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Economic volatility in childhood and subsequent adolescent mental health problems

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Abstract

Objective: The aim of the current paper was to investigate the association between patterns of duration, timing and sequencing of exposure to low family income during childhood, and symptoms of mental health problems in adolescence. **Setting:** Survey administered to a large population based sample of Norwegian adolescents. **Participants**: Survey data from 9154 16-19 year olds (53% participation rate, 52.7% girls), was linked to registry-based information about family income in childhood from tax return data from the Norwegian Tax Administration. **Outcome measures**: Latent class analysis and the BCH approach in Mplus was used to associate patterns of poverty exposure to mental health outcomes. Specifically, mental health outcomes were symptoms of emotional-, conduct-, hyperactivity, peer problems and general mental health problems measured with the Strengths and Difficulties questionnaire, symptoms of depression measured with SMFQ, and symptoms of attention-deficit/hyperactivity disorder measured with the ASRS. **Results.** Four latent classes of poverty exposure emerged from the analysis. Participants moving into poverty (2.3%), out of poverty (3.5%), or those chronic poor (3.1%) had in general more symptoms of mental health problems (Cohen's *d*s .16-.50) relative to those with no poverty exposure (91.1%). This pattern was, however, not found for symptoms of ADHD. The pattern of results was confirmed in robustness checks using observed data. **Conclusions.** Exposure to low income in childhood was found to be associated with most mental health problems in adolescence. There was no strong suggestion of any timing or sequencing effects in the patterns of associations.

Keywords: poverty; mental health; latent class analysis; childhood; adolescence; ADHD; youth@hordaland

Strengths and limitations of this study

- Data on mental health problems obtained from a survey administered to a large population based sample of Norwegian 16-19 year olds ($N = 9154$) was linked to registry-based information about family income in childhood from tax return data from the Norwegian Tax Administration.
- Using latent class analysis, four trajectories of poverty exposure during childhood was determined.
- The association between trajectories of childhood poverty exposure and symptoms of mental health problems in adolescence was investigated using Mplus and the BCH approach for estimating the means of distal outcomes across latent classes
- Robustness checks were used to verify the results using observed data.

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Author contributions:

TB made substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafted the work, approved the version to be published and is accountable for all aspects of the work.

JCS made substantial contributions to the analysis of data for the work; critically revised the work for important intellectual content, approved the version to be published, and is accountable for all aspects of the work.

BS & MH made substantial contributions to the conception and design of the work, the acquisition of data for the work, critically revised the work for important intellectual content, approved the version to be published, and is accountable for all aspects of the work.

KP, ED & HDZ made substantial contributions to the interpretation of data for the work; critically revised the work for important intellectual content, approved the version to be published, and is accountable for all aspects of the work.

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Economic volatility in childhood and adolescent mental health

Children who grow up in poverty experience mental health problems to a greater extent than their more affluent peers [1,2]. The associations are often modest [3], and even smaller when controlling for genetics, parenting practices, and other characteristics likely to influence children's development [4]. Wagmiller et al. [5] have argued that one reason for the modest association may be that most prior research uses what has been termed a "concurrent indicator approach" where income and the outcome are measured at the same time point. This approach is vulnerable to transitory fluctuations in income, and may camouflage systematic improvements and deteriorations of economic circumstances over time. Indeed, an emerging body of research suggests that it is not necessarily the overall level of concurrent deprivation that is key in understanding how income influences development, but rather, the persistence and timing of poverty, and dynamic changes in families' economic circumstances over time [6-8].

Dissatisfactions with the concurrent indicator approach has led researchers to find more thorough and ecologically valid estimates of families' economic circumstances over time, such as averaging over several years of income [3], or statistically estimating the permanent component of the economic resources available to the family [9,10]. Alternative approaches have measured the numbers of year a child is living in poverty (often termed cumulative or persistent poverty), or the number and durations of periods of poverty a child has experienced [11,12]. These methodological developments are more robust to transitory fluctuations in income than concurrent indicators, and do indeed produce stronger associations with developmental outcomes [2,3]. Still, these approaches may mask systematic transitory patterns of economic circumstances over time.

The timing of poverty across children's lives has also been a topic of considerable interest. Poverty in early (pre-school) childhood has been emphasized as especially detrimental to development [13,14], as it is a crucial time for brain development and may disrupt the many core cognitive and social competencies are acquired at this time. In contrast, others have highlighted middle childhood [15] and early adolescence as particularly sensitive periods [11]. Middle childhood is, for most, when formal schooling starts. This period also provides the foundation for further developments in adolescence and adulthood [16-18]. Support has been found for the importance of early childhood [14,19], and recent studies also underscore the importance of experiencing poverty in middle childhood and in early adolescence, especially in relation to development of internalizing and externalizing mental health problems [20,21]. Besides the demonstration of timing effects, these studies also demonstrated the detrimental effect of long-term, or repeated exposure to poverty [20,21].

The analytic approach in many studies of timing of poverty is often to investigate the effect of being persistently poor at a particular period during childhood relative to being poor at other times [14,20,21]. A potential limitation of some of the studies on timing is that this analytic approach may also obscure sequencing effects, i.e. that some children move out of, or into poverty between the different periods that are contrasted. In studies of sequencing per se, declines in income has been found to be associated with poorer developmental outcomes [6,22,23]. Furthermore, economic fluctuations seem especially consequential for children living in poverty [6,13], and it has been suggested that economic fluctuations may pose even greater risks to development compared to disadvantaged, but stable, economic circumstances [24].

Poverty mainly affects children indirectly through the detrimental influences it has on their physical and psychosocial surroundings [25]. Changes in family income have strong influences on parental stress, parenting practices and family interpersonal dynamics.

Instability or decline in income can increase parental stress [26], parental depression [27,28], and disrupt parent-child relationships [29], which all play a critical role in mediating the effects of economic disadvantage on child outcomes [22,30-32].

The present study was conducted in Norway which is a wealthy country with low income inequality (as indicated by a GINI-index of .25) and absolute deprivation is uncommon [33,34]. In 2012, 13.1% of children (aged under 18) lived in households with incomes below the poverty line. Norway provides an elaborate social safety net for its residents such as access to unemployment-, sickness-, and family related benefits; financial assistance; financial advice and debt counselling; temporary accommodation; employment schemes; and health services. These social benefits may buffer children and families with low socioeconomic status from exposure to some of the physical hardships and psychosocial stressors associated with poverty. However, even with these social services, poorer economic circumstances are still associated with mental health problems in Norwegian children [23,35,36]. In order to study the relatively small population of poor children with adequate power, large samples, such as in the present study, is required.

The aim of the present study was to investigate different economic trajectories and economic volatility during childhood and subsequent adolescent mental health. We capitalized on historic register-based income information linked to a large population-based study on adolescent mental health. Using latent class analysis, we classified children into groups based on their similarity in exposure to low income during childhood. Then, we investigated the association between class membership and mental health outcomes among 16-19-year-olds adolescents. The advantage of latent class analysis over alternative methods of measuring exposure to low income (e.g., approaches based on concurrent indicators, cumulative poverty exposure, average economic status over time, or importance of being poor in some stages of childhood relative to others), is that it allows us to simultaneously consider

the effects of duration, timing, and sequencing of exposure to low income during childhood [37].

Methods

Procedure and participants

In this population-based study, we used data from the youth@hordaland-survey of adolescents conducted in 2012 in the county of Hordaland in Western Norway ($N = 9154$). The main aim of youth@hordaland-survey was to assess mental health problems among all adolescents in Hordaland County aged 16 to 19 years. All adolescents in upper secondary education received information via e-mail, and one classroom school hour was allocated for them to complete the questionnaire. The questionnaire was web-based and covered a broad range of mental health issues, sleep behaviors and sleep problems, daily life functioning, use of health care and social services, demographics, as well as a request for permission to obtain school data, and to link the information with national registries. Those not in school received information by post to their home address. Uni Research Health collaborated with Hordaland County Council to conduct the study. The study was approved by The Regional Committee for Medical and Health Research Ethics in Western Norway.

Overall, Hordaland county is considered representative of Norway with regards to gender and rural/urban residence distribution, and the median household income is also similar to that of the national average [38]. In the period 2005-2010, the mean proportion of children characterized as *at-risk-of-poverty* (see details below) in Hordaland county was slightly lower (7.3%) than in the country as a whole (8.9%).

Measures

Measure of family income

Family income was drawn from the Norwegian national income registry and is based on tax return data from the Norwegian Tax Administration. As the information about income is used by the Norwegian government to estimate taxation, it is considered reliable, precise and of high quality. Using each participant's personal identification number, we were able to obtain information about the equivalised disposable household income for the period from 2004 when children were 8-11 years old, until 2010. Equivalised household income is a measure of household income (i.e. the sum of wages and salaries, income from self-employment, property income and transfers received minus total assessed taxes and negative transfers) that is adjusted by an equivalence scale in order to facilitate comparison between households of different size and composition. It may be viewed as an indicator of the economic resources that are available to a standardized household, and accounts for inflation/changes in median income over time. The equivalence scale used in the current study is the European Union scale (a modification of the OECD equivalence scale) where the first adult is given a weight of 1, subsequent adults are given a weight of 0.5 and each child below 14 is given the weight 0.3 [39]. From this measure of family income, we calculated the proportion of adolescents *at-risk-of-poverty*, defined as having an equivalised household income below 60% of the equivalised national median income for that particular year (e.g. to calculate poverty proportions for 2004 we used the median income for 2004) [40,41].

Symptoms of general mental health problems

In the youth@hordaland study, adolescents completed the self-report version of the Strengths and Difficulties Questionnaire [42,43]. The SDQ is available from http://www.sdqinfo.org and can be downloaded freely. It consists of five subscales, each

containing five items. The scales measure emotional symptoms, conduct problems, hyperactivity-inattention, peer relationship problems, and prosocial behaviors (not included in the current study). Respondents indicated on a three-point Likert-type scale to which extent a symptom applied to them, using the options "Not true", "Somewhat true", or "Certainly true". Each of the subscales consists of five items, and all scale scores ranged from 0-10 in the current sample. Four of the subscales (emotional-, conduct-, hyperactivity-inattention- and peer relationship problems) are summed to provide the SDQ total difficulties scale score (sample range 0-35), with higher scores indicating more problems. Due to the ordinal and categorical nature of the response options, reliability was assessed using polychoric correlation-based version of the reliability coefficients [44]. These analyses, suggested satisfactory internal consistency for the SDQ total difficulties scale ($\alpha = 0.86$) and for all subscales (αs emotional problems = 0.82, conduct problems = 0.71, hyperactivity-inattention = 0.76, peer problems = 0.75, and prosocial behaviors = 0.77).

Symptoms of depression

The short version of the Moods and Feelings Questionnaire (SMFQ) [45] was used to measure symptoms of depression. The SMFQ consists of 13 statements (e.g., "I am feeling low", "No one likes me", etc.) that the participants respond to using Norwegian translations of the response categories "Not true", "Sometimes true", and "True". The SMFQ has adequate psychometric properties [46], and a previous study based on the young@hordaland study found the SMFQ to be unidimensional, supporting the use of the sum score of SMFQ [47]. Reliability in the current sample was excellent (range = 0-26, ordinal $\alpha = 0.95$).

Symptoms of attention-deficit-/hyperactivity disorder

Hyperactivity-inattention was measured using a Norwegian version of the Adult ADHD Self-report scale [48]. The ASRS consists of 18 statements about hyperactivity-

inattention (e.g., “I never remember”, “I concentrate easily”), that the participants respond to using options “Never”, “Rarely”, “Sometimes”, “Often”, or “Always”. The ASRS was originally constructed for use in adults, but has been validated for use among adolescents [49]. The current study used the total score where all 18 items were added together (range = 0-72, ordinal $\alpha = 0.91$), the inattention scale consisting of nine items (range = 0-36, ordinal $\alpha = 0.89$), and the hyperactivity-impulsivity scale consisting of nine items (range = 0-36, ordinal $\alpha = 0.84$).

Demographic variables

Gender and date of birth was identified through personal identity number in the Norwegian National Population Register. Exact age was estimated by calculating the interval of time between date of birth and date of study participation. Family structure (i.e. single- [15%] or two-parent households), parental education levels (elementary [3.7%], intermediate [30.7%], and higher) and work affiliation (i.e. work [93.4%], benefits [3.8%], or other [including students, retirees and stay-at-home parents]), and ethnicity (Norwegian [96.3%], or foreign) were reported by adolescents.

Statistical analysis

Latent class analysis (LCA) was used to identify subsets of participants who shared a similar pattern of family income across all seven time points (2004-2010). LCA is a person-centered approach that we employed to estimate the number of latent classes that could be established based on the family income. The following criteria were used to decide on the number of classes to retain: Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and sample size adjusted BIC (adj BIC) [50]. Also, we used entropy to assess the quality of classification, as well as Vuong-Lo-Mendell-Rubin (VLMR) adjusted likelihood ratio test for the hypothesis that a model with one less class performs just as well. The LCA

was done in an iterative manner, where we started with 1 class, and increased the number of classes until the fit criteria suggested a good enough model. Deciding on the retained model, statistic criteria, parsimony, and meaningfulness of the classes was considered. Mplus version 7.4 was used for the LCA-analyses [51]. Differences in mental health variables between the identified classes of income were also tested in Mplus using the BCH approach for estimating the means of distal outcomes across latent classes [52]. Precursory analysis regressing family income classes on age did not suggest any effect of age-cohort.

We further conducted robustness checks using categorizations based on observed data. In a first set of analyses, those who had ever been below the relative poverty line in any of the years ($N = 1379$) were compared to those who had never been poor ($N = 7604$) using Welch corrected *t*-tests. In a second analysis, comparisons were made between the never poor participants, and those who experienced relative poverty early ($N = 811$) or late ($N = 466$) using analysis of variance (ANOVA) and Tukey's HSD procedure for pairwise comparisons. The two last groups were made based on having income below the relative poverty line the 2004-2006, but not later (i.e. poor early) or in 2007-2010, but not earlier (i.e. poor late). R for Mac version 3.3.2 [53] was used for all supplementary analyses.

Results

Classes of family income

While the model fit statistics indicated that a four or five class solution fitted the data best (see Table 1), the LMR-LRT test indicated that five classes was better than four and the entropy was slightly better (0.939 in the five-class model versus 0.929). Yet, inspection of the information criterions (AIC and BIC) indicated that little was gained by allowing for more than four classes. Moreover, comparison of the patterns in the four and five class models did

not suggest that the fifth class yielded additional information that was qualitatively important. Finally, it was evident that six or more classes were not supported by the data.

Insert Table 1 here

Thus, based on the overall consideration of the fit statistics, the meaningfulness of the classes and model efficiency, we chose the four-class model as our final model and (see Figure 1 for the final model).

Insert Figure 1 here

The largest class, by far, we termed 'never poor' (class 1; 91.1%). Participants in this class had little exposure to low income throughout childhood, and in any of the years measured, these participants had less than 5% chance of living in relative poverty. The next two classes were characterized by moving into- or out of low income. The 'moving into poverty' (class 2) constituted 2.3% of the sample. Participants in this class had low exposure in 2004-2006, and increasing exposure from 2007 and onwards, with a decline in 2010. The reverse was observed for the 'moving out of poverty' (class 3; 3.5% of the sample), which had relatively high exposure to low income in 2004-2006, before exposure declined towards 2010. The 'chronically poor' group (class 4) consisted of 3.1% of the sample, and had a much higher probability of exposure to low income in childhood at 75% or higher for six of the seven years measured, before dropping to around 65% in 2010.

Associations with relevant demographic information

The four classes that emerged from the final model were associated with relevant demographic variables in meaningful ways, supporting the validity of the classification. Those in the 'never poor' group had parents with higher education levels, were less likely to live in a single parent household, and their parents were also more likely to work, relative to the other

classes. Those in the 'chronically poor' group, were more likely to be ethnic minorities, have parents with lower education levels, and their parents were more likely to not be working. Participants in two classes of transitory poverty were placed in-between these two extremes in their association to demographic variables, see Table 2 (and supplementary figure 1).

