variable-centred approach (Muthén and Muthén 2000) which focuses on relationships among variables in principle; the goal is to predict outcomes or to study the influence of certain risk factors on disease outcomes. Examples are regression models and structural equation models. Often, a different approach, namely a person-centred approach can offer more insight than a variable-centred approach when wanting to account for population heterogeneity within the sample. Person-centred techniques focus on relationships among individuals, aiming to group similar individuals based on their characteristics (Muthén and Muthén 2000). Latent Class Models, specifically Latent Class Growth (Mixture) Modelling (LCGMM) are good examples of such a technique (Jung and Wickrama 2008; Muthén and Muthén 2000; Muthén 2006; Muthén 2002; Muthén 2004; Muthén and Muthén 2010; Nagin 1999). This paper will apply these techniques, following a rise in interest within life course research (Dunn 2010). As an example, we will use data from a relevant field of research; we will study the course of body fatness in relation to cardiovascular diseases (CVD). As it is well known that the prevalence of CVD is increasing rapidly across all age groups over the world (World Health Organisation 2007), a range of approaches has been undertaken to prevent the onset of CVD. Examples of such attempts are mainly weight loss and weight management programmes (Groeneveld et al 2008), but few have shown effectiveness. The application of LCGMM can give more insight in the heterogeneity of the (natural) development of obesity throughout the life course. Assessing cardiovascular disease consequences of distinct developmental patterns can provide opportunities for more targeted prevention of cardiovascular diseases, to increase (long-term) effectiveness. Moreover, the limited papers available utilising these techniques highlight the need for more papers, as it is becoming increasingly clear that in many fields of research (amongst others, in the field of cardiovascular diseases), multiple pathways to developing (chronic) diseases exist (Patrick and Schulenberg 2011; Schulenberg et al 2005; Dunn et al 2006; van Leeuwen et al 2011; Joinson et al 2009; Zavrelova et al 2011) therefore justifying taking into account this heterogeneity when analysing such data.

The aim of the current study is threefold. Our first aim is to analyse developmental patterns of body fatness from adolescence into adulthood, thereby determining the number and characteristics of distinct body fatness trajectories. Secondly, we aim to relate these distinct subgroups to indicators of cardiovascular disease risk (namely high-density lipoprotein (HDL)-cholesterol and mean arterial pressure, MAP) later in life, revealing subgroups specifically at risk. Thirdly, and overall, this paper will illustrate in more detail the application of LCGMM to longitudinal, observational data.

Materials and methods

Study design

The Amsterdam Growth and Health Longitudinal Study (AGAHLS) is an observational longitudinal cohort study which started in 1976. Approximately 650 boys and girls (mean age of 13 years) from the first two grades of two secondary schools in the Netherlands were included in the study. The initial goals of the study were to describe the natural development of growth, health and lifestyle and further to investigate associations between health and lifestyle. During the adolescence period, participants were measured annually, and thereafter, six more examinations took place, of which the most recent took place in 2006 (mean age of 42 years).

Medical ethical approval was obtained from the Medical Ethics Committee of the VU University Medical Centre, and written informed consent was obtained from each participant, as well as from the parent or guardian (during adolescence).

More detailed information on study design and specific measurements at each examination has been published elsewhere (Kemper 1995; Kemper 2004).

Inclusion and exclusion criteria

For the current study, participants from whom valid measurements of the cardiovascular disease risk factors were available *and* who had at least one measurement of body fatness over the previous 30 years, were included. If women were pregnant during a particular round of measurement, that measurement (for body fatness) was not included in the analyses. In total, 176 women (52.4%) and 160 men were included in the study (total n=336).

Body fatness measurements

Body fatness was quantified by the Body Mass Index (BMI). BMI was calculated by dividing body mass (kilograms) by body height squared (meters squared).

Indicators of cardiovascular disease risk

Fasting HDL cholesterol values were determined from blood drawn from the antecubital vein (Roche diagnostics, Mannheim, Germany). Blood pressure was measured every 5 minutes for 60 minutes using an automated device (Dinamap Procare 100). Subsequently, mean arterial pressure (MAP) was calculated as ((2*diastolic blood pressure + systolic blood pressure) / 3) (Sesso et al 2000).

Lifestyle covariates

Habitual energy intake was measured using a detailed cross-check dietary history face-to-face interview method, based on Beal (Beal 1967) and Marr (Marr 1971), and expressed in kilojoules per day. The interview was adapted for the AGAHLS. For the analyses, mean life course food intake was calculated in kilojoules per day.

Physical activity in minutes per week was measured using a detailed questionnaire, especially designed and validated for the AGAHLS (Verschuur 1987). For the analyses, mean life course physical activity was calculated in minutes per week.

Smoking behaviour was measured with a separate questionnaire (Bernaards et al 2004) , from which participants were categorised in one of three categories; never smoked, ever smoked (but not a current smoker), or current smoker.

Alcohol consumption was also measured with a short questionnaire (Koppes et al 2002), determining whether participants were alcohol drinkers or not (at the last time point).

Statistical analyses

Statistical analyses were conducted using the Mplus 6.1 (Muthén and Muthén 2011; Muthén and Muthén 2010) and the SPSS 17.0 software packages. The analyses for the current study consisted of two steps, described in detail below.

Step 1. (Piecewise) Latent Class Growth (Mixture) Modelling

Heterogeneity in longitudinal development of body fatness was analysed with (Piecewise (*defined in Procedures below*)) Latent Class Growth (Mixture) Modelling (LCGMM) (Muthén and Muthén 2010; Muthén and Muthén 2000; Muthén 2006; Muthén 2002). LCGMM is a contemporary longitudinal technique based on structural equation modelling, incorporating both continuous and categorical latent (unobserved) variables. The technique is an extension of conventional growth modelling. In conventional analyses, the assumption that all individuals in the study sample come from a single population should hold; meaning that one (average) trajectory will adequately describe the developmental pattern of the sample. This assumption is relaxed in LCGMM, meaning that individuals in the sample need not come from one single underlying population, but can come from multiple, underlying (or latent) sub-populations. Identifying the number and characteristics of these underlying sub-populations is the main aim of LCGMM. This is done by identifying *k* number of distinct latent classes (i.e. subgroups) of, in the present study, trajectories of body fatness. Each identified class has its own specific growth parameters (intercept, slope), which are also assumed to be unobserved, or latent. Furthermore,

LCGMM can also account for within-class variation in either, or both, of the growth factors, implying within-class heterogeneity on top of the between-class heterogeneity in initial status (intercept) or growth (slope).

Procedures

Various LCGMM models were run before choosing a final model. First, several linear LCGMM with fixed intercept and slope variance within-classes were investigated. Next, quadratic slopes were added to the model, allowing for curved developmental patterns. Thirdly, we investigated piecewise models which allowed for different phases in development. Models with three pieces were investigated, showing possibilities of different growth rates (and directions) during each phase. Phase one was defined as the adolescence phase (age 13-16), phase two was defined as the young adulthood phase (age 21-29) and phase three was defined as the adulthood phase (age 32-42).

For all models, a one to four class solution was modelled, starting with a one class solution (i.e. there are no subgroups within the data; all individuals follow the same trajectory over time), then adding classes one at a time.

After the choice for a final model was made, necessity for the estimation of within-class intercept and slope variance was assessed. The assessment was made based on another stepwise procedure; step by step, intercept and/or slope variances within classes were estimated in the model. After each step, model fit and clinical interpretation was assessed. Caution was taken when dealing with estimated slope variance, according to the current literature (Muthén and Muthén 2000; Muthén and Muthén 2010; Nylund et al 2007; Jung and Wickrama 2008).

Model selection (class identification)

To determine the optimal number of latent classes, we used two model fit indices; the Bayesian Information Criterion (BIC), and the bootstrap Likelihood Ratio Test (BLRT). The BIC (Schwarz 1978) is commonly used within mixture modelling analyses, considering both the likelihood of the model as well as the number of parameters in the model; a lower BIC value indicates a better model fit (a decrease of at least 10 points shows a sufficient improvement) (Raftery 1995). The BLRT uses bootstrap samples to estimate the distribution of the log likelihood difference test statistic. The test provides a p-value, indicating that a model with one class less (*k*-1 class model) has to be rejected in favour of the *k* class model. The BLRT has been shown to be a very consistent indicator of the optimal number of classes (Nylund et al 2006). To further determine the optimal number of classes, we looked at the posterior probabilities for each individual in the sample (Nylund et al 2006). For each individual in the sample, the probability of belonging to each of the *k* classes is estimated. The probability for the class to which the individual was assigned, should be considerably higher than the other probability/probabilities. By this means, the classes are clearly distinguished from each other. Finally we considered the usefulness of the separate classes in practice.

Technical issues

Missing data were handled according to the Expectation-Maximation Algorithm (EM-Algorithm) (Dempster et al 1977; Muthén and Shedden 1999). An important assumption of this algorithm is that the data should be missing at random (MAR). Although this assumption is difficult to test (Pothoff et al 2006), the included participants were compared with the excluded participants on the variables analysed. Regarding BMI at baseline (i.e. in 1976 at age 13), these two groups did not differ; the average BMI of the included participants was 17.39 (1.88), compared to 17.77 (2.23) for the excluded participants. Further, of the included participants, 52.4% were female, compared with 52.8% of the excluded participants. In the Mplus program (Muthén and Muthén 2010), it is in addition possible to extract missing data patterns to study the missing data in further detail. These assessments did not point to selective missing data either, corresponding to earlier research with data from the Amsterdam Growth and Health Longitudinal Study (see for example te Velde et al 2004).

LCGMM models are computationally-heavy models, often with convergence issues or hitting local maxima. Mplus incorporates random starts to avoid these issues as much as possible (Muthén and Muthén 2011; Muthén and Muthén 2010; Jung and Wickrama 2008). In the current paper, 750 random starting values were applied with 50 final optimisations. Only solutions with

replicated log likelihoods were accepted, where the OPTSEED procedure can help in making a final decision (Jung and Wickrama 2008; Muthén and Muthén 2010). Because LCGMM are complicated models, often problems arise when estimating more than three classes (Jung and Wickrama 2008; Muthén and Muthén 2010). By taking into account this complexity, together with the sample size and the number of hypothesized trajectories from previous studies (Mustillo et al 2003; Li et al 2007), we modelled a maximum of four trajectories.

Step 2. Linear Regression

The first step of the analyses provided us with a classification of the study sample into distinct trajectory subgroups, coded as a categorical variable with *k* number of categories. To study the association between the distinct trajectories and CVD risk (i.e. mean arterial pressure and HDL values) later in life (i.e. at 42 years of age), several linear regression analyses were performed. First, crude analyses were performed, in which class membership was related to the CVD risk indicators, correcting for gender. Second, adjusted analyses were carried out, adding the lifestyle covariates, described above, to the regression model.

Results

Illustrating the study sample, table 1 shows descriptive data for all subjects for body fatness (BMI) at each time point. Mean values seem to increase throughout the life course. Mean (standard deviation) HDL levels at age 42 for the total study population were 1.725 (0.423) mmol/l. Mean (standard deviation) MAP at age 42 was 84.970 (9.889). 57.9% of the study sample reported having never smoked up to age 42, whereas 26.6% did smoke in the past, but were not current smokers. Only 8.8% had never drunk alcohol at age 42.

Table 1. Descriptive information (mean (standard deviation)) regarding the development of body fatness

Age	Sample (Females, Males)	BMI (kg/m^2), SD Females	BMI (kg/m^2), SD Males	BMI (kg/m^2), SD Study sample
13	168, 153	17.81 (2.14)	16.93 (1.42)	17.39 (1.88)
14	155, 124	18.66 (2.08)	17.68 (1.49)	18.23 (1.90)
15	151, 121	19.41 (2.14)	18.38 (1.66)	18.95 (2.01)
16	153, 122	20.01 (2.10)	19.21 (1.70)	19.66 (1.97)
21	74, 57	21.65 (2.48)	21.20 (1.67)	21.45 (2.17)
27	73, 60	22.03 (2.36)	22.46 (2.17)	22.22 (2.28)
29	64, 61	22.46 (2.58)	22.94 (2.22)	23.70 (2.41)
32	169, 145	22.85 (3.13)	23.79 (2.41)	23.28 (2.85)
36	157, 143	23.57 (3.47)	24.60 (2.68)	24.06 (3.16)
42	175, 160	24.09 (3.87)	25.20 (2.92)	24.62 (3.49)

(Piecewise) Latent Class Growth (Mixture) Models

Table 2 shows the results of the (Piecewise) Latent Class Growth (Mixture) Models (LCGMM). First, several linear models (one-four classes) were conducted and compared. These models are shown in the top four rows of the table, pointing towards a three or four class solution. These four solutions were subsequently compared to the next four solutions which permit quadratic development in the class(es). However, the quadratic models with three and four classes are increasingly complex and lead to convergence problems. In our case, we had problems with the estimation of the standard errors due to a non-positive definite information matrix, and difficulties in estimating the quadratic slopes for some classes that appeared to include two or three individuals only. Therefore, for the quadratic models we had not four, but two models to compare. Next, four models with piecewise trajectories (piece one was defined by the ages 13-16, piece two by the ages 21-29 and piece three was defined by the ages 32-42) were conducted. It can be seen that the improvement of these models (specifically indicated by much lower BIC values) is clear.

