

Mental well-being in adolescence and eight years of follow-up for mental illness, risky behaviours, and mortality in 67,945 15–19-year-olds: a prospective cohort study



Janne S. Tolstrup,^{a,*} Sara Rudbæk Larsen,^a Ian Kelleher,^{b,c,d,e} Mary Cannon,^{f,g,h} Christina Viskum Lytken Larsen,^a and Merete Nordentoft^{i,j}

^aNational Institute of Public Health, University of Southern Denmark, Studiestræde 6, Copenhagen, DK-1455, Denmark

^bCentre for Clinical Brain Sciences (CCBS), University of Edinburgh, Kennedy Tower, Royal Edinburgh Hospital, Edinburgh, EH10 5HF, Scotland

^cSchool of Medicine, University College Dublin, Dublin 4, Belfield, Ireland

^dResearch Unit of Clinical Medicine, Faculty of Medicine, University of Oulu, Pentti Kaiteran Katu, Oulu, 90570, Finland

^eSt. John of God Hospital Services Group, Hospital House, Stillorgan, Dublin, A94 X5K8, Ireland

^fDepartment of Psychiatry, RCSI University of Medicine and Health Sciences, 123 St Stephen's Green, Dublin 2, D02 YN77, Ireland

^gFuture Neuro Research Ireland Centre, RCSI University of Medicine and Health Sciences, 123 St Stephen's Green, Dublin 2, D02 YN77, Ireland

^hDepartment of Psychiatry, Beaumont Hospital, Dublin 9, Ireland

ⁱCopenhagen Research Center for Mental Health – CORE, Mental Health Center Copenhagen, Mental Health Services in the Capital Region, Kristineberg 3, Copenhagen, DK-2100, Denmark

^jDepartment of Clinical Medicine, University of Copenhagen, Blegdamsvej 3B, Copenhagen, DK-2200, Denmark



Summary

Background Adolescence is a sensitive developmental period during which complaints of poor mental well-being increase drastically. We investigated how social determinants associated with self-reported mental well-being and how self-reported mental well-being associated prospectively from adolescence to young adulthood with mental illness, risky behaviours, and mortality.

Methods We used data on 67,945 Danish students aged 15–19, surveyed in 2014 (baseline). We employed a person-centred approach using Latent Class Analysis to define mental well-being subgroups with nine indicators of mental well-being: life satisfaction, self-esteem, irritability, low mood, stress, loneliness, self-efficacy, and confidence in parents and friends. By linkage to national health, social, and mortality registers, we obtained information on social determinants at baseline and the following outcomes during young adulthood: Mental illness, self-harm and suicide attempts, alcohol-related and substance use-related hospital contacts, emergency room contacts due to interpersonal violence, and all-cause mortality. Descriptive statistics were produced to illustrate associations between social determinants and mental well-being, and Poisson and Cox regression were used to estimate incidence rates and hazard ratios over the 8.2-year follow-up period.

Findings We identified four distinct groups of mental well-being: Good (32%), Moderate (35%), Poor (19%), and Very Poor (14%). We observed pronounced gradients of social and familial disadvantage such as financial difficulties and parental alcohol problems across mental well-being groups, with greater disadvantage linked to poorer mental well-being. The risk of mental illness, self-harm and suicide attempts, alcohol-related and substance use-related hospital contacts, emergency room contacts due to interpersonal violence, and all-cause mortality was consistently lowest in the Good, at intermediate levels in the Moderate and Poor, and substantially higher in those with Very Poor mental well-being. For example, hazard ratios for mental illness were 1.51 (95% CI = 1.39, 1.64), 2.61 (2.41, 2.82) and 5.32 (4.92, 5.76) in the Moderate, Poor and Very Poor, respectively, corresponding to incidence rate differences of 27.2 (21.5, 32.8), 85.5 (77.4, 93.5) and 230 (214, 246) per 10,000, as compared to the Good mental well-being group. The higher risk of all outcomes remained across 8.2 years of follow-up. The external validity of findings was confirmed by repeating all analyses in independent data.

Interpretation Our study reveals that poor adolescent mental well-being, as operationalised multidimensionally from self-reported information, predicts adverse outcomes and even mortality during young adulthood. These findings urgently call for mental health complaints in adolescents to be taken seriously and prioritised for identification and intervention.

