Changes in the adult consequences of adolescent mental ill-health: findings from the

1958 and 1970 British birth cohorts

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Abstract

Background: Adolescent mental health difficulties are increasing over time, whether their adulthood health and socio-economic consequences are changing over time is not known.

Methods: Participants (N=31,349) are from two prospective national birth cohort studies: 1958 National Child Development Study (n=16,091) and the 1970 British Cohort Study (n=15,258). Adolescent mental health was operationalised both as traditional internalising and externalising factors and a hierarchical bi-factor. Associations between adolescent psychopathology and age 42 health and wellbeing (mental health, general health, life satisfaction), social (cohabitation, voting behaviour) and economic (education and employment) outcomes are estimated linear and logistic multivariable regression across cohorts, controlling for a wide range of early life potential confounding factors.

Results: The prevalence of adolescent mental health difficulties increased and their associations with midlife health, wellbeing, social and economic outcomes became more severe or remained similar between those born in 1958 and 1970. For instance, a stronger association with adolescent mental health difficulties was found for those born in 1970 for midlife psychological distress (OR 1970=1.82[1.65,1.99], OR 1958=1.60[1.43,1.79], cohabitation (OR 1970=0.64[0.59,0.70], OR 1958=0.79[0.72,0.87]), and professional occupations (OR 1970=0.75[0.67,0.84], OR 1958=1.05[0.88,1.24]). The associations of externalising symptoms with later outcomes were mainly explained by their shared variance with internalising symptoms.

Conclusion: The widening of mental health based inequalities in midlife outcomes further supports the need to recognise that secular increases in adolescent mental health symptoms is a public health challenge with measurable negative consequences through the life course. Increased public health efforts to minimise adverse outcomes are needed.

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Introduction

Common mental health problems, such as anxiety and depression are a leading cause of disease burden (Whiteford et al., 2013). Estimated high prevalence of common mental health problems in children and adolescents is of particular concern as early onset symptoms often persist into adulthood (Last et al., 1997; Pine et al., 1998), causing substantial health and social costs in adult life (Colman et al., 2009; Goodman et al., 2011; Ploubidis et al., 2021). Mental ill-health frequently occurs in childhood and adolescence, with 1 in 8 5-19 year olds with a diagnosable disorder and a higher proportion of young people reporting high levels of internalising and externalising symptoms (Deighton et al., 2019; Sadler et al., 2018). It has also been observed that the prevalence of mental ill-health symptoms is changing across generations, with twice as many young people in the UK reporting frequent feelings of depression and anxiety from 1986 to 2006 (Collishaw et al., 2010), and almost twice as many adolescents experiencing high depressive symptoms in 2015 compared to 2005 (Patalay & Gage, 2019).

Studies providing evidence for the association between adolescent mental ill-health and psychosocial adult outcomes have been recently reviewed (Clayborne et al., 2019; Erskine et al., 2016), highlighting that adolescent mental ill-health has negative associations with several domains in adulthood, including socio-economic outcomes and physical and mental health. However, it is unclear whether the magnitude of these associations are also changing across cohorts. Investigating this may help inform health policy and planning in relation to the consequences and burden associated with increasing trends in adolescent mental health problems. Studies of adulthood outcomes in relation to adolescent mental health have been conducted using the British birth cohorts (Colman et al., 2009; Goodman et al., 2011; Richards et al., 2009), but with one exception (Ning et al., 2021), to our knowledge no investigations of differences between cohorts has been undertaken to-date, possibly due the requirement of a sequence of long running longitudinal studies to do so. A recent study investigated the association between childhood mental health difficulties at age 7 and adolescent outcomes (14-16 years) in three cohorts their findings indicate that these associations are similar magnitude across cohorts and might be getting slightly stronger for some outcomes in recent generations (Sellers et al., 2019).

In adolescent mental health, common difficulties are usually represented in two domains, internalising and externalising symptoms, which exhibit above chance levels of co-morbidity and have common antecedents (Patalay et al., 2017). Internalising psychopathology indicated by a liability to experience mood and anxiety related symptoms, whereas externalising psychopathology is indicated by a liability to experience antisocial behavioural related symptoms, substance use disorders, childhood oppositional defiance/conduct disorder, and adult antisocial personality (Caspi et al., 2014; Krueger et al., 2002). Regarding adult outcomes, there is some evidence that externalising difficulties might have stronger negative associations with educational and economic outcomes (Colman et al., 2009; Richards et al., 2009). However, it is unclear whether this is still the case when the shared variance with internalising symptoms is accounted for. In recent years, to account for their comorbidity and permit investigation of overall levels of mental health difficulties, mental health has been conceptualised as a general psychopathological construct that reflects shared variance between internalising and externalising symptoms (Caspi et al., 2014; Lahey et al., 2012). In young people this general psychopathology factor explains between 70-80% of the variance in symptomology, and is highly predictive of future outcomes (McElroy et al., 2018; Patalay et al., 2015).

The current study aimed to investigate whether cohort moderated the strength of associations between adolescent psychopathology (at age 16) and a wide range of health and wellbeing, social and economic outcomes in mid-life (at age 42) using simultaneous analysis of identically measured exposure, outcomes, and controls across the 1958 National Child Development Study and the 1970 British Cohort Study. In addition, adolescent mental health was conceptualised as traditional 2-domains (internalising and externalising difficulties) and also using a more recent bi-factor general psychopathology approach. A range of health and wellbeing (mental health, general health, life satisfaction), social (cohabitation, voting behaviour) and economic (education and employment) outcomes were investigated to provide a comprehensive picture of the health and socioeconomic consequences related to adolescent mental health and whether these are changing across cohorts.

Methods

Participants

This study used data from 31349 participants from two British birth cohort studies.

1958 NCDS

The 1958 National Child Development Study (1958 NCDS) follows the lives of 17,415 people born in England, Scotland and Wales in a single week of 1958 (Power & Elliott, 2006). Since the birth survey in 1958, there have been 11 further surveys of the cohort members at ages 7, 11, 16, 23, 33, 42, 44, 46, 50,55 and 62 years. In 2000 at age 42 years, 11,419 study members (50.7% female) participated in the survey. The analytic sample for this study consisted of 16091 participants (92.39% of the original sample) having excluded those who had died or emigrated by age 42 years.

1970 BCS

The 1970 British Cohort Study (1970 BCS) follows the lives of 17198 people born in England, Scotland and Wales in a single week of 1970 (Elliott & Shepherd, 2006). Since the birth survey in 1970, there have been ten surveys at ages 5, 10, 16, 26, 30, 34, 38,42, 46 and 50 years. In 2012 at age 42 years 9841 study members (52.20% female) participated in the survey. The analytic sample for this study consisted of 15258 participants (88.72% of the original sample) having excluded those who had died or emigrated by age 42 years.

Measures

Mental health at age 16

At age 16 one parent (usually the mother) of both 1958 NCDS and 1970 BCS cohort members completed the Rutter A scale (Rutter, 1970), consisting of 18 symptoms for which the parent was asked to indicate whether each 'does not apply' 'applies somewhat' or 'definitely applies'. Confirmatory 2-factor and bi-factor analyses were applied to derive latent factor scores, which were treated as continuous measures of internalising and externalising symptoms and general psychopathology.

Health and wellbeing outcomes at age 42

At age 42 psychological distress was measured in both cohorts using the 9 item version of the Malaise Inventory (Rodgers et al., 1999), which includes items assessing presence of symptoms such as 'feel miserable and depressed', 'get worried about things' and 'get easily upset or irritated'. On the sum score, a high score indicates greater psychological distress and there is an established cut-off of a score of above 3 indicating high psychological distress (Ploubidis et al., 2017, 2019a; Rutter et al., 1976).

Life satisfaction was assessed by the question 'How had life turned out so far': on a scale of 0 to 10, where 0 is not at all satisfied and 10 is completely satisfied. General state of health was also measured in both cohorts at age 42. In the 1958 NCDS cohort members were asked to rate their general health using 4 categories (1= Excellent, 2 = Good, 3 = Fair, 4 = Poor), and in the 1970 BCS cohort members were asked to rate their general health using 5 categories (1= Excellent; 2 = Very good; 3 = Good; 4 = Fair; 5 = Poor). To harmonise this variable, the linear stretch method was applied to each general health measure (de Jonge et al., 2014).

Social and economic outcomes at age 42

Whether the cohort member lives with a spouse or partner, their highest academic qualification, their employment status (managerial / professional / non-managerial / professional / never worked / long-term unemployed), and whether the cohort member voted in the last general election was recorded in both cohorts at age 42. A binary variable was derived for highest academic qualification, which represented those who had a degree (coded 1) vs those who had no or other qualifications (coded 0). A binary variable was also derived for employment status which represented those in professional managerial positions (coded 1) vs those in any other employment status.

Covariates

Socio-economic and health covariates derived from birth and early childhood were included in the analysis. All covariates were measured identically between cohorts.

