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Psychological Distress in Mid-Life: Evidence from the 1958 and 1970 British Birth Cohorts

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Abstract

Background. This paper addresses the levels of psychological distress experienced at age 42 by men and women born in 1958 and 1970. Comparing these cohorts born 12 years apart, we ask whether psychological distress has increased, and if so whether this increase can be explained by differences in their childhood conditions.

Method. Data were utilized from two well-known population based British birth cohorts, the National Child Development Study and the British Cohort Study 1970. Latent variable models and causal mediation methods were employed.

Results. After establishing the measurement equivalence of psychological distress in the two cohorts we found that men and women born in 1970 reported higher levels of psychological distress compared to those born in 1958. These differences were more pronounced in men, b = 0.314 (95%CI = 0.252 - 0.375), with the magnitude of the effect being twice as strong compared to women, b = 0.147 (95%CI = 0.076 - 0.218). The effect of all hypothesised early life mediators in explaining these differences was modest.

Conclusions. Our findings have implications for public health policy, indicating a higher average level of psychological distress among a cohort born in 1970 compared to a generation born 12 years earlier. Moreover, due to increases in life expectancy, more recently born cohorts are expected to live longer, which implies – if such differences persist - that they are likely to spend more years with mental health related morbidity compared to earlier born cohorts.

Keywords: Psychological distress; British cohorts; Compression of morbidity; Childhood experiences; Measurement Invariance.

Introduction

This paper addresses the levels of psychological distress experienced in mid-life (at age 42) by men and women born in 1958 and 1970. Comparing these cohorts born 12 years apart, we ask whether psychological distress has increased, and if so whether this increase can be explained by differences between the cohorts in their childhood conditions, including differences in their social and emotional adjustment during adolescence. While the huge costs to society, and to the economy, of poor mental health are undisputed (Layard, 2013), the idea that experiences of mental distress in adulthood are increasing across generations has not been much discussed, and yet if true, is of major societal and population health significance, also considering the effects of population ageing. Younger cohorts in the UK have gained years of life expectancy (Leon, 2011, 2015), but if the added years are to be lived healthily, a necessary condition is that they are healthier compared to older cohorts. In order for healthy life expectancy to grow faster than total life expectancy and for morbidity to be compressed, the age specific prevalence of major drivers of mortality has to be lower in younger cohorts. If not, morbidity will expand and more years will be lived in poor health, a scenario with wide implications for public policy.

A small number of previous studies have noted that psychological distress during adult life has been increasing across cohorts in Britain (Spiers et al., 2011) (Sacker and Wiggins, 2002). However, a common feature of these studies is that the cross cohort equivalence of mental health measures wasn't established and the reported findings could – at least partly – be attributed to between cohort differences in the comprehension of items and response tendencies, or other sources of measurement error. In this paper we use the latest available data from the 1970 cohort to compare psychological distress across the 1958 and 1970 cohorts at age 42, after formally establishing the equivalence of psychological distress measures in the two cohorts. Secondly, in acknowledgement that the roots of adult psychological distress often lie in childhood (Krause et al., 2003, Power et al., 2002, Colman et al., 2007), we exploit the rich longitudinal data available in these studies since birth and across childhood and attempt to understand whether any observed major differences in childhood conditions between the two cohorts appear to explain differences in psychological distress in mid - life.

Method

Sample

The National Child Development Study (NCDS) follows the lives of 17,416 people born in England, Scotland and Wales in a single week of 1958 (Power and Elliott, 2006). Also known as the 1958 Birth Cohort Study, it collects information on physical and educational development, economic circumstances, employment, family life, health behaviour, wellbeing, social participation and attitudes. Since the birth survey in 1958, there have been 10 further 'sweeps' of all cohort members at ages 7, 11, 16, 23, 33, 42, 44, 46, 50 and 55. Despite attrition, the study remains largely representative of the original sample (Hawkes and Plewis, 2006). At age 42 11,419 participants (65.5% of the original productive sample) took part in the survey. The 1970 British Cohort Study (BCS70) follows the lives of 16,569 people born in England, Scotland and Wales in a single week of 1970 (Elliott and Shepherd, 2006). In 2012 at age 42 9,354 study members participated in the survey (56.45% of the original sample). Despite attrition the study remains representative of the original sample's characteristics (Mostafa and Wiggins, 2015). Over the course of cohort members' lives, the BCS70 has collected information on health, physical, educational and social development, and economic circumstances among other factors. Since the birth survey in 1970, there have been eight surveys (or 'waves') at ages 5, 10, 16, 26, 30, 34, 38 and 42. Our analytic sample included participants that had at least four valid – not missing - responses on the Malaise inventory at age 42, n = 9976 women and n = 9270 men. This limited the presence of participants with missing data due to item non response to <5% of the overall sample. We employed Multiple Imputation with 20 imputed datasets using all variables (year of birth, hypothesised mediators and outcome) in the imputation process as has been suggested in the literature (Carpenter and Kenward, 2012) to impute missing data in the hypothesised mediators and the <5% of the analytic sample that was missing on the outcome. Multiple imputation operates under the Missing at Random (MAR) assumption (Little and Rubin, 2002), which in this case implies that our estimates are valid if missingness is due to variables included in our models.

Measures

Outcome

Psychological distress was measured by self-report at age 42 in both cohorts using the nine item version of the Malaise inventory (Rodgers et al., 1999, Rutter et al., 1970). In both surveys the Malaise items were assessed via written self-completion but on the 1970 cohort it was on paper, whereas on the 1958 cohort via computer. More information on the administration of the Malaise Inventory in the two surveys is available in Appendix I. Representative items enquire whether the participants often "feel miserable and depressed", "get worried about things" and "get easily upset or irritated". The Malaise inventory has been shown to have good psychometric properties (McGee et al., 1986) and has been used in general population studies as well as investigations of high risk groups (Furnham and Cheng, 2015). In both studies at age 42 the nine item version has very good reliability as indicated by the Kuder Richardson – 20 formula (Kuder and Richardson, 1937): $KR20_{NCDS} = 0.77$ and $KR20_{BCS70} = 0.79$. The nine item version correlates highly with the 24 items version, $r_{NCDS} = 0.91$ at age 42 & $r_{BCS70} = 0.92$ at age 30. Descriptive statistics of the prevalence of psychological distress symptoms indicated by positive responses in the nine items of the Malaise Inventory are presented in Table 1.

INSERT TABLE 1 ABOUT HERE

Mediators

The mediators we included in our analysis were divided into four groups, birth characteristics, parental characteristics, child characteristics and adult characteristics. All hypothesised early life mediators that are described below have been shown to influence adult mental health in the NCDS and other longitudinal studies (Rutter, 1995, Robins and Price, 1991, Power et al., 2002, Colman et al., 2007). The birth characteristics included in the models were birthweight ("normal ≥ 2500 kg" vs "low <2500kg), maternal smoking during pregnancy and breastfeeding (ever breastfeed and breastfed for more than one month). The parental characteristics were paternal social class at age 10 for the BCS70 and 11 for the NCDS (manual vs non-manual), whether the mother of the participants was employed (birth to age 5), divorce (by age 10), and years of education of both parents of the participants. The child characteristics we include in the analysis were nocturnal enuresis (wet at night after age 5) and the Rutter mental health assessment at age 16, using the same modified version of the Rutter 'A' scale (Rutter et al., 1970) in both cohorts. This version of the scale was completed by the mothers of the participants in both cohorts as part of the home interview. It generates an overall behavioural adjustment score in addition to four sub-scales: conduct problems, hyperactivity, emotional and peer problems. Although not the main focus of this paper, we also included some adult characteristics that vary between the two cohorts (Ferri et al., 2003) and have also been linked to psychological distress (Miech et al., 2007, Prince et al., 1999, Paul and Moser, 2009). These were, participants' highest education at age 33, partnership status at age 33, number of children by age 42 and employment status at age 33.

INSERT TABLE 2 ABOUT HERE

Descriptive statistics of all mediators in our analysis stratified by cohort and gender are presented in Table 2. Some maternal health behaviours deteriorated between the 1958 and 1970 cohorts. The proportion of children who were never breastfed roughly doubled from 31-32% in the 1958 cohort to 63-64% in the 1970 cohort. Smoking during pregnancy rose from 34% to 46%. The proportion of children experiencing parental divorce by age 10 increased from 5% in the earlier cohort to 11-12% in the later cohort. Bed-wetting after the age of five rose from10% of girls and 12% of boys in the 1958 cohort to 18% of girls and 25% of boys in the 1970 cohort. A modest increase was observed in the overall Rutter behavioural adjustment score, as well as in conduct and emotional problems. In adulthood, key changes are a substantial increase in educational levels, with 11% of women and 14% of men having a degree by age 33 in the 1958 cohort, rising to 37% of women and 34% of men in the 1970 cohort, and a decline in those living with a partner (defined as cohabitation including marriage) from 78-80% to 74-76% at age 33. In Table 3 we present the Odds Ratios and corresponding 95% confidence intervals of the associations (direct effects) between year of birth (cohort dummy variable) and all hypothesised mediators.