*Corresponding author. National Institute of Public Health, University of Southern Denmark, Studiestræde 6, Copenhagen K, DK-1455, Denmark.
E-mail address: jest@sdu.dk (J.S. Tolstrup).

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Research in context

Evidence before this study

We conducted a literature review in PubMed without language and time restrictions on June 7, 2024, using the search terms: (adolescents OR youth) AND (latent class analysis OR LCA OR latent growth mixture models OR LGMM OR latent profile analysis OR LPA) AND (mental health) AND (mental disorder OR psychiatric disorder OR eating disorder OR self-harm OR suicide attempt OR alcohol OR substance use OR mortality). Previous studies have defined mental health typologies in adolescents, but few utilized data from general population samples, and most relied on psychometric indicators such as anxiety or internalizing problems, omitting positive indicators. While a few studies were longitudinal, aiming to examine the development of mental health types over time, few, if any, assessed associations between mental health types and long-term risks of various pathological outcomes. Surveys indicate a rise in mental health complaints, and there has been a significant increase in mental health diagnoses in adolescents in recent years. With growing awareness of mental health issues, interpreting self-reported mental health concerns becomes challenging, as it is unclear whether they signify temporary problems or are markers of future risks. Therefore, assessing the association between adolescent mental health and long-term outcomes is critical, yet prospective studies involving general population samples are lacking.

Added value of this study

Our study demonstrates that using relatively simple mental well-being indicators to define mental health

multidimensionally can categorize young individuals into distinct and meaningful subgroups. We applied a person-centred approach to data from a large cohort of 15–19-year-olds from the general population of secondary school students ($n = 67,945$). The classification of adolescents into four groups of varying degrees of mental health was consistently and highly predictive of various adverse events in young adulthood, including mental illness, substance abuse, and mortality. We also identified a pronounced clustering of socioeconomic and familial indicators of disadvantage within the mental health groups with poor mental health. This finding underscores that young individuals with poor mental health constitute a vulnerable group, facing multiple challenges.

Implications of all the available evidence

Our study highlights the importance of taking mental health complaints in adolescents seriously and underscores the necessity of identifying and addressing mental health problems in this population. Our findings also support the growing body of research on the significance of social determinants of mental health in young people and demonstrate how the environment and actual situation of the young individual influence their current situation and highly impacts their immediate future. From a policy perspective, the strong association between mental health and long-term adverse outcomes is remarkable, especially considering that this cohort consisted of school students who are likely to be more resourceful compared to young individuals outside the educational system.

Introduction

Mental health and well-being are crucial for all aspects of life, especially for young people. Robust mental well-being is key to successfully transitioning into adulthood, involving increased responsibilities and independence. Recent country-level surveys indicate a significant rise in mental distress among young people, such as low life satisfaction and depressive symptoms.^{1–3} From 2009 to 2019, the proportion of American high school students feeling persistently sad or hopeless increased by 40%,² and in the UK, the National Health Service has observed that the prevalence of probable mental disorders rose between 2017 and 2023 by 13.2%.⁴ These trends are observed globally,

although most of the data come from high-income countries.

The growing prevalence of poor mental health in adolescents has sparked societal and academic concern. Suggested potential causes and triggers include social media, climate change anxiety, and academic pressure.^{5–10} Some also suggest that the trend is at least partly due to reporting bias stemming from a general increased awareness in the population.¹¹ Interpreting self-reported mental health issues in population-wide surveys can be challenging, as it is unclear whether they indicate temporary problems or are a marker of future risks. Most people experience occasional distress, which is usually short-lived and not a threat to long-term

well-being. This is particularly true for young people, who undergo rapid and profound biological (hormonal and neural), psychological, and social changes.^{12,13}

In this study, we used data from a large cohort of 15–19-year-olds from the general population of upper-secondary school students.¹⁴ First, we defined mental well-being as a multidimensional construct and used latent class analysis to explore its structure. In selecting indicators, we – like others before us^{15–17} – drew inspiration from the work of Keyes, as well as Ryan and Deci, and many subsequent researchers. These scholars conceptualize subjective mental well-being as comprising both emotional (hedonic) and functional (eudaimonic) dimensions.^{18,19} Accordingly, mental well-being encompasses the experience of positive emotions, along with a sense of autonomy and the ability to cope with everyday challenges. When choosing which indicators to include in our model, we aimed to capture both dimensions.