Insert Table 2 here

Associations with mental health

The results suggested that there was a main effect of class on all mental health measures with the exception of symptoms of ADHD as measured with the ASRS, see Table 3.

Insert Table 3 here

Generally, a pattern emerged where participants with a consistently low probability of being poor scored lower on mental health problems compared to participants with some exposure to relative poverty. For the SDQ total score, participants who were 'never poor' scored lower than participants who had experienced poverty, but there was no difference within the poverty exposure categories (see Figure 2A). For emotional-, conduct and hyperactivity-inattention problems, participants 'never poor' scored significantly lower relative to those who were moving into poverty, and for conduct problems, also relative to those 'chronically poor' (all *p*s <.05, see Figure 2B). Participants in the 'never poor' category also scored lower on peer problems and symptoms of depression relative to those 'chronically poor' and those 'moving out of poverty' (see Figures 2B & 3A). For peer problems, there were also significant differences within the poverty categories, where those 'chronically poor' had a higher symptom score relative to those moving into- or out of poverty. Differences within poverty categories were also observed for symptoms of hyperactivity-inattention, but the pattern was reversed, and 'chronically poor' participants had the lowest score. A similar, non-

significant, trend was also observed for symptoms of hyperactivity-inattention measured with the ASRS total score and for inattention and hyperactivity/impulsivity (see Figure 3B & 3C).

Insert Figure 2 here

Robustness checks

The results from the robustness checks using observed data were largely consistent with those obtained from the LCA analysis. Those who never had experienced poverty had significantly lower scores on all mental health outcomes (Cohen's *d*s = .09-.27, besides symptoms of hyperactivity/inattention measured with the ASRS; Cohen's *d* = .05) compared to those with any poverty exposure. Comparisons were also made between those categorized as never poor, those poor early and those poor late, and there was a significant main effect of categorization for all mental health outcomes (all *p*s <.05). For the SDQ total score, conduct problems and hyperactivity, those poor early and late had significantly higher scores than those who had never been exposed to relative poverty (Cohen's *d*s = .24-.27), but did not differ from each other. For SDQ emotional problems and symptoms of depression (measured with SMFQ), those never poor had lower scores than those poor early (Cohen's *d*s = .12-.17), but not those poor later. For SDQ peer problems, those in early relative poverty had significantly higher scores than those late or never below the poverty line (Cohen's *d*s = .09-.29). For hyperactivity/inattention measured with ASRS, the test of pairwise comparisons did not reveal any differences between groups (all *p*s > .05), although the ANOVA did show a main effect (*p* = .032), and the never poor group had the lowest mean score. This discrepancy is probably due to the adjustments for multiple comparisons in the Tukey HSD test.

Discussion

In this population-based study in Norway, an affluent country with very low poverty levels, we find that having experienced low income in childhood is associated with

significantly more symptoms of mental health problems in adolescence, relative to those who never experienced low income. However, an unexpected exception to this pattern was found for symptoms of hyperactivity/inattention, where those with the most exposure, had the fewest symptoms.

Previously, it has been found that accumulated poverty exposures are most harmful to children's development [54], suggesting that participants in the "Chronic poor" class should display most symptoms of mental health problems. If early exposure is key [14], there should be similarities in mental health problems among participants in the "Chronically poor" and "Moving out of poverty" classes, but if poverty exposure later in childhood is most important [55,56], we expect similarities in mental health problems in the "Chronically poor" and "Moving into poverty" classes. Finally, we would expect children in the "Moving into poverty" class to have the most symptoms of mental health problems if declines in income matter most [13,24].

For SDQ total score, symptoms of depression and SDQ peer problems, those never poor reported fewer symptoms relative to those moving out of poverty and those in the chronically poor group. This may be seen as support for the notion that early poverty exposure is particularly relevant for development of general mental health, depression and peer relationship problems. However, for the SDQ total score and depression, there were no differences within the poverty categories. For SDQ peer problems, those moving into and out of poverty, had lower scores relative to those in the chronically poor category. This finding suggests that long-term, rather than transient poverty exposure may be most relevant for development of peer problems. For SDQ emotional problems and conduct problems, there was a significant difference between the never poor and the moving into poverty group, implicating the importance of declining income. However, again, there were no statistical significant differences within poverty categories, and for conduct problems there was also

differences between those who were never poor, and those chronically poor, so alternative interpretations cannot be ruled out.

A curious finding was seen for symptoms of hyperactivity/inattention, measured with the SDQ. Here the never poor group had lower scores relative to those moving into or out of poverty, but not relative to the chronically poor group. Participants in the chronically poor group also had lower scores relative to those in the transient poverty groups. A similar trend was also observed when symptoms were measured with the ASRS. Previous studies do suggest that ADHD is associated with a range of socioeconomic indicators, including poor economic well-being and poverty [36,57], and as such, this unexpected finding warrants further investigation before firm conclusions can be reached.

In summary, the most consistent pattern of results appeared to be that participants who never experienced any poverty exposure had lower rates of mental health symptoms relative to participants with any exposure to poverty, and this pattern of results was confirmed across latent class analyses and in analyses using observed data. There was little evidence of associations between the timing and sequencing of exposure to low income and participant's levels or types of mental health problems.

Public health implications

In Norway [58], as well as in many other developed economies [34,59,60], the proportion of children that grow up in poverty has risen. This is concerning in light of the numerous studies that point to adverse short and long term negative consequences of childhood poverty exposure [e.g., 32,61]. In the current study, poverty exposure was associated with single-parent households, and more common among those with low parental education levels and lower parental workforce participation. Studies suggest that reforms or policies that reduce family unemployment in combination with progressive tax and benefit

systems may be effective in reducing child poverty rates [62]. Based on the findings from the current study, and many others, it is likely that reducing the number of children exposed to poverty will also have positive public health effects.

However, poverty influences on youth mental health are mainly indirect [22,30-32]. This suggests that strategies targeting parental mental health, family conflict, and parenting practices may also be viable compensatory strategies, as are interventions targeting many other domains [32]. In doing so, however, it is imperative to not oversimplify the complexities of poverty and the stressful environment it produces for children and families [63].

Strengths and limitations

Among the main strengths of the current study are the large sample size and use of well validated measures of mental health problems developed for use with adolescents. A particular strength is the register-based information about income that allowed us to capture fluctuations in family income variation across childhood. This is the same information used by the Norwegian government to estimate taxation, and is considered reliable, precise, and of high quality.

The main aim of this study was to investigate associations between trajectories of low income and mental health, and as such, we did not assess the factors associated with the actual trajectories themselves. There are several reasons why families experience fluctuations in income, such as changes in parental work affiliation or education levels, and structural changes in the family like divorce or reconstitution [5]. Due to lack of historic information about such events, factors causally associated with different trajectories were not explicitly investigated in the current study.

Another potential limitation relates to how we operationalized *low income*. The below 60% of median income cut-off has received criticism for being arbitrary, and only indirectly reflecting living conditions [64]. Still, it is the agreed international measure used throughout the EU [40,41] and is one of the most prominent and most-quoted of the EU social inclusion indicators. There are strengths and limitations to both absolute and relative measures of low income, and use of relative measures, such as those used in the current study, have their merits when used within countries to identify those at risk of poverty and social exclusion [34].

Finally, latent class analysis is probabilistic in nature, and the uncertainty of classification into the latent classes is expressed in the probability scale of being in either of the poverty trajectories at any given time during the period for which income information was available. As such, the classes may deviate from the result obtained if observed data had been used instead. However, the pattern of results was largely replicated in robustness checks using observed data, and the classes were associated with relevant socioeconomic factors in a meaningful way, increasing our confidence that the latent class approach has captured meaningful patterns in the income data.

Conclusion

We used latent class analysis to investigate the association between exposure to low income in childhood and mental health problems in a large sample of Norwegian adolescents. No consistent pattern emerged regarding the timing or sequencing of exposure and associations with particular types of mental health problems in adolescence, rather, having any experience to low income in childhood appeared to be positively associated with mental health problems in adolescence.

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Tables

Table 1. Model fit statistics for 2 through 6 classes. Bold indicates the selected model (*N* = 9154).

Number of classes	AIC	Sample-size adjusted BIC	Entropy	LMR-LRT	Parametric bootstrapped likelihood ratio test
2	18480.168	18538.862	0.947	<.001	<.001
3	18103.726	18193.723	0.946	<.001	<.001
4	**17808.447**	**17929.748**	**0.929**	**<.001**	**<.001**
5	17728.302	17880.907	0.939	<.001	<.001
6	17702.906	17886.814	0.943	0.078	<.001

AIC: Akaike information criterion; BIC: Bayesian information criterion; LMR-LRT: Lo-Mendell-Rubin adjusted likelihood ratio test.

Table 2. Descriptive characteristics of sample stratified by classes of family income during childhood (*N* = 9154).

	1. Never poor	2. Moving into poverty	3. Moving out of poverty	4. Chronic poor	p
N	8337	210	321	286	
Age (Median)	17.34	17.14	17.18	17.33	0.057
Male % (n)	47.1 (3924)	47.6 (100)	49.5 (159)	45.1 (129)	0.742
Foreign % (n)	3.7 (303)	13.5 (27)	15.2 (47)	42.6 (118)	<0.001
Single parent % (n)	15.3 (1135)	32.8 (59)	28.6 (78)	29.6 (69)	<0.001
Perceived economic well-being % (n)					<0.001
Poorer than others	5.9 (480)	18.4 (38)	14.0 (43)	26.4 (72)	
Equal to others	67.8 (5501)	60.2 (124)	68.7 (211)	56.8 (155)	
Better than others	26.3 (2138)	21.4 (44)	17.3 (53)	16.8 (46)	
Highest education in family % (n)					<0.001
Elementary	3.7 (304)	6.4 (13)	8.3 (26)	10.9 (30)	
Intermediate	30.7 (2532)	35.6 (72)	35.4 (111)	31.2 (86)	
Higher	46.9 (3859)	34.7 (70)	31.5 (99)	31.5 (87)	
Unknown	18.7 (1541)	23.3 (47)	24.8 (78)	26.4 (73)	
Maternal work affiliation % (n)					<0.001
Work	93.4 (7331)	77.3 (143)	81.8 (239)	66.1 (160)	
Benefits	3.8 (300)	15.1 (28)	11.6 (34)	20.2 (49)	
Other	2.8 (216)	7.6 (14)	6.5 (19)	13.6 (33)	
Paternal work affiliation % (n)					<0.001
Work	95.8 (7257)	88.3 (159)	88.5 (238)	76.8 (179)	
Benefits	2.8 (212)	8.3 (15)	7.4 (20)	14.6 (34)	
Other	1.4 (107)	3.3 (6)	4.1 (11)	8.6 (20)	

Table 3. Mental health variables in adolescence stratified by classes of family income during childhood (*N* = 9154).

	1. Never poor	2. Moving into poverty	3. Moving out of poverty	4. Chronic poor				
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	Chi square	df	p	Pairwise comparisons
SDQ Total	10.03 (0.06)	11.28 (0.32)	11.49 (0.48)	11.31 (0.40)	41.365	3	< .001	1 < 2, 3, 4
Emotion	2.99 (0.03)	3.28 (0.16)	3.52 (0.22)	3.29 (0.18)	14.792	3	0.002	1 < 3
Conduct	1.41 (0.02)	1.57 (0.09)	1.69 (0.13)	1.67 (0.10)	19.139	3	< .001	1 < 3, 4
Hyper	3.92 (0.02)	4.29 (0.14)	4.32 (0.20)	3.70 (0.17)	12.019	3	0.007	1 < 2, 3; 2 > 4; 3 > 4
Peer	1.71 (0.02)	2.15 (0.11)	1.95 (0.15)	2.65 (0.13)	77.107	3	< .001	1 < 2, 4; 2 < 4; 3 < 4
Depression	5.77 (0.07)	6.74 (0.41)	6.68 (0.52)	6.86 (0.51)	15.843	3	0.001	1 < 2, 4
ADHD	26.82 (0.12)	27.72 (0.68)	28.48 (0.93)	25.74 (0.88)	5.667	3	0.129	-
Inattention	14.49 (0.08)	14.92 (0.43)	15.33 (0.60)	13.63 (0.53)	4.704	3	0.195	-
Hyperactivity/ impulsivity	11.44 (0.06)	11.81 (0.37)	11.60 (0.50)	10.58 (0.48)	3.96	3	0.266	-

Figures

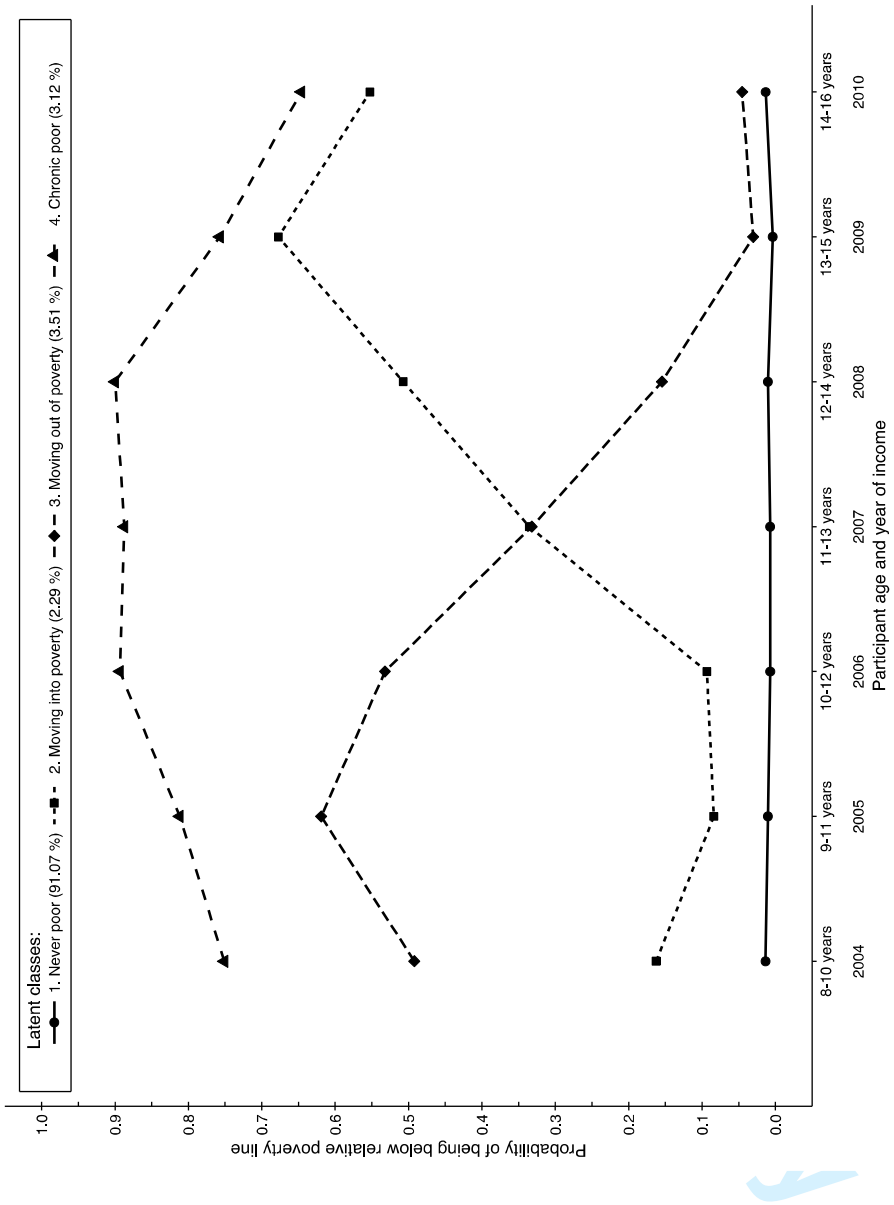


Figure 1. Latent classes across 7 time points from 2004 to 2010 (N = 9154).