INSERT TABLE 3 ABOUT HERE

Statistical analysis

Measurement invariance: We modelled the probability of response to the binary Malaise inventory items with a 2 parameter probit unidimensional latent variable measurement model (Muthen, 1984, Rabe-Hesketh and Skrondal, 2008). The general form of the measurement model is presented in Appendix II. In order to obtain a meaningful comparison between the NCDS and BCS70 with respect to psychological distress, strong measurement invariance between the two cohorts has to be established (Meredith, 1993). This implies that the measurement parameters of the model need to function equivalently between the two cohorts and gender in order for the latent psychological distress means to be comparable. To empirically test this assumption and control for systematic sources of measurement error that may arise in between cohort and/or between gender comparisons, from differences in the comprehension of items, in response tendencies or random sources of error, we estimated a multigroup confirmatory factor analysis, where measurement model parameters, in this instance factor loadings and thresholds, were not allowed to vary between the two cohorts as well as gender. In the literature this type of invariance is usually referred to as scalar or strong invariance and is the only form of invariance that allows the comparison of latent means (Muthén and Asparouhov, 2002, Meredith, 1993, Muthén and Asparouhov, 2013).

Causal mediation analysis: Preliminary results showed strong evidence of effect modification by gender of the association between year birth and psychological distress (results available from corresponding author). We thus report results separately for each gender. In order to quantify the association between year of birth and psychological distress we estimated a stratified by gender Multiple Causes Multiple Indicators (MIMIC) model using the already established invariant model of the Malaise Inventory as the outcome and year of birth (1958 vs 1970) as the predictor. In the final stage of the analysis and in order to investigate whether early life experiences and behavioural adjustment until age 16 account for between cohort differences in psychological distress at age 42 we extended the MIMIC model to include mediators. The indirect effect of year of birth captures the proportion of the between cohort difference in psychological distress that is due to – or is transmitted by - the intermediate variables (“mediators”). In the causal mediation literature several approaches have been proposed for the estimation of direct and indirect effects with an emphasis on different aspects of mediation (Ten Have and Joffe, 2012). In this instance we report Natural Indirect Effects (NIEs) that evaluate the action of potential mediating mechanisms and have been shown to be appropriate for the quantification of mediation effects in nonlinear systems (Imai et al., 2010, Myers, 2003, Griffiths et al., 2013, Pearl, 2001, Robins, 2003, Valeri and VanderWeele, 2013, Muthen and Asparouhov, 2015). Our approach allowed the computation of formal mediation estimates (NIEs) while simultaneously controlling for measurement error in psychological distress. Directed Acyclic Graphs that further clarify our model specification strategy are presented in Appendix III.

All our models were estimated with Mplus 7.4 (Muthen and Muthen, 1998-2015). The multigroup measurement model was estimated with the Weighted Least Squares, Mean and Variance adjusted (WLSMV) estimator with Delta parameterisation (results with the alternative Theta parameterisation were very similar, available from the corresponding author). Stratified by gender MIMIC models were estimated as mixture models with the "Known Class" option, with the Robust Maximum Likelihood (MLR) estimator with Monte Carlo integration (200 integration points).

Results

Between cohort and gender measurement invariance of the Malaise Inventory at age 42

The multigroup confirmatory factor analysis model representing strong (scalar) invariance had very good fit, Comparative Fit Index – CFI = 0.984, Tucker Lewis Index – TLI = 0.982, Root Mean Square Error of Approximation - RMSEA = 0.037 (95%CI = 0.035 to 0.039) indicating the measurement equivalence of the Malaise inventory in the four groups (two cohorts by two genders). A less restrictive multigroup model representing configural invariance (factor loadings and thresholds freely estimated) had only minimally better fit, CFI = 0.987, TLI = 0.982, RMSEA = 0.037 (95%CI = 0.035 to 0.040). The difference in model fit (Δ) was well within the criteria for not rejecting the null hypothesis of invariance (ΔCFI<0.01, ΔRMSEA<0.015 and overlapping RMSEA confidence intervals), further reinforcing our interpretation (Cheung and Rensvold, 2002, Sass, 2011). The standardised factor loadings (λ_i) of the multigroup model representing scalar invariance were all satisfactory and ranged between 0.600 and 0.894, whereas the item thresholds (τ_i) were mostly located as expected towards the high end of the latent psychological distress continuum (-0.116 – 1.605). The parameters of all models and model fit criteria are presented in Appendix II. The very good fit of the multigroup model with identical measurement parameters across the four groups and the minimal difference in model compared to less restrictive models, suggests that the comprehension of items and response tendencies can be assumed to be uniform between cohorts as well as genders and therefore between cohort and gender differences in latent psychological distress can be attributed to valid variation.

Between cohort differences in psychological distress at age 42

Once measurement invariance was established, we proceeded to estimate the total effect of the cohort dummy variable encoding year of birth (1958 or 1970) on psychological distress (between cohort differences) at age 42. For comparison purposes with other studies, we report results from models on three versions of the outcome: the latent variable derived from the measurement invariant model, the sum score (9 point Malaise scale) and a binary version that captures participants that have scored >3. Descriptive statistics of the sum and binary versions are presented in Table 4. Amongst those born in 1958, women were considerably more likely to be defined as showing signs of depression at 42 than men (16% compared with 10%). Twelve years later, among those born in 1970 at age 42 levels of psychological distress were higher among both men and women, and although it remained the case that women were more likely to show signs of psychological distress than men, a larger increase in levels of distress amongst men born in 1970 compared to in 1958 lead to the difference between men and women being reduced somewhat between the two cohorts (20% of women compared with 16% of men). In men, the BCS70 cohort score b = 0.314 (95%CI = 0.252 - 0.375) standard deviations higher on the latent psychological distress variable, b = 0.419 (95%CI = 0.342 - 0.495) points higher on the 9 point Malaise scale and OR = 1.788 (95%CI = 1.577 - 2.026) times more likely compared to the NCDS cohort to score more than 3 on the Malaise inventory. As expected from the descriptive statistics, the between cohort difference in psychological distress was less pronounced in women. Women born in 1970 scored b = 0.147 (95%CI = 0.076 - 0.218) standard deviations higher on the latent score, b = 0.253 (95%CI = 0.176 - 0.330) higher on the nine point Malaise score and were OR = 1.299 (95%CI = 1.172 - 1.440) times more likely to score more than 3 on the Malaise inventory.

INSERT TABLE 4 ABOUT HERE

Associations between mediators and psychological distress

In Table 5 we present latent regression parameters and corresponding 95% confidence intervals of the association between each mediator and the between cohort invariant psychological distress outcome. The associations between the mediators and the outcome were similar in magnitude in both cohorts and in the expected direction. For example, the total score as well as the dimensions of the Rutter scale were as expected strongly and positively associated with psychological distress at age 42 in both cohorts. On the contrary having a university degree had a strong negative association with psychological distress in men and women of both cohorts. Exceptions to the between cohort homogeneity of the mediator – outcome associations were the differences in magnitude observed in the associations between parental and maternal education, as well as unemployment at age 33 with psychological distress. When formally tested, we obtained weak evidence of interaction between mediators and year of birth.

INSERT TABLE 5 ABOUT HERE

Mediation

In Table 6, we present the total effect of the cohort dummy that encodes year of birth on psychological distress at age 42 and the Natural Indirect Effects (NIEs) for all hypothesised mediators. In both men and women some NIEs are positive while others are negative. The presence of negative NIEs, as for example the NIE for the mediating effect of having a university degree in women, b = -0.032 (95%CI = -0.048 - -0.015) is evidence for inconsistent mediation or regression suppression (MacKinnon et al., 2000, Friedman and Wall, 2005, Maassen and Bakker, 2001). Similarly, paternal social class, paternal and maternal education, peer problems, being unemployed at age 33 are all also found to be inconsistent mediators. We note that inconsistent mediators or suppressors, do not explain the observed difference between cohorts, as consistent mediators do. On the contrary, they might inflate the observed difference when they are included in the model, or "supress" it when they are excluded. For example the observed difference of b = 0.147 (95%CI = 0.076 - 0.218) between the two cohorts in women, increases to b = 0.206 (95%CI = 0.150 - 0.261) when women's education at age 33 is included in the model. Intuitively, this can be explained as follows - psychological distress is higher among the BCS70 cohort than the NCDS cohort, despite the increase in education among the younger cohort, which in itself is associated with lower psychological distress.