Second, we characterized the mental well-being subgroups by social determinants and familial indicators of disadvantage, using information such as parents' financial situation and medical status, including alcohol abuse.^{20,21} It seems reasonable to assume that a successful operationalization of mental well-being would equal a patterned clustering of such determinants. Third, we tested the hypothesis that those with poor mental well-being are at higher risk for adverse outcomes than those with good mental well-being, over an eight-year period. We studied outcomes that are substantial constituents of the disease burden among young people in high-income countries, such as mental illnesses, self-harm and suicide attempts, substance use disorders and interpersonal violence.²² As the most extreme outcome, mortality was also studied. Finally, we investigated the associations between mental well-being subgroups and adverse outcomes segmenting the eight-year follow-up period into two distinct intervals. We posited that mental well-being would exhibit a stronger association with outcomes in the initial interval relative to the latter, given the marked variability of adolescent mental well-being. This hypothesis is supported by prior literature indicating substantial intra-individual fluctuations during adolescence; for example, one study reported that fewer than 24% of individuals maintained a stable status from Grade 9 to Grade 12 (approximately ages 14–18).²³

Methods

We conducted a prospective cohort study by combining data from the Danish National Youth Study 2014 consisting of 75,853 young people from the general population of upper-secondary school students, with national register data covering socioeconomic and health aspects of the participants themselves as well as of their parents. Linkage was made possible using participants'

personal identification numbers, which also enabled linkage to parental data.²⁴

Data sources and setting

The Danish National Youth Study was conducted in 2014 and included a total of 75,853 students from high schools and vocational schools across Denmark.¹⁴ All 137 Danish high schools were invited to participate, with 119 schools (87%) accepting the invitation. At the class level, participation was 96%, and the individual student response rate was 85%. For vocational schools, twelve of the largest institutions (out of a total of 91 nationwide) were invited. Fewer vocational schools were included because unlike high schools, vocational schools have continuous enrolment, decentralized class structures, and off-site internships, making data collection more resource-intensive. As a result, participation was limited to a strategically selected sample based on school size and geographic distribution to ensure regional representation. Of the 12 vocational schools invited, 10 (83%) agreed to participate, and 5179 students (69% of those invited) completed the survey. Further details are available elsewhere.¹⁴

The questionnaire was web-based and consisted of approximately 250 core questions regarding mental and physical health, social relations, risk factors etc. It was designed and pilot tested to be completed within a school lesson of 45 min. Generally, students were between 15 and 20 years old, but some students were outside this age range. We excluded participants younger than 15 years old and 20 years and older ($n = 3762$). A total of 3597 students were excluded due to missing personal identification numbers, and 545 students were excluded due to missing information on all well-being indicators. Finally, we excluded 4 individuals with missing information on ethnicity. The final study population consisted of 67,945 participants (see [Supplementary Fig. S1](#) for flow diagram). Those excluded differed from those with full information on sex, ethnicity, type of education, school year and cohabitation status ([Supplementary Table S1](#)).

We also used data from the Danish National Youth Study 2019. This was, like the Danish National Youth Study 2014, a school-based survey conducted in students in upper secondary education. However, the 2019-version included a somewhat shorter questionnaire and fewer participants ($n = 29,086$).²⁵ We used this data set to test the external validity of our main findings.

Indicators of mental well-being

We aimed to describe mental well-being as a unified concept that encompasses various dimensions. We decided *á priori* to include indicators that represent functional (also referred to as eudaimonic) and emotional (also referred to as hedonic) mental well-being ([Supplementary Table S2](#)).

Items describing functional aspects

Competence capacity to effectively act on the world was measured by self-efficacy: “How often can you manage the things you decide to do?” in categories of Never, Rarely, Sometimes, Often and Very often.

Confidence in friends and parents was measured by the item: “How easy is it to talk to the following persons about things that bother you?”, asked separately for friends, and mother and father, with response options of Very easy, Easy, Difficult and Very difficult.²⁶ The information on mother and father was combined to a single measure, reflecting the highest level of confidence in either parent.

Items describing emotional aspects

Life satisfaction was measured using the Cantril ladder, rating the overall quality of life as a whole from 0 to 10.^{27,28} A score of 0 indicated the worst possible life and 10 the best possible life. Self-esteem was measured by the statement “I am good enough the way I am”, rated on a 5-point Likert scale from 1 (strongly agree) to 5 (strongly disagree).