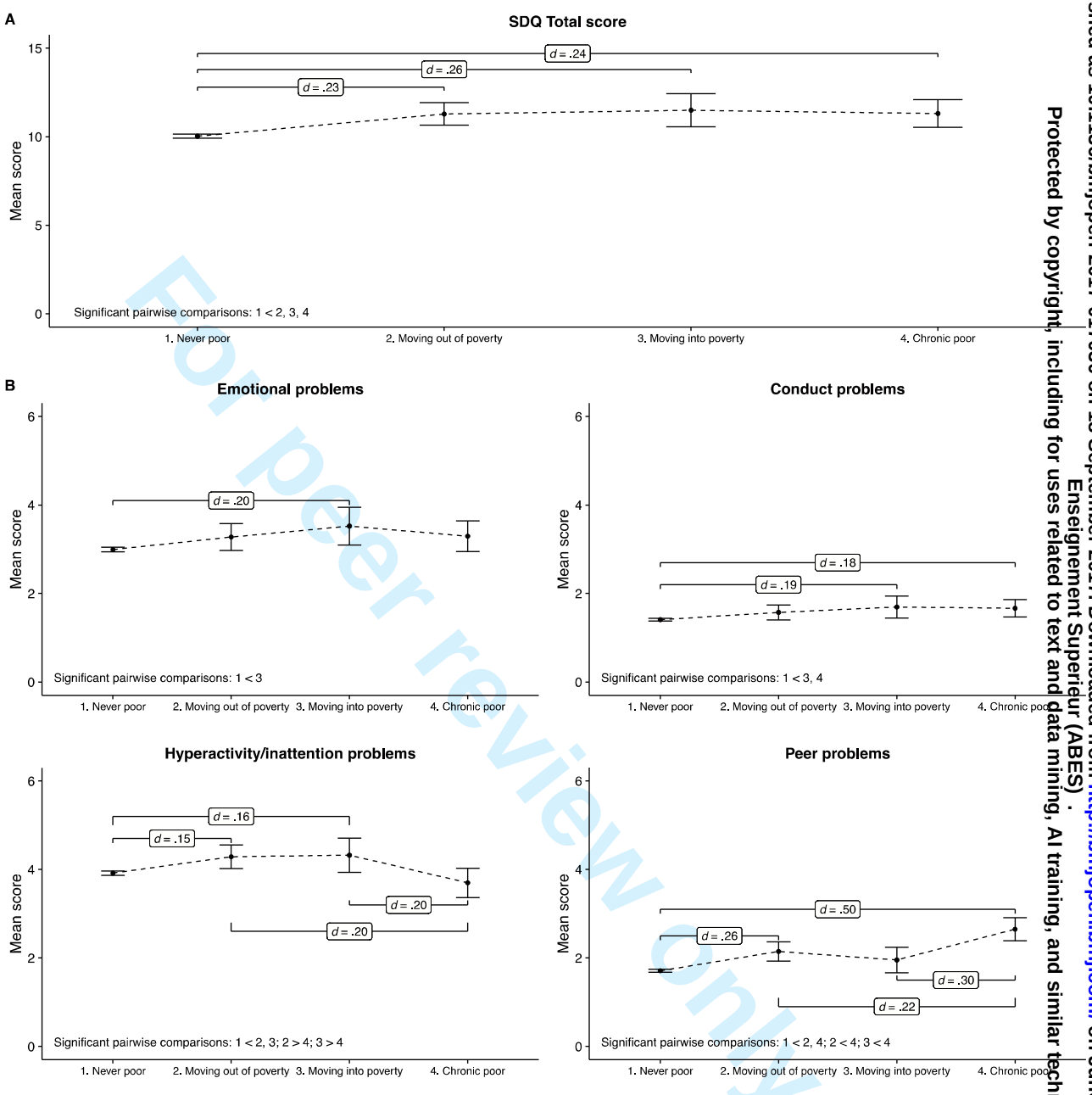


Figure 2. *Association between relative poverty class and symptoms of general mental health problems*

Point represent mean, error bars 95% confidence interval. *Note:* Scale on Y-axis is not the same across panels A and B.

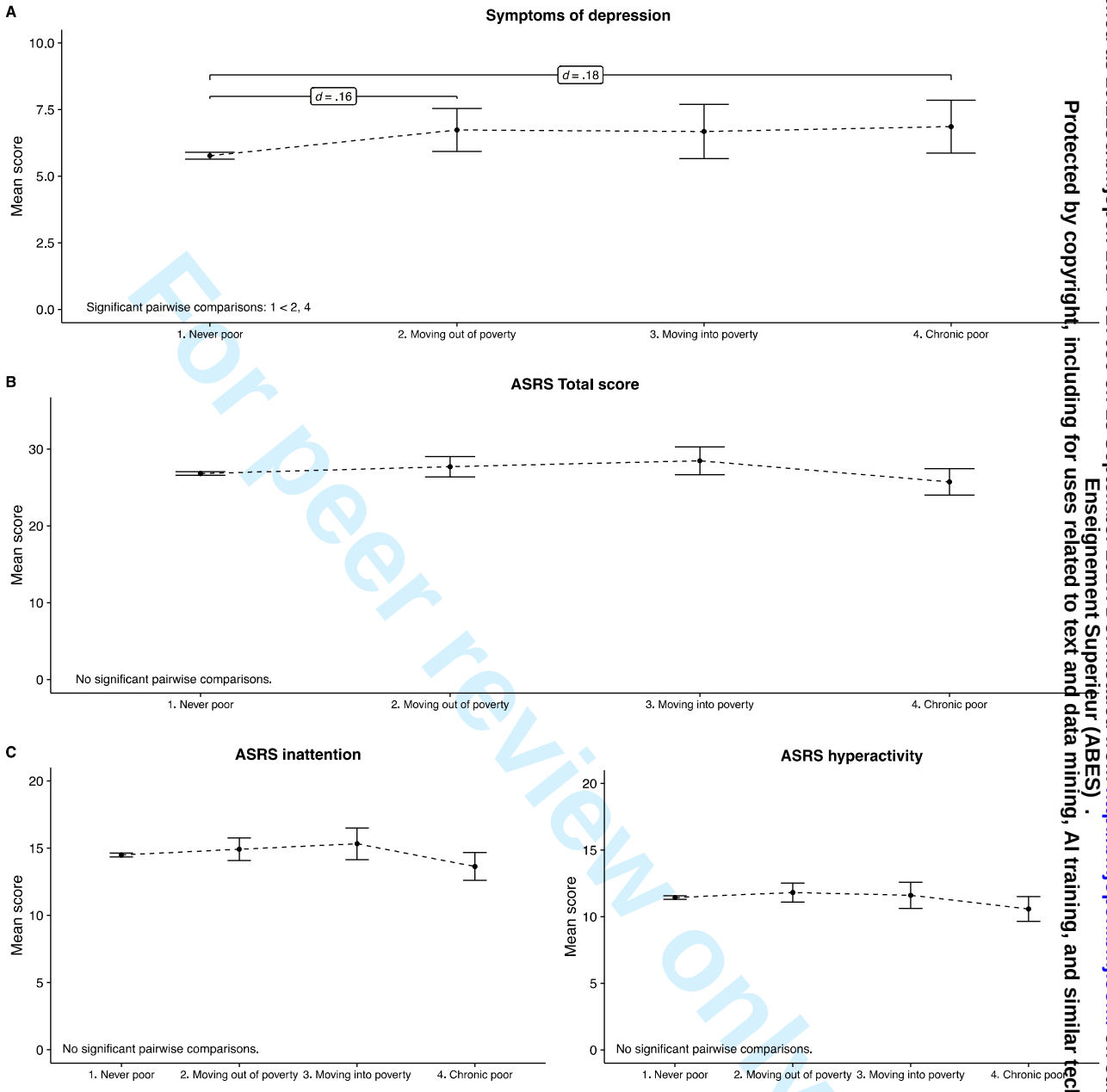
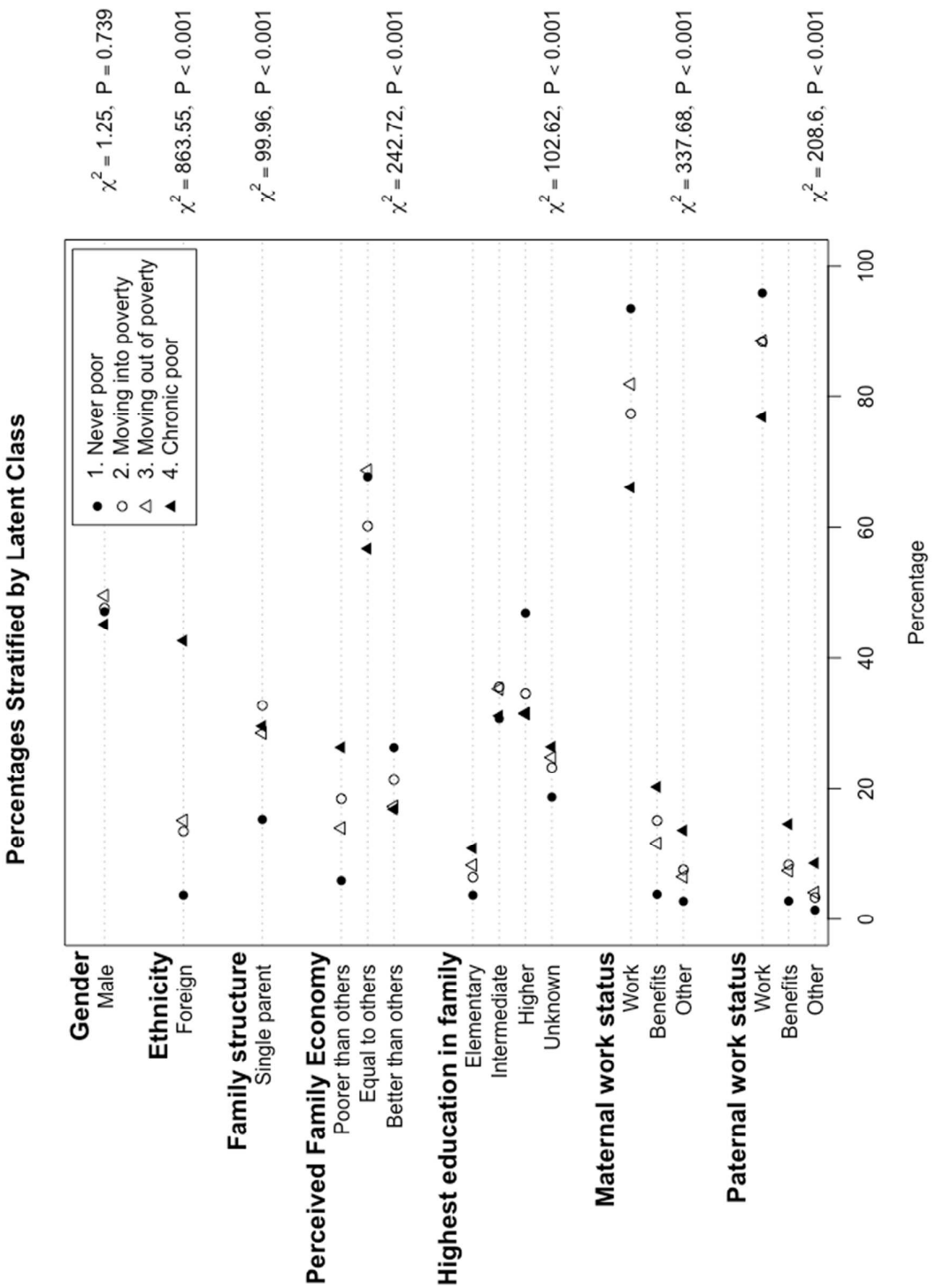


Figure 3. *Association between relative poverty class and symptoms of depression and ADHD*

Point represent mean, error bars 95% confidence interval. *Note:* Scale on Y-axis is not the same across panels A, B, and C.



Supplementary figure 1. *Association between relative poverty class and demographics*

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2	
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-5	
Objectives	3	State specific objectives, including any prespecified hypotheses	5	
Methods				
Study design	4	Present key elements of study design early in the paper	2	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6	
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6	
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case		
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8	
Bias	9	Describe any efforts to address potential sources of bias	14	
Study size	10	Explain how the study size was arrived at	6	

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	8-9
		(*c*) Explain how missing data were addressed	8-9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	8-9
		(*e*) Describe any sensitivity analyses	8-9
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6-9
		(b) Give reasons for non-participation at each stage	6-9
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-9
		(b) Indicate number of participants with missing data for each variable of interest	6-9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	*6-9*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-11
		(*b*) Report category boundaries when continuous variables were categorized	9-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6-9
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Economic volatility in childhood and subsequent adolescent mental health problems: A longitudinal population-based study of adolescents

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Economic volatility in childhood and subsequent adolescent mental health problems: A longitudinal population-based study of adolescents

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Abstract

Objective: The aim of the current paper was to investigate the association between the patterns of duration, timing and sequencing of exposure to low family income during childhood, and symptoms of mental health problems in adolescence. **Setting:** Survey administered to a large population-based sample of Norwegian adolescents. **Participants**: Survey data from 9154 16-19 year olds (53% participation rate, 52.7% girls), was linked to registry-based information about childhood family income from tax return data. **Outcome measures**: Mental health outcomes were symptoms of emotional, conduct, hyperactivity, peer problems and general mental health problems measured with the Strengths and Difficulties questionnaire (SDQ), symptoms of depression measured with Short Mood and Feelings Questionnaire (SMFQ), and symptoms of attention-deficit/hyperactivity disorder measured with the Adult ADHD Self-Report Scale (ASRS). **Results:** Latent class analysis and the BCH approach in Mplus were used to examine associations between patterns of poverty exposure and mental health outcomes. Four latent classes of poverty exposure emerged from the analysis. Participants moving into poverty (2.3%), out of poverty (3.5%), or those chronically poor (3.1%) had more symptoms of mental health problems (Cohen's *d*s .16-.50) than those with no poverty exposure (91.1%). This pattern was, however, not found for symptoms of ADHD. The pattern of results was confirmed in robustness checks using observed data. **Conclusions:** Exposure to poverty in childhood was found to be associated with most mental health problems in adolescence. There was no strong suggestion of any timing or sequencing effects in the patterns of associations.

Keywords: poverty; mental health; latent class analysis; childhood; adolescence; ADHD; youth@hordaland

Strengths and limitations of this study

- Data on mental health problems obtained from a survey administered to a large population based sample of Norwegian 16-19 year olds ($N = 9154$) was linked to registry-based information about family income in childhood from tax return data from the Norwegian Tax Administration.
- Using latent class analysis, four trajectories of poverty exposure during childhood were evident.
- The association between trajectories of childhood poverty exposure and symptoms of mental health problems in adolescence was investigated using Mplus and the BCH approach for estimating the means of distal outcomes across latent classes
- Robustness checks were used to verify the results using observed data.
- High attrition, low levels of poverty in Norway, and high school students being overrepresented in the sample, suggest care should be taken when generalizing the results.

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Author contributions:

TB made substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafted the work, approved the version to be published and is accountable for all aspects of the work.

JCS made substantial contributions to the analysis of data for the work; critically revised the work for important intellectual content, approved the version to be published, and is accountable for all aspects of the work.

BS & MH made substantial contributions to the conception and design of the work, the acquisition of data for the work, critically revised the work for important intellectual content, approved the version to be published, and is accountable for all aspects of the work.

KP, ED & HDZ made substantial contributions to the interpretation of data for the work; critically revised the work for important intellectual content, approved the version to be published, and is accountable for all aspects of the work.