In men, maternal smoking during pregnancy and ever being breastfed were consistent mediators of the association between year of birth and adult psychological distress that reached conventional levels of statistical significance, b = 0.010 (95%CI = 0.004 - 0.016) and b = 0.019 (95%CI = 0.001 - 0.037). Similarly, parental divorce at age 10, b = 0.013 (95%CI = 0.006 - 0.020) was the only parental characteristic with a consistent mediating effect in men. Among child characteristics, conduct and emotional problems both consistently mediated the association between year of birth and psychological distress, b = 0.025 (95%CI = 0.016 - 0.033) and b = 0.016 (95%CI = 0.008 to 0023), as did the total score of the Rutter scale b = 0.024 (95%CI = 0.014 - 0.034). Partnership status at 33 was the only adult characteristic with a consistent mediating effect, b = 0.005 (95%CI = 0.001 - 0.009). In women, maternal smoking during pregnancy, ever breastfed as well as breastfeeding for more than one month were consistent mediators, b = 0.013 (95%CI = 0.008 - 0.019), b = 0.018 (95%CI = 0.003 - 0.032) and b = 0.014 (95%CI = 0.004 - 0.024) respectively. Maternal employment by age 5, b = 0.004 (95%CI = 0.001 - 0.007) was the only parental characteristic with a consistent mediating effect in women. We found that conduct and emotional problems at 16 and general behavioural adjustment as captured by the total score of the Rutter scale at the same age were consistent mediators, b = 0.013 (95%CI = 0.007 - 0.020), b = 0.009 (95%CI = 0.003 - 0.016) and b = 0.010 (95%CI = 0.002 - 0.017). With respect to adult characteristics, partnership status at 33 was found to be a consistent mediator, b = 0.005 (95%CI = 0.002 - 0.008).

INSERT TABLE 6 ABOUT HERE

Discussion

We observed differences in psychological distress between the 1958 (NCDS) and 1970 (BCS70) cohorts at age 42. Men and women born in 1970 report more psychological distress symptoms than those born in 1958, but the observed differences were more pronounced in men, with the magnitude of the year of birth effect being almost twice as strong compared to women. The establishment of between cohort measurement invariance of the Malaise Inventory implies that the observed differences were due to valid between cohort variation in levels of psychological distress and not an artefact of cohort differences in random or systematic sources of measurement error such as response style, item comprehension and social desirability. This implies that the passage of 12 years hasn't differentially affected the interpretation of the survey questions that comprise the Malaise Inventory. A common bias might still have influenced the location of the latent mean of psychological distress equally in both cohorts, but not the magnitude of the observed difference. This relatively large difference in levels of psychological distress was observed despite the protective effect of the generally improved social and economic conditions that the 1970 cohort enjoyed, compared to the 1958 and older cohorts (Ferri et al., 2003). Our formal approach to mediation allowed us to empirically capture this protective effect in the form of "inconsistent mediation" or "regression suppression" (Friedman and Wall, 2005, Maassen and Bakker, 2001, MacKinnon et al., 2000), a finding that would have been overlooked if standard methods were employed.

The observation that the 1970 cohort have higher levels of psychological distress compared to an earlier born cohort in midlife has implications for public health policy, especially considering that depression is one of the leadings causes of Disability Adjusted Life Years worldwide (Ferrari et al., 2013). Taking into account that due to increases in life expectancy younger (more recently born) cohorts are expected to live longer, a necessary condition for compression of morbidity – in order for the added years to be lived healthily - is that controlling for age differences (or at a fixed age as in our paper), more recently born cohorts are healthier, so the average onset of morbidity is postponed (Fries, 1980, Fries et al., 2011). On the contrary, expansion of morbidity will occur if younger cohorts are less healthy, whereas similar health levels between cohorts will most likely lead to equilibrium or mild expansion of morbidity (Gruenberg, 1977, Manton, 1982, Olshansky et al., 1991). Our observation of higher average level of psychological distress in the 1970 cohort at age 42 increases the likelihood of expansion of mental health related morbidity, assuming that the observed difference will persist in the future. Therefore, unless as both cohorts age, those born in 1958 catch up and surpass the 1970 cohort on average levels of psychological distress, our findings imply that the average onset of mental health related morbidity will not be postponed in the 1970 cohort.

A reversal of the observed differences in the future, so that the 1958 cohort experience higher levels of psychological distress appears – in theory – not likely. First, the association between age and mental health outcomes is complex, but arguably weak (Jorm et al., 2005, Wu et al., 2012, Yang, 2007, Prince et al., 1999). This implies that large within cohort variation/changes in levels of psychological distress are not likely as both cohorts age. Furthermore, a very strong association between early life behavioural adjustment, mid-life mental health with later life depression has been reported in the literature (Lara et al., 2009, Robins and Price, 1991, Rutter, 1995). Lastly, the 1970 cohort reported higher levels of psychological distress than the 1958 cohort also at age 33 (Sacker and Wiggins, 2002), as well as at age 16 as we have shown in this paper. Both findings imply a relatively stable trend in between cohort differences over time.

We attempted to explain the observed between cohort variation by investigating the explanatory power of “consistent” mediators (rather than “inconsistent mediators” or “suppressors”) focussing on early life characteristics and behavioural adjustment. The magnitude of the effect of all early life consistent mediators was modest in both men and women. In men the observed between cohort differences were mostly due to breastfeeding and behavioural adjustment at age 16, with the 1970 cohort less likely to have been breastfed, and reporting more conduct and emotional problems which were related to higher levels of psychological distress at 42. The between cohort increase in parental divorce and in maternal smoking during pregnancy also explain the increase in psychological distress between cohorts in men, but less prominently. A different pattern of associations emerged in women. Birth characteristics such as ever being breastfed, breastfed for more than one month and maternal smoking during pregnancy, were the strongest consistent mediators of the association between year of birth and psychological distress at 42. Similarly with the early life characteristics, the adult social and demographic factors that were included in our study did not explain a substantial fraction of the association between year of birth and psychological distress. Partnership status at 33 was the only consistent mediator in both men and women, such that the decline in cohabiting and married relationships by age 33 in the 1970 cohort has contributed to increased distress levels at age 42.

Strengths of this study are the availability of two population based birth cohorts with various measures taken at the same stages of the life-course, our modelling strategy that allowed us to establish measurement invariance/equivalence across the two cohorts and the computation of formal mediation estimates while simultaneously controlling for measurement error. Limitations include our reliance on self-reported data in the assessment of psychological distress. Despite our efforts, common to both cohorts random or systematic error could have influenced the location of the latent psychological distress means, but not the observed differences between those means. Furthermore, we assumed an identical missing data generating mechanism in both cohorts, which implies that an identical set of observables (year of birth, all the mediators and the outcome in this instance) are responsible for missing data in both studies. It should also be noted that the BCS70 had a higher prevalence of missing data in both mediators and the outcome. Taking into account that by definition the only “complete” (without missing data) variable in our analysis was year of birth, it follows that as more missing data in the mediators and outcome are included the observed between cohorts difference tends to marginally increase. We report estimates allowing only a small fraction of missing data in the outcome in our models, and note that similar results were obtained in analyses with varying missing data inclusion criteria, including imputation of all missing data in the outcome and mediators.

Our results showcase the association between year of birth and psychological distress, but our analysis could not disentangle whether the observed difference is due to “cohort” or “period” effects (Keyes et al., 2010), since only one time point was considered. However, it is well known that even in studies with more time points Age – Period - Cohort models cannot be identified without added constraints, since no statistical model can simultaneously estimate age, period, and cohort effects because of the collinearity among these variables (Keyes et al., 2010). We note that establishing the association between year of birth and psychological distress is sufficient as an empirical test of compression of morbidity. Understanding whether the association between year of birth and psychological distress is due to “cohort” or “period” effects is a further step beyond the scope of this paper, which under assumptions would provide us with valuable insights on the mechanism that underlies the observed association between year of birth and psychological distress. Although not explicitly of interest in our study, the associations between the various mediators and year of birth may result in intermediate confounding (De Stavola et al., 2015). Further analyses showed that our results are unlikely to be biased by the presence of measured intermediate confounders (see Appendix II for further discussion). Another limitation is that our estimates depend on the assumption of no omitted variables/unmeasured confounders which is we believe reasonable for the year of birth – mediators and year of birth – psychological distress associations.