Table 2. (Piecewise) Latent Class Growth (Mixture) Models Results

Number of classes	Intercept	Slopes[1]	BIC	BLRT	Prob.	Subjects per class
1, linear slope	class 1: 18.248	0.269	9899.165	Not calculated	1.000	336
2, linear slope	class 1: 18.081	0.261	9884.609	P<0.001	0.930	324/12
	class 2: 21.658	0.434				
3, linear slope	class 1: 17.950	0.258	9887.077	P<0.001	0.863	310/10/16
	class 2: 23.545	0.140				
	class 3: 19.734	0.479				
4, linear slope	class 1: 19.397	0.465	9894.435	P=0.034	0.829	31/286/3/16
	class 2: 17.757	0.259				
	class 3: 25.537	0.267				
	class 4: 21.344	0.119				
1, quadratic slope	class 1: 17.809	0.436/-0.007	8671.655	Not calculated	1.000	336
2, quadratic slope	class 1: 20.661	0.530/-0.003	8639.308	P<0.001	0.956	14/322
	class 2: 17.663	0.431/-0.007				
1, Piecewise, linear slope	class 1: 17.442	0.743/1.208/0.538	8283.726	Not calculated	1.000	336
2, Piecewise, linear slope	class 1: 17.292	0.752/1.159/0.497	8262.715	P<0.001	0.936	324/12
	class 2: 20.892	0.515/2.299/1.528				
3, Piecewise, linear slope[2]	**class 1: 17.043**	**0.796/1.130/0.566**	**8265.720**	**P<0.001**	**0.867**	**297/24/15**
	class 2: 20.160	**0.551/1.514/-0.322**				
	class 3: 20.924	**0.517/2.313/1.502**				
4, Piecewise, linear slope[2]	class 1: 19.498	0.681/2.410/1.294	8274.552	P=0.05	0.910	16/2/294/24
	class 2: 25.892	0.184/0.824/2.080				
	class 3: 16.997	0.771/1.116/0.555				
	class 4: 20.238	0.525/1.431/-0.302				

Notes.
1. All values indicate linear slopes, except for the 1- and 2-class quadratic models where the second value indicates a quadratic slope
2. Piece one is defined by the ages 13-16, piece two is defined by the ages 21-29 and piece three is defined by the ages 32-42

Choosing the final model

Comparing the three sets of four models based in model fit alone was complicated, as often the different model fit indices are not in agreement with each other (Nylund et al 2007). Based on the BIC, for example, the "best" model (i.e. the model with the lowest value) is the two class piecewise model, although the BIC of the three class piecewise model is almost the same (a difference of three points). Literature advises about "significant" improvement in the BIC-values; improvement of at least 10 points indicates a sufficient improvement of the model (Raftery 1995), indicating that based on the BIC, the two and three class piecewise models have equivalent fit. Further, based on the BLRT, the "best" model is a four class model (indicated by a non-significant p-value). Both (BIC and BLRT) model fit indices therefore do not point consistently to one definite solution (Nylund et al 2007). Hence, we also took the clinical interpretation of the trajectories into account. Based on this, our final model was a three class piecewise model, showing a "normative" BMI trajectory (n=297), a progressively overweight, but stabilising trajectory (n=24) and a progressively overweight (n=15) trajectory.

When the choice for the number of classes in the final model has been made, the necessity of random intercept or slope variance within class was assessed. The results of these further analyses are not shown in the table, as none of the additional models showed a sufficient increase in model indices. Based on existing literature (Jung and Wickrama 2008), the ultimate final model was the most parsimonious model; a three class piecewise model without random intercept and slope variance within classes (shown in bold in Table 2). Figure 1 shows mean trajectories of the final model and Table 3 provides descriptive information of the three trajectories regarding the confounders used in the regression models.

Figure 1. Estimated trajectories of Body Mass Index (Y-axis) from the age of 13 to 42 years (X-axis)

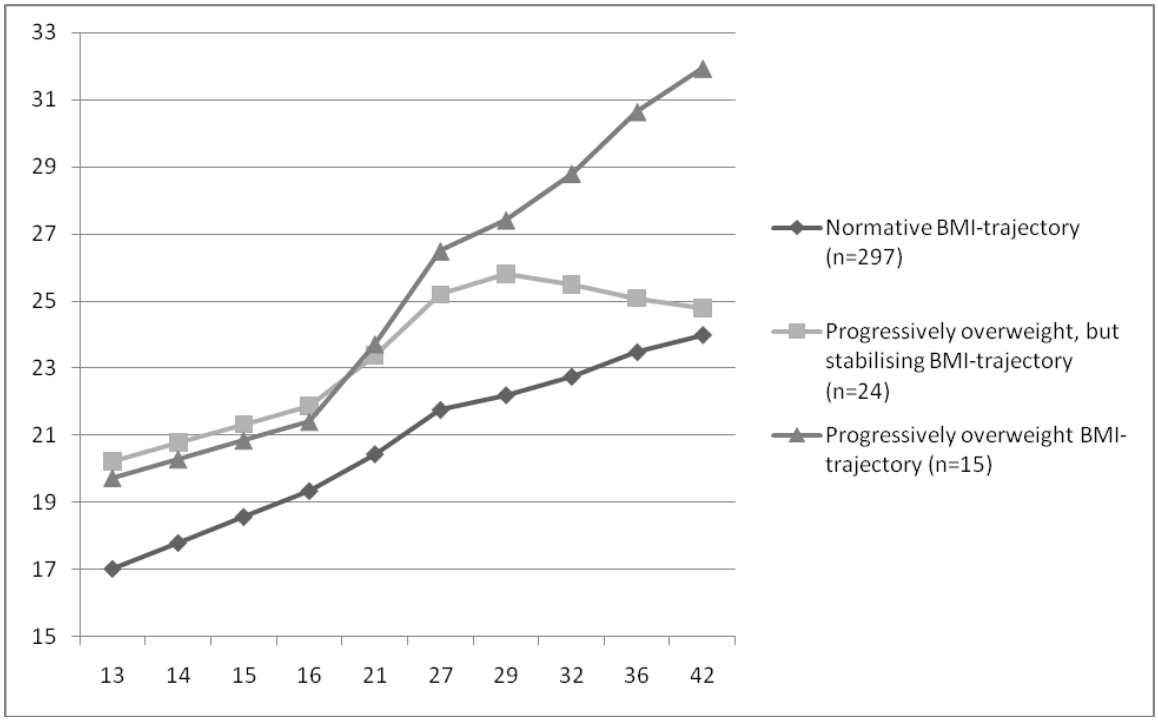

Table 3. Descriptive information of the three estimated trajectories of Body Mass Index

Variables of interest	Normative trajectory	Overweight, but stabilising trajectory	Progressively overweight trajectory
Gender			
% female	49.2	79.2	73.3
Smoking			
% smoker at age 42	15.9	4.2	26.7
% previous smoker	26.7	25.0	26.7
Alcohol intake			
% drinkers	92.2	95.8	66.7
Total Physical Activity (min/week)			
Average (SD)	559.33 (179.52)	472.28 (159.49)	424.73 (62.96)
Nutritional intake (KJ/day)			
Average (SD)	10805.38 (2157.70)	9083.25 (2140.79)	8647.71 (2118.43)

Linear Regressions

Table 4 summarises the results of the linear regression analyses investigating the associations between trajectory membership and MAP and HDL values at the age of 42 years.

For MAP, both the overweight, but stabilising and the progressively overweight classes were significantly different from the normative class. For HDL, the progressively overweight class showed significantly lower values compared to the two other classes. From the two adjusted models, it becomes clear that for both the analyses with MAP as well as HDL, gender is the most important confounder. After adding the lifestyle covariates, the effects in both models are much less affected.

Table 4. Linear Regression Analyses showing associations between class membership and indicators of CVD-risk

	Mean Arterial Pressure			***HDL-Cholesterol***		
	B	**95% CI**	***P*-value**	**B**	**95% CI**	***P*-value**
Crude:						
Overweight, stabilising	1.629	-2.593 to 5.851	0.448	0.115	-0.064 to 0.294	0.206
Progressively overweight	3.865	-1.465 to 9.195	0.155	-0.162	-0.380 to 0.057	0.146
Adjusted for gender:						
Overweight, stabilising	3.909	-0.078 to 7.896	0.055	-0.008	-0.168 to 0.153	0.926
Progressively overweight	6.168	1.158 to 11.177	0.016	-0.265	-0.460 to -0.070	0.008
Adjusted additionally for lifestyle:						
Overweight, stabilising	3.373	-0.612 to 7.358	0.097	-0.034	-0.192 to 0.123	0.668
Progressively overweight	5.013	-0.192 to 10.218	0.059	-0.212	-0.411 to -0.013	0.037

The "normative" trajectory was set as reference

Discussion

The current study gave particular attention to the application of Latent Class Growth (Mixture) Models on life course data. As an example, we investigated the possible existence of distinct life course trajectories of body fatness, in an apparently healthy sample. Developmental patterns of body mass index were studied from the age of 13 to 42 years, where three distinct trajectories emerged. Subsequently, class membership was related to CVD risk factors at the age of 42 years.

Researching heterogeneity in development of body fatness

The acknowledgement of the existence of heterogeneity within a study sample has gained interest over the past years. Especially within the field of alcohol research, recognising heterogeneity has led to theories of multiple developmental pathways of alcohol abuse (Schulenberg et al 1996; Maggs and Schulenberg 2002; Brennan et al 2011). Slowly, similar approaches are emerging in other fields of research (van Leeuwen et al 2011; Mustillo et al 2003; Dunn et al 2006). Comparing the analysis of heterogeneity of body fatness development with existing studies, shows that limited research has been conducted and methodologies differ a great deal. Studies with methods comparable to ours are, for example, the study by Li et al (2007). They studied developmental trajectories of BMI focussing only on childhood (American children of age 2 to 12 years). The authors found a three class solution to be the best option, containing a normative group, a consistently overweight group and a late-onset overweight group. Another study, by Mustillo et al (2003), also studied developmental patterns of body fatness, but with a slightly different statistical technique implemented in the SAS software (Nagin 1999). They studied American children from the age of 9 to 16 years, and found four distinct trajectories, where most children were classified in the group with a very low prevalence of obesity. A third study (Ostbye et al 2011), following up adults from the age of 18-49, also conducted the analyses in the SAS program, and analysing continuous BMI-values in their models is worth mentioning in the light of our study. Their sample, more heterogeneous in terms of race and socioeconomic status and larger compared to our sample, revealed four trajectories, three of them comparable to our trajectories. The papers highlighted above show consistently that body fatness development is heterogeneous throughout the life course, in various study populations. This indicates that researchers should be aware of this when analysing their data.

There are other noteworthy studies, which investigate differences in development of body fatness *retrospectively*, seeing differences in the development of body fatness between individuals at high and low risk of coronary artery disease (Youssef et al 2002), between people with and without the metabolic syndrome (Ferreira et al 2005) and also between people with high and low adult body fat (Nooyens et al 2007). Although the aim of these studies was also to investigate developmental patterns of risk factors, they were primarily interested in differencein development between patients and non-patients. This is an a priori categorisation of the study participants into predefined groups on the basis of their disease status, whereas the categorisation with LCGMM is on the basis of the developmental trajectory of the risk factor per se. When choosing a statistical method incorporating a heterogeneity component, one should keep in mind the differences between the techniques available, to allow for answering the research questions appropriately.

Methodological issues

In the current literature, there is discussion about the usage of Latent Class Growth (Mixture) Models within epidemiology. Models are mathematically complicated and care should be taken when applying them, as a wide range of possibilities is available for the specification of the model. The debate is mainly between the choice between a Latent Class Growth Model (LCGM) and a Latent Class Growth Mixture Model (LCGMM). In short, the LCGM methodology was developed by Nagin and colleagues (Roeder et al 1999; Nagin and Tremblay 2001a; Nagin 1999; Nagin and Tremblay 2001b; Jones et al 2001) and is implemented in the SAS software, whereas the LCGMM methodology was developed by Muthén and colleagues and implemented in the Mplus software

(LCGM is also possible in this framework) (Muthén and Muthén 2011; Muthén and Muthén 2000; Muthén and Muthén 2010; Muthén 2006; Muthén 2002). The difference between the two methods is the assumptions both have about the underlying (latent) populations. LCGM assumes no within-class variation (the variance within each class is fixed to zero), whereas LCGMM relaxes this assumption by allowing the within-class variance to be estimated. Hereby, LCGMM allows for additional heterogeneity in the model, thus being the more flexible technique. Because of this flexibility however, models can have difficulty arriving at a proper statistical solution. Although the underlying aims of both techniques are similar (namely, identifying distinct developmental trajectories), the approach can vary. It is important for researchers to clearly describe which approach they used, to allow for objective comparison and interpretation of the results.

Another important point of discussion is the decision of the number of classes (or subgroups). Several model fit indices are available to aid the researcher with this decision. However, these fit indices are not always consistent (Nylund et al 2007). Although an interesting simulation study has been published showing that the BLRT is the most consistent fit index, controversy remains. Therefore, in this paper, several indices are reported and all are used in deciding on the final model.