Covariates derived from birth and early childhood included birth weight, maternal smoking during pregnancy, whether cohort members were breastfed, childhood cognition and childhood body mass index. Covariates derived from parents included paternal social class at age 10/11 years (higher managerial, administrative and professional occupations, intermediate occupations, routine and manual occupations), housing tenure of parents at age 10, whether the mother of the participants was employed (birth to age 5 years), divorced (by age 10 or 16 years), and years of education of mother and father.

Statistical Analysis

Latent variable measurement models

Measurement models were run on the age 16 mental health measure. Confirmatory Factor Analyses (CFA) were conducted to test two models. A 2-factor model was estimated which confirmed the factor structure for internalising and externalising psychopathology. Second, a bi-factor model where each symptom loads on to general psychopathology as well as

internalising and externalising factors. CFA models were estimated using Mplus 8 (Muthén & Muthén, 2013) and the weighted least square mean and variance (WLSMV) estimator was used for categorical manifest variables (Beauducel & Herzberg, 2009). We tested the measure for invariance between cohorts and found it to be invariant at the configural, metric and scalar levels, indicating between cohort comparisons could be made using this measure (see Supplementary Table 1) (Gregorich, 2006).

To compare the relative variance explained of both the general and specific factors, the explained common variance (ECV) for each factor was calculated for externalising, internalising and general psychopathology. ECV values range from 0 to 1, with values closer to 1 suggesting a greater share of variance explained. There are no established cut-offs in ECV values; it has been suggested that ECV values ranging from .60 to .85 indicate that a factor is the main source of shared variance (Reise et al., 2012).

Missing data

Multiple imputation using chained equations was implemented to impute missing data on all exposures, covariates and outcomes, with fifty imputations conducted separately in both cohorts (see Supplementary Table 4 for counts and percentages of non-imputed data for each predictor and outcome). This multiple imputation approach includes a number of covariates and auxiliary variables in the models, which improves the plausibility of the missing at random (MAR) assumption (Little et al., 2014; Mostafa et al., 2021).

Regression analyses

Linear and logistic multivariable regression models were fitted to test associations between psychopathology at age 16 and health and socio-economic outcomes at ages 42, adjusting for a rich set of early life covariates. Data from both cohorts were combined in a single dataset post imputation and model comparison tests between models with and without cohort interactions were conducted. Where log-likelihood tests indicated that the models with cohort interactions had better fit, we present stratified models by cohort to help illustrate the direction and size of the coefficients in each cohort. Given significant improvements in model fit when including cohort*age 16 mental health interaction terms, stratified models are presented by cohort for all outcomes. We further illustrate the cohort differences in *exposure-outcome associations* across the distribution of the exposure using predictive margins from the regression models. We also investigated whether associations between adolescent mental health and midlife outcomes differed between sexes using sex*cohort*age 16 mental health

interactions. An alpha level of .05 was used with adjustment made for rate of false discovery due to multiple outcomes testing using the Benjamini-Hochberg procedure (Benjamini & Hochberg, 1995). To adjust individual p values using Benjamini-Hochberg procedure, critical values were calculated using the formula (i/m)Q (where 'i' is the individual p-values rank, 'm' is the total number of tests and 'Q' is the false discovery rate [FDR]). The false discovery rate was 5% (i.e. Q = .05). Multiple imputation and subsequent analyses were conducted using Stata (V.15).

Results

Factor models

The first CFA estimated the 2-factor model using separate externalising and internalising latent factors. Factor loadings and model fit statistics for this model are displayed in Supplementary Table 1. The second CFA estimated the bi-factor model with externalising, internalising specific and a general psychopathology bi-factor. Factor loadings and model fit for this model are displayed in Supplementary Table 2. Estimating the ECV indicates that the general psychopathology factor accounted for 72.1% of the variance in symptoms, externalizing symptoms accounted for 14.8% of the variance and internalising symptoms accounted for 13% of the variance.

Descriptive statistics

Table 1 displays the mean factor scores for adolescent mental health and the means / proportions for each harmonised outcome variable. Most mental health symptoms scores at ages 16 were higher for in the 1970 cohort than for those 1958 cohort (with the exception of the externalising specific factor from the bi-factor model, tests of cohort differences are presented in supplementary table 6). Supplementary Table 5 displays the correlations between adolescent mental health and age 42 health and social outcomes. Correlations are similar or of higher magnitude between each exposure-outcome pair for those born in the 1970 cohort than for those in the 1958 cohort.

Associations between adolescent mental ill-health and health and social outcomes in adulthood

Model comparison tests of models with and without cohort interactions indicated that for all outcomes models with cohort interactions with age 16 mental health from the bi-factor model (and all except two from the 2-factor model) had improved model fit than without the cohort

interactions, supporting the presentation of cohort stratified estimates (log-likelihood tests for the model comparisons are presented in Table 2).

All coefficients for the exposure-outcome associations stratified by cohort are displayed in Table 3. The coefficients describe the change in outcomes associated with one unit increase in the age 16 mental health scores. Histograms describing the distribution of age 16 mental health scores are presented in Supplementary Figure 5 and 6 to help illustrate what a unit increase in scores means relative to the population distribution of symptoms).

Externalising symptoms (from the 2-factor model) were associated with high psychological distress and lower likelihood of living with a partner, low education attainment and disadvantaged occupational class in both cohorts, with consistently weaker associations in BCS 1970. Internalising symptoms (from the 2-factor model) were associated similarly in both cohorts with life satisfaction, living with a spouse and obtaining a degree in both cohorts. However, a clear cohort effect is observed for age 42 psychological distress where higher internalising symptoms at age 16 is associated with 1.72 higher odds (95% CI: 1.56,1.91) in NCDS 1958 and 2.13 higher odds (95%CI: 1.95,2.32) in BCS 1970 (Supplementary Figure 1 illustrates associations by cohort for each 2-factor exposure-outcome pair).

General psychopathology at age 16 was associated with poorer outcomes for most adult outcomes examined in both cohorts. Figure 1 illustrates the associations by cohort for general psychopathology and each outcome. We observe that at higher levels of adolescent difficulties, for several outcomes, including psychological distress, general health, higher education attainment, and employment, the associations with adverse adult outcomes are greater in the BCS 1970 cohort. For instance, age 16 mental health is not associated with lower likelihood of higher occupational class in the NCDS 1958: OR=1.05 (.88,1.24) whereas it is associated with substantially lower odds of higher occupational class in the BCS 1970 cohort: OR=0.75 (0.67,0.84).

After accounting for the shared variance associated with general psychopathology, there was one independent association between externalising symptoms and lower levels of psychological distress for the NCDS 1958. No associations between externalising symptoms (from the bi-factor model) and any of the other outcomes tested were significant in either cohorts. Internalising symptoms (from the bi-factor model) were still independently associated with several adulthood outcomes including greater psychological distress, lower

life satisfaction, and lower likelihood of cohabitation; however, the specific internalising symptoms were associated with attaining a higher degree. Supplementary figure Supplementary Figure 2 illustrates the associations by cohort for externalising and internalising bi-factor exposure-outcome pairs.

We also conducted log-likelihood tests with models including sex*cohort interactions to examine whether the exposure-outcome associations across cohorts were moderated by sex (Table 2). For most exposure-outcome associations, the models including sex interactions did not have better model fit, indicating that cohort differences observed are similar for males and females. A consistent exception was psychological distress at age 42 years, where we observe that the cohort effect is starker in males with either externalising and internalising mental health at age 16 (from 2-factor model) and the bi-factor (see Figure 2 and Supplementary Figure 3). For likelihood of cohabitation we see that the lower likelihood by greater age 16 mental health difficulties are similar in males and females in the 1970 cohort, however, in the 1958 cohort this association was not observed in females and lower likelihood of cohabiting was only observed in males (see Figure 2) and there is evidence of cohort effects being moderated by sex for professional occupations (see Supplementary Figure 4).

Discussion

The findings of the paper highlight that the consequences of early life mental ill-health on a wide range of mid-life outcomes were stronger for many examined outcomes (or did not substantially change) in a cohort born in 1970 compared to a generation prior born in 1958. Alongside growing prevalence of adolescent mental ill-health, which we also observe between these two cohorts, the larger mental health based inequalities in life outcomes in the more recently born cohort call attention to the large and increasing public health and societal burden of mental ill-health through the life course.

The associations between early life mental ill-health and mid-life social and economic outcomes followed a consistent general pattern of direction of effects in both cohorts, however, the magnitude of these associations became stronger in the younger generation for certain outcomes predicting greater mid-life mental health, lower likelihood of co-habitation with a partner, likelihood to vote and being in professional employment. For instance, greater general psychopathology at 16 was associated with a 60% increased risk of mid-life psychological distress in the 1958 cohort and 82% increased risk in the 1970 cohort. In

another example, adolescents with higher symptoms were 21% less likely to be in cohabiting relationship at age 42 in the 1958 born cohort, whereas they were 36% less likely to be co-habiting in the 1970 born cohort. If sustained in the long term in more recently born cohorts (e.g. Millennium Cohort Study, born 2000-01), a hypothesis we cannot currently test with the available data, this trend will likely have a considerable societal and public health impact.