Overall, we find that despite the secular changes that resulted in important differences between the two cohorts in early life characteristics, these account for a modest fraction of the between cohort variation in psychological distress at age 42. This finding indicates that other factors in early adulthood and mid-life are responsible for the observed between cohort differences. The observed increase in the levels of psychological distress experienced by people in mid-life in Britain has major policy implications, given that the increase has occurred despite economic growth. The 1958 cohort are part of the ‘Lucky Generation’ of post-war baby boomers, who experienced high absolute levels of social mobility, and lower levels of social inequality, whereas the 1970 cohort are part of ‘Generation X’, who have experienced greater uncertainty and insecurity over the whole of their adult lives and a more individualistic ideological climate (Sullivan et al., 2015). If these generational changes lie behind the increase in psychological distress, then we would predict that future generations will be worse off still if such trends were to continue. An alternative explanation is that the elevated levels of psychological distress in the 1970 cohort at age 42 were mostly due to the social context at the timing of the interview. 2012 was a post-recession year with austerity measures already being in place in the UK. This is in stark comparison with 2000 – when the 1958 cohort were aged 42 - that can generally be described as a post millennial year of cultural and economic boom. The unemployment rate in 2000 fluctuated between 5.2% and 5.5%, whereas in 2012 it had increased to 8.1%. Furthermore, previous studies suggest recessions are expected to affect men more severely (Hoynes et al., 2012, Katikireddi et al., 2012) and unemployment has been linked to poor mental health in both men and women (Booker and Sacker, 2011, Gallo et al., 2000). Nevertheless, we believe that it is not plausible that the increase in psychological distress between the 1958 and 1970 cohorts at age 42 is due largely to a time of interview/period effect, as a similar cross-cohort increase in psychological distress was observed in this study in adolescence and has also been found in earlier adulthood (Sacker and Wiggins, 2002).

In future work we will employ more time points to capture adult trajectories of mental health and to establish whether the elevated level of psychological distress in the 1970 cohort represents a general trend in more recently born cohorts. We will also consider what other factors – especially in adulthood - may explain the observed between cohort difference. Furthermore, the fact that men appear to be closing the gap on women's historically higher levels of psychological distress is also troubling, and demands further investigation.

References

2015. Human Mortality Database. University of California, Berkeley (USA), and Max Planck Institute for Demographic Research (Germany).

BOOKER, C. L. & SACKER, A. 2011. Psychological well-being and reactions to multiple unemployment events: adaptation or sensitisation? *Journal of Epidemiology and Community Health*.

CARPENTER, J. & KENWARD, M. 2012. *Multiple imputation and its application*, John Wiley & Sons.

CHEUNG, G. W. & RENSVOLD, R. B. 2002. Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural equation modeling,* 9**,** 233-255.

COLMAN, I., PLOUBIDIS, G. B., WADSWORTH, M. E. J., JONES, P. B. & CROUDACE, T. J. 2007. A longitudinal typology of symptoms of depression and anxiety over the life course. *Biological Psychiatry,* 62**,** 1265-1271.

DE STAVOLA, B. L., DANIEL, R. M., PLOUBIDIS, G. B. & MICALI, N. 2015. Mediation analysis with intermediate confounding: structural equation modeling viewed through the causal inference lens. *Am J Epidemiol,* 181**,** 64-80.

ELLIOTT, J. & SHEPHERD, P. 2006. Cohort Profile: 1970 British birth cohort (BCS70). *International Journal of Epidemiology,* 35**,** 836-843.

FERRARI, A. J., CHARLSON, F. J., NORMAN, R. E., PATTEN, S. B., FREEDMAN, G., MURRAY, C. J. L., VOS, T. & WHITEFORD, H. A. 2013. Burden of Depressive Disorders by Country, Sex, Age, and Year: Findings from the Global Burden of Disease Study 2010. *PLoS Med,* 10**,** e1001547.

FERRI, E., BYNNER, J. & WADSWORTH, M. 2003. *Changing Britain, changing lives*, Institute of Education Press.

FRIEDMAN, L. & WALL, M. 2005. Graphical views of suppression and multicollinearity in multiple linear regression. *American Statistician,* 59**,** 127-136.

FRIES, J. F. 1980. Aging, natural death, and the compression of morbidity. *New England Journal of Medicine,* 303**,** 130-135.

FRIES, J. F., BRUCE, B. & CHAKRAVARTY, E. 2011. Compression of morbidity 1980-2011: a focused review of paradigms and progress. *Journal of aging research,* 2011**,** 261702-261702.

FURNHAM, A. & CHENG, H. 2015. The stability and change of malaise scores over 27 years: Findings from a nationally representative sample. *Personality and Individual Differences,* 79**,** 30-34.

GALLO, W. T., BRADLEY, E. H., SIEGEL, M. & KASL, S. V. 2000. Health effects of involuntary job loss among older workers: findings from the health and retirement survey. *J Gerontol B Psychol Sci Soc Sci,* 55**,** S131-40.

GRIFFITHS, L. J., CORTINA-BORJA, M., SERA, F., POULIOU, T., GERACI, M., RICH, C., COLE, T. J., LAW, C., JOSHI, H., NESS, A. R., JEBB, S. A. & DEZATEUX, C. 2013. How active are our children? Findings from the Millennium Cohort Study. *BMJ Open,* 3.

GRUENBERG, E. M. 1977. Failures of success. *Milbank Memorial Fund Quarterly-Health and Society,* 55**,** 3-24.

HAWKES, D. & PLEWIS, I. 2006. Modelling non-response in the national child development study. *Journal of the Royal Statistical Society: Series A (Statistics in Society),* 169**,** 479-491.

HOYNES, H., MILLER, D. L. & SCHALLER, J. 2012. Who Suffers During Recessions? *The Journal of Economic Perspectives,* 26**,** 27-47.

IMAI, K., KEELE, L. & TINGLEY, D. 2010. A General Approach to Causal Mediation Analysis. *Psychological Methods,* 15**,** 309-334.

JORM, A. F., WINDSOR, T. D., DEAR, K. B. G., ANSTEY, K. J., CHRISTENSEN, H. & RODGERS, B. 2005. Age group differences in psychological distress: the role of psychosocial risk factors that vary with age. *Psychological Medicine,* 35**,** 1253-1263.

KATIKIREDDI, S. V., NIEDZWIEDZ, C. L. & POPHAM, F. 2012. Trends in population mental health before and after the 2008 recession: a repeat cross-sectional analysis of the 1991–2010 Health Surveys of England. *BMJ Open,* 2.

KEYES, K. M., UTZ, R. L., ROBINSON, W. & LI, G. 2010. What is a cohort effect? Comparison of three statistical methods for modeling cohort effects in obesity prevalence in the United States, 1971–2006. *Social Science & Medicine,* 70**,** 1100-1108.

KRAUSE, E. D., MENDELSON, T. & LYNCH, T. R. 2003. Childhood emotional invalidation and adult psychological distress: the mediating role of emotional inhibition. *Child Abuse & Neglect,* 27**,** 199-213.

KUDER, G. F. & RICHARDSON, M. W. 1937. The theory of the estimation of test reliability. *Psychometrika,* 2**,** 151-160.

LARA, C., FAYYAD, J., DE GRAAF, R., KESSLER, R. C., AGUILAR-GAXIOLA, S., ANGERMEYER, M., DEMYTTENEARE, K., DE GIROLAMO, G., HARO, J. M., JIN, R., KARAM, E. G., LEPINE, J.-P., MORA, M. E. M., ORMEL, J., POSADA-VILLA, J. & SAMPSON, N. 2009. Childhood Predictors of Adult Attention-Deficit/Hyperactivity Disorder: Results from the World Health Organization World Mental Health Survey Initiative. *Biological Psychiatry,* 65**,** 46-54.

LAYARD, R. 2013. Mental health: the new frontier for labour economics. *IZA Journal of Labor Policy,* 2**,** 1-16.

LEON, D. A. 2011. Trends in European life expectancy: a salutary view. *International Journal of Epidemiology,* 40**,** 271-277.

LITTLE, R. J. A. & RUBIN, D. B. 2002. *Statistical Analysis with Missing Data* Chichester, Willey.

MAASSEN, G. H. & BAKKER, A. B. 2001. Suppressor variables in path models - Definitions and interpretations. *Sociological Methods & Research,* 30**,** 241-270.

MACKINNON, D. P., KRULL, J. L. & LOCKWOOD, C. M. 2000. Equivalence of the Mediation, Confounding and Suppression Effect. *Prevention science : the official journal of the Society for Prevention Research,* 1**,** 173.

MANTON, K. G. 1982. Changing concepts of morbidity and mortality in the elderly population. *Milbank Memorial Fund Quarterly-Health and Society,* 60**,** 183-244.

MCGEE, R., WILLIAMS, S. & SILVA, P. A. 1986. An evaluation of the Malaise inventory. *Journal of Psychosomatic Research,* 30**,** 147-152.

MEREDITH, W. 1993. Measurement invariance, factor analysis and factorial invariance. *Psychometrika,* 58**,** 525-543.