General remarks

We have shown that LCGMM is a promising technique to distinguish between subjects with different developmental trajectories. It can help researchers in the field of obesity and cardiovascular disease risk specifically and epidemiology in general, amongst others, to gain insight in the relationships between developmental patterns of risk factors for chronic disease and provide interesting novel research opportunities. However, researchers should use caution when utilising these complex techniques, as they still have to cope with technical issues that have not all been resolved. Careful application, with careful interpretation of the results, can, however, bring valuable insights in many fields of research and instigate new research ideas.

We have shown that elaborate comprehension of heterogeneity in the progress of risk factors for (preventable) chronic diseases is interesting for aetiology and prevention. Our results have shown that body fatness development from adolescence into adulthood is heterogeneous, consistent with previous studies (Li et al 2007; Mustillo et al 2003; Ostbye et al 2011). Trajectory membership was associated with CVD risk at age 42 even if lifestyle variables are taken into account. This indicates that fatness trajectory shape matters for the magnitude of CVD risk in this study population. However, effects were small and our study sample is relatively healthy, making it difficult to generalise these findings to other study samples or the general population. The AGAHLS is one of few studies following up participants for over thirty years, throughout life, making these findings very valuable. Further research, studying the technical issues LCGMM are currently experiencing, should be conducted, but also continued application of these models on data from diverse fields of research is warranted, to continue to explore the usability and applicability of these models.

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Incidence of cardiovascular risk factors by education level 2000-2005: the Australian diabetes, obesity and lifestyle (AusDiab) Cohort Study

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Abstract

Lower socio-economic position (SEP) is associated with a higher prevalence of major risk factors for cardiovascular disease (CVD). However, few longitudinal studies have examined the association between SEP and CVD risk factors over time. We aimed to determine whether educational attainment is associated with the onset of CVD risk factors over 5 years in an Australian adult cohort study. Participants in the Australian Diabetes, Obesity and Lifestyle study (AusDiab) study aged 25 years and over, who attended both baseline and 5-year follow-up examinations (n=5,568) were categorised according to educational attainment. Cardiovascular risk factor data at both time points were ascertained through questionnaire and physical measurement. Women with lower education had a greater risk of progressing from normal weight to overweight or obesity than those with higher education (adjusted OR 1.54, 95% CI 1.04-2.27). Both men and women with lower education were more likely to develop diabetes (adjusted OR from higher education 1.71, 95% CI 1.10-2.66 and 3.09, 95% CI 1.28-7.42, respectively). A lower level of education was associated with a greater increase in the number of risk factors accumulated over time in women. In this Australian population-based study, lower educational attainment was associated with an increased risk of developing overweight/ obesity and diabetes over a 5-year period in women. Men with lower education were also more likely to develop incident diabetes than those with higher education. These findings suggest that social inequalities in CVD will persist into the future.

Keywords: Socio-economic position, risk factor incidence, cardiovascular disease, diabetes, obesity

Background

Cardiovascular disease is the leading cause of death globally, with the burden of disease greater among lower socio-economic groups (Kaplan and Keil 1993; Australian Institute of Health and Welfare (AIHW) 2006; Mackenbach et al 2008). Such inequalities do not just affect the most disadvantaged groups in a society. There is clear evidence for a social gradient in CVD that runs across the entire socio-economic spectrum so that overall, the lower an individual's socio-economic position, the worse their cardiovascular health (Lynch et al 2006; Marmot et al 2008; Marmot 2010). For example, the Whitehall Study of British civil servants was instrumental in demonstrating that inequalities in CVD exist across all occupational classes (Marmot 1992). While the mechanisms and pathways underlying this social gradient in CVD are not fully understood, major risk factors for atherothrombotic disease are thought to play a significant role. Tobacco smoking, abnormal lipids, high blood pressure, diabetes and abdominal obesity in combination, account for up to 90% of the population attributable risk (PAR) of acute myocardial infarction (Yusuf et al 2004). In addition, many longitudinal studies have reported that social gradients in the prevalence of these and other risk factors account for a significant proportion of the social gradient in CVD (Lynch et al 1996; Beauchamp et al 2010). People from lower socio-economic groups also tend to have a higher number of cardiovascular risk factors, leading to an increased overall risk of CVD among the more disadvantaged (AIHW 2005).

Despite this evidence, our understanding of how social gradients in CVD risk develop in individuals over time remains limited. Prospective studies describing the incidence of cardiovascular risk factors according to socio-economic position (SEP) are few, and findings are inconsistent. While several studies have found that the incidence of hypertension is higher among lower socio-economic groups, [Conen et al 2009; Diez Roux et al 2002; Mathews et al 2002), others have shown that these associations vary according to age, race and gender (Dyer et al 1999; Ford and Cooper 1991; Vargas et al 2000). Findings are equally inconsistent for incident obesity (Ball and Crawford 2005; Martikainen and Marmot 1999; Mujahid et al 2005) and diabetes (Kumari et al 2004; Maty et al 2005; Maty et al 2010; Robbins et al 2005). In addition, while it is known that risk factors in combination are more closely associated with CVD risk than single factors in isolation (NVDPA 2009), and that lower SEP groups tend to have a greater number of cardiovascular risk factors (AIHW 2005), few longitudinal studies have examined whether SEP is associated with the accumulation of cardiovascular risk factors over time (Dupre 2008). Further evidence for the association between SEP and the incidence of both individual and cumulative risk factors will make an important contribution to our knowledge of which factors to target in order to reduce future inequalities in CVD.

Using data from an Australian adult cohort study, we aimed to determine whether educational attainment (as an indicator of SEP) is both a predictor of incident cardiovascular risk factors, and is associated with the development of a greater number of risk factors over time.

Methods

The Australian Diabetes, Obesity and Lifestyle study (AusDiab) is a population-based, stratified cluster survey of 11,247 adults aged 25 years or older in 1999 -2000. Methods and response rates have been described previously (Dunstan et al 2002). A five-year follow-up was conducted in 2004-2005. From the original cohort there were 10,788 participants eligible for follow-up and of these, 6400 returned for physical examination and interviewer-administered questionnaire. For this analysis we excluded participants missing baseline data on education (n=47), diabetes or CVD (n=72), and baseline or follow-up data on smoking, systolic blood pressure, cholesterol, body mass index (BMI), and medication use (n=314), leaving 5,967 participants who had attended both baseline and follow-up examinations. We excluded a further 399 participants with self-reported history of CVD at baseline, leaving a total of 5,568 participants. Ethics approval was obtained from the International Diabetes Institute and Monash University, Melbourne. All participants consented to participate in the study.

Education level was ascertained by asking the question "Which of these describes the highest qualification you have received?" Education was categorised as secondary only (comprising those with a secondary school qualification), diploma (comprising nursing or teaching qualification, trade certificate or undergraduate diploma), and degree

(comprising bachelor degree, post-graduate diploma or masters degree/doctorate). These categories are considered to represent hierarchical stages of education, each of which has important socio-economic implications (Dutton 2005).

Baseline and follow-up assessments followed a similar protocol. Data were collected by interviewer-administered questionnaires on age, sex and current use of anti-hypertensive and lipid-lowering medications. Self-reported CVD was ascertained by asking if participants had been told by a doctor or nurse that they had angina, coronary heart disease, or stroke. Smoking status was defined as 1) current daily smoker and 2) ex-smoker (now smoking less than daily for at least the last 3 months, but used to smoke daily) and non-smoker (never smoked tobacco daily) combined.

Blood pressure was measured using a Dinamap or a standard mercury sphygmomanometer (Briganti et al 2003). Height and weight were measured using standard methods, (Briganti et al 2003; Dalton et al 2003) and BMI was calculated as weight (kg)/height $(m)^2$. (Dalton et al. 2003) Fasting serum total cholesterol was measured with an Olympus AU600 analyser (Olympus Optical, Tokyo, Japan) at a central laboratory (Magliano et al 2007).

Classification of diabetes status has been described elsewhere (Magliano et al 2007). Briefly, participants were classified as having 'known diabetes mellitus' if they reported having physician-diagnosed diabetes mellitus and were either taking hypoglycaemic medication or had fasting plasma glucose (FPG)≥ 7.0 mmol/L or a 2-hour plasma glucose (PG) ≥ 11.1 mmol/L. Participants not reporting diabetes mellitus but with FPG ≥ 7.0 mmol/L or 2-hour PG ≥ 11.1 mmol/L were classified as having 'newly diagnosed diabetes mellitus'.

Statistical analysis

Analyses were conducted using sample weights to account for the sampling design of the study (Dunstan et al 2002). For continuous risk factor variables, the significance of a trend across educational categories was assessed using linear regression. For dichotomous variables, the significance of a trend across educational categories was assessed using logistic regression. Two-sided p values are presented, with p-values <0.05 regarded as significant.

For each individual risk factor at baseline, we created "low risk" groups according to baseline measurement or use of prescription medication for that risk factor. The cut-point for being considered "low risk" for hypertension was a baseline systolic blood pressure reading of <140 mmHg or a baseline diastolic blood pressure reading of <90mmHg, and not on anti-hypertensive medication. For cholesterol, the cut-point for being "low risk" was <5.5mmol/l and not on cholesterol-lowering medication at baseline, and for BMI, the cut-point was <25kg/m^2.

We used logistic regression to analyse the incidence of risk in those participants designated "low risk" according to these cut-points. The odds ratios represent the odds of progressing from being "low risk" at baseline to "high risk" at follow-up for that risk factor within each education category, relative to the highest educated group. Three models are presented; model 1 (unadjusted), model 2 (adjusted for age and ethnicity), and model 3 (adjusted for age, ethnicity and baseline measure of that risk factor). Linear regression was used to describe the association between education and the number of risk factors at follow up, adjusting for the number of risk factors at baseline. This analysis reports the increase in risk factors over time according to educational attainment. Tests of interaction between education and sex were significant for diabetes and therefore results of sex-stratified analyses are presented.

Results

Non-attendees

Baseline characteristics were compared between participants who attended follow-up and those who did not (data not shown). Compared to those who did attend, non-attendees were on average 2 years older. Mean levels of systolic blood pressure, cholesterol, and BMI were similar between the two groups. The prevalence of smoking in male non-attendees according to educational category was 28%, 28% and 15% for secondary, diploma and degree-educated groups, respectively, and for female non-attendees was 24%, 21% and 14%, respectively. Diabetes prevalence in male non-attendees was 10%, 9% and 5% for secondary, diploma and degree-educated groups, respectively, and 9%, 6% and 4%, respectively for female non-attendees. For men, the odds of not attending (when eligible) were 1.60

(95% CI 1.33-1.93) times greater for those with secondary compared to tertiary education and 1.30 (95% CI 1.12-1.51) times greater for those with diploma compared to tertiary education. For women, the odds of not attending (when eligible) were 1.65 (95% CI 1.40-1.95) and 1.32 (95% CI 1.12-1.51), respectively.

The baseline characteristics of study participants are shown in Table 1. Compared to the lower educated groups, participants with degree level education were younger. Inverse gradients were observed for most risk factors, reflecting a more adverse risk factor profile and a greater likelihood of being at "high risk" for those with lower education compared to those with higher education. The numbers of risk factors at baseline (out of a total number of 5) also differed according to education for both men and women, with lower educated participants having the greater number.

Table 2 presents mean risk factor levels for those participants defined as "low risk" for each risk factor according to the cut-points described earlier. For men, educational gradients were seen for fasting blood glucose only. Among women, inverse educational gradients were seen for all risk factors with the exception of diastolic blood pressure.

Incidence of risk factors

The likelihood of progression to "high risk" for each risk factor according to education level is shown in Table 3. In age and ethnicity-adjusted analyses, women with secondary education and those with diploma level education were more likely to progress to increased risk for BMI (OR compared to degree level education 1.54 (95% CI 1.04-2.27) and 1.70 (95% CI 1.24-2.34) respectively). This association became non significant after adjustment for baseline BMI. Women with secondary and diploma level education were also more likely to develop incident diabetes than were those with higher education (adjusted OR from degree level education 3.09 (95% CI 1.28-7.42), and from diploma level education 2.65 (95% CI 1.11, 6.30). Among men, this association was seen only for those with secondary education (adjusted OR from degree level education 1.71 (95% CI 1.10-2.66). After adjusting for baseline FBG level, the associations between education and diabetes remained significant for both men and women.