Some cohort effects were also gendered, and we observe starker cohort differences in males in relation to their mid-life psychological distress and starker cohort differences in females in relation to their likelihood of being in a partnership in mid-life. Reasons for this gendered pattern need better understanding and in regard to mental health outcomes, might reflect greater stigma faced by males preventing them for help seeking despite a greater number experiencing mental health difficulties in recent cohorts (Patalay & Gage, 2019).

With respect to how adolescent mental health was conceptualised, internalising symptoms were associated with higher psychological distress, a higher likelihood obtaining a degree, and poorer life satisfaction at age 42 years. This also remains the case for most outcomes (excluding life satisfaction), when using a specific internalising factor accounting for covariance with externalising symptoms in the bi-factor model. Externalising difficulties were associated with poorer general health, voting behaviour and degree attainment, however, this was no longer the case when accounting for the covariance between internalising and externalising symptoms using the bi-factor model. The findings from the 2-factor model of internalising and externalising symptoms are in line with previous literature which shows both domains are associated with poorer outcomes (Clayborne et al., 2019; Colman et al., 2009; Erskine et al., 2016; Richards et al., 2009). Notably however, the bi-factor approach which allows us to account for the high levels of shared variance between these domains, highlights that most of the negative associations are predicted by the general psychopathology bi-factor. This finding contradicts previous evidence from a different longitudinal birth cohort study, which indicated externalising symptoms as an important factor in the prediction of mid-life socio-economic outcomes, while controlling for internalising difficulties (Colman et al., 2009). However, the former study was based on data from the 1946 British birth cohort, where symptoms were reported by teachers and externalising and internalising have weak associations, whereas the findings from this study are based on parent report of symptoms, where internalising and externalising symptoms were highly correlated.

It is important to understand the reasons for the observed cohort differences in the associations between earlier mental health and later life outcomes. As mental health difficulties become more common in adolescence, it might be expected that their impacts are weakened due to the increased normality of any experienced difficulty; however, we do not find that this is the case. Possible explanations for observed cohort differences are described. First, changes in socio-economic inequalities in mental health, such that those with higher symptoms are more likely to be from socio-economically disadvantaged backgrounds and the greater likelihood of co-occurring adversities might be responsible for poorer later-life outcomes (Collishaw et al., 2019). However, in this study we controlled for socio-economic circumstances and the associations remain suggesting that the socio-economic changes are unlikely to be the sole explanation for the observed cohort differences. Second, increased co-occurrence of poor mental health with other health impacting behaviours such as substance use (Gage & Patalay, 2021; Jokela et al., 2020). As smoking and alcohol use have become less common in the population, they have decreased at slower rates among those with poor mental health (Gage & Patalay, 2021; Jokela et al., 2020), as a result these are more likely to cluster in those with poor mental health with potential consequences for later health outcomes. Third, the economy has been changing to a more hourglass shape (more people with lower skilled and professional jobs with middle-ranked jobs shrinking) with a larger focus on the knowledge-based jobs and skills (Holmes & Mayhew, 2012). In these changing contexts the impacts on those with poorer earlier life mental health might become greater due to an amplification of known negative impacts on education and other life chances (Goodman et al., 2011), here are likely to also be other possible explanations for cohort differences in the associations between early life mental health and later life outcomes and now that these differences have been described in this paper, future research to understand and explain these will be beneficial. In addition, it is possible that poorer social and economic outcomes in mid-life are mediated by mental health in adulthood and that there are bi-directional associations between the health and socio-economic factors examined in this paper; whether these bi-directional cycles are stronger in the more recent cohorts would be important to understand.

Strengths and limitations

Successive national population-representative birth cohort studies with comparable measures of common mental health problems provide a unique opportunity to make robust comparisons across cohorts using aggregated analytical techniques. Previous cross-cohort research is limited by differences in how outcomes and exposures are assessed (Sellers et al., 2019),

resulting in uncertainty of whether observed cohort effects are method artefacts. By using completely harmonised exposure, outcome and control variables we can be confident that the cohort effects we observe are robust, especially since the mental health measures showed evidence of measurement invariance across cohorts. Another notable strength of this study was the range of outcomes across health and socio-economic domains. One limitation of the data was that rates of selective attrition across cohorts were not identical. To address the issue of missing data that is unavoidable in long running birth cohorts, multiple imputation was applied with a detailed set of early life auxiliary predictors to minimise the risk of observed effects being due to potential differences in those retained in the cohorts (Mostafa et al., 2021).

Implications

Recent research highlights growing levels of adolescent internalising symptoms in more recently born cohorts (Patalay & Gage, 2019). This is also observed in the cohorts compared in our study, with those born in 1970 reporting greater levels of mental health difficulties in adolescence and midlife (Ploubidis et al., 2017). One often suggested explanation for observed increases in adolescent mental health problems across cohorts is that it might be driven by differences in how these measures are completed due to less stigma and more awareness around mental health (Collishaw, 2015). However, we establish that there is measurement invariance for the Rutter mental health scale at age 16 and others have established measurement invariance for the Malaise Inventory at age 42 across these two cohorts (Ploubidis et al., 2017, 2019b), implying that potential sources of bias such as age effects, survey design, period effects, or cohort specific effects do not influence the way participants in the two cohorts respond to the symptoms described. Moreover, our results indicate that consequences of poor mental health in adolescents are consistently observed between cohorts, and in some cases are more severe in the youngest cohort studied here (e.g. lower likelihood of living with a partner and poorer mental health in midlife). The widening of mental health based inequalities in life outcomes, further supports the need to recognise that secular increases in adolescent mental health symptoms is a public health challenge with measurable negative consequences through the lifecourse (Patalay & Gage, 2019; Sellers et al., 2019).

In summary, as evidence from more recent generations indicate that common mental health difficulties are increasing further (Patalay & Gage, 2019), our findings indicate that negative

consequences of these difficulties might persist or even increase in younger cohorts, with implications not only for social and economic outcomes but also potentially for morbidity and stalling life expectancies (Archer et al., 2018; Ploubidis et al., 2021).

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Data Sharing Statement: The datasets used in this research are available for use to all researchers, free of charge, from the UK data service (https://ukdataservice.ac.uk/).

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Table 1. Means / proportions and 95% confidence intervals (CIs) for exposure and outcome variables.

			Cohort	
			1958 NCDS	**1970 BCS**
			n = 16,091	n = 15,258
			Mean / % (95% CIs)	Mean / % (95% CIs)
Exposure (age 16)	Mental Health (2-factor model)	Externalising Symptoms	Mean = .06 (.056, .074)	Mean = .24 (.23, .25)
		Internalising Symptoms	Mean = .05 (.04, .06)	Mean = .12 (.12, .13)
	Mental Health (Bi-factor model)	Externalising Symptoms	Mean = .07 (.06, .07)	Mean = -.18 (-.18, -.17)
		Internalising Symptoms	Mean = .02 (.02, .03)	Mean = .07 (.06, .08)
		General psychopathology	Mean = .07 (0.7, .08)	Mean = .22 (.21, .23)
Outcome (age 42)	Psychological distress (continuous score)	Malaise inventory	Mean = 1.54 (1.51, 1.58)	Mean = 1.92 (1.87, 1.96)
	High psychological distress (binary)	Malaise inventory >3	% = 11.9 (11.3, 12.4)	% = 16.7 (16.1, .17.04)
	General Health		Mean = .02 (-.01, .03)	Mean = .03 (.01, .05)
	Life Satisfaction		Mean = 7.25 (7.22, 7.29)	Mean = 7.31 (7.27, 7.34)
	Living with spouse or partner	No	% = 20.1 (19.3, 21.6)	% = 25.5 (24.5, 26.4)
	Voted in the last general election	No	% = 23.8 (22.9, 24.6)	% = 27.7 (26.4, 29.1)
	Obtained a degree	No	% = 80.8 (80.2, 81.5)	% = 69.0 (68.1, .69.9)
	Employment type	Professional/managerial	% = 57.6 (56.7, 58.6)	% = 58.7 (57.7, 59.8)

Table 2. Likelihood ratio tests comparing models with main effects only and cohort interactions to assess cohort differences in associations between age 16 mental health exposures and age 42 outcomes