MIECH, R., POWER, C. & EATON, W. W. 2007. Disparities in psychological distress across education and sex: A longitudinal analysis of their persistance within a cohort over 19 years. *Annals of Epidemiology,* 17**,** 289-295.

MOSTAFA, T. & WIGGINS, R. 2015. Handling attrition and non-response in the 1970 British Cohort Study. *Longitudinal and Life Course Studies*.

MUTHEN, B. 1984. A General Structural Equation Model with Dichotomous, Ordered Categorical, and Continuous Latent Variable Indicators. *Psychometrika,* 49**,** 115-132.

MUTHEN, B. & ASPAROUHOV, T. 2015. Causal Effects in Mediation Modeling: An Introduction With Applications to Latent Variables. *Structural Equation Modeling-a Multidisciplinary Journal,* 22**,** 12-23.

MUTHÉN, B. & ASPAROUHOV, T. 2002. Latent variable analysis with categorical outcomes: Multiple-group and growth modeling in Mplus. *Mplus web notes,* 4**,** 1-22.

MUTHÉN, B. & ASPAROUHOV, T. 2013. New methods for the study of measurement invariance with many groups. *Mplus. statmodel. com [12.04. 2014]*.

MUTHEN, L. K. & MUTHEN, B. O. 1998-2015. *Mplus User's Guide. Seventh Edition,* Los Angeles, CA.

MYERS, J. 2003. Exercise and Cardiovascular Health. *Circulation,* 107**,** e2-e5.

OLSHANSKY, S. J., RUDBERG, M. A., CARNES, B. A., CASSEL, C. K. & BRODY, J. A. 1991. Trading Off Longer Life for Worsening Health: The Expansion of Morbidity Hypothesis. *Journal of Aging and Health,* 3**,** 194-216.

PAUL, K. I. & MOSER, K. 2009. Unemployment impairs mental health: Meta-analyses. *Journal of Vocational Behavior,* 74**,** 264-282.

PEARL, J. Direct and indirect effects. Proceedings of the seventeenth conference on uncertainty in artificial intelligence, 2001. Morgan Kaufmann Publishers Inc., 411-420.

POWER, C. & ELLIOTT, J. 2006. Cohort profile: 1958 British Birth Cohort (National Child Development Study). *International Journal of Epidemiology,* 35**,** 34-41.

POWER, C., STANSFELD, S. A., MATTHEWS, S., MANOR, O. & HOPE, S. 2002. Childhood and adulthood risk factors for socio-economic differentials in psychological distress: evidence from the 1958 British birth cohort. *Social Science & Medicine,* 55**,** 1989-2004.

PRINCE, M. J., BEEKMAN, A. T. F., DEEG, D. J. H., FUHRER, R., KIVELA, S. L., LAWLOR, B. A., LOBO, A., MAGNUSSON, H., MELLER, I., VAN OYEN, H., REISCHIES, F., ROELANDS, M., SKOOG, I., TURRINA, C. & COPELAND, J. R. M. 1999. Depression symptoms in late life assessed using the EURO-D scale - Effect of age, gender and marital status in 14 European centers. *British Journal of Psychiatry,* 174**,** 339-345.

RABE-HESKETH, S. & SKRONDAL, A. 2008. Classical latent variable models for medical research. *Statistical Methods in Medical Research,* 17**,** 5-32.

ROBINS, J. M. 2003. Semantics of causal DAG models and the identification of direct and indirect effects. *Green, P., I-ljort, N., Richardson, S.(eds) In Highly Structured Stochastic Systems***,** 70-8.

ROBINS, L. N. & PRICE, R. K. 1991. ADULT DISORDERS PREDICTED BY CHILDHOOD CONDUCT PROBLEMS - RESULTS FROM THE NIMH EPIDEMIOLOGIC CATCHMENT-AREA PROJECT. *Psychiatry-Interpersonal and Biological Processes,* 54**,** 116-132.

RODGERS, B., PICKLES, A., POWER, C., COLLISHAW, S. & MAUGHAN, B. 1999. Validity of the Malaise Inventory in general population samples. *Social psychiatry and psychiatric epidemiology,* 34**,** 333-341.

RUTTER, M. 1995. RELATIONSHIPS BETWEEN MENTAL-DISORDERS IN CHILDHOOD AND ADULTHOOD. *Acta Psychiatrica Scandinavica,* 91**,** 73-85.

RUTTER, M., TIZARD, J. & WHITMORE, K. 1970. *Education, health and behaviour,* Longman Publishing Group.

SACKER, A. & WIGGINS, R. 2002. Age–period–cohort effects on inequalities in psychological distress, 1981–2000. *Psychological Medicine,* 32**,** 977-990.

SASS, D. 2011. Testing measurement invariance and comparing latent factor means within a confirmatory factor analysis framework. *Journal of Psychoeducational Assessment***,** 0734282911406661.

SPIERS, N., BEBBINGTON, P., MCMANUS, S., BRUGHA, T. S., JENKINS, R. & MELTZER, H. 2011. Age and birth cohort differences in the prevalence of common mental disorder in England: National Psychiatric Morbidity Surveys 1993–2007. *The British Journal of Psychiatry,* 198**,** 479-484.

SULLIVAN, A., BROWN, M. & BANN, D. 2015. Guest Editorial: Generation X enters middle age. *Longitudinal and Life Course Studies,* 6**,** 120-130.

TEN HAVE, T. R. & JOFFE, M. M. 2012. A review of causal estimation of effects in mediation analyses. *Statistical Methods in Medical Research,* 21**,** 77-107.

VALERI, L. & VANDERWEELE, T. J. 2013. Mediation Analysis Allowing for Exposure-Mediator Interactions and Causal Interpretation: Theoretical Assumptions and Implementation With SAS and SPSS Macros. *Psychological Methods,* 18**,** 137-150.

WU, Z., SCHIMMELE, C. M. & CHAPPELL, N. L. 2012. Aging and Late-Life Depression. *Journal of Aging and Health,* 24**,** 3-28.

YANG, Y. 2007. Is old age depressing? Growth trajectories and cohort variations in late-life depression. *Journal of Health and Social Behavior,* 48**,** 16-32.

Table 1. Prevalence of psychological distress symptoms indicated by positive responses in the nine items of the Malaise Inventory

	NCDS				BCS70			
	Men		Women		Men		Women	
	f	%	*f*	%	*f*	%	*f*	%
Do you feel tired most of the time?	1557	28.10	2268	39.50	1291	34.50	1910	45.20
Do you often feel miserable or depressed?	918	16.60	1356	23.60	739	19.80	936	22.20
Do you often get worried about things?	2103	38.00	3153	54.90	1726	46.20	2570	60.90
Do you often get into a violent rage?	231	4.20	316	6.00	143	3.80	118	2.80
Do you often suddenly become scared for no reason?	261	4.70	564	9.80	254	6.80	443	10.50
Are you easily upset or irritated?	901	16.30	1408	24.50	1018	27.40	1440	34.10
Are you constantly keyed up and jittery?	297	5.40	360	6.30	294	7.90	342	8.10
Does every little thing get on your nerves?	196	3.50	325	5.70	393	10.60	486	11.50
Does your heart often race like mad?	328	5.90	604	10.50	324	8.70	467	11.10

Table 2. Descriptive statistics of all hypothesised mediators

		NCDS		BCS70	
		Men	**Women**	**Men**	**Women**
Birth Characteristics		%	%	%	%
Birthweight	< 2500kg	6.8	8.5	7.5	8.3
	≥ 2500kg	93.2	91.5	92.5	91.7
Maternal smoking during pregnancy	No	66.3	66.4	53.8	53.9
	Yes	33.7	33.6	46.2	46.1
Breastfeeding	Never	32.3	31.0	64.2	63.4
	Yes	67.7	69.0	35.8	36.6
Breastfeeding > 1 month	No	57.0	56.1	83.4	82.2
	Yes	43.0	43.9	16.6	17.8
Parental characteristics		%	%	%	%
Paternal Social Class (10/11)	Manual	59.2	59.0	52.1	51.8
	Non - manual	40.8	41.0	47.9	48.2
Maternal working (birth to 5)	No	70.9	69.7	66.6	65.6
	Yes	29.1	30.3	33.4	34.4
Parental divorce by age 10	No	95.5	95.3	88.6	88.5
	Yes	4.5	4.7	11.4	11.5
Years of education - Father	<11 years	88.3	87.7	81.4	81.1
	≥11 years	11.7	12.3	18.6	18.9
Years of education - Mother	<11 years	90.4	89.1	81.7	82.5
	≥11 years	9.6	10.9	18.3	17.5
Child characteristics		%	%	%	%
Enuresis - wet at night after 5 years	No	87.9	90.1	75.0	81.9
	Yes	12.1	9.9	25.0	18.1
Total Rutter score (age 16)	<6	79.7	78.6	78.1	77.3
	≥ 6	20.3	21.4	21.9	22.7
Conduct problems	<1	84.6	86.1	79.3	83.5
	≥1	15.4	13.9	20.7	16.5
Hyperactivity problems	<1	80.1	87.1	82.9	87.3
	≥1	19.9	12.9	17.1	12.7
Emotional problems	<1	80.9	70.1	78.7	68.2
	≥1	19.1	29.9	21.3	31.8
Peer problems	<1	81.8	88.5	87.4	89.9
	≥1	18.2	11.5	12.6	10.1
Adult characteristics		%	%	%	%
Unemployed	No	94.0	98.0	97.5	98.6
	Yes	6.0	2.0	2.5	1.4
Education - has a degree at age 33	No	85.9	88.9	65.8	63.3
	Yes	14.1	11.1	34.2	36.7
Cohabitation	No	21.7	19.6	26.4	24.2
	Yes	78.3	80.4	73.6	75.8
Number of children at 42	<2	77.6	75.2	81	77.9
	≥2	22.4	24.8	19	22.1