Data sharing statement: No additional data available

Economic volatility in childhood and adolescent mental health

Children who grow up in poverty experience mental health problems to a greater extent than their more affluent peers [1,2]. The associations are often modest [3], however, and particularly small when controlling for genetics, parenting practices, and other characteristics likely to influence children's development [4]. Wagmiller et al. [5] have argued that one reason for the modest association may be that most prior research uses what has been termed a "concurrent indicator approach" where income and the outcome are measured at the same time point. This approach ignores stability and change in income over time, camouflaging improvements and deteriorations of economic circumstances. Indeed, an emerging body of research suggests that it is not necessarily the overall level of concurrent deprivation that is key in understanding how income influences development, but rather, the persistence and timing of poverty, and dynamic changes in families' economic circumstances over time [6-8]. Consistent with this perspective, instability or decline in income can increase parental stress [9], parental depression [10,11], and disrupt parent-child relationships [12]. In turn, these family stress responses to income volatility play a critical role in mediating the effects of economic disadvantage on child outcomes [13-16].

Dissatisfactions with the concurrent indicator approach has led some researchers to find more thorough and ecologically valid estimates of families' economic circumstances over time, such as averaging over several years of income [3], or statistically estimating the permanent component of the economic resources available to the family [17,18]. Alternative approaches have involved measuring the numbers of year a child is living in poverty (often termed cumulative or persistent poverty), or the number and durations of poverty episodes a child has experienced [19,20]. In general, these methodological approaches to capturing income over time produce stronger associations with developmental outcomes than concurrent income indicators [2,3]. Still, these approaches do not fully address the possibility

that families may experience a variety of transitory patterns of economic circumstances over time. Indicators of the number of episodes a child has experienced poverty, for example, may ignore the consequences of when those episodes occurred in a child's life.

The timing of poverty across children's lives has also been a topic of considerable interest. Different types of mental health problems debut at different ages [21], and investigating the co-occurrence of risk factors such as poverty at potentially vulnerable periods may provide more insight into mediating mechanisms. Research is equivocal about whether poverty occurring at an early or later stage of childhood has the most impact on mental health outcomes. Poverty in early (pre-school) childhood has been emphasized as especially detrimental to development [22,23], as this is a crucial time for brain development and may disrupt the many core cognitive and social competencies being acquired during this time. In contrast, others have highlighted middle childhood [24] and early adolescence as particularly sensitive periods [19].

The analytic approach in many studies of timing of poverty is often to investigate the effect of being persistently poor at a particular period during childhood relative to being poor at other times [23,25,26]. A potential limitation of some of the studies on timing is that this analytic approach may also obscure sequencing effects, i.e. that some children move out of, or into poverty between the different periods that are contrasted. In studies of sequencing per se, declines in income has been found to be associated with poorer developmental outcomes [6,13,27]. Furthermore, economic fluctuations seem especially consequential for children living in poverty [6,22], and it has been suggested that economic fluctuations may pose even greater risks to development, compared to disadvantaged, but stable, economic circumstances [28].

The present study was conducted in Norway which is a wealthy country in which absolute deprivation is uncommon [29,30] and where there is relatively little income inequality (as indicated by a GINI-index of .25). In 2012, for example, only 13.1% of children (aged under 18) lived in households in relative poverty. Moreover, Norway provides an elaborate social safety net for its residents such as access to unemployment, sickness, and family related benefits; financial assistance; financial advice and debt counselling; temporary accommodation; employment schemes; and health services. These social benefits may buffer children and families with low socioeconomic status from exposure to some of the physical hardships and psychosocial stressors associated with poverty. However, even with these social services, poorer economic circumstances do appear to be associated with mental health problems in Norwegian children [27,31,32]. Yet, in order to study the relatively small population of poor children with adequate power, large samples, such as in the present study, are required.

In Norway [33], as well as in many other developed economies [30,34,35], the proportion of children that grow up in poverty has risen. The aim of the present study was to investigate different economic trajectories and economic volatility during childhood and subsequent adolescent mental health. We capitalized on historic register-based income information linked to a large population-based study on adolescent mental health. Using latent class analysis, we classified children into groups based on their similarity in exposure to low income during childhood. Then, we investigated the association between class membership and mental health outcomes among 16-19-year-olds adolescents. The advantage of latent class analysis over alternative methods of measuring exposure to low income (e.g., approaches based on concurrent indicators, cumulative poverty exposure, average economic status over time, or importance of being poor in some stages of childhood relative to others), is that it

allows us to simultaneously consider the effects of duration, timing, and sequencing of exposure to low income during childhood [36].

Methods

Procedure and participants

In this population-based study, we used data from the youth@hordaland-survey of adolescents conducted in 2012 in the county of Hordaland in Western Norway ($N = 9154$). The main aim of youth@hordaland-survey was to assess mental health problems among all adolescents in Hordaland County aged 16 to 19 years. All adolescents in upper secondary education received information via e-mail, and one classroom school hour was allocated for them to complete the questionnaire. The questionnaire was web-based and covered a broad range of mental health issues, sleep behaviors and sleep problems, daily life functioning, use of health care and social services, demographics, as well as a request for permission to obtain school data, and to link the information with national registries. Those not in school received information by post to their home address. Uni Research Health collaborated with Hordaland County Council to conduct the study. The study was approved by The Regional Committee for Medical and Health Research Ethics in Western Norway. The results from the current observational study are reported according to the STROBE guidelines.

Overall, Hordaland county is considered representative of Norway with regards to gender and rural/urban residence distribution, and the median household income is also similar to that of the national average [37]. In the period 2005-2010, the mean proportion of children characterized as being *relative poor* (see details below) in Hordaland county was slightly lower (7.3%) than in the country as a whole (8.9%).

Measures

Measure of relative poverty

Family income was drawn from the Norwegian national income registry and was based on tax return data from the Norwegian Tax Administration. As the information about income is used by the Norwegian government to estimate taxation, it is considered reliable, precise and of high quality. Using each participant's personal identification number, we were able to obtain information about the equivalised disposable household income for the period from 2004 when children were 8-11 years old, until 2010. Equivalised household income is a measure of household income (i.e. the sum of wages and salaries, income from self-employment, property income and transfers received minus total assessed taxes and negative transfers) that is adjusted by an equivalence scale in order to facilitate comparison between households of different size and composition. It may be viewed as an indicator of the economic resources that are available to a standardized household, and accounts for inflation/changes in median income over time. The equivalence scale used in the current study is the European Union scale (a modification of the OECD equivalence scale) where the first adult is given a weight of 1, subsequent adults are given a weight of 0.5 and each child below 14 is given the weight 0.3 [38]. From this measure of family income, we calculated the proportion of adolescents in *relative poverty,* defined as having an equivalised household income below 60% of the equivalised national median income for that particular year (e.g. to calculate relative poverty proportions for 2004 we used the median income for 2004) [39,40].

Symptoms of general mental health problems

In the youth@hordaland study, adolescents completed the self-report version of the Strengths and Difficulties Questionnaire [41,42]. The SDQ is available from http://www.sdqinfo.org and can be downloaded freely. It consists of five subscales, each

containing five items. The scales measure emotional symptoms, conduct problems, hyperactivity-inattention, peer relationship problems, and prosocial behaviors (not included in the current study). Respondents indicated on a three-point Likert-type scale to which extent a symptom applied to them, using the options "Not true", "Somewhat true", or "Certainly true". Each of the subscales consists of five items, and all scale scores ranged from 0-10 in the current sample. Four of the subscales (emotional-, conduct-, hyperactivity-inattention- and peer relationship problems) are summed to provide the SDQ total difficulties scale score (sample range 0-35), with higher scores indicating more problems. Due to the ordinal and categorical nature of the response options, reliability was assessed using polychoric correlation-based version of the reliability coefficients [43]. These analyses, suggested satisfactory internal consistency for the SDQ total difficulties scale ($\alpha = 0.86$) and for all subscales (αs emotional problems = 0.82, conduct problems = 0.71, hyperactivity-inattention = 0.76, peer problems = 0.75, and prosocial behaviors = 0.77). Previous investigations has found the SDQ to be reliable and valid instrument to use in samples of adolescents [44]

Symptoms of depression

The short version of the Moods and Feelings Questionnaire (SMFQ) [45] was used to measure symptoms of depression. The SMFQ consists of 13 statements (e.g., "I am feeling low", "No one likes me", etc.) that the participants respond to using Norwegian translations of the response categories "Not true", "Sometimes true", and "True". The SMFQ is a valid instrument [46] with adequate psychometric properties [47], and a previous study based on the youth@hordaland study found the SMFQ to be unidimensional, supporting the use of the sum score of SMFQ [48]. Reliability in the current sample was excellent (range = 0-26, ordinal $\alpha = 0.95$).

Symptoms of attention-deficit-/hyperactivity disorder

Hyperactivity-inattention was measured using a Norwegian version of the Adult ADHD Self-report scale [49]. The ASRS consists of 18 statements about hyperactivity-inattention (e.g., "I never remember", "I concentrate easily"), that the participants respond to using options "Never", "Rarely", "Sometimes", "Often", or "Always". The ASRS was originally constructed for use in adults [50], but has also been validated for use among adolescents [51]. The current study used the total score where all 18 items were added together (range = 0-72, ordinal $\alpha = 0.91$), the inattention scale consisting of nine items (range = 0-36, ordinal $\alpha = 0.89$), and the hyperactivity-impulsivity scale consisting of nine items (range = 0-36, ordinal $\alpha = 0.84$). This additional measure of ADHD was included as symptoms of ADHD are only briefly measured by the SDQ, and the age-range in the current sample is at the upper end of the norms of the SDQ.

Demographic variables

Gender and date of birth were identified through personal identity number in the Norwegian National Population Register. Exact age was estimated by calculating the interval of time between date of birth and date of study participation. Family structure (i.e. single- [15%] or two-parent households), parental education levels (elementary [3.7%], intermediate [30.7%], and higher) and work affiliation (i.e. work [93.4%], benefits [3.8%], or other [including students, retirees and stay-at-home parents]), and ethnicity (Norwegian [96.3%], or foreign) were reported by adolescents.

Statistical analysis

Latent class analysis (LCA) was used to identify subsets of participants who shared a similar pattern of family income across all seven time points (2004-2010). LCA is a person-centered approach that we employed to estimate the number of latent classes that could be

established based on the family income. The following criteria were used to decide on the number of classes to retain: Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and sample size adjusted BIC (adj BIC) [52]. Also, we used entropy to assess the quality of classification, as well as Vuong-Lo-Mendell-Rubin (VLMR) adjusted likelihood ratio test for the hypothesis that a model with one less class performs just as well. The LCA was done in an iterative manner, where we started with 1 class, and increased the number of classes until the fit criteria suggested a good enough model. Deciding on the retained model, statistic criteria, parsimony, and meaningfulness of the classes was considered. Mplus version 7.4 was used for the LCA-analyses [53]. Differences in mental health variables between the identified classes of income were also tested in Mplus using the BCH approach for estimating the means of distal outcomes across latent classes [54]. Precursory analysis regressing family income classes on age did not suggest any effect of age-cohort. Missing data was handled by the full information maximum likelihood procedure in Mplus.

We further conducted robustness checks using categorizations based on observed data. In a first set of analyses, those who had ever been below the relative poverty line in any of the years (N = 1379) were compared to those who had never been poor (N = 7604) using Welch corrected t-tests. In a second analysis, comparisons were made between the never poor participants, and those who experienced relative poverty early (N = 811) or late (N = 466) using analysis of variance (ANOVA) and Tukey's HSD procedure for pairwise comparisons. The two last groups were made based on having income below the relative poverty line the 2004-2006, but not later (i.e. poor early) or in 2007-2010, but not earlier (i.e. poor late). R for Mac version 3.3.2 [55] was used for all supplementary analyses.

Results

Classes of family income

Based on the overall consideration of the fit statistics, the meaningfulness of the classes and model efficiency, we chose the four-class model as our final model and (see Figure 1 for the final model). Specifically, while the model fit statistics indicated that a four or five class solution fitted the data best (see Table 1), the LMR-LRT test indicated that five classes was better than four and the entropy was slightly better (0.939 in the five-class model versus 0.929). Yet, inspection of the information criterions (AIC and BIC) indicated that little was gained by allowing for more than four classes. Moreover, comparison of the patterns in the four and five class models did not suggest that the fifth class yielded additional information that was qualitatively important. Finally, it was evident that six or more classes were not supported by the data.

Insert Table 1 here

Insert Figure 1 here

The largest class, by far, we termed 'never poor' (class 1; 91.1%). Participants in this class had little exposure to low income throughout childhood, and in any of the years measured, these participants had less than 5% chance of living in relative poverty. The next two classes were characterized by moving into- or out of low income. The 'moving into poverty' (class 2) constituted 2.3% of the sample. Participants in this class had low exposure in 2004-2006, and increasing exposure from 2007 and onwards, with a decline in 2010. The reverse was observed for the 'moving out of poverty' (class 3; 3.5% of the sample), which had relatively high exposure to low income in 2004-2006, before exposure declined towards 2010. The 'chronically poor' group (class 4) consisted of 3.1% of the sample, and had a much

higher probability of exposure to low income in childhood at 75% or higher for six of the seven years measured, before dropping to around 65% in 2010.

Associations with relevant demographic information

The four classes that emerged from the final model were associated with relevant demographic variables in meaningful ways, supporting the validity of the classification. Those in the 'never poor' group had parents with higher education levels, were less likely to live in a single parent household, and their parents were also more likely to work, relative to the other classes. Those in the 'chronically poor' group, were more likely to be ethnic minorities, have parents with lower education levels, and their parents were more likely to not be working. Participants in two classes of transitory poverty were placed in-between these two extremes in their association to demographic variables, see Table 2 (and supplementary figure 1).

Insert Table 2 here

Associations with mental health

The results suggested that there was a main effect of class on all mental health measures with the exception of symptoms of ADHD as measured with the ASRS, see Table 3.

Insert Table 3 here

Generally, a pattern emerged where participants with a consistently low probability of being poor scored lower on mental health problems compared to participants with some exposure to relative poverty. For the SDQ total score, participants who were 'never poor' scored lower than participants who had experienced poverty, but there was no difference within the poverty exposure categories (see Figure 2A). For emotional, conduct and hyperactivity-inattention problems, participants 'never poor' scored significantly lower relative to those who were moving into poverty, and for conduct problems, also relative to

those 'chronicallyally poor' (all *p*s <.05, see Figure 2B). Participants in the 'never poor' category also scored lower on peer problems and symptoms of depression relative to those 'chronically poor' and those 'moving out of poverty' (see Figures 2B & 3A). For peer problems, there were also significant differences within the poverty categories, where those 'chronicallyally poor' had a higher symptom score relative to those moving into- or out of poverty. Differences within poverty categories were also observed for symptoms of hyperactivity-inattention, but the pattern was reversed, and 'chronically poor' participants had the lowest score. A similar, non-significant, trend was also observed for symptoms of hyperactivity-inattention measured with the ASRS total score and for inattention and hyperactivity/impulsivity (see Figure 3B & 3C).

Insert Figure 2 here

Robustness checks

The results from the robustness checks using observed data were largely consistent with those obtained from the LCA analysis. Those who never had experienced poverty had significantly lower scores on all mental health outcomes (Cohen's *d*s = .09-.27, besides symptoms of hyperactivity/inattention measured with the ASRS; Cohen's *d* = .05) compared to those with any poverty exposure. Comparisons were also made between those categorized as never poor, those poor early and those poor late, and there was a significant main effect of categorization for all mental health outcomes (all *p*s <.05). For the SDQ total score, conduct problems and hyperactivity, those poor early and late had significantly higher scores than those who had never been exposed to relative poverty (Cohen's *d*s = .24-.27), but did not differ from each other. For SDQ emotional problems and symptoms of depression (measured with SMFQ), those never poor had lower scores than those poor early (Cohen's *d*s = .12-.17), but not those poor later. For SDQ peer problems, those in early relative poverty had

significantly higher scores than those late or never below the poverty line (Cohen's *d*s = .09-.29). For hyperactivity/inattention measured with ASRS, the test of pairwise comparisons did not reveal any differences between groups (all *p*s > .05), although the ANOVA did show a main effect ($p = .032$), and the never poor group had the lowest mean score. This discrepancy is probably due to the adjustments for multiple comparisons in the Tukey HSD test.