Table 1. Baseline risk factor measures, prevalence and number of risk factors in 5,568 AusDiab men and women participants, by educational attainment

		Men				Women			
		Highest level of education				Highest level of education			
		Secondary (n=668)	Diploma (n=1,234)	Degree (n=582)	p-value[1]	Secondary (n=1,374)	Diploma (n=1,177)	Degree (n=533)	p-value [1]
Age	mean (SD)	52.6 (12.8)	50.9 (12.3)	47.9 (11.2)	<0.001	53.1 (12.4)	50.0 (11.8)	45.1 (10.1)	<0.001
Systolic BP	mean (SD)	133.9 (16.8)	131.4 (15.9)	130.1 (15.6)	0.001	128.1 (19.0)	124.3 (17.1)	119.1 (14.5)	<0.001
Diastolic BP	mean (SD)	75.4 (10.6)	74.5 (10.6)	74.8 (10.6)	0.33	67.2 (11.1)	65.9 (11.0)	65.5 (10.0)	0.001
Hypertension[2] at baseline	n (%)	256 (38%)	392 (32%)	147 (25%)	<0.001	451 (33%)	284 (24%)	64 (12%)	<0.001
Total cholesterol	mean (SD)	5.71 (1.01)	5.75 (1.03)	5.57 (0.97)	0.004	5.75 (1.03)	5.64 (1.01)	5.27 (1.01)	<0.001
Hypercholesteraemia[2] at baseline	n (%)	425 (64%)	775 (63%)	328 (56%)	0.010	879 (64%)	688 (58%)	219 (41%)	<0.001
Body mass index	mean (SD)	27.5 (4.1)	27.1 (3.9)	26.6 (3.9)	<0.001	27.0 (5.3)	26.6 (5.6)	25.4 (5.0)	<0.001
Overweight/obese[2] at baseline	n (%)	480 (72%)	866 (70%)	377 (65%)	0.002	832 (61%)	619 (53%)	240 (45%)	<0.001
Fasting blood glucose	mean (SD)	5.79 (1.19)	5.70 (0.86)	5.63 (1.04)	0.007	5.45 (1.00)	5.36 (0.92)	5.20 (0.83)	<0.001
Diabetes[2] at baseline	n (%)	62 (9%)	86 (7%)	28 (5%)	0.002	94 (7%)	55 (5%)	12 (2%)	0.002
Smoking[2] at baseline	n (%)	126 (19%)	162 (13%)	44 (8%)	0.000	157 (11%)	116 (10%)	30 (6%)	0.002
Proportion with no risk factors[2]	n (%)	47 (7%)	125 (10%)	94 (16%)	<0.001	168 (12%)	243 (21%)	169 (32%)	<0.001
Proportion with one risk factor [2]	n (%)	165 (25%)	325 (26%)	172 (30%)	0.06	416 (30%)	369 (31%)	209 (39%)	<0.001
Proportion with two risk factors[2]	n (%)	235 (35%)	455 (37%)	210 (36%)	0.75	431 (31%)	333 (28%)	111 (21%)	<0.001
Proportion with three risk factors[2]	n (%)	166 (25%)	255 (21%)	89 (15%)	<0.001	291 (21%)	189 (16%)	40 (8%)	<0.001
Proportion with four risk factors[2]	n (%)	51 (8%)	71 (6%)	16 (3%)	<0.001	59 (4%)	43 (4%)	4 (1%)	0.004
Proportion with five risk factors[2]	n (%)	4 (0.6%)	3 (0.2%)	1 (0.2%)	0.28	9 (1%)	0	0	

Notes: [1]P-value for continuous variables = trend across education categories using linear regression; for proportions = trend across education categories using logistic regression. Abbreviations BP=blood pressure; [2]Risk factors defined as follows: hypertension (systolic blood pressure ≥ 140mmHg or diastolic blood pressure ≥ 90mmHg or on blood pressure lowering medication); hypercholesteraemia (total cholesterol ≥ 5.5mmol/l or on cholesterol lowering medication); overweight or obese (BMI, ≥ 25 kg/m^2); diabetes (known or newly diagnosed); smoking (current smoker).

Table 2. Mean risk factor measurements in those AusDiab men and women considered "low risk"[1] at baseline, by educational attainment

		Men				Women			
		Highest level of education				Highest level of education			
		Secondary	Diploma	Degree	p-value[2]	Secondary	Diploma	Degree	p-value[2]
Systolic BP	mean (SD) if "not at risk"	124.4 (9.3)	123.4 (9.1)	123.8 (9.8)	0.38	118.7 (11.0)	117.6 (11.1)	115.7 (10.3)	<0.001
Diastolic BP	mean (SD) if "not at risk"	73.1 (9.1)	72.1 (8.8)	72.4 (8.7)	0.20	65.7 (9.9)	64.6 (10.2)	65.0 (9.7)	0.06
Total cholesterol	mean (SD) if "not at risk"	4.75 (0.52)	4.80 (0.47)	4.77 (0.50)	0.72	4.78 (0.52)	4.75 (0.51)	4.63 (0.62)	0.010
Body mass index	mean (SD) if "not at risk"	23.0 (1.6)	23.0 (1.6)	22.8 (1.5)	0.30	22.4 (1.7)	22.3 (1.8)	21.9 (1.8)	0.002
Fasting blood glucose	mean (SD) if "not at risk"	5.38 (0.32)	5.37(0.35)	5.33 (0.31)	0.032	5.19 (0.36)	5.17 (0.39)	5.07 (0.36)	<0.001

Notes: [1]"Low risk" defined for each risk factor as follows: : For hypertension, systolic blood pressure < 140mmHg or diastolic blood pressure < 90mmHg & not on blood pressure lowering medication; for cholesterol < 5.5mmol/l & not on treatment; BMI, 25 , < 25 kg/m^2 or less; for diabetes, no known or newly diagnosed diabetes; for fasting blood glucose ≤6.0mmol/L; for smoking former or non-smoker [2]P-value for continuous variables = trend across education categories using linear regression; Abbreviations; BP=blood pressure; SD=standard deviation

Table 3. Risk of incident risk factors at 5-year follow-up in men and women AusDiab participants according to educational attainment

		Model 1[1]				Model 2[2]				Model 3[3]				
Men		**Secondary**		**Diploma**		**Secondary**		**Diploma**		**Secondary**		**Diploma**		**Degree**
	n	*OR*	*(95% CI)*	*OR*	*(95% CI)*	*OR*	*(95% CI)*	*OR*	*(95% CI)*	*OR*	*(95% CI)*	*OR*	*(95% CI)*	*(reference category for all models)*
Hypertension: "Low risk"[4] at baseline to "High risk"* at follow-up	241	1.09	(0.83,1.41)	1.08	(0.84,1.38)	0.93	(0.70,1.22)	0.97	(0.76,1.24)	0.94	(0.70-1.24)	1.10	(0.85-1.43)	1.00
Total cholesterol: " Low risk"[4] at baseline to "High risk"* at follow-up	162	0.97	(0.61,1.55)	0.81	(0.52,1.25)	0.94	(0.58,1.52)	0.79	(0.51,1.23)	1.01	(0.61-1.68)	0.77	(0.49-1.22)	1.00
Body mass index: " Low risk"[4] at baseline to "High risk"* at follow-up	177	0.93	(0.60,1.46)	1.14	(0.75,1.71)	1.02	(0.64,1.63)	1.21	(0.80,1.84)	0.88	(0.45-1.6)	1.08	(0.65-1.78)	1.00
No diabetes at baseline to diabetes at follow-up	90	**2.05**	**(1.32,3.18)**	0.88	(0.47,1.65)	**1.71**	**(1.10,2.66)**	0.78	(0.41,1.48)	**1.55**	**(0.97-2.49)**	0.69	(0.36-1.29)	1.00
Women		**Secondary**		**Diploma**		**Secondary**		**Diploma**		**Secondary**		**Diploma**		**Degree**
	n	*OR*	*(95% CI)*	*OR*	*(95% CI)*	*OR*	*(95% CI)*	*OR*	*(95% CI)*	*OR*	*(95% CI)*	*OR*	*(95% CI)*	*(reference category for all models)*
Hypertension: " Low risk"[4] at baseline to "High risk"* at follow-up	275	**1.68**	**(1.10,2.56)**	1.41	(0.90,2.19)	1.14	(0.73,1.77)	1.09	(0.71,1.68)	1.00	(0.63-1.59)	0.99	(0.62-1.60)	1.00
Total cholesterol. " Low risk"[4] at baseline to "High risk"* at follow-up	260	1.44	(0.95,2.19)	1.34	(0.85 2.12)	1.20	(0.76,1.90)	1.27	(0.80,2.02)	1.10	(0.68-1.76)	1.20	(0.76-1.89)	1.00
Body mass index. " Low risk"[4] at baseline to "High risk"* at follow-up	311	**1.51**	**(1.01,2.27)**	**1.69**	**(1.23,2.33)**	**1.54**	**(1.04,2.27)**	**1.70**	**(1.24,2.34)**	1.34	(0.82-2.17)	1.48	(0.98-2.24)	1.00
No diabetes at baseline to diabetes at follow-up	86	**3.20**	**(1.36,7.50)**	**2.68**	**(1.14,6.31)**	**3.09**	**(1.28,7.42)**	**2.65**	**(1.11,6.30)**	**2.69**	**(1.04-6.98)**	**2.52**	**(1.01-6.30)**	1.00

Notes: [1]Model 1 unadjusted; [2]Model 2 adjusted for age and ethnicity; [3]Model 3 adjusted for age, ethnicity and baseline measures of: systolic and diastolic blood pressure; or total cholesterol; or body mass index; or fasting blood glucose; [4] "Low risk" defined for each risk factor as follows ("High risk" has the opposite definition in each case): For hypertension, systolic blood pressure < 140mmHg or diastolic blood pressure < 90mmHg and not on blood pressure lowering medication; for cholesterol < 5.5mmol/l and not on treatment; for BMI < 25 kg/m^2; for diabetes, no known or newly diagnosed diabetes: Abbreviations OR=Odds ratio; CI=confidence interval.

Table 4. Difference in the number of risk factors[1] between baseline and 5 year follow up in male and female AusDiab participants according to educational attainment

	Model 1 – adjusted for baseline risk factor number[2]						Model 2 – adjusted for baseline risk factor number, age & ethnicity					
	Secondary		Diploma		Degree	*p* for trend[3]	Secondary		Diploma		Degree	*p* for trend[3]
Increase in mean number of risk factors between baseline and follow up	*coefficient*	*(95% CI)*	*coefficient*	*(95% CI)*	*ref*		*coefficient*	*(95% CI)*	*coefficient*	*(95% CI)*	*ref*	
Men	0.09	(-0.01,0.19)	0.02	(-0.05,0.09)	0.00	0.06	0.08	(-0.02,0.18)	0.01	(-0.06,0.09)	0.00	0.09
Women	**0.14**	**(0.06,0.21)**	**0.11**	**(0.04,0.18)**	0.00	0.006	**0.10**	**(0.02,0.19)**	**0.09**	**(0.02,0.17)**	0.00	0.06

Notes: [1]Presence of each risk factor defined as follows: For hypertension, systolic blood pressure < 140mmHg or diastolic blood pressure < 90mmHg and not on blood pressure lowering medication; for cholesterol < 5.5mmol/l and not on treatment; for BMI < 25 kg/m^2; for diabetes, no known or newly diagnosed diabetes. [2] All models adjusted for baseline number of risk factors. [3] p for trend across educational categories using linear regression: Abbreviations CI=confidence interval.

Change in smoking status

The proportions of current smokers decreased between baseline and follow up in most educational groups (data not shown). Participants with lower education were more likely to stop smoking between baseline and follow up, than those with higher education. Among men, age and ethnicity-adjusted odds ratios for smoking cessation for secondary compared to tertiary education were 2.55 (95%CI 1.31-4.94), and for diploma compared to tertiary education, 1.78 (95%CI 1.01-3.15). For women, the corresponding odds ratios were 3.74 (95% CI 1.42-9.86) and 2.54 (95%CI 0.95- 6.82), respectively.

Increase in the number of risk factors

After adjusting for age and ethnicity, and for the number of risk factors at baseline, women with lower education had an increased mean number of risk factors at follow up compared to women with higher education (increased by 0.10, (95%CI 0.02-0.19) for secondary education and 0.09, (95% CI 0.02-0.17) for diploma education in comparison to degree-level education). No relationship was observed for males.

Discussion

Overall findings

This study found that over 5 years, lower education was positively associated with the onset of overweight/ obesity in women, and of diabetes in both men and women. The likelihood of accumulating a higher number of risk factors between baseline and follow up was greater for lower compared to higher educated women.

Strengths and limitations

This contemporary study was undertaken on a large sample with accurate measurement of risk factors. However, there was a significant loss to follow-up, and so the sample may not be representative of the Australian population, limiting the generalisability of the results from this study. Non-attendance was associated with lower educational attainment in both men and women and this may lead to some selection bias and possible underestimation of our findings. In addition, the prevalence of smoking was higher among non-attendees. However, this was the case for all educational groups and therefore would be unlikely to affect our findings concerning the relationship between education and smoking. We described risk using categories rather than continuous measurements. There is known to be a continuous relationship between risk factor levels and risk of disease; as a risk factor progressively increases, so too does the risk of developing CVD (Law 2002). While our results therefore do not present information regarding risk accumulation across the entire risk spectrum, describing development of high risk in this manner may be more meaningful and applicable to clinicians. For example, clinical guidelines for the prevention of atherosclerotic heart disease use risk factor cut-off points as indicators of treatment (National Heart Foundation 2007; Pearson et al 2002: European Society of Cardiology 2007).