Table 3. Odds Ratios (OR) and 95% confidence intervals of the associaiton (direct effect) between year of birth and the hypothesised mediators

		Men			Women	
	OR	**95% Confidence Interval**		**OR**	**95% Confidence Interval**	
Birth characteristics						
Birthweight ≥2500 kg	0.849	0.697	1.033	1.097	0.930	1.293
Maternal smoking during pregnancy	1.547	1.417	1.688	1.560	1.436	1.695
Breastfeeding	0.285	0.261	0.312	0.292	0.268	0.318
Breastfeeding > 1 month	0.327	0.296	0.361	0.341	0.311	0.375
Parental characteristics	**OR**	**95% CI**		**OR**	**95% CI**	
Paternal Social Class (10/11)	1.489	1.357	1.634	1.513	1.384	1.655
Mother working (birth to 5)	1.166	1.054	1.289	1.164	1.06	1.278
Parental divorce (by age 10)	2.722	2.26	3.279	2.651	2.243	3.133
Years of education - Father	1.855	1.637	2.103	1.793	1.588	2.026
Years of education - Mother	2.303	2.018	2.628	1.959	1.729	2.219
Child characteristics	**OR**	**95% CI**		**OR**	**95% CI**	
Enuresis - wet at night after 5 years	2.354	2.086	2.656	1.940	1.706	2.207
Total Rutter score (age 16)	1.144	0.999	1.31	0.985	0.872	1.112
Conduct	1.537	1.333	1.773	1.180	1.027	1.357
Hyperactivity	0.859	0.748	0.988	0.855	0.736	0.994
Emotional	1.192	1.047	1.359	1.096	0.987	1.216
Peer	0.597	0.510	0.698	0.816	0.693	0.960
Adult characteristics	**OR**	**95% CI**		**OR**	**95% CI**	
Unemployed (age33)	0.385	0.29	0.513	0.678	0.468	0.982
Education - has a degree (age33)	3.370	3.017	3.764	5.004	4.481	5.588
Married or Cohabiting (age 33)	0.744	0.667	0.831	0.773	0.695	0.859
≥ 2 children (by age 42)	0.750	0.687	0.820	0.807	0.739	0.880

Table 4. Summary descriptive statistics of the Malaise Inventory

	Men	
	1958	**1970**
Malaise > 3	9.6% (8.9 – 10.5)	16.0% (14.7 – 17.1)
Malaise sum score mean	1.23 (1.19 – 1.27)	1.65 (1.60 – 1.72)
	Women	
	1958	**1970**
Malaise > 3	16.3% (15.5 – 17.4)	20.2% (19.1 - 21.4)
Malaise sum score mean	1.80 (1.75 – 1.86)	2.05 (1.99 – 2.11)

Table 5. Regression parameters and 95% confidence intervals of the association (direct effects) between the hypothesisied mediatrors and latent psychological distress at age 42.

NCDS	**Men**			**Women**		
Birth Characteristics	**b**	**95% Confidence Interval**		**b**	**95% Confidence Interval**	
Birthweight ≥ 2500kg	-0.070	-0.241	0.100	-0.028	-0.151	0.095
Maternal smoking during pregnancy	0.114	0.016	0.212	0.112	0.038	0.187
Breastfeeding	-0.032	-0.117	0.052	-0.051	-0.128	0.026
Breastfeeding > 1 month	0.013	-0.070	0.096	-0.056	-0.131	0.018
Parental characteristics	**b**	**95% Confidence Interval**		**b**	**95% Confidence Interval**	
Paternal Social Class (10/11)	-0.061	-0.152	0.030	-0.188	-0.275	-0.100
Mother working (birth to 5)	0.037	-0.067	0.142	0.133	0.058	0.209
Parental divorce (by age 10)	0.181	-0.025	0.388	0.037	-0.114	0.189
Years of education - Father	-0.090	-0.202	0.022	-0.052	-0.150	0.046
Years of education - Mother	-0.026	-0.145	0.094	-0.065	-0.164	0.033
Child characteristics	**b**	**95% Confidence Interval**		**b**	**95% Confidence Interval**	
Enuresis - wet at night after 5 years	0.101	-0.026	0.228	0.074	-0.033	0.182
Total Rutter score (age 16)	0.428	0.333	0.522	0.326	0.247	0.405
Conduct	0.267	0.165	0.368	0.223	0.135	0.310
Hyperactivity	0.172	0.080	0.264	0.128	0.036	0.220
Emotional	0.373	0.278	0.469	0.361	0.295	0.426
Peer	0.164	0.062	0.266	0.141	0.053	0.230
Adult characteristics	**b**	**95% Confidence Interval**		**b**	**95% Confidence Interval**	
Unemployed (age33)	0.231	0.060	0.402	0.060	-0.194	0.313
Education - has a degree (age33)	-0.102	-0.212	0.007	-0.093	-0.194	0.007
Married or Cohabiting (age 33)	-0.095	-0.192	0.002	-0.103	-0.182	-0.024
≥ 2 children (by age 42)	0.053	-0.029	0.136	0.122	0.051	0.192
BCS70	**Men**			**Women**		
Birth Characteristics	**b**	**95% Confidence Interval**		**b**	**95% Confidence Interval**	
Birthweight ≥ 2500kg	-0.012	-0.203	0.179	-0.114	-0.268	0.040
Maternal smoking during pregnancy	0.070	-0.026	0.166	0.156	0.079	0.233
Breastfeeding	-0.092	-0.181	-0.003	-0.061	-0.140	0.018
Breastfeeding > 1 month	-0.063	-0.182	0.056	-0.099	-0.181	-0.016
Parental characteristics	**b**	**95% Confidence Interval**		**b**	**95% Confidence Interval**	
Paternal Social Class (10/11)	-0.150	-0.241	-0.059	-0.171	-0.252	-0.091
Mother working (birth to 5)	0.173	0.055	0.291	0.092	-0.013	0.196
Parental divorce (by age 10)	0.236	0.088	0.385	0.077	-0.037	0.192
Years of education - Father	-0.053	-0.159	0.053	-0.099	-0.202	0.004
Years of education - Mother	-0.107	-0.231	0.017	-0.113	-0.208	-0.019
Child characteristics	**b**	**95% Confidence Interval**		**b**	**95% Confidence Interval**	
Enuresis - wet at night after 5 years	0.080	-0.022	0.182	0.058	-0.052	0.168
Total Rutter score (age 16)	0.404	0.293	0.515	0.397	0.314	0.480
Conduct	0.249	0.150	0.348	0.226	0.134	0.318
Hyperactivity	0.207	0.089	0.324	0.190	0.098	0.282
Emotional	0.482	0.382	0.583	0.430	0.353	0.506
Peer	0.180	0.064	0.296	0.187	0.080	0.295
Adult characteristics	**b**	**95% Confidence Interval**		**b**	**95% Confidence Interval**	
Unemployed (age33)	0.334	-0.019	0.687	0.408	0.035	0.781
Education - has a degree (age33)	-0.107	-0.211	-0.003	-0.138	-0.222	-0.055
Married or Cohabiting (age 33)	-0.170	-0.272	-0.068	-0.179	-0.270	-0.089
≥ 2 children (by age 42)	0.037	-0.069	0.143	0.067	-0.018	0.152