		Log likelihood difference test							
		Psychological distress	High psychological distress (Yes)	General Health	Life Satisfaction	Living with spouse or partner (Yes)	Voted in the last general election (Yes)	Obtained a degree	Employment type (professional/managerial)
Models compared		χ2 (df)	χ2 (df)	χ2 (df)	χ2 (df)	χ2 (df)	χ2 (df)	χ2 (df)	χ2 (df)
Main effects VS Cohort*Age 16 mental health	Two factor model	**27.14 (2)**	**7.98 (2)**	**18.18 (2)**	**19.72 (2)**	**27.97 (2)**	**10.09 (2)**	2.49 (2)	1.57 (2)
	Bi-factor model	**185.58 (4)**	**102.40 (4)**	**14.80 (4)**	**40.76 (4)**	**89.25 (4)**	**51.43 (4)**	**554.63 (4)**	**21.04 (4)**
Cohort*Age 16 mental health VS Sex*cohort*Age 16 mental health	Two factor model	2.58 (4)	**12.21 (4)**	4.82 (4)	0.81 (4)	**15.41(4)**	2.34 (4)	4.74 (4)	**10.45 (4)**
	Bi-factor model	4.77 (6)	**14.28 (6)**	10.23(6)	1.47 (6)	12.12 (6)	8.88 (6)	5.15 (6)	9.67 (6)

Note: Results in bold are where log-likelihood difference test indicated differences in models being compared (p<0.05)

Table 3. Multivariable regressions estimating associations between adolescent psychopathology and age 42 health and social outcomes in NCDS 1958 and BCS 1970 cohorts

			Psychological distress	High psychological distress (Yes)	General Health	Life Satisfaction	Living with spouse or partner (Yes)	Voted in the last general election (Yes)	Obtained a degree	Employment type (professional managerial)
			Coef (95% CI)	OR (95% CI)	Coef (95% CI)	Coef (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
1958 NCDS	Two factor model	Externalising Symptoms	.02 (-.15, .17)	**1.46 (1.32, 1.61)**	.18 (-.07, .03)	-.07 (-.26, .11)	**.83 (.76, .89)**	**.75 (.62, .91)**	**.62 (.49, .78)**	**.76 (.59, .97)**
Age 16 mental health		Internalising Symptoms	**.60 (.44, .75)**	**1.72 (1.56, 1.91)**	.05 (-.03, .14)	**-.37 (-.57, -.16)**	**.74 (.68, .81)**	1.05 (.79, 1.49)	**1.37 (1.08, 1.73)**	1.16 (.97, 1.40)
	Bi-factor model	Externalising Symptoms	-.07 (-.28, .14)	**.84 (.73, .96)**	-.02 (-.14, .10)	.06 (-.14, .25)	.93 (.83, 1.04)	1.19 (.86, 1.65)	1.12 (.78, 1.60)	.90 (.73, 1.11)
		Internalising Symptoms	**.37 (.28, .46)**	**1.49 (1.36, 1.63)**	.03 (-.01, .08)	**-.17 (-.29, -.05)**	**.85 (.79, .92)**	1.07 (.95, 1.20)	**1.23 (1.07, 1.42)**	**1.14 (1.00, 1.31)**
		General psychopathology	**.48 (.34, .61)**	**1.60 (1.43, 1.79)**	.18 (-.09, .06)	**-.40 (-.54, -.25)**	**.79 (.72, .87)**	**.75 (.63, .88)**	**.74 (.59, .92)**	1.05 (.88, 1.24)
1970 BCS	Two factor model	Externalising Symptoms	-.64 (-.26, .13)	**1.63 (1.50, 1.80)**	**.13 (.03, .23)**	-.11 (-.37, .14)	**.69 (.64, .74)**	**.64 (.42, .95)**	**.54 (.41, .72)**	**.59 (.44, .80)**
Age 16 mental health		Internalising Symptoms	**.78 (.57, .98)**	**2.13 (1.95, 2.32)**	.12 (-.03, .28)	**-.37 (-.65, -.09)**	**.71 (.65, .76)**	1.31 (.91, 1.88)	**1.38 (1.09, 1.74)**	**1.50 (1.02, 2.20)**
	Bi-factor model	Externalising Symptoms	.09 (-.51, .33)	.95 (.83, 1.10)	.02 (-.12, .16)	.14 (-.18, .47)	1.01 (.89, 1.14)	1.14 (.83, 1.58)	1.15 (.84, 1.57)	1.15 (.74, 1.78)
		Internalising Symptoms	**.47 (.30, .64)**	**1.71 (1.57, 1.87)**	.06 (-.06, .17)	-.16 (-.37, .05)	**.92 (.86, .99)**	**1.29 (1.01, 1.64)**	**1.22 (1.04, 1.43)**	1.24 (.99, 1.55)
		General psychopathology	**.49 (.32, .66)**	**1.82 (1.65, 1.99)**	**.24 (.17, .32)**	**-.42 (-.68, -.16)**	**.64 (.59, .70)**	**.72 (.55, .92)**	**.62 (.49, .79)**	**.75 (.67, .84)**

Note. NCDS 1958 (*n* = 16,091). BCS 1970 (*n* = 15,258). Models were adjusted using birth weight, maternal smoking during pregnancy, whether cohort members were ever breastfed, childhood cognition, housing tenure, body mass index at age 10/11 years, paternal social class at age 10/11 years, mothers employment status (birth to age 5 years), parental divorce (by age 10 or 16 years), and years of education of mother and father. Note: Coefficients in bold are where the 95% CIs do not cross the null and significant *p* values are retained after adjusting for multiple testing using the Benjamini-Hochberg procedure.
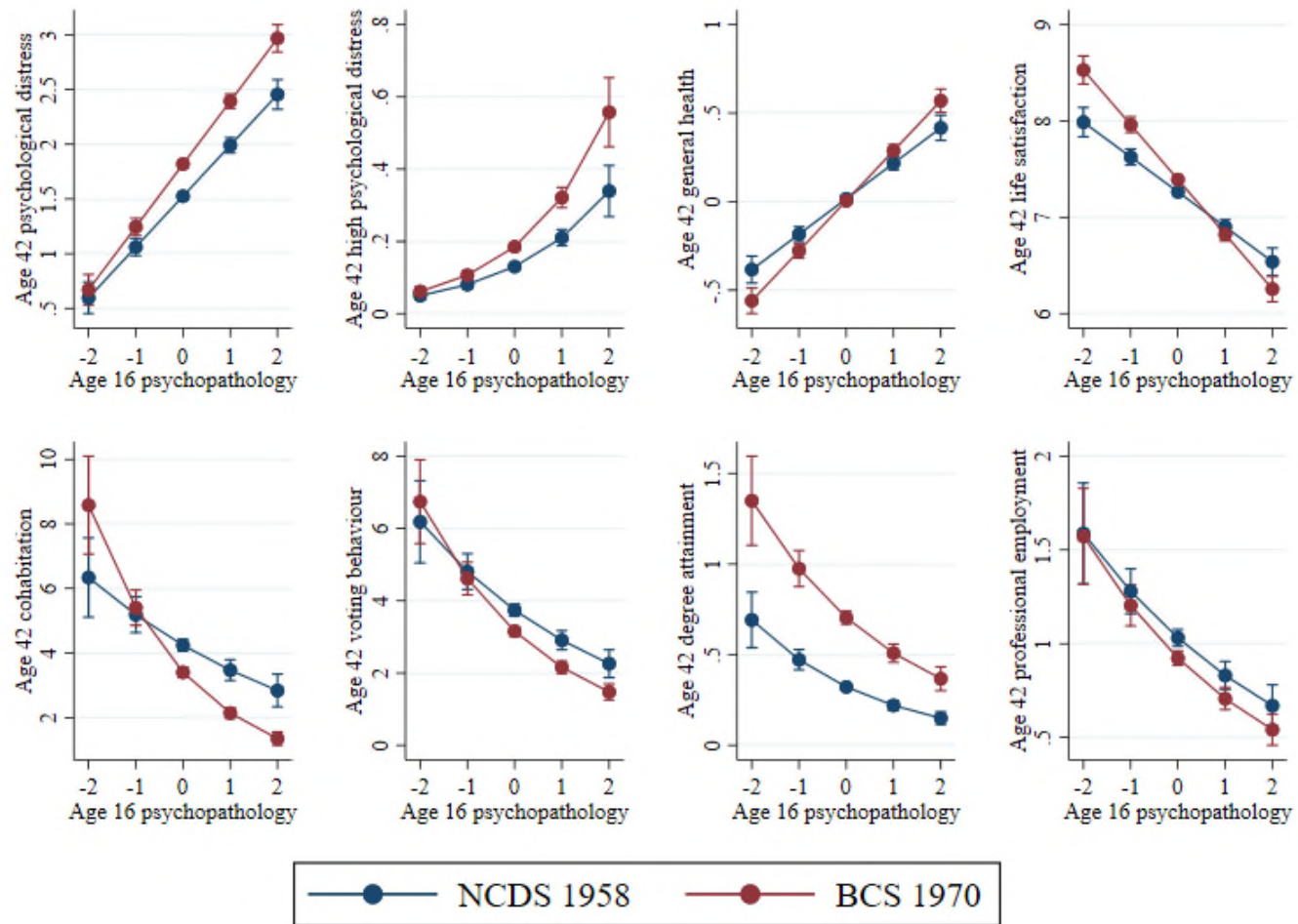
Figure 1. Predicted probabilities for mental health at age 16 (x-axis) association with each outcome at age 42 in the two cohorts (from the bi-factor model).
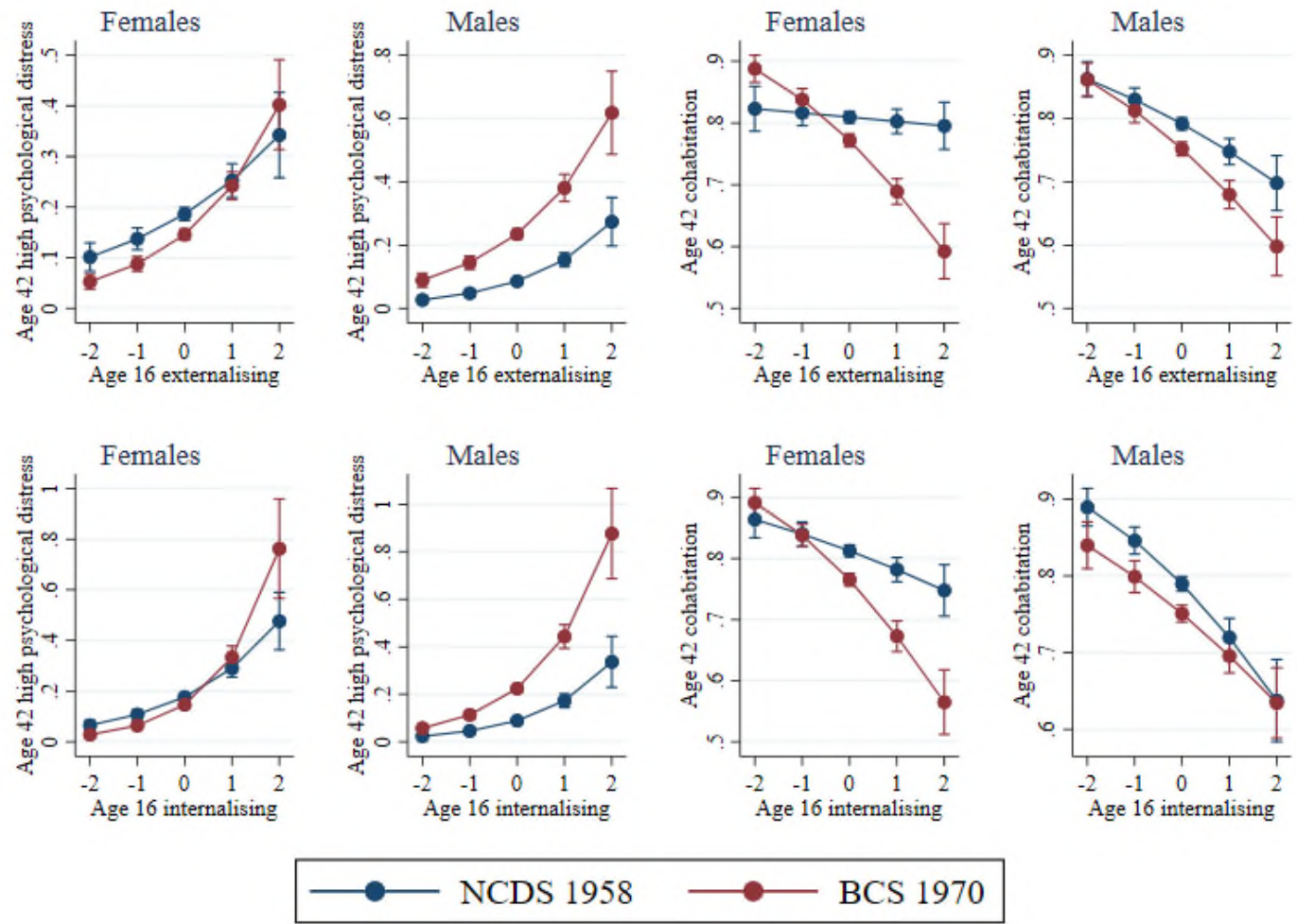
Figure 2. Predicted probabilities in males and females for mental health at age 16 (x-axis) association with high psychological distress and cohabitation at age 42 in the two cohorts (from the two-factor model).