While we used one indicator only to measure SEP, education is considered a robust measure as it is relatively easy to measure, has high response rates, tends to exclude fewer members of the population than occupational-based measures, and is less likely to change after adulthood than other indicators (Shavers 2007, Dutton et al 2005). Many studies have demonstrated consistent associations between education level and CVD risk factors, both singly and accumulated (Helmert et al 1990; Winkleby et al 1992; Luoto et al 1994; Choiniere et al 2000; Yu et al 2000; Stelmach et al 2004; Maty et al 2005; Robbins et al 2005). Educational attainment has also been shown to have a strong association with CVD mortality (Winkleby et al 1992; Kilander et al 2001; Lee et al 2005). There are several mechanisms through which education might influence health status. For example, education provides knowledge and life skills that allow people to gain ready access to information and health promotion resources (Adler and Newman 2002). Individuals with higher education may also be more likely to have better work and economic conditions and psychological resources, although the stability of education can sometimes mask changes in an individual's circumstances. It is important to note however, that no single indicator will capture all aspects of SEP.

The meaning of educational attainment will also vary between different birth cohorts as school leaving age increases, or higher education becomes more widely available. For example, in Australia in 1945, the majority of school children completed only 2-3 years of secondary education, whereas in 1971, more than half completed 4 years. In 1939,

less than 3 percent of adults aged 17-22 were in full-time tertiary education; in 1971 this was 9 percent (Encel 1972). It is difficult to assess the effect of this upon our results. Our analysis controlled for age, which may have mediated some of the effects of changes in education policy, nevertheless this may prove to be an important limitation on the use of educational attainment as a measurement of SEP in longitudinal studies that contain multiple birth cohorts.

Individual risk factors

Consistent with our findings, several longitudinal studies report that lower SEP is associated with incident overweight or obesity over time (Ball et al 2002; Coogan et al 2010). We also found that lower educated women of normal weight were more likely to progress to incident overweight or obesity than were those with higher education. This may be driven by the higher mean BMI observed at baseline among women with lower education, as the association was no longer significant after adjustment for baseline BMI. There was no educational gradient seen in BMI among men of normal weight, possibly accounting for some of the differences seen in our study between men and women. Gender-related differences in the social gradient in BMI gain have also been reported by others, although findings are conflicting (Matheson et al 2008; Ross et al 2007; Dennis et al 2000; Sundquist and Johansson 1998). Overweight or obesity has previously been associated with other risk factors such as diabetes and systolic blood pressure (Dennis et al 2000). Therefore, the contribution of BMI to future socio-economic gradients in CVD is potentially of great importance, particularly among women.

Other studies also report that diabetes incidence is inversely associated with SEP (Kumari et al 2004; Maty et al 2005; Maty et al 2010; Krishnan et al 2010; Lidfeldt et al 2007). The greater incidence of diabetes among lower educated women in our study may be related to the co-existing increases seen in overweight and obesity. Several studies report an attenuation of the effect of SEP on incident diabetes after adjusting for BMI (Maty et al 2005; Robbins et al 2005; Krishnan et al 2010; Lidfeldt et al 2007), suggesting that obesity is an important mediator in this relationship. However, in our study, the social gradient in diabetes is much stronger than that seen for BMI, implying that other factors may play a part.

There was no educational gradient seen in incident hypertension in either men or women. Few studies have examined incident hypertension according to SEP, with most finding that education, income and neighbourhood are all predictors of onset of this risk factor (Diez Roux et al 2002; Dyer et al 1999; Vargas et al 2000; Conen et al 2000). The lack of a significant finding in our study may reflect small numbers of incident hypertension. While there was no educational gradient seen in mean systolic blood pressure among men who were “not at risk” for hypertension at baseline (Table 2), a gradient was apparent when the total population was examined (including those on anti-hypertensive medication). This may indicate educational differences in the treatment of hypertension among men.

We found the prevalence of smoking declined across all socio-economic groups, apart from among women with degree level education. Similar to other studies, the pattern was one of a greater decrease among the lower educated (Kanjilal et al 2006; Lyratzopolous et al 2006; Strand and Tverdal 2006). These findings are likely to reflect secular trends in smoking due to the effect of public health policies such as increased tobacco taxation. This strategy is considered one of the most effective deterrents to smoking, and has been shown to be effective among lower SEP groups in some settings including Australia (White et al 2003). Overall our findings are encouraging, as smoking has previously been shown to contribute to approximately 30% of the excess risk of CVD mortality among lower SEP groups (Jha et al 2006).

Multiple risk factors

It is known that having more than one risk factor can accelerate the development of atherosclerosis and CVD mortality (Lowe et al 1998; Berenson et al 1998), and that socio-economic disadvantage is inversely associated with the number of risk factors present (AIHW 2005). The pattern of a smaller number of risk factors in higher SEP groups and a greater number in lower SEP groups seen in our study has been observed by others (AIHW 2005; Karlamangla et al 2005), however, few studies have examined the accumulation of risk factors over time according to SEP (Dupre 2008; Karlamangla et al 2005). One United States study, utilising 20 years of data from the National Health and Nutrition Epidemiologic Follow-up Study, reported that education was

associated with the accumulation of behavioural risk factors for CVD, namely smoking, alcohol and obesity (Dupre 2008). Our results also showed that women with lower education were more likely than those with higher education to increase their number of risk factors over time, potentially contributing to continued socio-economic gradients in CVD in the future.

Implications

Our findings have important implications for the future burden of CVD among lower educated groups. They suggest that people with less education carry a greater burden of individual cardiovascular risk factors, and are also more likely to progress to an overall increased risk. Our findings also suggest that more educated participants, particularly females, are less likely to develop incident risk factors, which together with the existing social gradient, will potentially lead to increased gradients over time. These findings thus reinforce the need to direct intervention efforts towards reducing socio-economic differences in CVD.

Not only do our results have implications for the development of CVD, but for other risk factors and conditions more broadly. Obesity has been associated with a wide range of chronic conditions such as diabetes, hypertension, kidney disease, and certain cancers (Field et al 2001; Kramer et al 2005; Wang et al 2008). Being obese also influences the ability to successfully manage many chronic conditions such as arthritis (Ogden et al 2007; AIHW 2005). It is therefore possible that educational gradients in the incidence of these risk factors will adversely impact upon educational gradients in chronic diseases overall.

The implications of the gender-based differences seen in our study are also of interest. The adverse effects of cardiovascular risk factors have previously been shown to be stronger for women compared to men (Chrysohoou et al 2003; Yu et al 2000). For example in the INTERHEART study, the population attributable risk for hypertension was 36% in women and 19% in men (Yusuf et al 2004). Diabetes has also been associated with a higher risk of CHD in women than in men (Haffner et al 1997), although this may be due to the fact that women also tend to have a higher number of coexisting risk factors than men (Kanaya et al 2002; Oda et al 2006). The reasons for these gender-based differences in CVD risk are unclear although patho-physiological factors, or treatment differences, may play a role (Vaccarino 2010). In addition, CVD risk factors have been more consistently and strongly associated with SEP among women compared to men (Strand and Tverdal 2006; Lyrotzopolous et al 2006; Luepker et al 1993; Bennett 1995; Yu et al 2000; Helmert et al 1990). Findings such as ours, that show an increased incidence of major risk factors among women, suggest that social gradients in CVD events will continue to widen among women.

Conclusion

Our findings provide evidence for the association between SEP and incident cardiovascular risk factors for CVD in a cohort of Australian men and women. Among women in particular, lower education was associated with an increased risk of developing both individual and accumulated CVD risk factors over a 5-year period. These findings suggest that educational inequalities in CVD will continue into the future.

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The German National Educational Panel Study: a wealth of potential for research in school-to-work transitions

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Abstract

Advanced societies in general, and Germany in particular, are faced with many unanswered questions regarding their vocational education and training (VET) systems in terms of access, outcomes, and individual skill formation. Is VET still capable of providing the skills necessary for a successful transition into the labour market? How can low-achieving youth enter and finish vocational training? How do cognitive and non-cognitive competencies develop in the course of VET? At the moment, however, we do not have sufficient longitudinal data to give profound answers to these and other questions. The German National Educational Panel Study (NEPS), launched in 2008 and funded by the German Federal Ministry of Education and Research, will provide unique longitudinal data on life histories in combination with measures on competence development over the life course. Within NEPS, the so-called Stage 6, 'Vocational Education and Training and Transitions into the Labour Market', is devoted to collecting and providing longitudinal data on the transitions of young people from secondary schools into the labour market. In this paper, we shall describe the main features of the survey design of Stage 6 and discuss the research potential offered by this new type of data.

Keywords: Education, school-to-work transition, Germany

Introduction

The competitiveness and performance of national economies are inherently linked to the productivity of their workforce. Changes in labour markets and in the world of work imply an increase in the level of average skill requirements – coupled with the constant risk of a polarization of skills – as well as fast turnovers in the content of skills. Schooling and initial vocational and professional training have maintained their primary significance for occupational careers; however, the content and timing of schooling and training are under pressure to change (Mayer and Solga 2008).

For a long time, the so-called German 'dual system' has attracted much attention in international debates. It has been seen as one of the skill formation systems (or skill regimes) that have 'appeared capable of reconciling high wages with high productivity via high skills and high value-added production' (*ibid* 8). Accompanied by compressed wage differentials, it has still been regarded as capable of integrating less educated youths into procedures enhancing skill formation (Streeck 1989; Reich 1991; Culpepper and Finegold 1999; Estevez-Abe, Iversen and Soskice 2001). The ability of the German vocational education and training (VET) system to adapt to new technological and market conditions has, however, increasingly been called into question (Herrigel and Sabel 1999;

Baethge 2000; Baethge, Solga and Wieck 2007; Culpepper and Thelen 2008). Is VET still capable of providing the skills necessary for a successful transition into the labour market? How is it possible for low-achieving youth to enter and finish vocational training? How do cognitive and non-cognitive competencies develop in the course of vocational education and training?

For some of these questions, we have (preliminary) answers; for others, however, we still lack the necessary data and interdisciplinary research efforts. During the past 20 years, longitudinal datasets covering early labour-market experiences have become widely available.[i] However, these large-scale datasets do not provide sufficiently detailed information to allow for valid conclusions about the factors that shape school-to-work transitions and about the consequences these transitions may have. More detailed data on competencies, educational biographies, and the manifold transitions in young adulthood are needed, for example. Some specialized studies on school-to-work transitions do include a broader range of variables, but these are limited in their potential for generalization because of sample restrictions in terms of the region(s) or social group(s) covered.[ii] Finally, large-scale comparative studies on the individual competence attainment of children, adolescents, and adults have been conducted in the past decade, but as cross-sectional surveys, they cannot provide information on educational pathways, competence development, and the influence of these two factors on job placement and other labour market outcomes.[iii]

A longitudinal, prospective panel survey of individuals' educational and environmentally embedded life histories that simultaneously collects data on cognitive competencies, non-cognitive capabilities (such as personality traits, learning strategies, values, interests, motivations, attitudes), as well as on decision-making processes will provide a unique opportunity for studying school-to-work transitions in more detail. The German National Educational Panel Study (NEPS) is a new longitudinal study designed to investigate the relationships between educational biographies, learning environments, competence development and returns to education over the life course for nearly *all* age groups. Within NEPS, the so-called Stage 6, 'Vocational Education and Training and Transitions into the Labour Market', specifically collects and provides longitudinal data on school leavers' transitions into the labour market. It opens up the opportunity to examine young people's motivation and competence endowment, their decisions and constraints concerning participation in VET, the information and support they may receive from families and other social networks, or the learning environments they encounter in companies and vocational schools. With this type of innovative data, it will become possible to answer many of the open questions on school-to-work transitions, both for the specific case of Germany and with regard to cross-national comparisons.

Since NEPS data collection only started in late 2010, the goal of this paper is not to provide initial answers to the above-mentioned questions. Rather, it aims to introduce the study design and research potential of NEPS Stage 6 to those who may be interested in either working with this dataset in the future, or in using its design in other empirical studies, such as cross-national comparisons. NEPS is based on a complex research design; therefore, we shall begin by presenting a (necessarily brief) overview of NEPS as a whole, before outlining the specific survey design and research potential of NEPS Stage 6. First of all, however, we shall provide some background information on the German VET system, to facilitate a better understanding of the challenges and potential of this unique longitudinal study.

Vocational Education and Training (VET) in Germany

The German VET system is characterized by a number of special features. In contrast to countries such as the United States, where young people acquire general, non-specific credentials mostly through schools and colleges, and job-related skills through on-the-job-training, about 60 per cent of German adolescents leave school comparatively early in order to acquire occupation-specific credentials through a period of VET, typically lasting three years. This arrangement is based on the rigid tracking of pupils after four to six years of primary schooling into three types of secondary schools: lower secondary schools (*Hauptschule* and special education schools for youths with disabilities, lasting nine or ten years), middle secondary schools (*Realschule*, lasting ten years), and upper secondary schools (*Gymnasium*, lasting 12 to 13 years). Pupils who leave lower or middle secondary school

normally head for VET, whereas those who complete *Gymnasium* are entitled to enter university and actually do so in large numbers.