Table 6. Standardised Natural Indirect Effects and 95% confidence intervals

	Men			Women		
	b	**95% Confidence interval**		**b**	**95% Confidence interval**	
Year of birth Total Effect - Ref:1958 cohort	**0.314**	**0.252**	**0.375**	**0.147**	**0.076**	**0.218**
Cohort via Birth characteristics						
Birthweight ≥ 2500kg	0.001	-0.001	0.001	0.001	-0.001	0.001
Maternal smoking during pregnancy	**0.010**	**0.004**	**0.016**	**0.013**	**0.008**	**0.019**
Breastfeeding	**0.019**	**0.001**	**0.037**	**0.018**	**0.003**	**0.032**
Breastfeeding > 1 month	0.004	-0.008	0.017	**0.014**	**0.004**	**0.024**
Cohort via Parental characteristics	**b**	**95% Confidence interval**		**b**	**95% Confidence interval**	
Paternal Social Class (10/11)	**-0.008**	**-0.013**	**-0.003**	**-0.016**	**-0.022**	**-0.011**
Mother working (birth to 5)	**0.003**	**0.001**	**0.006**	**0.004**	**0.001**	**0.007**
Parental divorce (by age 10)	**0.013**	**0.006**	**0.020**	0.006	-0.001	0.012
Years of education - Father	-0.003	-0.007	0.001	**-0.004**	**-0.007**	**-0.001**
Years of education - Mother	-0.004	-0.010	0.001	**-0.005**	**-0.009**	**-0.001**
Cohort via Child characteristics	**b**	**95% Confidence interval**		**b**	**95% Confidence interval**	
Enuresis - wet at night after 5 years	**0.009**	**0.001**	**0.018**	0.004	-0.002	0.010
Total Rutter score (age 16)	**0.024**	**0.014**	**0.034**	**0.010**	**0.002**	**0.017**
Conduct	**0.025**	**0.016**	**0.033**	**0.013**	**0.007**	**0.020**
Hyperactivity	0.003	-0.001	0.007	0.002	-0.001	0.005
Emotional	**0.030**	**0.020**	**0.041**	**0.014**	**0.005**	**0.022**
Peer	-0.003	-0.007	0.001	0.001	-0.003	0.003
Cohort via Adult characteristics	**b**	**95% Confidence interval**		**b**	**95% Confidence interval**	
Unemployed (age33)	**-0.008**	**-0.012**	**-0.003**	-0.001	-0.003	0.001
Education - has a degree (age33)	**-0.023**	**-0.039**	**-0.007**	**-0.032**	**-0.048**	**-0.015**
Married or Cohabiting (age 33)	**0.006**	**0.002**	**0.011**	**0.006**	**0.002**	**0.009**
≥ 2 children (by age 42)	-0.004	-0.010	0.001	**-0.007**	**-0.011**	**-0.003**

* Highlighted parameters are statistically significant at the 0.001 level. Underlined and highlighted parameters indicate significant consistent (black) and inconsistent (red) mediating effects

Appendix I
Administration procedure of the Malaise Inventory in the NCDS and BCS70

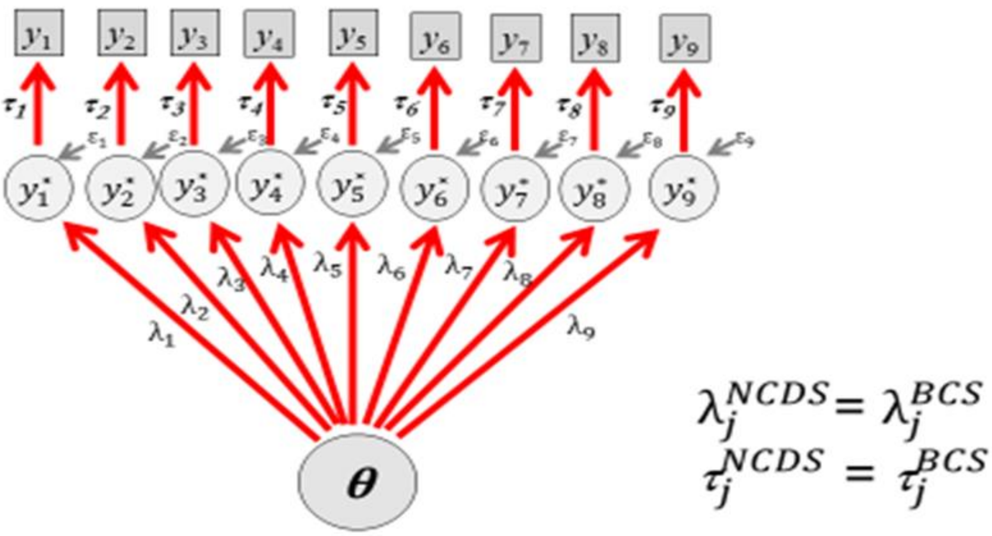
In both surveys the Malaise items were assessed via written via self-completion but on the 1970 cohort it was on paper, whereas on the 1958 cohort via computer. In the 1970 cohort Age 42 survey the Malaise scale was included as part of the paper self-completion questionnaire. This was posted to respondents ahead of their interview and in the majority of cases was completed before the visit so that the interviewer could pick it up when they arrived to do the main interview. It was a 16 page questionnaire – and Malaise was towards the end on page 15. Before completing the Malaise the respondent would have answered questions about: Leisure activities, Sports participation, a series of attitude questions, political interest, voting, membership of organisations, TV watching, reading, computer use, religion, diet, then on page 13 – the Warwick Edinburgh Mental Well Being Scale, the AUDIT scale (problematic alcohol use) and sleep quality. In NCDS (1958 cohort) Age 42 survey the Malaise scale was included in the computerised self-completion (CASI) section at the end of the interview. Within the CASI module, the Malaise scale was preceded by the following: Attitudes, relationship satisfaction, sharing of domestic labour, the General Health Questionnaire (GHQ), and questions about skills. The CASI module comes after the full interview which within the health module contains further questions about mental health conditions.

The establishment of between cohort measurement invariance of the Malaise Inventory implies that the observed differences were due to valid between cohort variation in levels of psychological distress and not an artefact of cohort differences in the administration procedure, or other forms of systematic measurement error such as response style, item comprehension or social desirability. It has also shown that differences in the administration procedure, paper versus computer assisted completion for example, are unlikely to introduce bias (De Leeuw and Hox, 2011). Based the on between cohort strong invariance and the previous literature, we are confident that differences in the administration procedure have not influenced our findings

Appendix II
Unidimensional 2 parameter probit latent variable measurement model

We modelled the probability of response to the binary Malaise inventory items with a latent variable specification of a 2 parameter probit model (Muthen, 1984, Rabe-Hesketh and Skrondal, 2008). The model is presented in Diagram 1, where $\boldsymbol{\theta}$ represents latent (unobserved) psychological distress, which is assumed to have a normal distribution N ~ (0, 1), λ is the factor loading that captures the strength of the association between the latent variable $\boldsymbol{\theta}$ and the observed items and τ is the threshold or "difficulty" parameter which quantifies the level of the latent continuum that underlies each item that needs to be reached for a response to an observed item to switch from 0 to 1.

Diagram 1. Measurement model of the Malaise Inventory



Categorical/ binary observed indicators (y_{ij}) are related to continuous latent variables (θ_j) via a normal ogive response model, such that:

$$y_{ij} = \begin{cases} 1 & \text{if } y_{ij}^* > \tau_i \\ 0 & \text{otherwise} \end{cases} \qquad (1)$$

where $y_{ij}^* = \beta_i + \lambda_i\theta_j + \varepsilon_{ij}$

for i=1,…, I_j (I_j being the number of observed indicators for latent variable j). We also assume that

$$\eta_j \sim N(0, \Psi),\ \varepsilon_{ij} \sim N(0,1),\ COV\left(\eta_j, \varepsilon_{ij}\right) = 0$$

where Ψ is a diagonal matrix and COV stands for covariance.

Model (1) can be equivalently expressed as:

$$\Pr\left(y_{ij} = 1 \mid \theta_j\right) = \Pr\left(y_{ij}^* > \tau_i \mid \theta_j\right) = \Phi\left(\beta_i + \lambda_i\theta_j\right)$$

$$\Phi^{-1}\Pr\left(y_{ij} = 1 \mid \eta_j\right) = \beta_i + \lambda_i\theta_j$$

Where $\Phi(\cdot)$ is the cumulative standard normal distribution and Φ^{-1} is the probit link

With this approach measurement error in the observed Malaise inventory items is controlled since the latent dimension $\boldsymbol{\theta}_j$ captures only the common variation in these and leaves out unique to each item variance (measurement error - ε_{ij}) that is not due to latent $\boldsymbol{\theta}$. However, additional sources of error may arise in between cohort comparisons from differences in the comprehension of items and in response tendencies which may vary by cohort so their distribution as sources of error cannot be assumed to be uniform between cohorts (Meredith, 1993). In order to obtain a meaningful comparison between the NCDS and BCS70 with respect to psychological distress ($\boldsymbol{\theta}_j$) the measurement parameters (τ and λ) of the model need to function equivalently between the two cohorts. To empirically test this assumption we estimated a multigroup, two parameter probit model, where measurement model parameters (τ and λ) were not allowed to vary between the two cohorts.