Discussion

In this population-based study in Norway, an affluent country with very low poverty levels, we find that having experienced relative poverty in childhood is associated with significantly more symptoms of mental health problems in adolescence, relative to those who never experienced relative poverty. However, an unexpected exception to this pattern was found for symptoms of hyperactivity/inattention, where those with the most exposure, had the fewest symptoms.

Previously, it has been found that accumulated poverty exposures are most harmful to children's development [56], suggesting that participants in the 'chronically poor' class should display most symptoms of mental health problems. If early exposure is key [23], there should be similarities in mental health problems among participants in the 'chronically poor' and 'moving out of poverty' classes, but if poverty exposure later in childhood is most important [57,58], we expect similarities in mental health problems in the 'chronically poor' and 'moving into poverty' classes. Finally, we would expect children in the 'moving into poverty' class to have the most symptoms of mental health problems if declines in income matter most [22,28].

For SDQ total score, symptoms of depression and SDQ peer problems, those 'never poor' reported fewer symptoms relative to those moving out of poverty and those in the 'chronically poor' group. This may be seen as support for the notion that early poverty

exposure is particularly relevant for development of general mental health, depression and peer relationship problems. However, for the SDQ total score and depression, there were no differences within the poverty categories. For SDQ peer problems, those moving into and out of poverty, had lower scores relative to those in the 'chronically poor' category. This finding suggests that long-term, rather than transient poverty exposure may be most relevant for development of peer problems. For SDQ emotional problems and conduct problems, there was a significant difference between the 'never poor' and the 'moving into poverty' group, implicating the importance of declining income. However, again, there were no statistically significant differences within poverty categories, and for conduct problems there were also differences between those who were 'never poor', and those 'chronically poor', so alternative interpretations cannot be ruled out.

A curious finding was seen for symptoms of hyperactivity/inattention, measured with the SDQ. Here the 'never poor' group had lower scores relative to those moving into or out of poverty, but not relative to the 'chronically poor' group. Participants in the 'chronically poor' group also had lower scores relative to those in the transient poverty groups. A similar trend was also observed when symptoms were measured with the ASRS. Previous studies do suggest that ADHD is associated with a range of socioeconomic indicators, including poor economic well-being and poverty [32,59,60], and as such, this unexpected finding warrants further investigation before firm conclusions can be reached.

In summary, the most consistent pattern of results appeared to be that participants who never experienced any poverty exposure had lower rates of mental health symptoms relative to participants with any exposure to poverty, and this pattern of results was confirmed across latent class analyses and in analyses using observed data. There was little evidence of associations between the timing and sequencing of exposure to low income and participant's levels or types of mental health problems.

Public health implications

The increase in the proportion of children who grow up in poverty is concerning in light of the numerous studies that point to adverse short and long term negative consequences of childhood poverty exposure [e.g., 16,61]. In the current study, poverty exposure was associated with single-parent households, and more common among those with low parental education levels and lower parental workforce participation. Studies suggest that reforms or policies that reduce family unemployment in combination with progressive tax and benefit systems may be effective in reducing child poverty rates [62]. Based on the findings from the current study, and many others, it is likely that reducing the number of children exposed to poverty will also have positive public health effects.

However, poverty influences on youth mental health are mainly indirect [13-16]. This suggests that strategies targeting parental mental health, family conflict, and parenting practices may also be viable compensatory strategies, as are interventions targeting many other domains [16]. In doing so, however, it is imperative to not oversimplify the complexities of poverty and the stressful environment it produces for children and families [63].

Strengths and limitations

Among the main strengths of the current study are the large sample size and use of well validated measures of mental health problems developed for use with adolescents. A particular strength is the register-based information about income that allowed us to capture fluctuations in family income variation across childhood. This is the same information used by the Norwegian government to estimate taxation, and is considered reliable, precise, and of high quality.

The main aim of this study was to investigate associations between trajectories of low income and mental health, and as such, we did not assess the factors associated with the actual trajectories themselves. There are several reasons why families experience fluctuations in income, such as changes in parental work affiliation or education levels, and structural changes in the family like divorce or reconstitution [5]. Due to lack of historic information about such events, factors causally associated with different trajectories were not explicitly investigated in the current study. Information about mental health outcomes is self-reported. Although adolescents may provide accurate information about their own mental health [64], there would have been stronger support for the results had measures such as clinical evaluations been available. Another potential limitation relates to how we operationalized *low income*. The below 60% of median income cut-off has received criticism for being arbitrary, and only indirectly reflecting living conditions [65]. Still, it is the agreed international measure used throughout the EU [39,40] and is one of the most prominent and most-quoted of the EU social inclusion indicators. There are strengths and limitations to both absolute and relative measures of low income, and use of relative measures, such as those used in the current study, have their merits when used within countries to identify those at risk of poverty and social exclusion [30]. Still, Norway has low levels of poverty and economic inequality, which may restrict generalizability of these results.

Attrition from the study could affect generalizability, with a response rate of about 53% and with adolescents in schools overrepresented. Unfortunately, non-participation in survey research is on the rise [66], and non-response is found related to better socioeconomic status [67], i.e., official data shows that in 2012, 92% of all adolescents in Norway aged 16-19 attend high school [68], compared to 98% in the current study. Previous research from the former waves of the Bergen Child Study (a longitudinal study nested within youth@hordaland), has also identified psychological problems as a predictor for non-

participation [69]. As the current sample may be skewed towards better socioeconomic status and psychological health, the results may be a conservative estimate of the number of adolescents growing up in poor families and their associated mental health problems.

Finally, latent class analysis is probabilistic in nature, and the uncertainty of classification into the latent classes is expressed in the probability scale of being in either of the poverty trajectories at any given time during the period for which income information was available. As such, the classes may deviate from the result obtained if observed data had been used instead. However, the pattern of results was largely replicated in robustness checks using observed data, and the classes were associated with relevant socioeconomic factors in a meaningful way, increasing our confidence that the latent class approach has captured meaningful patterns in the income data. Still, the method does not adjust for overall level of income, and it does not give an indication of the magnitude of the economic transition (e.g., moving from affluence to poverty may have greater consequences that moving from relative poverty to poverty).

Conclusion

We used latent class analysis to investigate the association between exposure to low income in childhood and mental health problems in a large sample of Norwegian adolescents. No consistent pattern emerged regarding the timing or sequencing of exposure and associations with particular types of mental health problems in adolescence, rather, having any exposure to relative poverty in childhood appeared to be positively associated with mental health problems in adolescence.

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Tables

Table 1. Model fit statistics for 2 through 6 classes. Bold indicates the selected model (*N* = 9154).

Number of classes	AIC	Sample-size adjusted BIC	Entropy	LMR-LRT	Parametric bootstrapped likelihood ratio test
2	18480.168	18538.862	0.947	<.001	<.001
3	18103.726	18193.723	0.946	<.001	<.001
4	**17808.447**	**17929.748**	**0.929**	**<.001**	**<.001**
5	17728.302	17880.907	0.939	<.001	<.001
6	17702.906	17886.814	0.943	0.078	<.001

AIC: Akaike information criterion; BIC: Bayesian information criterion; LMR-LRT: Lo-Mendell-Rubin adjusted likelihood ratio test.

Table 2. Descriptive characteristics of sample stratified by classes of family income during childhood (*N* = 9154).

	1. Never poor	2. Moving into poverty	3. Moving out of poverty	4. Chronically poor	p
N	8337	210	321	286	
Age (Median)	17.34	17.14	17.18	17.33	0.057
Male % (n)	47.1 (3924)	47.6 (100)	49.5 (159)	45.1 (129)	0.742
Foreign % (n)	3.7 (303)	13.5 (27)	15.2 (47)	42.6 (118)	<0.001
Single parent % (n)	15.3 (1135)	32.8 (59)	28.6 (78)	29.6 (69)	<0.001
Perceived economic well-being % (n)					<0.001
Poorer than others	5.9 (480)	18.4 (38)	14.0 (43)	26.4 (72)	
Equal to others	67.8 (5501)	60.2 (124)	68.7 (211)	56.8 (155)	
Better than others	26.3 (2138)	21.4 (44)	17.3 (53)	16.8 (46)	
Highest education in family % (n)					<0.001
Elementary	3.7 (304)	6.4 (13)	8.3 (26)	10.9 (30)	
Intermediate	30.7 (2532)	35.6 (72)	35.4 (111)	31.2 (86)	
Higher	46.9 (3859)	34.7 (70)	31.5 (99)	31.5 (87)	
Unknown	18.7 (1541)	23.3 (47)	24.8 (78)	26.4 (73)	
Maternal work affiliation % (n)					<0.001
Work	93.4 (7331)	77.3 (143)	81.8 (239)	66.1 (160)	
Benefits	3.8 (300)	15.1 (28)	11.6 (34)	20.2 (49)	
Other	2.8 (216)	7.6 (14)	6.5 (19)	13.6 (33)	
Paternal work affiliation % (n)					<0.001
Work	95.8 (7257)	88.3 (159)	88.5 (238)	76.8 (179)	
Benefits	2.8 (212)	8.3 (15)	7.4 (20)	14.6 (34)	
Other	1.4 (107)	3.3 (6)	4.1 (11)	8.6 (20)	

Table 3. Mental health variables in adolescence stratified by classes of family income during childhood (*N* = 9154).

	1. Never poor	2. Moving into poverty	3. Moving out of poverty	4. Chronically poor				
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	Chi square	df	p	Pairwise comparisons
SDQ Total	10.03 (0.06)	11.28 (0.32)	11.49 (0.48)	11.31 (0.40)	41.365	3	< .001	1 < 2, 3, 4
Emotion	2.99 (0.03)	3.28 (0.16)	3.52 (0.22)	3.29 (0.18)	14.792	3	0.002	1 < 3
Conduct	1.41 (0.02)	1.57 (0.09)	1.69 (0.13)	1.67 (0.10)	19.139	3	< .001	1 < 3, 4
Hyper	3.92 (0.02)	4.29 (0.14)	4.32 (0.20)	3.70 (0.17)	12.019	3	0.007	1 < 2, 3; 2 > 4; 3 > 4
Peer	1.71 (0.02)	2.15 (0.11)	1.95 (0.15)	2.65 (0.13)	77.107	3	< .001	1 < 2, 4; 2 < 4; 3 < 4
Depression	5.77 (0.07)	6.74 (0.41)	6.68 (0.52)	6.86 (0.51)	15.843	3	0.001	1 < 2, 4
ADHD	26.82 (0.12)	27.72 (0.68)	28.48 (0.93)	25.74 (0.88)	5.667	3	0.129	-
Inattention	14.49 (0.08)	14.92 (0.43)	15.33 (0.60)	13.63 (0.53)	4.704	3	0.195	-
Hyperactivity/ impulsivity	11.44 (0.06)	11.81 (0.37)	11.60 (0.50)	10.58 (0.48)	3.96	3	0.266	-

Figures

Figure 1. Latent classes across 7 time points from 2004 to 2010 (N = 9154).

Figure 2. Association between relative poverty class and symptoms of general mental health problems

Note. Point represent mean, error bars 95% confidence interval. *Note:* Scale on Y-axis is not the same across panels A and B.

Figure 3. Association between relative poverty class and symptoms of depression and ADHD

Note. Point represent mean, error bars 95% confidence interval. *Note:* Scale on Y-axis is not the same across panels A, B, and C.

Supplementary figure 1. Association between relative poverty class and demographics.

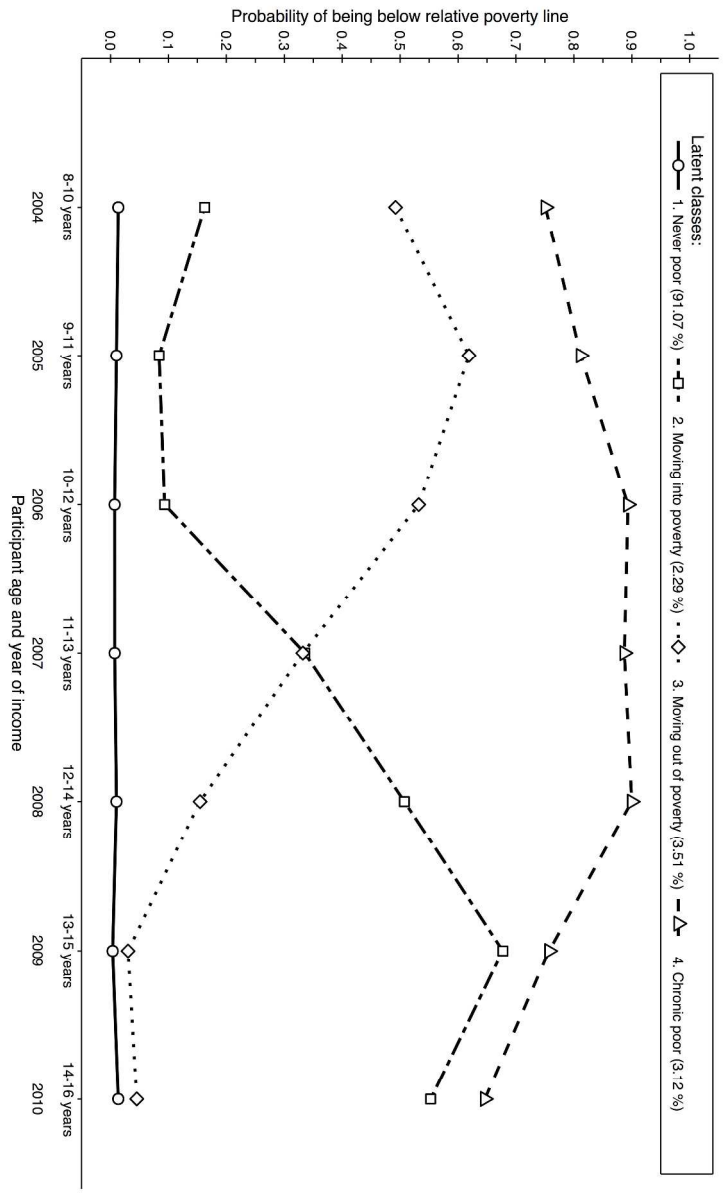

Figure 1. Latent classes across 7 time points from 2004 to 2010 (N = 9154).