VET can take place either by way of an apprenticeship in the so-called 'dual system' or in full-time vocational schools. The dual system of vocational training combines an apprenticeship in a company with part-time schooling. School-based VET programmes provide training through full-time schooling, combined with periods of practical training, mainly via internships. Both company- and school-based programmes lead to nationally recognized occupation-specific VET certificates. The dual system trains young people for manufacturing and industry occupations and some of the white-collar occupations (such as commercial, retail, and administrative occupations), whereas full-time school-based VET programmes prepare trainees for personal service occupations (such as nurses, midwives, medium-level care professionals, kindergarten teachers, and social workers) and medium-level technical occupations (such as dental technicians). A few exceptions notwithstanding, company- and school-based VET programmes thus are not alternative pathways leading to the same occupations but pathways segmented by occupations (and mostly by gender, i.e. by male and female-dominated occupations).

What looks rather clear in principle – a segregated system of compulsory schooling with graduates below the *Gymnasium* level entering either the dual system or a full-time school-based VET programme – has in fact become much more complicated and blurred in recent decades. For example, *Gymnasium* graduates have increasingly started to opt for VET below the university level. Combined with a decrease in the number of apprenticeships offered by companies, not compensated for by increases in the school-based VET system, this development has resulted in the enormous expansion of what is called the pre-vocational transition system, in which young people are either taught basic occupational skills or acquire additional secondary school education in courses typically lasting one year. Thus, making a direct transition into VET after completing grades 9 and 10 is no longer feasible for many of today's youth in Germany (Baethge, Solga and Wieck 2007; Dietrich et al 2009).

To complicate things even more, some *Hauptschule* or *Realschule* graduates choose to prolong their general schooling in an attempt to obtain a higher-level school certificate to become more competitive in the search for an apprenticeship, or to be entitled to enter university. In addition, about 20 per cent of apprentices terminate their contract prematurely, typically to start anew in a different occupation or with a different company. Finally, some students quit university prematurely to continue their education in the VET system, whereas others enter university after completing a VET programme. For many school leavers, therefore, the transition from school to work is a prolonged and risky period of 'passing' or 'muddling through' the VET system, of eventually obtaining one or more vocational education certificates, and of finally launching their career (Eberhard, Krewerth and Ulrich 2006). Furthermore, school leavers' multiple transitions do not always follow a 'coordinated' sequencing pattern in terms of educational biography or skill development (Buchmann 1989).

Yet, we have little knowledge about whether and, if so, why, different pathways result in different competence and general employment skills endowments. It is of high importance, therefore, to collect data that captures all of these different pathways from school to work, and that, at the same time, provides multi-time measurements of young people's (cognitive and non-cognitive) competencies.

Research Design of Stage 6: Vocational Training and Education and Transitions into the Labour Market

One basic prerequisite for adequately dealing with the complexities of current transition patterns is using a large sample, combined with a sound strategy for sampling and minimising (selective) panel attrition. These aspects will be addressed in the following, preceded by a short introduction to the overall NEPS design.

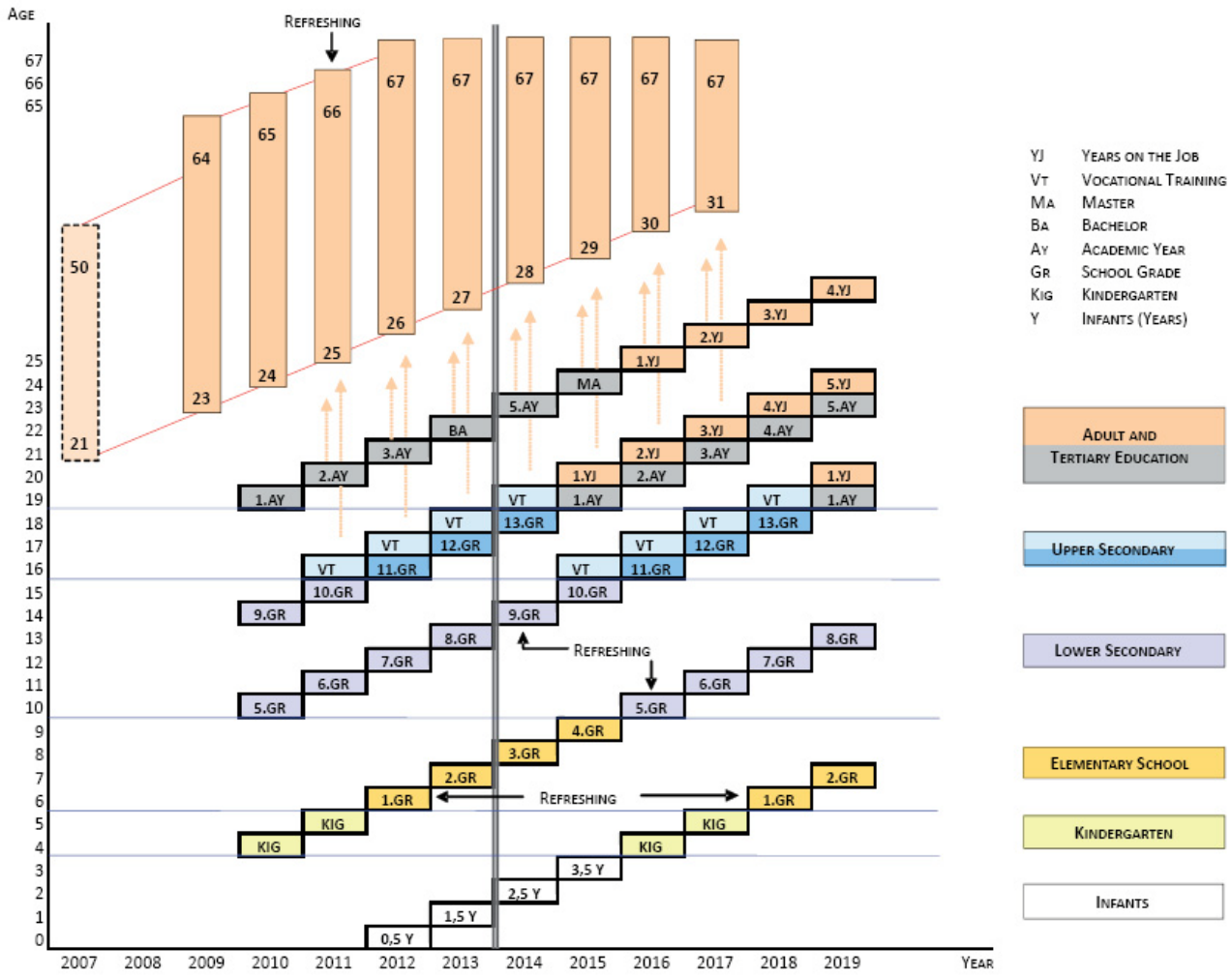
Study design of NEPS: a brief overview

NEPS as a whole starts with six different cohorts (Blossfeld, Schneider and Doll 2009, 26-29): (1) newborns (2) kindergarten children at the age of four (3) students at the beginning (fifth graders), and (4) shortly before the end of lower secondary schooling (ninth graders) (5) first-year college and university students (6) adults aged 23 to 64. Figure 1 shows how each of the starting cohorts moves

through a variety of so-called 'educational stages' over the life course. These educational stages include the distinct stages of formal education, as well as the preceding and subsequent stages of early childhood education at home and in kindergarten on the one hand, and adult education and training on the other.

For each of the educational stages, one research team of specialists in the respective area has been formed. With regard to the starting cohort of ninth graders, it is of interest to note that subsequent trajectories are sub-divided into two distinct educational stages of upper secondary education, in accordance with the German education system. Stage 5 surveys trajectories within general schooling (i.e. *Gymnasium)*, whereas Stage 6 collects information on all school leavers' transitions to VET and into the labour market (until the age of 24). That is, if a respondent leaves *Gymnasium* prematurely, s/he will continue to be followed just like any other school leaver. In other words, although specialized research teams develop questionnaires and tests tailored to each specific educational stage, the overall research design provides opportunities for following all members of all samples, and for administering the instruments that are appropriate to the specific circumstances of each individual. Thus, Figure 1 depicts the transition, from school to VET and on to work, in a highly idealized fashion.

Figure 1. The Multi-Cohort-Sequence Design of the NEPS



(Source: Blossfeld, Schneider and Doll 2009, 28)

Sampling of NEPS Stage 6

With a starting sample size of 16,044 ninth graders, Stage 6 will be able to draw on a very high number of respondents for conducting differentiated analyses of school-to-work transitions (see Table 1). All of the target persons are young adults attending grade nine at German secondary schools in autumn 2010. For the purpose of sampling, the population was stratified by the different types of schools, and an institutionally-based, random sample, using schools as sampling units, was drawn. This clustering of students in classes and schools allows for an analysis of structural and compositional context effects (Blossfeld, Schneider and Doll 2009, p. 27). The response rate of the first wave was 60.5 per cent. This is quite high, considering the fact that students could only be included in the survey if they themselves and their parents signed an agreement to participate in the panel study.[iv]

Table 1. Sample design and size for NEPS Stage 6, ninth grade (2010)

School type	Number of schools	Number of ninth graders
Lower secondary schools (*Hauptschulen*)	181	3,688
Middle secondary schools (*Realschulen*)	104	3,174
Integrated comprehensive schools (*Integrierte Gesamtschulen*)	55	1,654
School offering multiple tracks (except the *Gymnasium* track)	55	1,154
University-preparatory schools (*Gymnasium*)	149	5,211
Special education schools (for students with learning disabilities)	105	1,163

Lower secondary schools (*Hauptschulen*) and integrated comprehensive schools (*integrierte Gesamtschulen*) are oversampled in order to facilitate the study of the various trajectories of disadvantaged youth and their outcomes, as well as the problems of migrant youth (who attend these two school types in disproportionate numbers). In addition to pupils from all regular school types, NEPS includes a considerable number of pupils enrolled at special education schools with an emphasis on learning disabilities – a unique survey feature for Germany and many other countries. The segregation rate of disabled children is still very high in Germany (Powell 2009). About 90 per cent of the children classified as disabled attend one of the ten school types for children with special needs (of these, 50 per cent attend schools for children with learning disabilities). These children account for 6 per cent of all school leavers and for about half of those leaving school without a school degree.

Follow-up, testing, and surveying of participants

In grade nine, pupils are surveyed and tested by means of paper-and-pencil questionnaires (PAPI). NEPS not only surveys educational trajectories, certificates, and grades as educational outcomes, but also tests important basic skills – initially (2010) in the first wave (German reading and writing, maths, science and computer skills), again three years later (reading, maths and computer skills), and so forth. This allows for analyzing the extent to which adolescents' various transition pathways have an effect on their competence development upon graduation. In addition, information regarding young people's non-cognitive competencies (e.g. self-efficacy, personality traits), their academic self-concept, interests, educational and training goals, vocational training plans, decision parameters, social networks, and leisure activities have been collected in ninth grade; some of them will be re-collected in regular intervals (in subsequent waves). As a result, a variety of measures for influences on and outcomes of adolescents' future educational and employment trajectories will become available.

Additionally, up until the end of compulsory schooling, parents are surveyed via telephone interviews once every year, to gather first-hand information on pupils and their parents (e.g. about parents' educational aspirations for their children, the ways in which they support their children's

transition to vocational education and training, or the importance of parents' cultural and social capital for finding an apprenticeship position). Teachers and principals are surveyed, too, in order to get a better understanding of institutional support or barriers for individual transitions from school to VET.

Once participants have left compulsory schooling, they will be tracked individually (Blossfeld, Schneider and Doll 2009, 27). School leavers will be contacted at six-month intervals and questioned in detail via computer-assisted telephone interviews (CATI). The main survey will always take place in the autumn, and will take about 40 minutes. A shorter interview of about 20 minutes will be conducted each spring, mainly to update the longitudinal life history episodes and to record changes that may have taken place. The individual data generated in this way, will be enriched by adding structural information regarding training companies and employers, with the help of register data collected at the Federal Employment Agency, in order to gain information on young people's company-based learning environments.

Young people in Germany can leave school after completing grade 9, 10, 11, 12, or 13, and may thus enter Stage 6 at very different points. The first wave of Stage 6, to be conducted in autumn 2011, will include pupils leaving school after completing grade nine. After a loss of 10 per cent due to panel mortality in grade nine, we expect about 18 per cent of ninth graders at regular secondary schools and about 75 per cent of ninth graders at special education schools to actually leave school; these persons will thereafter be tracked individually. The majority of pupils, however, will make the transition to vocational education and training after completing grade ten. Therefore, in autumn 2012, we expect to survey about 70 per cent of the remaining pupils who attended regular schools in 2010 and all remaining pupils from special education schools; by 2014–2015, the entire (remaining) start cohort will have entered Stage 6. Due to the protracted nature of the transition process, entry into the labour market will last until the age of 22 (or until about 2017) for the majority of those not entering university, and until the age of 25 (or 2020) for university graduates.

In order to keep the panel attrition rate low and to avoid attrition selectivity as much as possible, a number of special measures will be applied. First of all, computer-assisted telephone interviews will be conducted in all waves that do not include tests (in those that do, face-to-face interviews will be conducted). Telephone interviews allow for a very high number of attempts to get in contact with target persons. In addition, the fast-growing use of mobile phones (especially among young people) over the last ten years has served to increase respondents' availability, as interviews can be conducted – or at least initial contact can be made – even when target persons are not at home. However, respondents not reachable by phone, or unwilling to give a telephone interview, will be contacted by on-site visits of interviewers at the respondents' place of residence, and CAPI (computer-assisted personal interviews) will be conducted with those who agree (about 10 per cent of the sample).