The students were asked how often they were feeling low and irritable, respectively, in categories of Almost every day, More than once a week, About every week, About every month, and Rarely or never, derived from the HBSC Symptom Check.²⁹ Loneliness was assessed by the item “How often do you feel lonely” in categories of Very often, Often, Sometimes, and Never. Stress was measured by the question “How often do you feel stressed?”, in categories of Never/almost never, Monthly, Weekly, and Daily.

Indicators of family disadvantage

Indicators of the nature of the close environment of the young individual, known to associate with mental well-being, were selected to characterise the groups at baseline^{20,21}: Information on parents receiving social benefits, separation of parents, parental chronic diseases (operationalised by Charlson score ≥ 4 ³⁰) and parental mental illness was obtained from national register information. Self-reported information was used to gain information on financial problems (“Do your parents ever have trouble paying bills?”), alcohol problems in the near family and death of a parent or sibling.

Outcomes

Denmark is a welfare society with free access to welfare benefits, including medical services. When a patient is referred to the hospital, it is mandatory to report the reason for contact in the event of injury resulting from accident, act of violence or intentional self-harm. The Danish National Patient Register contains information on all hospital contacts, including emergency departments and outpatient contacts.³¹ The register is complete with regard to conditions requiring hospital

encounter and the validity (positive predictive value) has been estimated to be 73–83% with variations between clinical specialties.³² Information on mortality was obtained from The Danish Register of Causes of Death.³³

The outcomes were: 1) any mental illness not induced by alcohol, drugs, self-harm or suicide attempt, 2) self-harm and suicide attempts, 3) alcohol-related contacts including events of intoxication and discharges due to alcohol use disorder 4) any substance abuse other than alcohol, 5) emergency contacts due to inter-personal violence and 6) all-cause mortality. Please refer to [Supplementary Table S3](#) for specific ICD-10 codes.

Statistical analysis

Latent class analysis (LCA) is a person-centred approach suited for identifying homogeneous subgroups, in this case to identify adolescents who were similar regarding reporting of the mental well-being indicators.³⁴ Once the model with the optimum number of classes has been fitted, the probability of belonging to a certain group is estimated for each individual who is then assigned to a specific subgroup. We adhered to the approach for conducting and reporting LCA as suggested by Weller et al.³⁵ We used the `proc lca` procedure in SAS v. 9.4, taking into account clustering by school. Mental well-being indicator response levels were collapsed to ensure a minimum of five percent in each category and a maximum of five categories for any indicator ([Supplementary Table S2](#)).

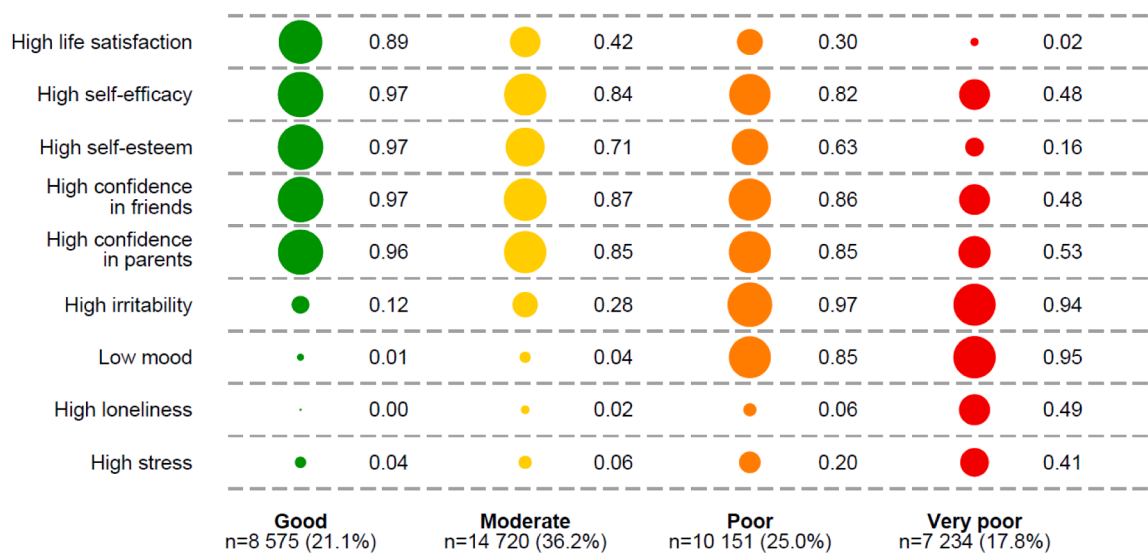
The final number of classes was decided upon based on statistical criteria as well as interpretability.^{35–38} We ran multiple models with increasing number of classes from one to seven, producing a number of statistics to evaluate model fit and class separation ([Supplementary Table S4](#)). Although there is no single best criterium to select a final model, reporting multiple fit statistics and especially paying attention to the Bayesian information criterion (BIC) has been recommended.³⁵ Further, we looked at the average latent class posterior probability (ALCPP) which is the mean of the individual probabilities ([Supplementary Tables S4 and S5](#)). High values of ALCPP reflect better separation of classes as the higher the individual posterior probability the more this individual belongs to one particular class. BIC and the posterior probability are depicted in [Supplementary Fig. S2](#), along with relative class sizes (pie charts). Lastly, the number of individuals in the smallest classes were taken into account as our main interest was general mental well-being and we did not want to study rare subgroups (<5%).³⁷