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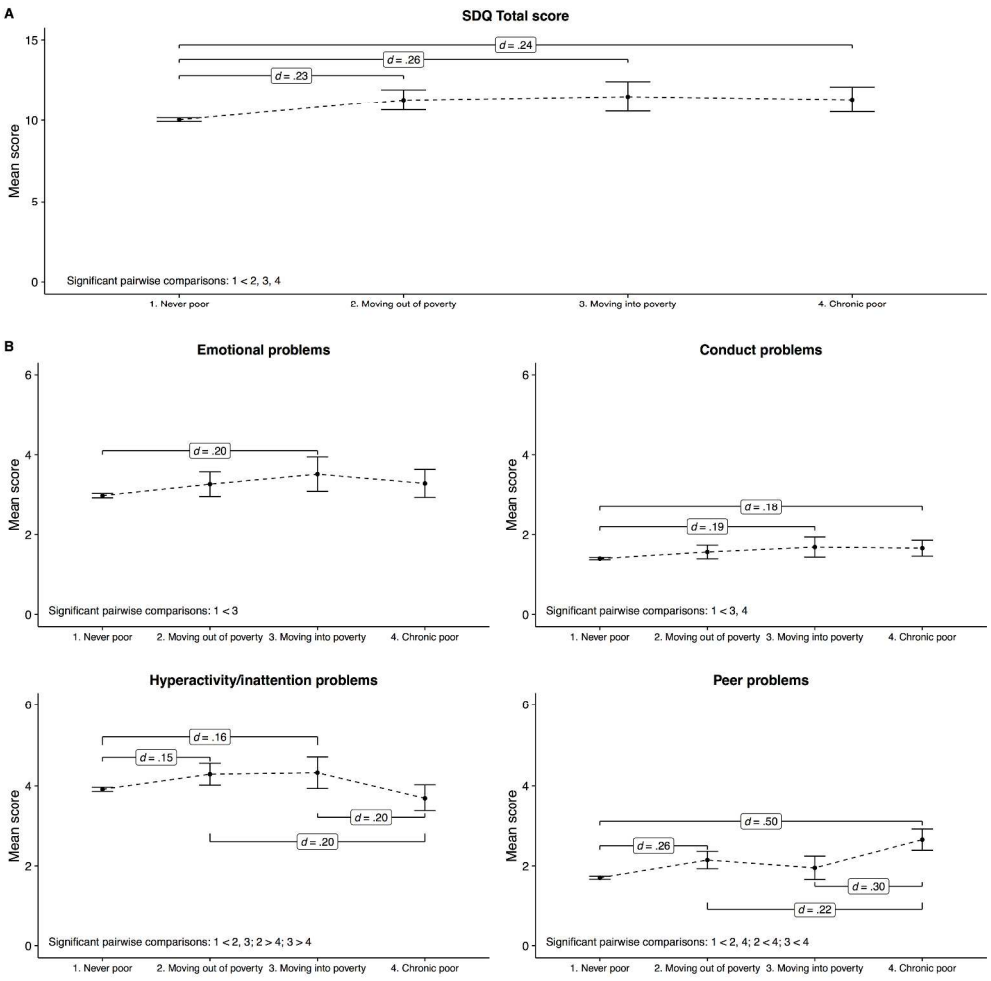

Figure 2. Association between relative poverty class and symptoms of general mental health problems. Note. Point represent mean, error bars 95% confidence interval. Note: Scale on Y-axis is not the same across panels A and B.‼ ┼

355x355mm (300 x 300 DPI)

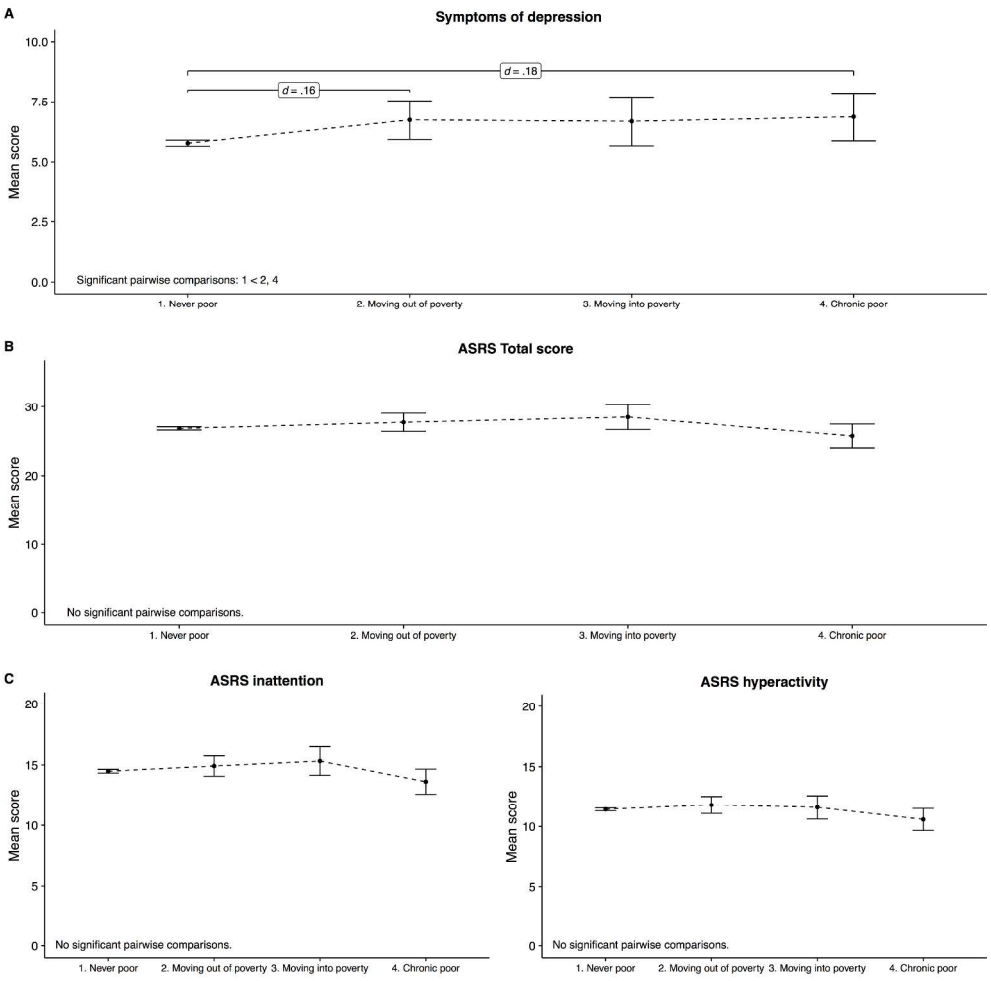

Figure 3. Association between relative poverty class and symptoms of depression and ADHD
Note. Point represent mean, error bars 95% confidence interval. Note: Scale on Y-axis is not the same across panels A, B, and C.

355x355mm (300 x 300 DPI)

189x136mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Title, 2	Title: Economic volatility in childhood and subsequent adolescent mental health problems: A longitudinal population-based study of adolescents
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	Exposure to low income in childhood was found to be associated with most mental health problems in adolescence. There was no strong suggestion of any timing or sequencing effects in the patterns of associations.
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-8	
Objectives	3	State specific objectives, including any prespecified hypotheses	7-8	
Methods				
Study design	4	Present key elements of study design early in the paper	2,3,7	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9	
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	8	

		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-11
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-11
Bias	9	Describe any efforts to address potential sources of bias	12,14,15-16,19-20
Study size	10	Explain how the study size was arrived at	8

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	12
		(*b*) Describe any methods used to examine subgroups and interactions	12
		(*c*) Explain how missing data were addressed	12
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	12, 19-20
		(*e*) Describe any sensitivity analyses	12
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 28
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	29-30
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18-19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-21
Generalisability	21	Discuss the generalisability (external validity) of the study results	19-20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	4

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Economic volatility in childhood and subsequent adolescent mental health problems: A longitudinal population-based study of adolescents

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Economic volatility in childhood and subsequent adolescent mental health problems: A longitudinal population-based study of adolescents

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Abstract

Objective: The aim of the current paper was to investigate the association between the patterns of duration, timing and sequencing of exposure to low family income during childhood, and symptoms of mental health problems in adolescence. **Setting:** Survey administered to a large population-based sample of Norwegian adolescents. **Participants**: Survey data from 9154 16-19 year olds (53% participation rate, 52.7% girls), was linked to registry-based information about childhood family income from tax return data. **Outcome measures**: Mental health outcomes were symptoms of emotional, conduct, hyperactivity, peer problems and general mental health problems measured with the Strengths and Difficulties questionnaire (SDQ), symptoms of depression measured with Short Mood and Feelings Questionnaire (SMFQ), and symptoms of attention-deficit/hyperactivity disorder measured with the Adult ADHD Self-Report Scale (ASRS). **Results:** Latent class analysis and the BCH approach in Mplus were used to examine associations between patterns of poverty exposure and mental health outcomes. Four latent classes of poverty exposure emerged from the analysis. Participants moving into poverty (2.3%), out of poverty (3.5%), or those chronically poor (3.1%) had more symptoms of mental health problems (Cohen's *d*s .16-.50) than those with no poverty exposure (91.1%). This pattern was, however, not found for symptoms of ADHD. The pattern of results was confirmed in robustness checks using observed data. **Conclusions:** Exposure to poverty in childhood was found to be associated with most mental health problems in adolescence. There was no strong suggestion of any timing or sequencing effects in the patterns of associations.

Keywords: poverty; mental health; latent class analysis; childhood; adolescence; ADHD; youth@hordaland

Strengths and limitations of this study

- Data on mental health problems obtained from a survey administered to a large population based sample of Norwegian 16-19 year olds ($N = 9154$) was linked to registry-based information about family income in childhood from tax return data from the Norwegian Tax Administration.
- Using latent class analysis, four trajectories of poverty exposure during childhood were evident.
- The association between trajectories of childhood poverty exposure and symptoms of mental health problems in adolescence was investigated using Mplus and the BCH approach for estimating the means of distal outcomes across latent classes
- Robustness checks were used to verify the results using observed data.
- High attrition, low levels of poverty in Norway, and high school students being overrepresented in the sample, suggest care should be taken when generalizing the results.

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Declaration of conflicts of interest: None of the authors have any conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript.

Author contributions:

TB made substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafted the work, approved the version to be published and is accountable for all aspects of the work.

JCS made substantial contributions to the analysis of data for the work; critically revised the work for important intellectual content, approved the version to be published, and is accountable for all aspects of the work.

BS & MH made substantial contributions to the conception and design of the work, the acquisition of data for the work, critically revised the work for important intellectual content, approved the version to be published, and is accountable for all aspects of the work.

KP, ED & HDZ made substantial contributions to the interpretation of data for the work; critically revised the work for important intellectual content, approved the version to be published, and is accountable for all aspects of the work.

Data sharing statement: No additional data available

Economic volatility in childhood and adolescent mental health

Children who grow up in poverty experience mental health problems to a greater extent than their more affluent peers [1,2]. The associations are often modest [3], however, and particularly small when controlling for genetics, parenting practices, and other characteristics likely to influence children's development [4]. Wagmiller et al. [5] have argued that one reason for the modest association may be that most prior research uses what has been termed a "concurrent indicator approach" where income and the outcome are measured at the same time point. This approach ignores stability and change in income over time, camouflaging improvements and deteriorations of economic circumstances. Indeed, an emerging body of research suggests that it is not necessarily the overall level of concurrent deprivation that is key in understanding how income influences development, but rather, the persistence and timing of poverty, and dynamic changes in families' economic circumstances over time [6-8]. Consistent with this perspective, instability or decline in income can increase parental stress [9], parental depression [10,11], and disrupt parent-child relationships [12]. In turn, these family stress responses to income volatility play a critical role in mediating the effects of economic disadvantage on child outcomes [13-16].

Dissatisfactions with the concurrent indicator approach has led some researchers to find more thorough and ecologically valid estimates of families' economic circumstances over time, such as averaging over several years of income [3], or statistically estimating the permanent component of the economic resources available to the family [17,18]. Alternative approaches have involved measuring the numbers of year a child is living in poverty (often termed cumulative or persistent poverty), or the number and durations of poverty episodes a child has experienced [19,20]. In general, these methodological approaches to capturing income over time produce stronger associations with developmental outcomes than concurrent income indicators [2,3]. Still, these approaches do not fully address the possibility

that families may experience a variety of transitory patterns of economic circumstances over time. Indicators of the number of episodes a child has experienced poverty, for example, may ignore the consequences of when those episodes occurred in a child's life.

The timing of poverty across children's lives has also been a topic of considerable interest. Different types of mental health problems debut at different ages [21], and investigating the co-occurrence of risk factors such as poverty at potentially vulnerable periods may provide more insight into mediating mechanisms. Research is equivocal about whether poverty occurring at an early or later stage of childhood has the most impact on mental health outcomes. Poverty in early (pre-school) childhood has been emphasized as especially detrimental to development [22,23], as this is a crucial time for brain development and may disrupt the many core cognitive and social competencies being acquired during this time. In contrast, others have highlighted middle childhood [24] and early adolescence as particularly sensitive periods [19].

The analytic approach in many studies of timing of poverty is often to investigate the effect of being persistently poor at a particular period during childhood relative to being poor at other times [23,25,26]. A potential limitation of some of the studies on timing is that this analytic approach may also obscure sequencing effects, i.e. that some children move out of, or into poverty between the different periods that are contrasted. In studies of sequencing per se, declines in income has been found to be associated with poorer developmental outcomes [6,13,27]. Furthermore, economic fluctuations seem especially consequential for children living in poverty [6,22], and it has been suggested that economic fluctuations may pose even greater risks to development, compared to disadvantaged, but stable, economic circumstances [28].

The present study was conducted in Norway which is a wealthy country in which absolute deprivation is uncommon [29,30] and where there is relatively little income inequality (as indicated by a GINI-index of .25). In 2012, for example, only 13.1% of children (aged under 18) lived in households in relative poverty. Moreover, Norway provides an elaborate social safety net for its residents such as access to unemployment, sickness, and family related benefits; financial assistance; financial advice and debt counselling; temporary accommodation; employment schemes; and health services. These social benefits may buffer children and families with low socioeconomic status from exposure to some of the physical hardships and psychosocial stressors associated with poverty. However, even with these social services, poorer economic circumstances do appear to be associated with mental health problems in Norwegian children [27,31,32]. Yet, in order to study the relatively small population of poor children with adequate power, large samples, such as in the present study, are required.

In Norway [33], as well as in many other developed economies [30,34,35], the proportion of children that grow up in poverty has risen. The aim of the present study was to investigate different economic trajectories and economic volatility during childhood and subsequent adolescent mental health. We capitalized on historic register-based income information linked to a large population-based study on adolescent mental health. Using latent class analysis, we classified children into groups based on their similarity in exposure to low income during childhood. Then, we investigated the association between class membership and mental health outcomes among 16-19-year-olds adolescents. The advantage of latent class analysis over alternative methods of measuring exposure to low income (e.g., approaches based on concurrent indicators, cumulative poverty exposure, average economic status over time, or importance of being poor in some stages of childhood relative to others), is that it

allows us to simultaneously consider the effects of duration, timing, and sequencing of exposure to low income during childhood [36].

Methods

Procedure and participants

In this population-based study, we used data from the youth@hordaland-survey of adolescents conducted in 2012 in the county of Hordaland in Western Norway ($N = 9154$). The main aim of youth@hordaland-survey was to assess mental health problems among all adolescents in Hordaland County aged 16 to 19 years. All adolescents in upper secondary education received information via e-mail, and one classroom school hour was allocated for them to complete the questionnaire. The questionnaire was web-based and covered a broad range of mental health issues, sleep behaviors and sleep problems, daily life functioning, use of health care and social services, demographics, as well as a request for permission to obtain school data, and to link the information with national registries. Those not in school received information by post to their home address. Uni Research Health collaborated with Hordaland County Council to conduct the study. The study was approved by The Regional Committee for Medical and Health Research Ethics in Western Norway. The results from the current observational study are reported according to the STROBE guidelines.

Overall, Hordaland county is considered representative of Norway with regards to gender and rural/urban residence distribution, and the median household income is also similar to that of the national average [37]. In the period 2005-2010, the mean proportion of children characterized as being *relative poor* (see details below) in Hordaland county was slightly lower (7.3%) than in the country as a whole (8.9%). Official data shows that in 2012, 92% of all adolescents in Norway aged 16-19 attended high school [38], compared

to 98% in the current sample. The GPA in current sample was comparable to the national GPA, but somewhat lower than the GPA in Hordaland country [39].

Measures

Measure of relative poverty

Family income was drawn from the Norwegian national income registry and was based on tax return data from the Norwegian Tax Administration. As the information about income is used by the Norwegian government to estimate taxation, it is considered reliable, precise and of high quality. Using each participant's personal identification number, we were able to obtain information about the equivalised disposable household income for the period from 2004 when children were 8-11 years old, until 2010. Equivalised household income is a measure of household income (i.e. the sum of wages and salaries, income from self-employment, property income and transfers received minus total assessed taxes and negative transfers) that is adjusted by an equivalence scale in order to facilitate comparison between households of different size and composition. It may be viewed as an indicator of the economic resources that are available to a standardized household, and accounts for inflation/changes in median income over time. The equivalence scale used in the current study is the European Union scale (a modification of the OECD equivalence scale) where the first adult is given a weight of 1, subsequent adults are given a weight of 0.5 and each child below 14 is given the weight 0.3 [40]. From this measure of family income, we calculated the proportion of adolescents in *relative poverty,* defined as having an equivalised household income below 60% of the equivalised national median income for that particular year (e.g. to calculate relative poverty proportions for 2004 we used the median income for 2004). This criteria corresponds to the criteria used in income inequality statistics in the European Union [41,42].