Given that about 20 to 30 per cent of the target persons in NEPS Stage 6 are rather low-achieving youths, we will have to try as best as we can not to overburden them, lest they drop out of the NEPS panel. One way of doing so is, as already mentioned above, to subdivide the questionnaire for each wave into two separate interviews: a short interview in spring and a longer interview in the autumn of each year.

Finally, all of these strategies will be accompanied by target-group-oriented incentives, which consist of fixed monetary rewards for each completed interview, as well as participation in a lottery (with substantial prizes) after completing four interviews. These strategic activities offer a promising approach for achieving the ambitious goals of keeping panel attrition and its selectivity low, and of following participants from secondary schooling to vocational training and from there into the labour market.

Table 2 offers an overview of the survey modes, target population, and survey duration of the first four panel waves up to autumn 2013. The contents of the survey will be explained below, along with information on selected potential research areas of Stage 6.

Table 2. Research design of NEPS Stage 6

Wave	Target population	Survey mode	Survey duration
First wave 2010-2011	Ninth graders, their parents, teachers, and principals	Classroom PAPI (survey and tests)	3 class periods testing, 1 period questionnaire (autumn, spring)
Second wave 2011-2012	School leavers	CATI (survey)	40 min. (autumn) + 20 min. (spring)
Third wave 2012-2013	School leavers	CATI (survey)	40 min. (autumn) + 20 min. (spring)
Fourth wave 2013 (autumn)	School leavers	CAPI/PAPI (survey and tests)	65 min. testing, 25 min. interview

Selected Potential Research Areas with NEPS Stage 6

The aim of Stage 6 is to map the trajectories of adolescents' school-to-work transitions in as much detail as possible (including the trajectories of those who never enter or complete vocational training). Providing precise descriptions is a subordinate, albeit important, concern, considering the lack of a comprehensive picture of the diversity of pathways. The primary research goal is to study the causes of the differences in school leavers' transition pathways and outcomes. Defining these causes requires a process-related analysis that examines the interplay between individual factors (adolescents' interests, motivation, and skills), social contexts (parental support, embeddedness in peer groups, social networks), and the given VET programmes and learning environments at the decisive points in individual transitional biographies.

In an ideal-typical way, the transition from school to work involves three distinct processes: (1) adolescents' placement in the VET system (access to vocational training) (2) adolescents' success in a given VET programme (3) labour market entry. Since several years have yet to pass before NEPS participants enter the labour market, we will focus on important areas of research potential for the first two processes.

Placement in the VET system and access to fully qualifying training programmes

Adolescents' placement in the VET system is known to be heavily influenced not only by their school certificates, but also by their social background and the social resources in their environment, their migrant background, and their gender. School drop-outs are particularly disadvantaged in this context (Solga 2004, 2008).

Against the backdrop of the opportunity structures defined by these factors, VET placement ultimately results from the interplay between adolescents' occupational aspirations and their strategies for finding an apprenticeship position on the one hand, and the range of available apprenticeship positions in the dual or full-time school-based VET system, as well as schools' and employers' recruitment processes and criteria, on the other. Moreover, the Federal Employment Agency functions as a gatekeeper for a sizeable group of adolescents because of its ability to use its career guidance and placement services, thereby structuring and restricting applicants' opportunities. The Agency does so in an even more decisive way, by categorizing some adolescents as 'suitable' and 'mature enough for VET' (*ausbildungsreif*) – a precondition for qualifying for career guidance and placement services in the first place – while denying these labels to others.

On the adolescents' side, research may begin by exploring how they perceive the available VET offer and their own chances of accomplishing their training goals, and how they go about their educational decision-making and search strategies. They will not be viewed as isolated actors here, however, since variables such as parental support, school-based career guidance programmes, and VET entry support services, as well as the importance of peer groups, various sources of information, or learning experiences and contacts acquired through part-time jobs and internships, will be available. Finally, additional 'context' information for the occupational search process in ninth grade will be generated by aggregating individual data for the whole class. Furthermore, over the subsequent course

of NEPS, the short intervals between survey waves will allow us to study the changes in students' search and application behaviour and the ways in which they adapt their goals to what appears feasible.

These data and the information collected on adolescents' skills, motivation, or even health-related limitations, will produce indicators for apprenticeship applicants' behaviour and performance. These may be contrasted with the more 'tangible' or observable characteristics that Employment Agency career counsellors, employers, or other training institutions tend to use to assess apprenticeship applicants (i.e. their educational biography, final grades, and social background) for classifying them as 'suitable' or 'not (yet) mature enough for VET'. Observing the interplay of these factors enables us to explore not only which types of adolescents' behaviour, but also which types of selection processes, tend to structure their access to VET positions, and to study the role of regional differences in VET programmes and labour market prospects.

In doing so, we will not only consider fully qualifying VET programmes, but also the pre-vocational transition system. While the official goal of pre-vocational programmes is to improve applicants' chances of finding a (company- or school-based) apprenticeship position, there has been ongoing scepticism about the actual efficacy of these programmes. One of the reasons why it is difficult to arrive at a well-grounded assessment here is that while participants enrolled in pre-vocational programmes represent a specifically selected group, the processes on which their selection is based are largely unknown.

The differentiated data on ninth graders provided by NEPS will enable us to study whether and how adolescents enrolled in a variety of programmes are different from one another and, more importantly, whether and how they are different from those who were able to obtain a fully qualifying apprenticeship position right away. This will allow us to analyze whether unequal opportunities to access fully qualifying VET programmes may be traced back to adolescents' initial level of skills and motivation, to regional opportunity structures, or to differences in the ways career counsellors, employers, or other training institutions ascribe certain skills to applicants with different educational biographies.

Dropping out of VET and completing VET programmes successfully

It is a well-known fact that a sizeable number of apprentices drop out of their training programmes, often as early as in their first year; however, a remarkable share of these drop-outs tends to find a new training opportunity fairly quickly. Again, the NEPS data will allow us to study the interplay between adolescents' skills and other characteristics, their (initial) occupational aspirations (surveyed *prior* to their apprenticeship search and subsequent drop-out), and their training environment, in order to come to a more precise analysis of what influences possible 'ruptures' in VET trajectories and how adolescents deal with these ruptures. Because of its longitudinal design, NEPS will supplement existing studies of VET drop-out rates, which may often explore adolescents' re-entry into the VET system only, and not their final training success or failure. Moreover, NEPS also includes full-time school-based VET programmes, which so far have received little attention. As a result, comprehensive knowledge about VET trajectories that either turn out successfully, are fraught with complications, or end in 'failure' – and their outcomes, for example in terms of labour market success, well-being and health, and political participation – will become possible.

Finally, there is a substantial research gap with regard to the acquisition of occupation-specific or cross-occupational competencies in a VET programme. We therefore plan to select a few occupations and try to use tests for measuring occupation-specific skills developed in recent years (Winther and Achtenhagen 2009). Here, our primary concern is to find out *whether* these extensive testing procedures are at all feasible within NEPS (which is not a specialized study of individual occupations) in order to gather experiences for applying them more broadly during the second funding term. Furthermore, we seek to develop a concept for cross-occupational competencies.

Outlook

This paper provided an overview on the survey design and the potential for scientific analysis in NEPS Stage 6 'Vocational Education and Training and Transition into the Labour Market'. NEPS Stage 6 has the capacity to provide a database which is capable of answering some of the fundamental questions in relation to VET – not only for Germany, but also in general. Which skills are necessary for a successful

transition into the labour market, and what is the best way to acquire them? What are appropriate ways for enabling low-achieving youth to enter and complete vocational training? How do cognitive and non-cognitive competencies develop in the course of vocational education and training? And what role do they play in relation to other market signals, such as educational certificates or gender, ethnic background, and health?

NEPS uniquely combines an ambitious longitudinal design for capturing life histories, with psychometric tests of cognitive and non-cognitive competencies – allowing us to apply advanced longitudinal methods of analysis, such as event history analysis, sequence analysis, or the estimation of random and fixed effects panel models. Due to its design and set-up, NEPS Stage 6 has some major advantages, compared to existing German and international data sets, on the transition from school to work. It is the first data set to enable researchers to investigate how competencies develop and how this development is influenced by the various learning environments that young people are part of and confronted with. Due to the high number of cases and the strategy of oversampling groups that are particularly disadvantaged in the German VET system (low-achieving school leavers, youth with learning disabilities, or migrants), it becomes possible to study the trajectories of these young people, not least to investigate whether the pre-vocational training measures they so often embark on provide opportunities for entering the regular VET system later on, or whether they are more of a 'dead end' where the young people move from one measure to the next. The large sample size of disadvantaged youth also allows intra-group analyses in order to investigate the interplay of individual and institutional factors for resilience or 'success against all odds'. Moreover, the inclusion of a large sample of young people with learning disabilities provides a data set for international scholars to study the competence development and life course trajectories of this largely under-investigated group (a statement that holds true not only for Germany).

Furthermore, NEPS Stage 6 will enable researchers to take into account the multitude of learning environments young people are confronted with at the end of compulsory schooling. This refers not only to the different types of vocational training, where it will be possible to compare dual-system apprenticeships in smaller companies with those in larger companies or with school-based vocational training, but also to the (often very selective) learning environments in pre-vocational training measures. Finally, how learning facilities at home, partners, family, and social networks support or impede learning and competence development, can be studied in more detail.

Yet, it will require a lot of patience before this research potential can be fully exploited. The first survey of ninth graders took place in autumn 2010. In autumn 2011, data collection will start on the transitions to the VET system for the subgroup of those adolescents who leave school after grade nine. The vast majority of pupils, however, will only leave school after completing grade ten (i.e. in 2012), or even after completing grades 12 or 13 (2013/2014). Because of the complex research design of NEPS, data from the first survey wave (ninth grade/2010) will not be available before 2012. Data (and analyses) regarding the first step of ninth and tenth grade graduates (wave 2/2011 and spring wave 2012) may not be expected before late 2013. The data sets will be made available for the scientific community as scientific use files by the Institute for Longitudinal Education Research Bamberg (INBIL). More and up-dated information can be found on the NEPS webpage:

http://www.uni-bamberg.de/en/neps/

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Endnotes

[i] For example, the German Life History Study (GLHS) collected data retrospectively from several birth cohorts on their educational and employment biographies. The German Socio-economic Panel Study (SOEP), a general public survey carried out every year in Germany since 1984, combines retrospective data on the work and family-related event history with prospective panel data on, amongst others, educational participation as well as job and income mobility.

[ii] For example, the 'Transition Panel' (*Übergangspanel*) of the German Youth Institute (DJI) focuses on the transitions of 'disadvantaged' students who have finished the lower school track, tracing their paths into the vocational training system and into the labour market. Furthermore, there is the ULME study (*Untersuchung von Leistungen, Motivation und Einstellungen zu Beginn der beruflichen Ausbildung*), which investigates the competencies of apprentices in the city of Hamburg at the end of their vocational education, but does not follow them as they enter the labour market.

[iii] OECD studies such as PISA (Programme for International Student Assessment), TIMSS (Third International Mathematics and Science Study), IALS (International Adult Literacy Study), or ALL (Adult Literacy and Life Skills Survey), and cohort studies of several countries either provide competence tests in several domains or focus on specific domains (such as numeracy or reading/language), but are cross-sectional in design and/or do not include multi-time measurements of competencies.

[iv] For data protection procedures applied in the NEPS, see von Maurice, Leopold and Blossfeld (2009).

Book Review Symposium[1]

A Companion to Life Course Studies: the social and historical context of the British birth cohort studies. Michael Wadsworth and John Bynner (Eds) 2011 Routledge, New York and Oxford: 237pp ISBN 978-0-415-49540-0

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The primary aim of this collection is to provide a resource for users of the series of British birth cohort studies - whether researchers seeking to exploit the accumulated data-sets or members of policy communities wishing to draw on the vast array of research findings that have already emerged from these studies. The collection brings together seven review essays dealing with different aspects of British economic and social history over the period covered by the studies: i.e. from the end of the Second World War down to the present day. In this way, a rather comprehensive historical backcloth is created against which the life courses of the members of the successive cohorts may be better analysed and understood.

The editors introduce the collection by giving a brief but still highly informative account of the origins and the progress of the five cohort studies that are currently in train: the MRC National Survey of Health and Development (the 1946 cohort); the National Child Development Study (the 1958 cohort); the 1970 British National Birth Cohort Study; the Avon Longitudinal Study of Parents and Children (the 1991/2 cohort); and the Millennium Cohort Study. Two relatively minor but still intriguing questions that are prompted but not taken up are the following. First, why are the data of the earliest study still not readily available in the public domain? Second, where exactly does responsibility lie for the fact that no cohort study was started in the early 1980s - Mrs Thatcher is usually blamed but what was the full story?