Online supplementary file

Changes in the adult consequences of adolescent mental ill-health: findings from the 1958 and 1970 British birth cohorts

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Contents

Supplementary Table 1. Measurement invariance analysis for the Rutter scales at age 16 across cohorts

	Configural invariance model	Metric invariance model	Scalar invariance model
RMSEA	.069	.067	.065
SRMR	.083	.084	.084
CFI	.865	.862	.864

Note. For the RMSEA and SRMR, a score closest to zero indicates good model fit, whereas for CFI it is closest to one. Rules of thumb for model comparison applied are from Chen (2007) as follows: for RMSEA invariance is met if a change between models is smaller than 0.015, for SRMR if it is smaller than 0.03 and for CFI if it is smaller than 0.01 (Chen, 2007).

Supplementary Table 2. Standardised factor loadings (two factor model) for 1958 NCDS and 1970 BCS cohort (multigroup model)

Items	1958 NCDS Factor Loadings (SE)		1970 BCS Factor Loadings (SE)	
	EXT	INT	EXT	INT
restless, difficulty staying seated	0.73 (.01)	-	0.63 (.01)	-
squirmy, fidgety child	0.78 (.01)	-	0.65 (.01)	-
often destroys others property	0.71 (.02)	-	0.73 (.02)	-
frequently fights, quarrelsome	0.68 (.01)	-	0.74 (.01)	-
not much liked by other children	0.56 (.02)	-	0.63 (.02)	-
irritable, flies off the handle	0.65 (.01)	-	0.73 (.01)	-
twitches, mannerisms, tics-face or body	0.41 (.02)	-	0.45 (.03)	-
is often disobedient	0.70 (.01)		0.81 (.001)	
cannot settle more than a few moments	0.69 (.01)		0.71 (.01)	
often tells lies	0.69 (.01)	-	0.76 (.01)	-
bullies other children	0.65 (.01)	-	0.76 (.01)	-
often worries about things	-	0.62 (.01)	-	0.69 (.01)
does things on own, rather solitary	-	0.32 (.01)	-	0.50 (.01)
appears miserable, unhappy & tearful		0.86 (.01)		0.86 (.01)
fearful of new situations or things	-	0.54 (.01)	-	0.59 (.01)
fussy, over particular	-	0.35 (.01)	-	0.47 (.01)

Note. Model fit was assessed using the comparative fit index (CFI), Tucker Lewis index (TLI) and root mean square error of approximation (RMSEA). CFI and TLI closer to 1 indicate good fit to the data and RMSEA closer to 0 indicates good fit. Owing to the non-nested nature of the models, models could not be compared directly using a difference in fit statistic (e.g. Akaike information criterion) as they cannot be estimated when WLSMV estimation is used. Hence, model fit criteria and factor loadings were used to assess the quality of models. Externalising factor (EXT); Internalising factor (INT). Model fit indices for the two-factor CFA: 1958 NCDS ($n = 11654$): RMSEA = 0.07; CFI = 0.86; TLI =0.84; 1970 BCS ($n = 8904$): RMSEA = 0.06; CFI = 0.91; TLI =0.89

Supplementary Table 3. Standardised factor loadings (two factor model) for 1958 NCDS and 1970 BCS cohort (multigroup model)

| Items	1958 NCDS (1958)			1970 BCS (1970)		
	Factor Loadings (SE)			Factor Loadings (SE)		
	EXT	INT	GEN	EXT	INT	GEN
restless, difficulty staying seated	0.67 (.02)	-	0.61 (.02)	0.71 (.02)	-	0.53 (.02)
squirmy, fidgety child	0.62 (.02)	-	0.63 (.02)	0.64 (.02)	-	0.60 (.02)
often destroys others property	0.04 (.03)	-	0.73 (.02)	0.03 (.02)	-	0.74 (.01)
frequently fights, quarrelsome	0.28 (.03)	-	0.71 (.01)	0.23 (.02)	-	0.67 (.011)
not much liked by other children	0.08 (.03)	-	0.57 (.02)	0.09 (.02)	-	0.60 (.01)
irritable, flies off the handle	0.09 (.02)	-	0.69 (.01)	0.05 (.02)	-	0.67 (.01)
twitches, mannerisms, tics- face or body	0.18 (.03)	-	0.39 (.02)	0.22 (.03)	-	0.40 (.02)
is often disobedient	0.17 (.03)		0.73 (.01)	0.15 (.02)		0.75 (.01)
cannot settle more than a few moments	0.33 (.03)		0.65 (.02)	0.33 (.02)		0.67 (.01)
often tells lies	0.16 (.03)	-	0.71 (.01)	0.14 (.02)	-	0.71 (.01)
bullies other children	0.32 (.03)	-	0.67 (.02)	0.30 (.02)	-	0.68 (.01)
often worries about things	-	0.71 (.02)	0.30 (.01)	-	0.74 (.02)	0.32 (.01)
does things on own, rather solitary	-	0.32 (.01)	0.16 (.01)	-	0.27 (.01)	0.27 (.01)
appears miserable, unhappy & tearful		0.39 (.02)	0.57 (.02)		0.34 (.01)	0.58 (.01)
fearful of new situations or things	-	0.60 (.02)	0.23 (.01)	-	0.56 (.02)	0.30 (.01)
fussy, over particular	-	0.32 (.01)	0.19 (.01)	-	0.27 (.01)	0.23 (.01)