Table 1. Factor loadings and thresholds of all estimated measurement models

Men 1958		**Men 1970**	
Factor Loading (λ)	Threshold (τ)	Factor Loading (λ)	Threshold (τ)
0.606	0.579	0.651	0.402
0.829	0.97	0.855	0.848
0.811	0.305	0.785	0.096
0.684	1.731	0.688	1.770
0.764	1.673	0.797	1.490
0.758	0.983	0.764	0.603
0.836	1.610	0.852	1.413
0.848	1.806	0.857	1.251
0.675	1.561	0.768	1.362
Women 1958		**Women 1970**	
Factor Loading (λ)	Threshold (τ)	Factor Loading (λ)	Threshold (τ)
0.602	0.266	0.621	0.121
0.819	0.718	0.844	0.766
0.738	-0.124	0.751	-0.277
0.587	1.598	0.691	1.912
0.725	1.292	0.747	1.254
0.749	0.690	0.785	0.410
0.846	1.532	0.869	1.398
0.869	1.584	0.855	1.198
0.680	1.253	0.747	1.223
Multigroup – Scalar Invariance			
Factor Loading (λ)	Threshold (τ **)**		
0.600	0.273		
0.802	0.762		
0.740	-0.116		
0.582	1.605		
0.702	1.332		
0.767	0.632		
0.850	1.520		
0.894	1.522		
0.669	1.271		

Table 2. Goodness of fit criteria of the unidimensional Malaise inventory two parameter probit model

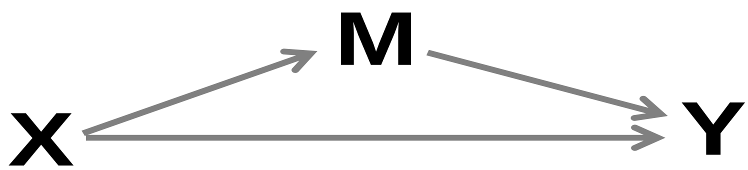
Model	CFI	TLI	RMSEA	RMSEA 95% Confidence Interval
Men 1958	0.986	0.981	0.034	0.030 to 0.038
Men 1970	0.988	0.984	0.040	0.034 to 0.045
Women 1958	0.985	0.980	0.038	0.034 to 0.042
Women1970	0.988	0.985	0.038	0.033 to 0.034
Multigroup - Scalar	0.984	0.982	0.037	0.035 to 0.039
Multigroup - Configural	0.987	0.982	0.037	0.035 to 0.040

Appendix III- Model adjustment strategy

Directed Acyclic Graph 1. Total effect of X on Y

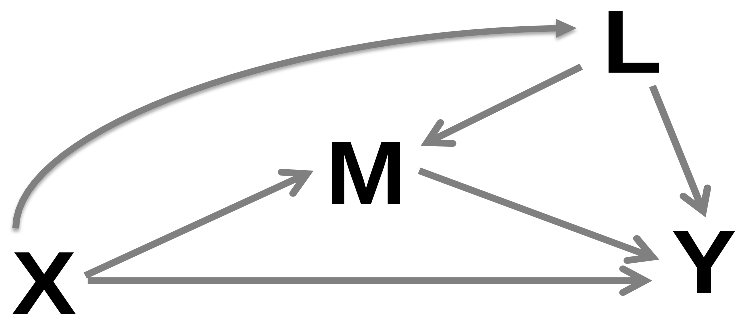
"X" represents year of birth/cohort indicator and "Y" the between cohort equivalent latent psychological distress as captured by the nine item Malaise Inventory. "Y" is regressed on "X", the coefficient captures the between cohort difference on psychological distress.

Directed Acyclic Graph 2. Introducing M as the mediator



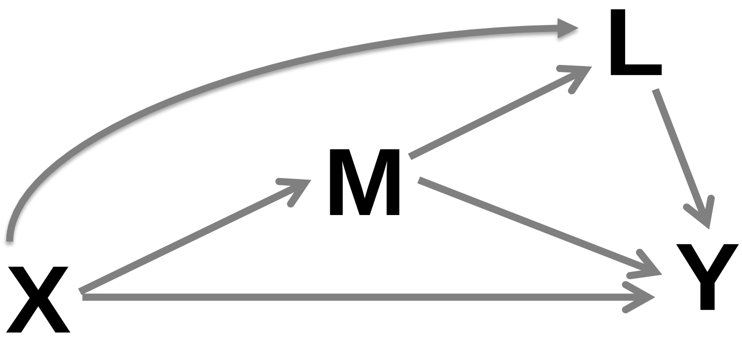
"M" is introduced as the mediator. We hypothesise that at least part of the effect of "X" on "Y" is via "M". In this instance "M" are birth characteristics. We report the Natural Indirect Effect from models that include only the year of birth/cohort indicator "X", one birth characteristic at a time as mediator "M" (birthweight for example) and psychological distress "Y" as the outcome.

Directed Acyclic Graph 3. Intermediate confounding



In this scenario which relevant to child and adult characteristics as mediators, “L” is an intermediate confounder, since it confounds the association between the mediator “M” and the outcome “Y”, but at the same time is influenced by the exposure “X”. Although not explicitly of interest in our study, the associations between the various mediators and year of birth may result in intermediate confounding (De Stavola et al., 2015). For example, from the set of consistent mediators, conduct problems in men mediate the association between year of birth and psychological distress but simultaneously confound the association between partnership status at 33 and psychological distress at 42. In the presence of intermediate confounding in nonlinear systems, the Natural Indirect Effect can be identified in the absence of individual level exposure mediator interaction (Robins and Greenland, 1992). We tested for two way interactions between year of birth and all mediators and found weak or no evidence for interaction. Further analysis where interactions terms were included in the model returned very similar Controlled Direct and Natural Direct Effects, indicating that the mediation effect captured by the Natural Indirect Effect is not substantially biased by the presence of intermediate confounders. We note that we obtained similar results with alternative mediation methods that do not assume the absence of intermediate confounding but make alternative assumptions (MacKinnon et al., 2007), or to date are not available for use in conjunction with latent variables (Vanderweele et al., 2014, Daniel et al., 2011). These findings reinforced our interpretation that the observed results are not biased by the presence of intermediate confounders in our data. Since the NIE was the quantity of interest and not the remaining not mediated “direct” effect, all models were adjusted with variables from previous stages of the life course. For example when a child characteristic (conduct problems) was assessed as a mediator, the model was adjusted for parental and birth characteristics. When an adult characteristic was modelled as a mediator, the model was adjusted for birth, parental and child characteristics.

Directed Acyclic Graph 4. "L" as a collider



This is a similar scenario to DAG 3, but instead of an intermediate confounder, "L" is now influenced by the mediator "M". "L" is a child of both "X" and "M" and is therefore a "collider" that shouldn't be adjusted for in the models. The model in this case is specified as in the scenario presented in DAG3. An example of a collider in our paper is number of children by age 42 ("L"), which is associated with psychological distress "Y", but at the same time is influenced by maternal years of education "M" and year of birth "X".

References

Daniel, R. M., De Stavola, B. L. & Cousens, S. N. (2011). gformula: Estimating causal effects in the presence of time-varying confounding or mediation using the g-computation formula. Stata Journal 11, 479-517.

De Leeuw, E. D. & Hox, J. J. (2011). Internet surveys as part of a mixed-mode design. Social and Behavioral research and the internet, 45-76.

De Stavola, B. L., Daniel, R. M., Ploubidis, G. B. & Micali, N. (2015). Mediation analysis with intermediate confounding: structural equation modeling viewed through the causal inference lens. Am J Epidemiol 181, 64-80.

MacKinnon, D. P., Lockwood, C. M., Brown, C. H., Wang, W. & Hoffman, J. M. (2007). The intermediate endpoint effect in logistic and probit regression. Clinical Trials 4, 499-513.

Meredith, W. (1993). Measurement invariance, factor analysis and factorial invariance. Psychometrika 58, 525-543.

Muthen, B. (1984). A General Structural Equation Model with Dichotomous, Ordered Categorical, and Continuous Latent Variable Indicators. Psychometrika 49, 115-132.

Rabe-Hesketh, S. & Skrondal, A. (2008). Classical latent variable models for medical research. Statistical Methods in Medical Research 17, 5-32.

Robins, J. M. & Greenland, S. (1992). Identifiability and exchangeability for direct and indirect effects. Epidemiology 3, 143-55.

Vanderweele, T. J., Vansteelandt, S. & Robins, J. M. (2014). Effect decomposition in the presence of an exposure-induced mediator-outcome confounder. Epidemiology 25, 300-6.