In general, the authors of the review essays, and no doubt the editors too, are to be commended for the high standards of factual accuracy that appear to have been attained in dealing with some complex narratives and topics - the perhaps inevitable Homeric nod coming when the 1945 Labour government is at one point placed under the leadership of Harold Wilson. The essays also for the most part display a nice balance in dealing with academically or politically controversial issues - those by Hugh Pemberton on the economy and by Lynda Clarke and Ceridwen Roberts on the family, being exemplary in this regard. However, one instance in which some one-sidedness on a major issue might be thought to arise, comes in Michael Wadsworth's contribution on health. While Wadsworth rightly notes the growing emphasis now placed in accounting for ill-health on the interaction of genetic and environmental influences over the entire life course, he appears largely to equate this approach with that of Michael Marmot and Richard Wilkinson who focus on the role of psychosocial processes operating via stress and the effects of stress hormones. No reference is made to the alternative, 'neo-materialist' approach which, on present evidence, would seem no less persuasive (see e.g. Lynch et al 2000, 2004). One could expect that in clarifying and perhaps in some way resolving the difficult questions that here arise, the cohort studies will in fact play an increasingly important part in the years ahead.

It is likely that researchers will most frequently make use of this volume by turning to relevant chapters in search of various kinds of contextual information that they need to obtain or confirm. Within a few weeks of receiving the book, I have myself already benefited in this way by resorting to the contributions on education by Gary McCulloch and on the labour market by David Ashton and John Bynner. However, taken as a whole, the collection has a larger significance in providing valuable pointers - some of which are spelled out in the editors' concluding chapter - to the research opportunities and strategies that are available to those drawing on the rich data of the cohort studies.

In this regard, what should, as a preliminary, be recognised is what research questions the cohort studies are *not* well designed to answer. The cohort studies do not usually provide the data-sets of choice for determining long-term population trends. What is in this case required is not cohort data but data from repeated cross-sectional studies. For example, results of analyses made by economists (Blanden et al 2004) of changes in inter-

[1] The next LLCS issue will include an author response to the reviews

generational income mobility as between the 1958 and 1970 cohorts, have been taken to show, especially in political and media circles, that social mobility in Britain is in decline. But the comparison of two birth cohorts, just twelve years apart, is an inadequate basis for conclusions of this kind. The economists have in fact to turn to the cohort studies because, regrettably, they are the only sources of data on inter-generational income mobility available to them in Britain. But if mobility is considered in terms of social class, in which case data of a repeated cross-sectional kind extending over several decades can be obtained, then a very different picture emerges - one of an essential constancy in the endogenous mobility regime (Goldthorpe and Mills 2008).

Where the cohort studies come into their own is where the focus of interest is on the life courses that individuals follow and, in particular for social scientists, on the relation between different aspects of these life courses and the differing economic and socio-cultural contexts within which, over time, they are located: or where the focus is, as Wright Mills memorably put it in *The Sociological Imagination* (1959), on 'the intersection of biography and history'. The essays brought together in the collection serve to indicate the several contrasting types of situation that may in this respect be identified and exploited.

In some instances it is evident that the life courses of members of the cohorts studied are set within processes of change that are of a continuous, directional kind - such as, say, the decline in mortality, the rise in material living standards, or the increase in time spent in, and qualifications gained from, education. Life courses are then chiefly shaped by what would be described as period effects. At whatever age one compares members of successive cohorts, those born later will, on average, be at a lower risk of death, have greater consumer power, be better educated etc than those born earlier.

However, in other instances, while period effects could again be said to operate, they bear on cohort members' lives in a different, more discontinuous way. This is the case when 'step' changes occur which in their impact, whether at a particular stage in the life course or more extensively, essentially divide birth cohorts into 'before' and 'after'. One such change would be the sharp rise in income inequality that took place in the 1980s and early 1990s - with wide ranging consequences; but a yet more striking example is provided by the rapid shift in social norms and actual behaviour in regard to pre-marital sex and cohabitation that was triggered off in the early 1970s and that has since transformed the nature of partnership and family formation.

Finally, though, a further contrast arises where the changes that shape life courses are ones of a fluctuating kind as, for example, in fertility or in economic conditions. In this case, specific cohort effects come into play. As a result of being born in certain years, rather than earlier or later, some children are 'baby boomers', others not; some young people enter the labour market in times of economic expansion, others in times of recession. And the cohort effects that ensue may be of a lasting kind - as can be seen, say, in adverse features of the work histories of men in the 1958 cohort which can be traced back to their first years in the labour market under the severe conditions of the early 1980s and which set then them at a long-term disadvantage relative to men in both the 1946 and the 1970 cohorts (Gregg 2001; Bukodi and Goldthorpe 2011).

These differing forms of interaction between historical change and individual lives are at the heart of many present-day academic and policy issues, and the birth cohort studies are the prime resource that we have for dealing with them. A former Chief Executive of the ESRC once understandably described the cohort studies as 'the crown jewels of British social research'. But while the crown jewels are for symbolic display, the cohort studies are for use. Wadsworth and Bynner's volume will contribute greatly to making this use ever more effective.

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The earliest of the British birth cohorts, the 1946, began over 65 years ago, while the youngest is a mere 11 years of age. Over the intervening years a profound transformation has occurred in what it means to live a 'British way of life', with each cohort providing an unique snapshot into the lives of a separate generation of Britons.

From the first page to the last, this book is very aptly named. It is not a summary of all that has been learnt from the birth cohorts but a companion. It is meant to sit next to the volumes of findings produced from the cohort data and help the reader make sense of the context which produced the findings. What is unique about this book and what the authors themselves allude to in the preface, is that Wadsworth and Bynner are former directors of three out of the five major birth cohorts. This book is akin to sitting down to a cup of tea with these two men, and seven colleagues, soaking up their expert knowledge of history and culture over the period when the birth cohort data were collected . They take you behind the findings; show you the historical context by which the patterns of cohort members lives were formed.

The person who would experience the most benefit from this book would be someone new to life course epidemiology; the birth cohorts in particular. Reams of data on people's health, social circumstances, education, cognitive abilities, diet – to name a few – have been compiled on millions of pages, converted to miles of electronic numbers, and stored across the UK. Faster processing speeds of computers allow us to crunch analyses unlike ever before. Yet at the end of the day these rich resources are only numbers on a page or frequencies in a computer. It takes the researcher knowing what forces have acted to put a particular set of numbers in a certain order in order to conjecture about causation. Otherwise, our data is just a rather large and expensive black box.

In addition to the novice, experienced researchers have a few reasons to add this to their book shelf as well. We can all use a refresher of how populations of different ages may have been experiencing life differently, particularly if the exposures we are investigating have changed across our age populations. Knowing the general pattern by which exposures have been changing may also help us predict rates of disease in future to which the exposures we have been analyzing are linked.

This book would be of particular use for persons conducting work on data sets where subjects' historical exposures must be taken into consideration. I speak not from conjecture but personal experience. As a part of the Healthy Ageing across the Lifecourse (HALCyon) project, we have linked residential addresses across the lives of the 1946 birth cohort to examine when in life, area socioeconomic factors are important for physical performance, cognitive performance, and well-being in mid-life. One of the main results has been that the proportion of persons in an area with partly or un-skilled occupations, unemployment, and a lower educated population were particularly related to physical performance measures at age 53 years[1].

What became an important part of the project was being able to determine whether each of these measures represented the same construct historically. Turning the pages of this book McCulloch provides a nice background to the educational policy changes which led to a marked increase in the number of Britons attending school at all ages. Yet at the same time, Ashton and Bynner's chapter on the labour market shows the growing importance of education on job prospects and social standing. Therefore, differences in educational achievement could mean more for health outcomes during modern compared to historical periods. In addition, Pemberton's economic chapter became particularly interesting as it was realized that areas in England which had

experienced the largest de-industrialization just so happened to share all three of the area measures most related to worse physical performance. One avenue of future research would then be to explore how de-industrialization could be influencing individual's health behaviours and risks of morbidity and mortality. Granted, this information may be available elsewhere but not in such a succinct and handy form.

This book however is not just a resource for figuring out the secrets of one birth cohort. When analysis is restricted to one birth cohort the findings will only reflect the exposures that particular age cohort experienced. A universal theme running through this work is the potential benefit of cross-cohort comparisons in understanding how decisions at the larger political, economic level, and social forces could be harnessed to improve the lives of Britons. Large changes in exposures within relatively short age/time bands presents a prime opportunity to examine which of these changes may have contributed to alterations in disease rates across the generations. For example, comparisons of the 1946 and 1958 cohorts in height and body mass index across the life course showed that the younger cohort gained weight faster and became obese at younger ages[2]; surely reflecting the advent of the obesity epidemic in the 1980s. This is however only a comparison of two cohorts only 12 years apart in age. Work which encompassed the full age breadth of these cohorts and the societal changes which occurred within them could provide quite unique perspectives on the development of disease patterns.

The final chapter suggests many more areas of future research encompassing comparisons of the cohorts' political, family, educational, economic, and health experiences. Readers should take these suggestions as basic starting points; hints at the treasure trove of data that is available. In addition, Bynner and Wadsworth re-iterate the overarching themes which emerge from the book: four distinct cultural periods, the advent of globalization, decline of community in favour of the individual, technological advance, inequality, and cultural changes; an upstream perspective which can only be viewed by having compiled a breadth of work such as this. So take a step back, make a cup of tea, and read along with your 'companion' in this little slice of history.

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Elder's classic *Children of the Great Depression* (1974) provides compelling evidence of the impact of historical change on individual development: the adult life pathways of young people who lived through the economic collapse of the 1930s differed markedly depending on their age at the time when economic hardship struck. These observations - and many others like them – formed a key plank in the development of what is now known as the life course perspective on human development.

The economic changes facing the Berkeley and Oakland cohorts that Elder studied were sudden and acute, permeating all aspects of their families' lives. But it is not only cataclysmic events of this kind that have the potential to affect development. The social, political and economic landscapes are constantly changing, creating unique constellations of opportunities, expectations and constraints that form the backdrop to the lives of each new generation. Knowledge of these contextual changes, whether dramatic or more modulated, is crucial for all studies taking a life course approach to longitudinal research.

This volume is designed to help with that task, mapping in key elements of the social and policy changes that faced the UK generations born since the end of the Second World War. The social history of this period has, of course, been extensively documented before. The purpose of this new book is a more focused one: to provide a 'companion' for researchers working on data from the five major UK birth cohort studies established in the UK between the 1940s and the turn of the new Millennium. To do this, the editors have drawn together experts in the fields of politics, economics, labour markets, education, health, family life and leisure, and asked them to contribute chapters with a quite specific brief: to sketch in key outlines of the social changes taking place in these areas in the decades since the end of World War II; to weave in accounts of related policy change; and to give

pointers to the ways in which analyses of the cohort study data could benefit from this knowledge. The editors themselves contribute an introductory chapter giving an overview of the period, and of the cohort studies, and a concluding discussion drawing together the key themes that have emerged.

The result provides a vivid account of the major transformations that occurred in many aspects of British society over the post-war years. Inevitably, individual chapters vary somewhat in style and focus, but most are in themselves a 'good read', and many offer fascinating insights. Depending on their disciplinary background, most readers are likely to be familiar with the material covered in some chapters, and quite unfamiliar with that in others. For myself, for example, though I was broadly aware of the changes mapped out in relation to health and education, and very familiar with the trends in family demographics, the picture of our changing – or as it turns out, rather unchanging – use of leisure time was quite novel, and full of unexpected insights and treats. Bringing together the main threads of social policy development alongside the detail of social and political change is also an illuminating approach.

The main audience for this volume is the ever-growing cadre of UK and international researchers who use data from the British cohort studies to illuminate the unfolding of individual lives. How well will the book work for them? Understandably, perhaps, reports from these studies are often designed to explicate the influences on development that are traceable from within each data-set – often a complex and challenging task in itself. In almost all instances, however, studies of individual cohorts would be enriched by an awareness of the broader social context mapped out in this volume – and for comparisons across the cohorts, background data of this kind should arguably be mandatory reading. Linking the issues being examined in individual research studies to this broader background will not always be straightforward, and will require some work – but the pay-off in terms of increased understanding of the factors that go to shape individual development is likely to be immense.

The chapters in this volume cover a broad spectrum of issues, spanning the massive changes in the family and in men and women's working lives occurring in the post-war decades; the changing economic and political landscape; and the major changes that took place in the provision of education and health care. Inevitably, perhaps, with their appetites whetted, many readers will be left wanting more. For me, this volume prompted questions about the ways in which these relatively 'broad-brush' changes in the social and political landscape influenced (and were influenced by) changing social attitudes, and how they impacted on more detailed aspects of the fabric of individual's day-to-day lives. In addition, there were some more major topics – most notably, perhaps, the shape and effects of the various waves of migration to the UK that occurred from the 1950s onwards– that received relatively little attention. These and other issues are, of course, documented elsewhere, and references to those accounts are included in this volume; one of the measures of its success will be its capacity to prompt longitudinal researchers to consult these wider sources of evidence in their future research.

Individually, each of the British birth cohort studies has already made remarkable contributions to our understanding of human development, and will continue to do so in the years to come. Together, they represent an unparalleled resource for examining the impact of social change on individual's life trajectories. Cohort comparative studies of this kind are demanding, and not surprisingly, perhaps, are relatively limited to date. This volume provides brief pointers to the existing literature in this area, and a wider range of suggested issues in which they could be developed further. For researchers willing to take up those challenges, this volume will be an essential – and a good - companion.

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