Note. The model fit indices for the bi-factor CFA: 1958 NCDS (*n* = 11654*)*: RMSEA = 0.04; CFI = 0.96; TLI =0.94 (just under the accepted threshold for very good model fit (0.95); 1970 BCS (*n* = 8904*)*: RMSEA = 0.04 CFI = 0.94; TLI =0.94

Supplementary Table 4. Count and percentage of available data for the exposures and outcomes in each cohort

| | Domain | Measure | Cohort | | | | | | | | | |
| | | | 1958 NCDS | | | | | 1970 BCS70 | | | | |
			Age	year	N valid (%)	N missing (%)	N of total valid sample* (%)	age	year	N valid (%)	N missing (%)	N of total valid sample* (%)
Exposure at age 16	Adolescent internalising symptoms	Rutter Behavioural Scale	16	1974	11080 (61.4)	5011 (38.6)	16091 (100)	16	1986	7882 (51.6)	7376 (48.4)	15258 (100)
	Adolescent ixternalising symptoms	Rutter Behavioural Scale	16	1974	11080 (61.4)	5011 (38.6)	16091 (100)	16	1986	7885 (51.7)	7373 (48.3)	15258 (100)
Outcomes at age 42	Health and well-being	Malaise Inventory	42	2000	11277 (60.8)	4814 (39.2)	16091 (100)	42	2012	7979 (52.3)	7279 (47.7)	15258 (100)
		General Health	42	2000	11374 (70.7)	4717 (29.3)	16091 (100)	42	2012	9069 (56.6)	7527 (43.4)	15258 (100)
		Life Satisfaction	42	2000	11268 (70)	4823 (30)	16091 (100)	42	2012	8973 (58.8)	6285 (41.2)	15258 (100)
	Socio-economic	Whether CM lives with a spouse or partner	42	2000	11380 (70.7)	4711 (29.3)	16091 (100)	42	2012	9106 (59.7)	6152 (40.3)	15258 (100)
		Voting behaviour	42	2000	11350 (70.5)	4741 (29.5)	16091 (100)	42	2012	7890 (51.7)	7368 (48.3)	15258 (100)
		Highest NVQ level up to 2000/2012	42	2000	11397 (70.8)	4694 (29.2)	16091 (100)	42	2012	9106 (59.7)	6152 (40.3)	15258 (100)
		Employment Status	42	2000	8285 (51.49)	7806 (48.51)	16091 (100)	42	2012	7854 (51.5)	7404 (48.5)	15258 (100)

Supplementary Table 5. Bivariate correlations between adolescent mental health and age 42 health and social outcomes.