Symptoms of general mental health problems

In the youth@hordaland study, adolescents completed the self-report version of the Strengths and Difficulties Questionnaire [43,44]. The SDQ is available from http://www.sdqinfo.org and can be downloaded freely. It consists of five subscales, each containing five items. The scales measure emotional symptoms, conduct problems, hyperactivity-inattention, peer relationship problems, and prosocial behaviors (not included in the current study). Respondents indicated on a three-point Likert-type scale to which extent a symptom applied to them, using the options "Not true", "Somewhat true", or "Certainly true". Each of the subscales consists of five items, and all scale scores ranged from 0-10 in the current sample. Four of the subscales (emotional-, conduct-, hyperactivity-inattention- and peer relationship problems) are summed to provide the SDQ total difficulties scale score (sample range 0-35), with higher scores indicating more problems. Due to the ordinal and categorical nature of the response options, reliability was assessed using polychoric correlation-based version of the reliability coefficients [45]. These analyses, suggested satisfactory internal consistency for the SDQ total difficulties scale ($\alpha = 0.86$) and for all subscales (αs emotional problems = 0.82, conduct problems = 0.71, hyperactivity-inattention = 0.76, peer problems = 0.75, and prosocial behaviors = 0.77). Previous investigations has found the SDQ to be reliable and valid instrument to use in samples of adolescents [46]

Symptoms of depression

The short version of the Moods and Feelings Questionnaire (SMFQ) [47] was used to measure symptoms of depression. The SMFQ consists of 13 statements (e.g., "I am feeling low", "No one likes me", etc.) that the participants respond to using Norwegian translations of the response categories "Not true", "Sometimes true", and "True". The SMFQ is a valid instrument [48] with adequate psychometric properties [49], and a previous study based on

the youth@hordaland study found the SMFQ to be unidimensional, supporting the use of the sum score of SMFQ [50]. Reliability in the current sample was excellent (range = 0-26, ordinal $\alpha = 0.95$).

Symptoms of attention-deficit-/hyperactivity disorder

Hyperactivity-inattention was measured using a Norwegian version of the Adult ADHD Self-report scale [51]. The ASRS consists of 18 statements about hyperactivity-inattention (e.g., "I never remember", "I concentrate easily"), that the participants respond to using options "Never", "Rarely", "Sometimes", "Often", or "Always". The ASRS was originally constructed for use in adults [52], but has also been validated for use among adolescents [53]. The current study used the total score where all 18 items were added together (range = 0-72, ordinal $\alpha = 0.91$), the inattention scale consisting of nine items (range = 0-36, ordinal $\alpha = 0.89$), and the hyperactivity-impulsivity scale consisting of nine items (range = 0-36, ordinal $\alpha = 0.84$). This additional measure of ADHD was included as symptoms of ADHD are only briefly measured by the SDQ, and the age-range in the current sample is at the upper end of the norms of the SDQ.

Demographic variables

Gender and date of birth were identified through personal identity number in the Norwegian National Population Register. Exact age was estimated by calculating the interval of time between date of birth and date of study participation. Family structure (i.e. single- [15%] or two-parent households), parental education levels (elementary [3.7%], intermediate [30.7%], and higher) and work affiliation (i.e. work [93.4%], benefits [3.8%], or other [including students, retirees and stay-at-home parents]), and ethnicity (Norwegian [96.3%], or foreign) were reported by adolescents.

Statistical analysis

Latent class analysis (LCA) was used to identify subsets of participants who shared a similar pattern of family income across all seven time points (2004-2010). LCA is a person-centered approach that we employed to estimate the number of latent classes that could be established based on the family income. The following criteria were used to decide on the number of classes to retain: Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and sample size adjusted BIC (adj BIC) [54]. Also, we used entropy to assess the quality of classification, as well as Vuong-Lo-Mendell-Rubin (VLMR) adjusted likelihood ratio test for the hypothesis that a model with one less class performs just as well. The LCA was done in an iterative manner, where we started with 1 class, and increased the number of classes until the fit criteria suggested a good enough model. Deciding on the retained model, statistic criteria, parsimony, and meaningfulness of the classes was considered. Mplus version 7.4 was used for the LCA-analyses [55]. Differences in mental health variables between the identified classes of income were also tested in Mplus using the BCH approach for estimating the means of distal outcomes across latent classes [56]. Precursory analysis regressing family income classes on age did not suggest any effect of age-cohort. Missing data was handled by the full information maximum likelihood procedure in Mplus.

We further conducted robustness checks using categorizations based on observed data. In a first set of analyses, those who had ever been below the relative poverty line in any of the years (N = 1379) were compared to those who had never been poor (N = 7604) using Welch corrected t-tests. In a second analysis, comparisons were made between the never poor participants, and those who experienced relative poverty early (N = 811) or late (N = 466) using analysis of variance (ANOVA) and Tukey's HSD procedure for pairwise comparisons. The two last groups were made based on having income below the relative poverty line the

2004-2006, but not later (i.e. poor early) or in 2007-2010, but not earlier (i.e. poor late). R for Mac version 3.3.2 [57] was used for all supplementary analyses.

Results

Classes of family income

Based on the overall consideration of the fit statistics, the meaningfulness of the classes and model efficiency, we chose the four-class model as our final model and (see Figure 1 for the final model). Specifically, while the model fit statistics indicated that a four or five class solution fitted the data best (see Table 1), the LMR-LRT test indicated that five classes was better than four and the entropy was slightly better (0.939 in the five-class model versus 0.929). Yet, inspection of the information criterions (AIC and BIC) indicated that little was gained by allowing for more than four classes. Moreover, comparison of the patterns in the four and five class models did not suggest that the fifth class yielded additional information that was qualitatively important. Finally, it was evident that six or more classes were not supported by the data.

Insert Table 1 here

Insert Figure 1 here

The largest class, by far, we termed 'never poor' (class 1; 91.1%). Participants in this class had little exposure to low income throughout childhood, and in any of the years measured, these participants had less than 5% chance of living in relative poverty. The next two classes were characterized by moving into- or out of low income. The 'moving into poverty' (class 2) constituted 2.3% of the sample. Participants in this class had low exposure in 2004-2006, and increasing exposure from 2007 and onwards, with a decline in 2010. The reverse was observed for the 'moving out of poverty' (class 3; 3.5% of the sample), which

had relatively high exposure to low income in 2004-2006, before exposure declined towards 2010. The 'chronically poor' group (class 4) consisted of 3.1% of the sample, and had a much higher probability of exposure to low income in childhood at 75% or higher for six of the seven years measured, before dropping to around 65% in 2010.

Associations with relevant demographic information

The four classes that emerged from the final model were associated with relevant demographic variables in meaningful ways, supporting the validity of the classification. Those in the 'never poor' group had parents with higher education levels, were less likely to live in a single parent household, and their parents were also more likely to work, relative to the other classes. Those in the 'chronically poor' group, were more likely to be ethnic minorities, have parents with lower education levels, and their parents were more likely to not be working. Participants in two classes of transitory poverty were placed in-between these two extremes in their association to demographic variables, see Table 2 (and supplementary figure 1).

Insert Table 2 here

Associations with mental health

The results suggested that there was a main effect of class on all mental health measures with the exception of symptoms of ADHD as measured with the ASRS, see Table 3.

Insert Table 3 here

Generally, a pattern emerged where participants with a consistently low probability of being poor scored lower on mental health problems compared to participants with some exposure to relative poverty. For the SDQ total score, participants who were 'never poor' scored lower than participants who had experienced poverty, but there was no difference within the poverty exposure categories (see Figure 2A). For emotional, conduct and

hyperactivity-inattention problems, participants 'never poor' scored significantly lower relative to those who were moving into poverty, and for conduct problems, also relative to those 'chronicallyally poor' (all *p*s <.05, see Figure 2B). Participants in the 'never poor' category also scored lower on peer problems and symptoms of depression relative to those 'chronically poor' and those 'moving out of poverty' (see Figures 2B & 3A). For peer problems, there were also significant differences within the poverty categories, where those 'chronicallyally poor' had a higher symptom score relative to those moving into- or out of poverty. Differences within poverty categories were also observed for symptoms of hyperactivity-inattention, but the pattern was reversed, and 'chronically poor' participants had the lowest score. A similar, non-significant, trend was also observed for symptoms of hyperactivity-inattention measured with the ASRS total score and for inattention and hyperactivity/impulsivity (see Figure 3B & 3C).

Insert Figure 2 here

Robustness checks

The results from the robustness checks using observed data were largely consistent with those obtained from the LCA analysis. Those who never had experienced poverty had significantly lower scores on all mental health outcomes (Cohen's *d*s = .09-.27, besides symptoms of hyperactivity/inattention measured with the ASRS; Cohen's *d* = .05) compared to those with any poverty exposure. Comparisons were also made between those categorized as never poor, those poor early and those poor late, and there was a significant main effect of categorization for all mental health outcomes (all *p*s <.05). For the SDQ total score, conduct problems and hyperactivity, those poor early and late had significantly higher scores than those who had never been exposed to relative poverty (Cohen's *d*s = .24-.27), but did not differ from each other. For SDQ emotional problems and symptoms of depression (measured

with SMFQ), those never poor had lower scores than those poor early (Cohen's *d*s = .12-.17), but not those poor later. For SDQ peer problems, those in early relative poverty had significantly higher scores than those late or never below the poverty line (Cohen's *d*s = .09-.29). For hyperactivity/inattention measured with ASRS, the test of pairwise comparisons did not reveal any differences between groups (all *p*s > .05), although the ANOVA did show a main effect ($p = .032$), and the never poor group had the lowest mean score. This discrepancy is probably due to the adjustments for multiple comparisons in the Tukey HSD test.

Discussion

In this population-based study in Norway, an affluent country with very low poverty levels, we find that having experienced relative poverty in childhood is associated with significantly more symptoms of mental health problems in adolescence, relative to those who never experienced relative poverty. However, an unexpected exception to this pattern was found for symptoms of hyperactivity/inattention, where those with the most exposure, had the fewest symptoms.

Previously, it has been found that accumulated poverty exposures are most harmful to children's development [58], suggesting that participants in the 'chronically poor' class should display most symptoms of mental health problems. If early exposure is key [23], there should be similarities in mental health problems among participants in the 'chronically poor' and 'moving out of poverty' classes, but if poverty exposure later in childhood is most important [59,60], we expect similarities in mental health problems in the 'chronically poor' and 'moving into poverty' classes. Finally, we would expect children in the 'moving into poverty' class to have the most symptoms of mental health problems if declines in income matter most [22,28].

For SDQ total score, symptoms of depression and SDQ peer problems, those 'never poor' reported fewer symptoms relative to those moving out of poverty and those in the 'chronically poor' group. This may be seen as support for the notion that early poverty exposure is particularly relevant for development of general mental health, depression and peer relationship problems. However, for the SDQ total score and depression, there were no differences within the poverty categories. For SDQ peer problems, those moving into and out of poverty, had lower scores relative to those in the 'chronically poor' category. This finding suggests that long-term, rather than transient poverty exposure may be most relevant for development of peer problems. For SDQ emotional problems and conduct problems, there was a significant difference between the 'never poor' and the 'moving into poverty' group, implicating the importance of declining income. However, again, there were no statistically significant differences within poverty categories, and for conduct problems there were also differences between those who were 'never poor', and those 'chronically poor', so alternative interpretations cannot be ruled out.

A curious finding was seen for symptoms of hyperactivity/inattention, measured with the ASRS. Here the 'never poor' group had lower scores relative to those moving into or out of poverty, but not relative to the 'chronically poor' group. Participants in the 'chronically poor' group also had lower scores relative to those in the transient poverty groups. A similar trend was also observed when symptoms were measured with the SDQ. Previous studies do suggest that ADHD is associated with a range of socioeconomic indicators, including poor economic well-being and poverty [32,61,62], and as such, this unexpected finding warrants further investigation before firm conclusions can be reached.

In summary, the most consistent pattern of results appeared to be that participants who never experienced any poverty exposure had lower rates of mental health symptoms relative to participants with any exposure to poverty, and this pattern of results was confirmed

across latent class analyses and in analyses using observed data. There was little evidence of associations between the timing and sequencing of exposure to low income and participant's levels or types of mental health problems.

Public health implications

The increase in the proportion of children who grow up in poverty is concerning in light of the numerous studies that point to adverse short and long term negative consequences of childhood poverty exposure [e.g., 16,63]. In the current study, poverty exposure was associated with single-parent households, and more common among those with low parental education levels and lower parental workforce participation. Studies suggest that reforms or policies that reduce family unemployment in combination with progressive tax and benefit systems may be effective in reducing child poverty rates [64]. Based on the findings from the current study, and many others, it is likely that reducing the number of children exposed to poverty will also have positive public health effects.

However, poverty influences on youth mental health are mainly indirect [13-16]. This suggests that strategies targeting parental mental health, family conflict, and parenting practices may also be viable compensatory strategies, as are interventions targeting many other domains [16]. In doing so, however, it is imperative to not oversimplify the complexities of poverty and the stressful environment it produces for children and families [65].

Strengths and limitations

Among the main strengths of the current study are the large sample size and use of well validated measures of mental health problems developed for use with adolescents. A particular strength is the register-based information about income that allowed us to capture

fluctuations in family income variation across childhood. This is the same information used by the Norwegian government to estimate taxation, and is considered reliable, precise, and of high quality.

The main aim of this study was to investigate associations between trajectories of low income and mental health, and as such, we did not assess the factors associated with the actual trajectories themselves. There are several reasons why families experience fluctuations in income, such as changes in parental work affiliation or education levels, and structural changes in the family like divorce or reconstitution [5]. Due to lack of historic information about such events, factors causally associated with different trajectories were not explicitly investigated in the current study. Information about mental health outcomes is self-reported using relatively brief measures. Although adolescents may provide accurate information about their own mental health [66], there would have been stronger support for the results had more comprehensive measures such as clinical evaluations been available. Another potential limitation relates to how we operationalized *low income*. The below 60% of median income cut-off has received criticism for being arbitrary, and only indirectly reflecting living conditions [67]. Still, it is the agreed international measure used throughout the EU [41,42] and is one of the most prominent and most-quoted of the EU social inclusion indicators. There are strengths and limitations to both absolute and relative measures of low income, and use of relative measures, such as those used in the current study, have their merits when used within countries to identify those at risk of poverty and social exclusion [30]. Still, Norway has low levels of poverty and economic inequality, which may restrict generalizability of these results.

Non-participation in the study could affect generalizability, with a response rate of about 53% and with adolescents in schools overrepresented. Unfortunately, non-participation in survey research is on the rise [68], and non-response is found related to lower socioeconomic status [69], i.e., official data shows that in 2012, 92% of all adolescents in

Norway aged 16-19 attend high school [38], compared to 98% in the current study. Previous research from the former waves of the Bergen Child Study (a longitudinal study nested within youth@hordaland), has also identified psychological problems as a predictor for non-participation [70]. As the current sample may be skewed towards better socioeconomic status and psychological health, the results may be a conservative estimate of the number of adolescents growing up in poor families and their associated mental health problems.

Finally, latent class analysis is probabilistic in nature, and the uncertainty of classification into the latent classes is expressed in the probability scale of being in either of the poverty trajectories at any given time during the period for which income information was available. As such, the classes may deviate from the results obtained if observed data had been used instead. However, the pattern of results was largely replicated in robustness checks using observed data, and the classes were associated with relevant socioeconomic factors in a meaningful way, increasing our confidence that the latent class approach has captured meaningful patterns in the income data. Still, the method does not give an indication of the magnitude of the economic transition (e.g., moving from affluence to poverty may have greater consequences than moving from relative poverty to poverty).