| Cohort	Age 16 mental health exposure variables		Age 42 health and social outcomes correlations							
			Mental Health	Mental Health (binary variable)	General Health	Life Satisfaction	Co-habitation	Voted in the last general election	Obtained a degree	Employment type
1958	Mental Health (2-factor model)	Externalising Symptoms	.15	.13	.14	-0.10	-.07	-.08	-.14	-.12
		Internalising Symptoms	.19	.14	.12	-0.11	-.07	-.04	-.06	-.06
	Mental Health (Bi-factor model)	Externalising Symptoms	-.03	.02	.01	.01	-.01	.005	-.01	-.01
		Internalising Symptoms	.15	.09	.02	-.05	-.03	.01	.02	.02
		General psychopathology	.16	.12	.14	-.11	-.07	-.08	-.13	-.11
1970	Mental Health (2-factor model)	Externalising Symptoms	.17	.14	.18	-.13	-.11	-.11	-.16	-.13
		Internalising Symptoms	.22	.17	.16	-.13	-.10	-.06	-.09	-.07
	Mental Health (Bi-factor model)	Externalising Symptoms	-.02	-.01	-.03	.01	.01	-.04	.01	.04
		Internalising Symptoms	.16	.10	.05	-.04	-.02	.05	.04	.02
		General psychopathology	.18	.15	.19	-.14	-.11	-.02	-.16	-.13
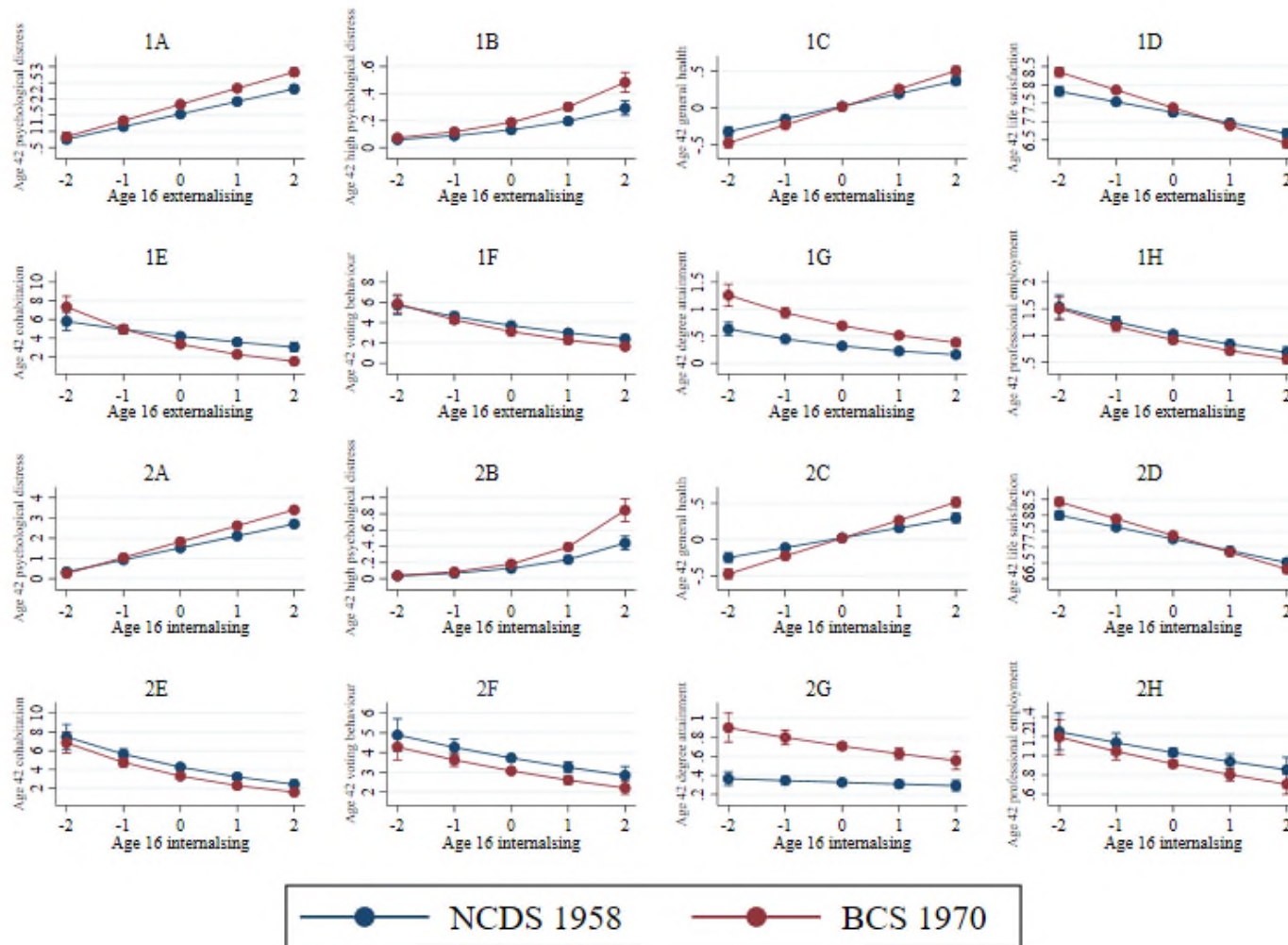
Supplementary Figure 1. Predicted probabilities (from the two-factor model) for externalising (1) and internalising (2) symptoms at age 16 (x-axis) association with each outcome at age 42 in the two cohorts.
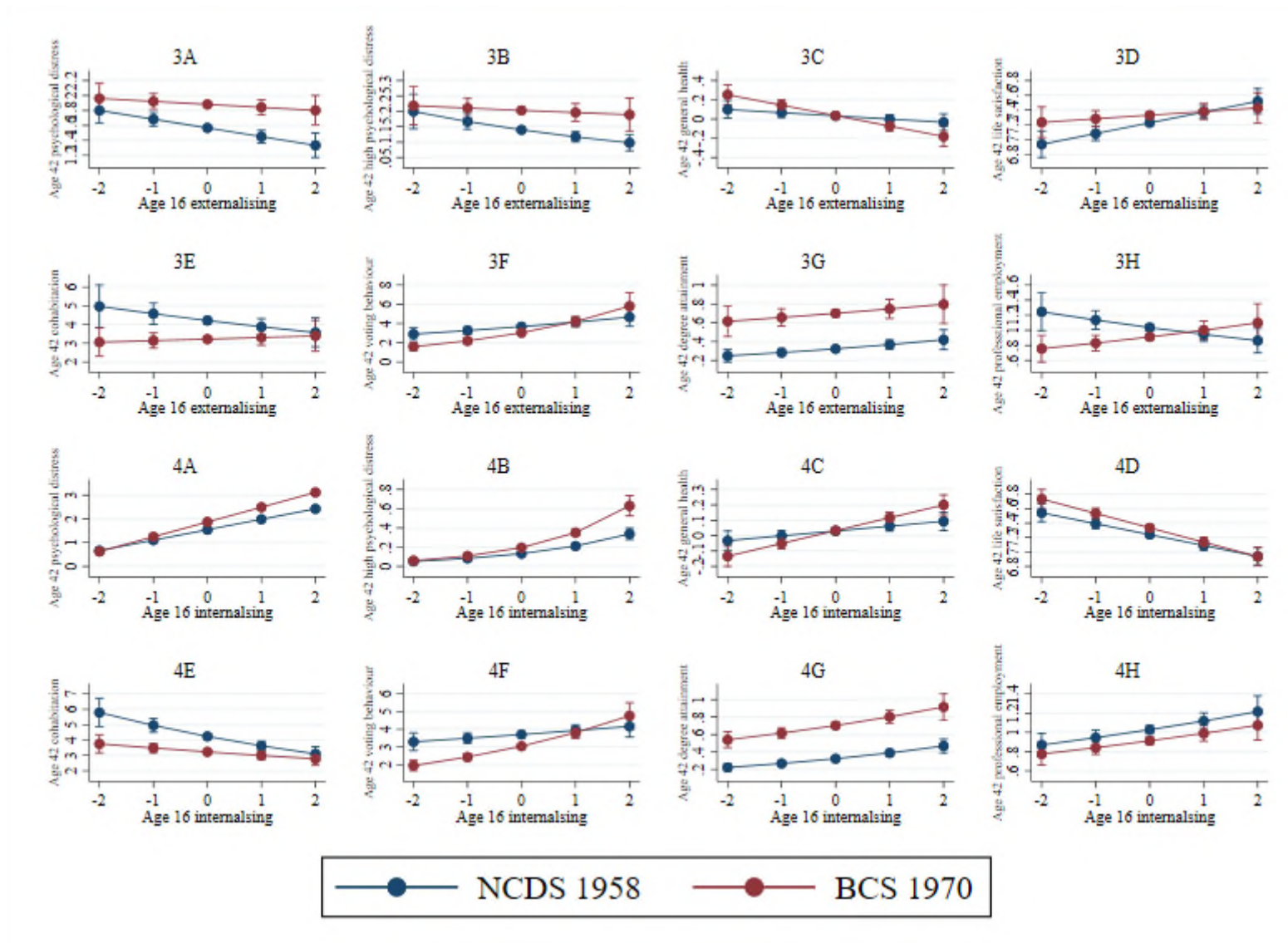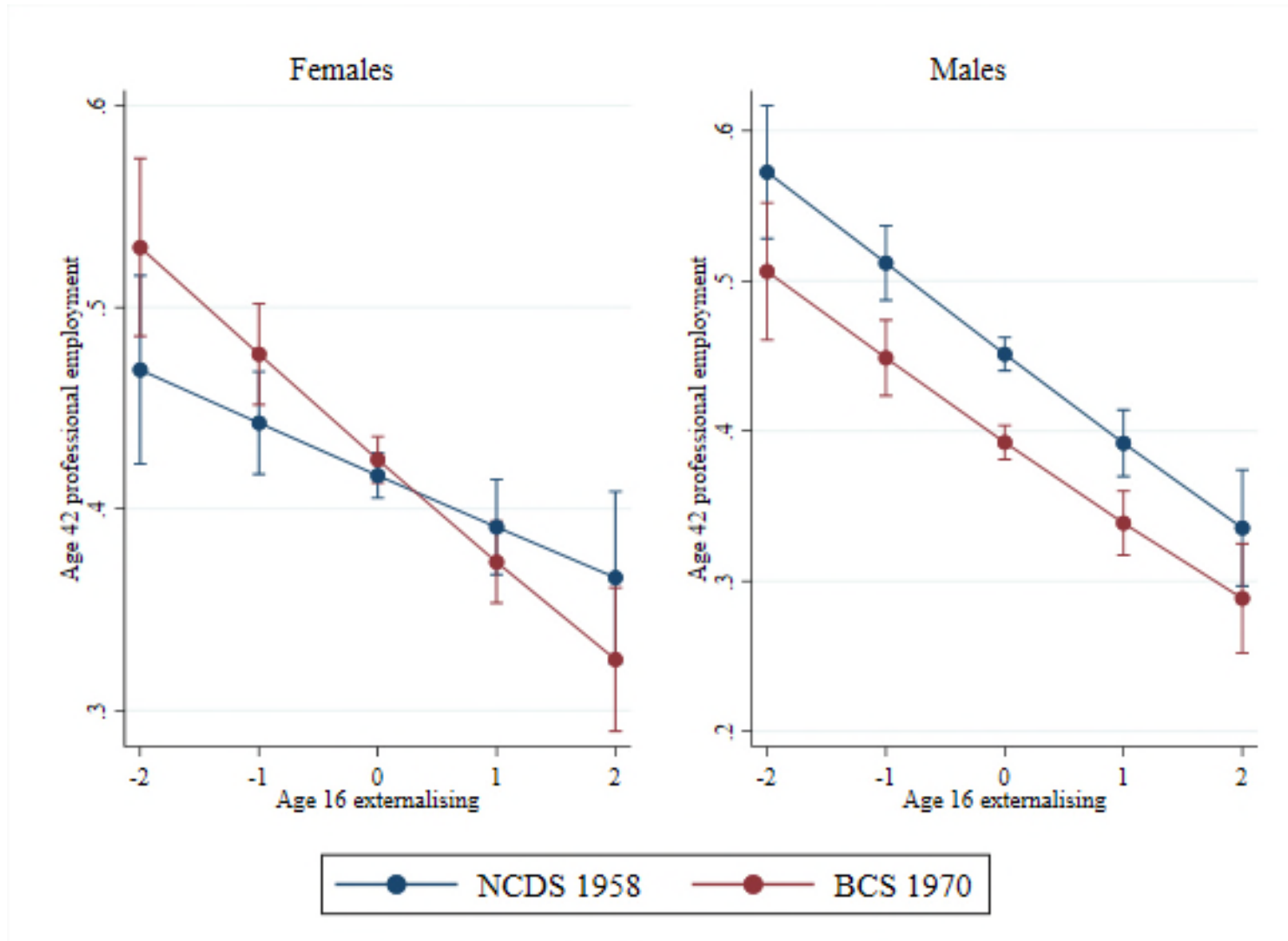
Supplementary Figure 2. Predicted probabilities (from the bi-factor model) for externalising (3) and internalising (4) symptoms at age 16 (x-axis) association with each outcome at age 42 in the two cohorts.
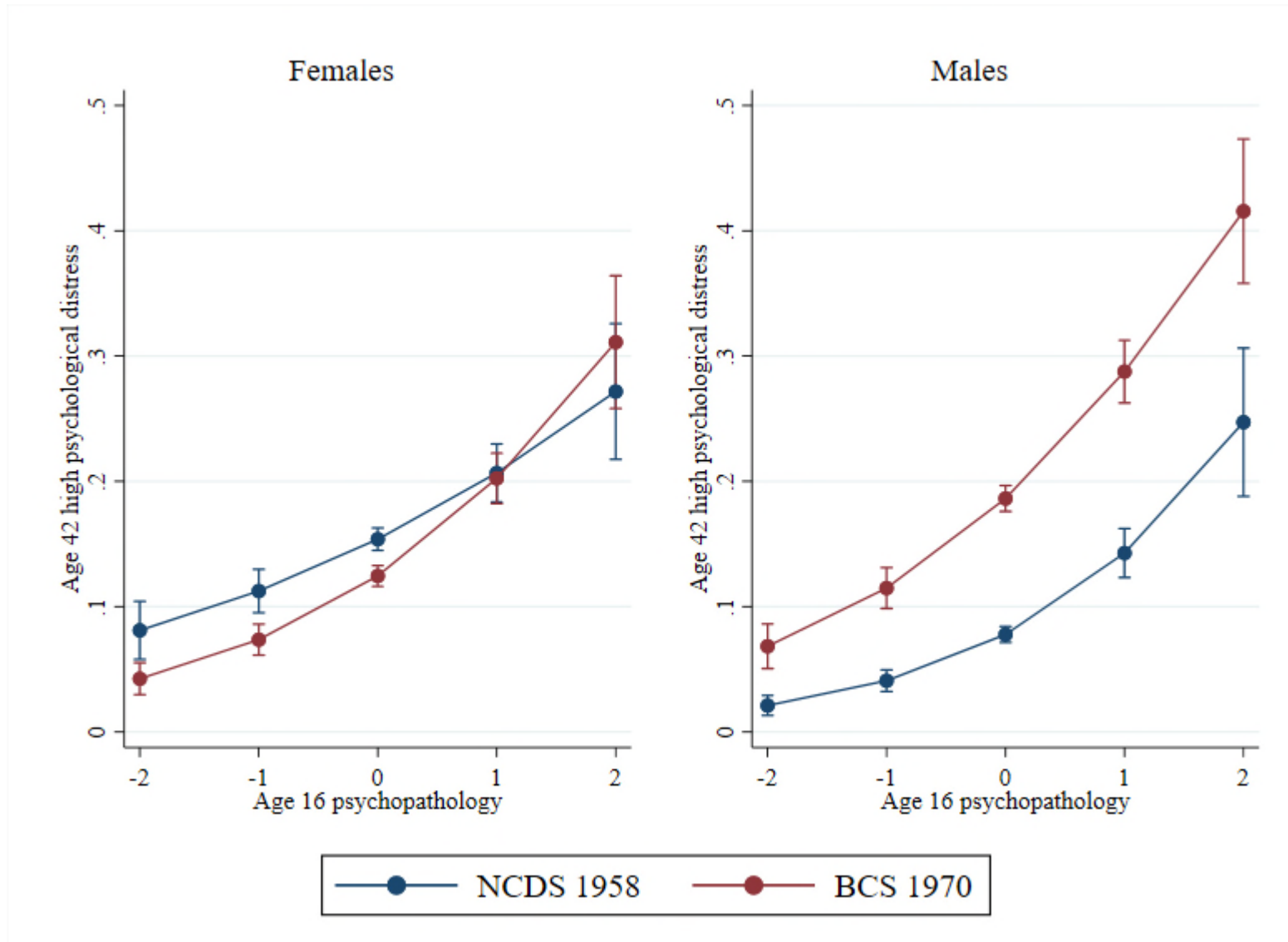
Supplementary Figure 3. Predicted probabilities (from the bi-factor model) in males and females for general psychopathology at age 16 (x-axis) association with high psychological distress

Supplementary Figure 4. Predicted probabilities (from the two-factor model) in males and females for *externalising symptoms* at age 16 (x-axis) association with professional employment.
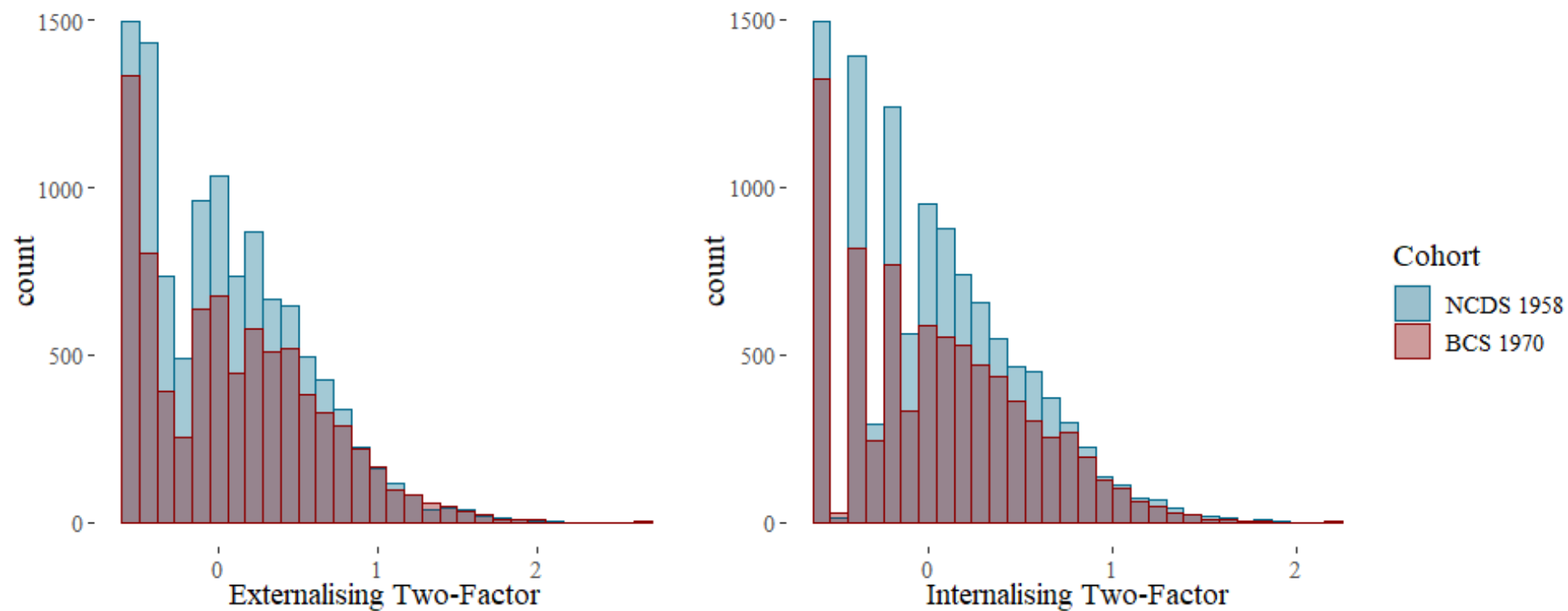
Supplementary Figure 5. Frequency histogram of age 16 externalising and internalising symptoms (from the two-factor model)
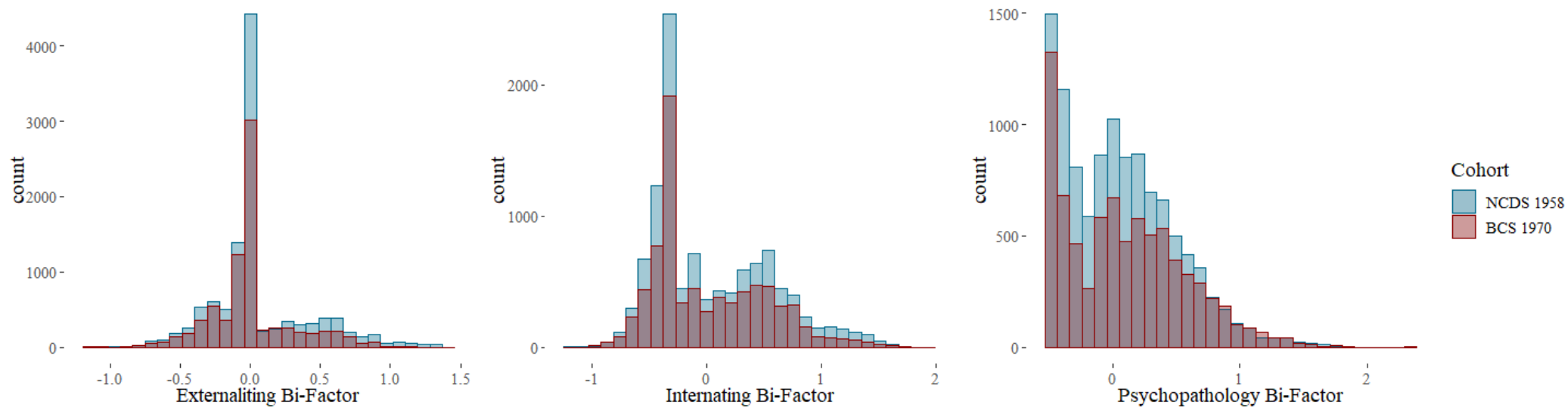
Supplementary Figure 6. Frequency histogram of age 16 externalising, internalising and general psychopathology symptoms (from the bi-factor model)

Supplementary Table 6. Independent samples t-test comparing NCDS 1958 and BCS 1970 cohorts on age 16 mental health.

	Age 16 mental health exposure variables	NCDS 1958 Mean (SD)	BCS 1970 Mean (SD)	*t* (df)	*p* value
Mental Health (2-factor model)	Externalising Symptoms	.04 (.04)	.09 (.53)	-5.65 (16113)	<.001
	Internalising Symptoms	.05 (.47)	.06 (.5)	-1.18 (16366)	0.239

Mental Health (Bi-factor model)	Externalising Symptoms	.06 (.35)	.01 (.3)	9.08 (18236)	<.001
	Internalising Symptoms	.04 (.52)	.02 (.49)	2.98 (17312)	<.001
	General psychopathology	.06 (.43)	.1 (.47)	-5.76 (16000)	<.001

References

Chen, F.F. (2007) Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling*. 14 (3), pp. 464–504. doi:10.1080/10705510701301834.