Conclusion

We used latent class analysis to investigate the association between exposure to low income in childhood and mental health problems in a large sample of Norwegian adolescents. No consistent pattern emerged regarding the timing or sequencing of exposure and associations with particular types of mental health problems in adolescence, rather, having any exposure to relative poverty in childhood appeared to be positively associated with mental health problems in adolescence.

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Tables

Table 1. Model fit statistics for 2 through 6 classes. Bold indicates the selected model (*N* = 9154).

Number of classes	AIC	Sample-size adjusted BIC	Entropy	LMR-LRT	Parametric bootstrapped likelihood ratio test
2	18480.168	18538.862	0.947	<.001	<.001
3	18103.726	18193.723	0.946	<.001	<.001
4	**17808.447**	**17929.748**	**0.929**	**<.001**	**<.001**
5	17728.302	17880.907	0.939	<.001	<.001
6	17702.906	17886.814	0.943	0.078	<.001

AIC: Akaike information criterion; BIC: Bayesian information criterion; LMR-LRT: Lo-Mendell-Rubin adjusted likelihood ratio test.

Table 2. Descriptive characteristics of sample stratified by classes of family income during childhood (*N* = 9154).

	1. Never poor	2. Moving into poverty	3. Moving out of poverty	4. Chronically poor	p
N	8337	210	321	286	
Age (Median)	17.34	17.14	17.18	17.33	0.057
Male % (n)	47.1 (3924)	47.6 (100)	49.5 (159)	45.1 (129)	0.742
Foreign % (n)	3.7 (303)	13.5 (27)	15.2 (47)	42.6 (118)	<0.001
Single parent % (n)	15.3 (1135)	32.8 (59)	28.6 (78)	29.6 (69)	<0.001
Perceived economic well-being % (n)					<0.001
Poorer than others	5.9 (480)	18.4 (38)	14.0 (43)	26.4 (72)	
Equal to others	67.8 (5501)	60.2 (124)	68.7 (211)	56.8 (155)	
Better than others	26.3 (2138)	21.4 (44)	17.3 (53)	16.8 (46)	
Highest education in family % (n)					<0.001
Elementary	3.7 (304)	6.4 (13)	8.3 (26)	10.9 (30)	
Intermediate	30.7 (2532)	35.6 (72)	35.4 (111)	31.2 (86)	
Higher	46.9 (3859)	34.7 (70)	31.5 (99)	31.5 (87)	
Unknown	18.7 (1541)	23.3 (47)	24.8 (78)	26.4 (73)	
Maternal work affiliation % (n)					<0.001
Work	93.4 (7331)	77.3 (143)	81.8 (239)	66.1 (160)	
Benefits	3.8 (300)	15.1 (28)	11.6 (34)	20.2 (49)	
Other	2.8 (216)	7.6 (14)	6.5 (19)	13.6 (33)	
Paternal work affiliation % (n)					<0.001
Work	95.8 (7257)	88.3 (159)	88.5 (238)	76.8 (179)	
Benefits	2.8 (212)	8.3 (15)	7.4 (20)	14.6 (34)	
Other	1.4 (107)	3.3 (6)	4.1 (11)	8.6 (20)	

Table 3. Mental health variables in adolescence stratified by classes of family income during childhood (*N* = 9154).

	1. Never poor	2. Moving into poverty	3. Moving out of poverty	4. Chronically poor				
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	Chi square	df	p	Pairwise comparisons
SDQ Total	10.03 (0.06)	11.28 (0.32)	11.49 (0.48)	11.31 (0.40)	41.365	3	< .001	1 < 2, 3, 4
Emotion	2.99 (0.03)	3.28 (0.16)	3.52 (0.22)	3.29 (0.18)	14.792	3	0.002	1 < 3
Conduct	1.41 (0.02)	1.57 (0.09)	1.69 (0.13)	1.67 (0.10)	19.139	3	< .001	1 < 3, 4
Hyper	3.92 (0.02)	4.29 (0.14)	4.32 (0.20)	3.70 (0.17)	12.019	3	0.007	1 < 2, 3; 2 > 4; 3 > 4
Peer	1.71 (0.02)	2.15 (0.11)	1.95 (0.15)	2.65 (0.13)	77.107	3	< .001	1 < 2, 4; 2 < 4; 3 < 4
Depression	5.77 (0.07)	6.74 (0.41)	6.68 (0.52)	6.86 (0.51)	15.843	3	0.001	1 < 2, 4
ADHD	26.82 (0.12)	27.72 (0.68)	28.48 (0.93)	25.74 (0.88)	5.667	3	0.129	-
Inattention	14.49 (0.08)	14.92 (0.43)	15.33 (0.60)	13.63 (0.53)	4.704	3	0.195	-
Hyperactivity/ impulsivity	11.44 (0.06)	11.81 (0.37)	11.60 (0.50)	10.58 (0.48)	3.96	3	0.266	-

Figures

Figure 1. Latent classes across 7 time points from 2004 to 2010 (N = 9154).

Figure 2. Association between relative poverty class and symptoms of general mental health problems

Note. Point represent mean, error bars 95% confidence interval. *Note:* Scale on Y-axis is not the same across panels A and B.

Figure 3. Association between relative poverty class and symptoms of depression and ADHD

Note. Point represent mean, error bars 95% confidence interval. *Note:* Scale on Y-axis is not the same across panels A, B, and C.

Supplementary figure 1. Association between relative poverty class and demographics.

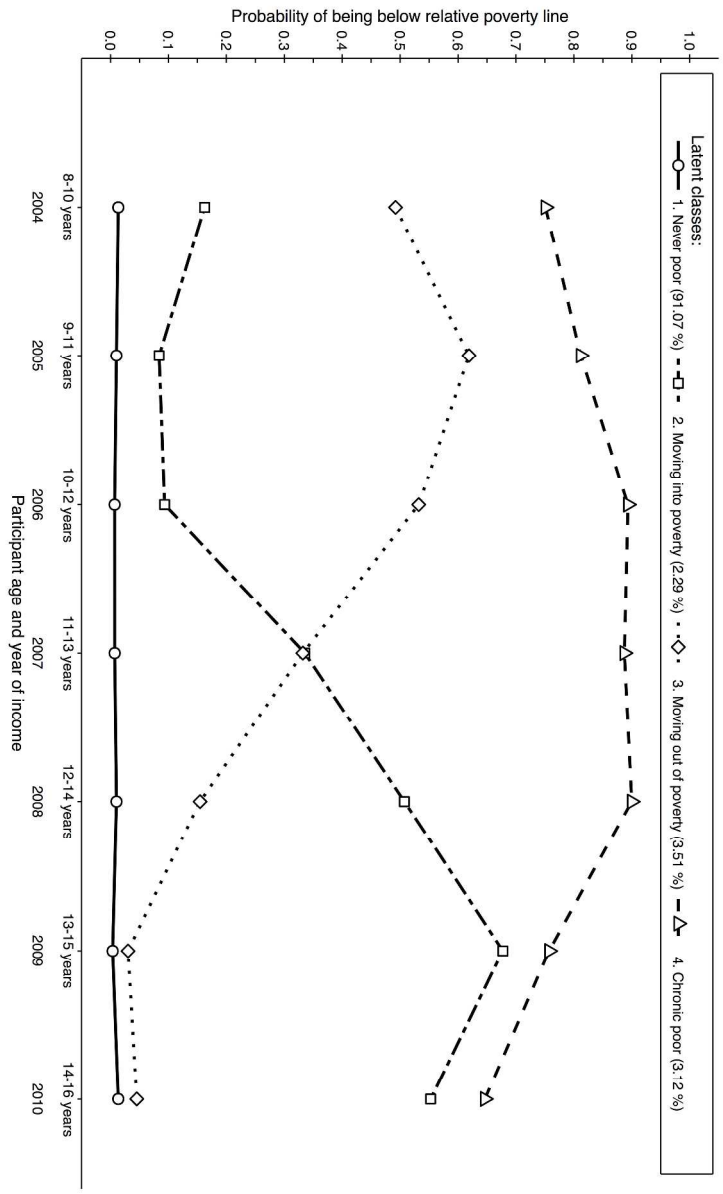

Figure 1. Latent classes across 7 time points from 2004 to 2010 (N = 9154).

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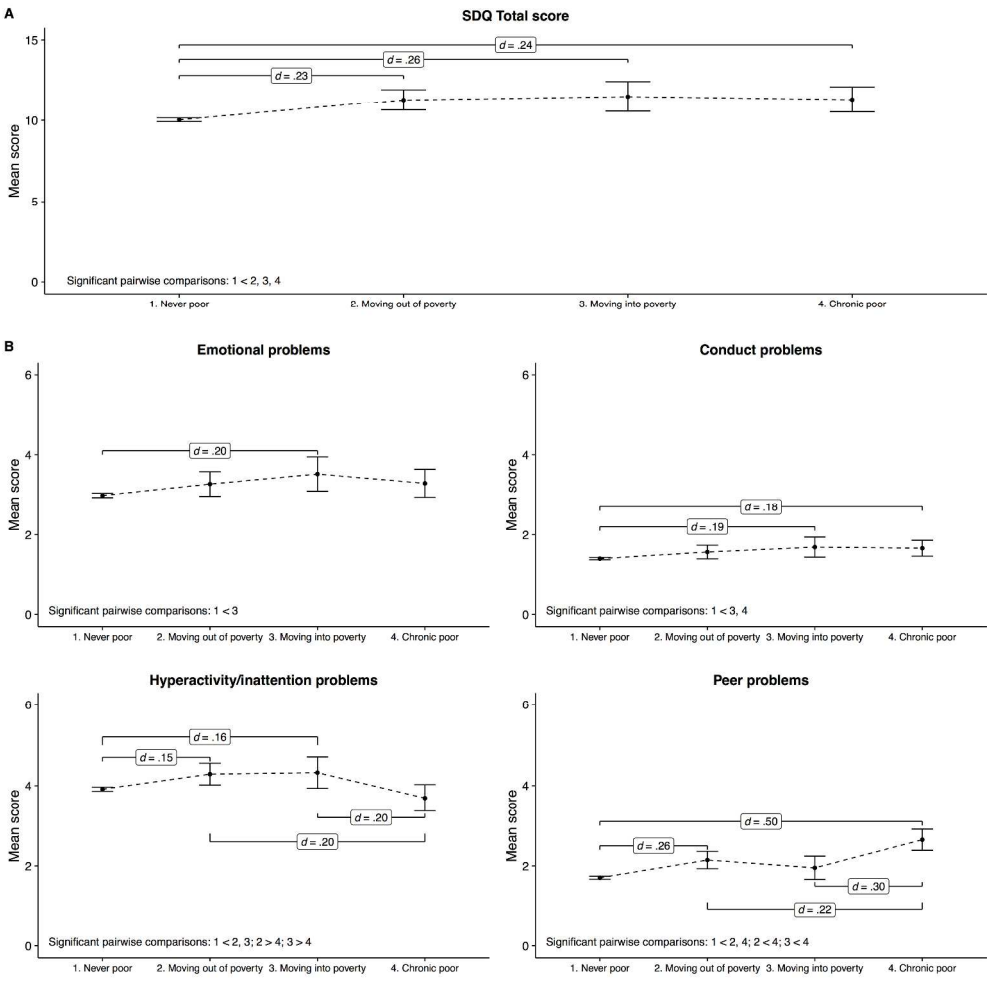

Figure 2. Association between relative poverty class and symptoms of general mental health problems. Note. Point represent mean, error bars 95% confidence interval. Note: Scale on Y-axis is not the same across panels A and B.‼ ┼

355x355mm (300 x 300 DPI)

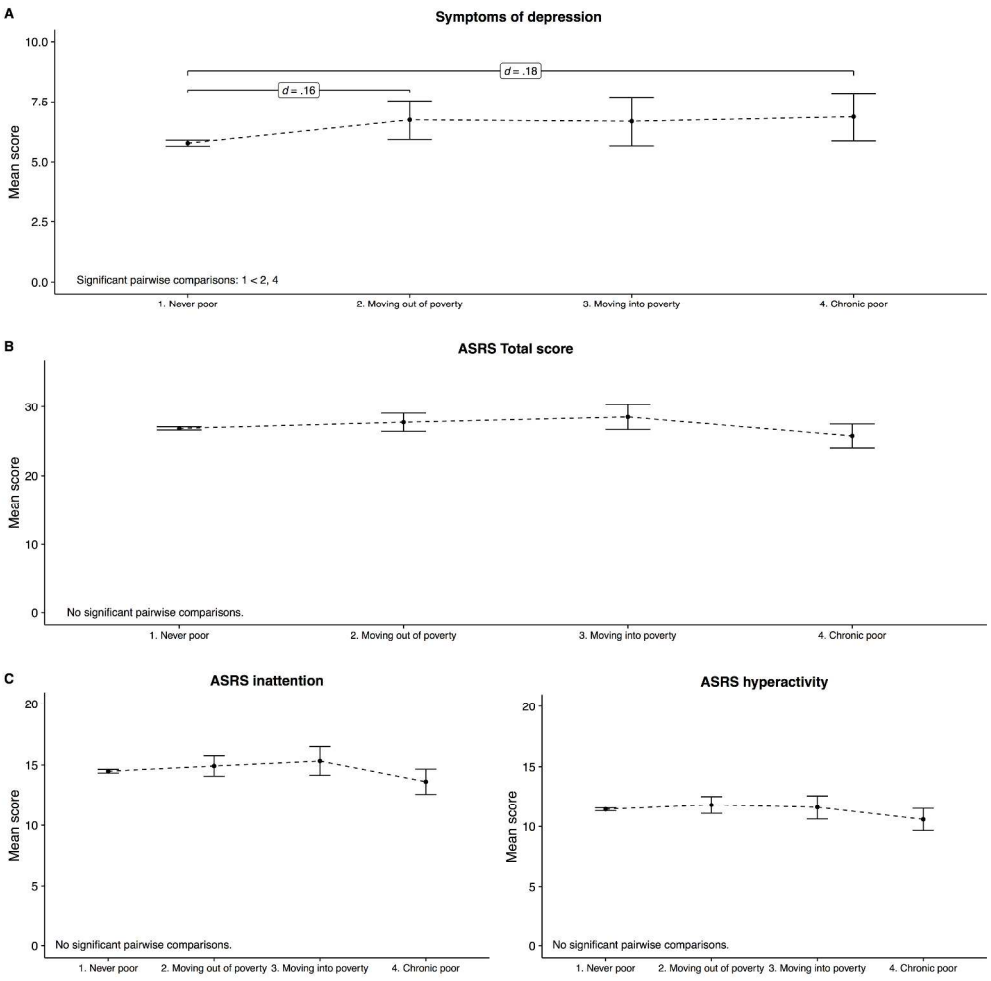

Figure 3. Association between relative poverty class and symptoms of depression and ADHD
Note. Point represent mean, error bars 95% confidence interval. Note: Scale on Y-axis is not the same across panels A, B, and C.

355x355mm (300 x 300 DPI)

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Title, 2	Title: Economic volatility in childhood and subsequent adolescent mental health problems: A longitudinal population-based study of adolescents
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	Exposure to low income in childhood was found to be associated with most mental health problems in adolescence. There was no strong suggestion of any timing or sequencing effects in the patterns of associations.
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-8	
Objectives	3	State specific objectives, including any prespecified hypotheses	7-8	
Methods				
Study design	4	Present key elements of study design early in the paper	2,3,7	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9	
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	8	

		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-11
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-11
Bias	9	Describe any efforts to address potential sources of bias	12,14,15-16,19-20
Study size	10	Explain how the study size was arrived at	8

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	12
		(*b*) Describe any methods used to examine subgroups and interactions	12
		(*c*) Explain how missing data were addressed	12
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	12, 19-20
		(*e*) Describe any sensitivity analyses	12
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 28
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	29-30
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18-19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-21
Generalisability	21	Discuss the generalisability (external validity) of the study results	19-20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	4

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.