Finally, our choice was between the four and the five class solution, where we decided on the former. The five-class model had lower values of AIC and BIC and differed significantly from the four-class solution (as estimated by the Vuong-Lo-Mendell-

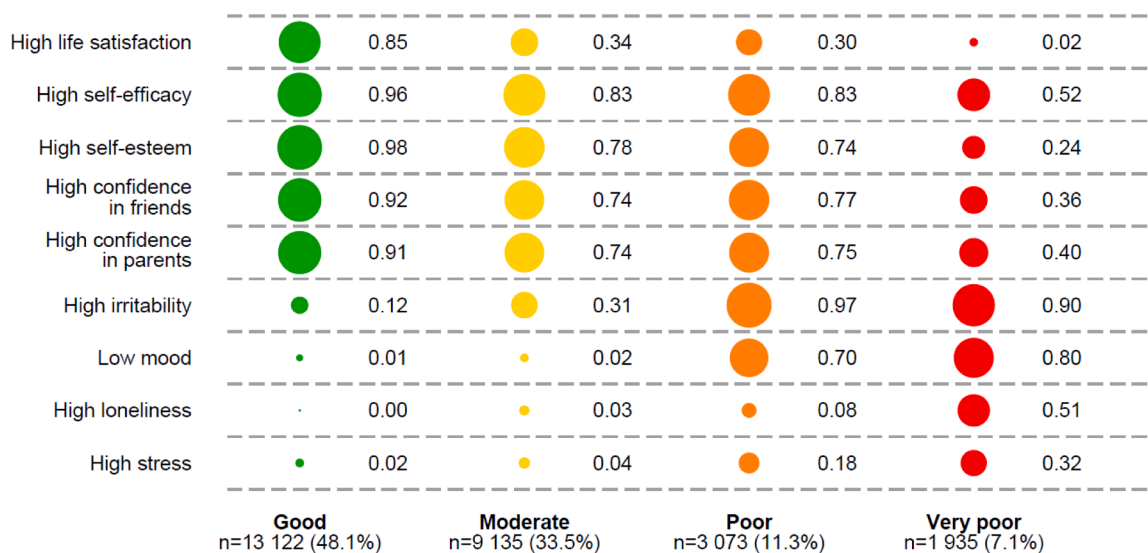
Rubin test).^{39,40} However, the five-class model led to a solution with two very similar classes as judged by the distribution of the mental well-being indicators and thus not contributing additional information as compared to the four-class solution, and the entropy and AICPP was speaking in favour of a four-class solution (Supplementary Fig. S2 and Table S4). Loadings for the final model can be found in Supplementary Table S6.

We ran models on females and males combined because we hypothesised a universal mental well-being typology. We illustrate characteristics of mental well-being classes in females and males separately because of the different prevalences (Fig. 1, please refer to Supplementary Table S2 for cut points). Further, we tested if effects of belonging to a certain class differed in females and males by introducing interaction terms (Supplementary Tables S7 and S8). Our main results

Females (n=40 680)

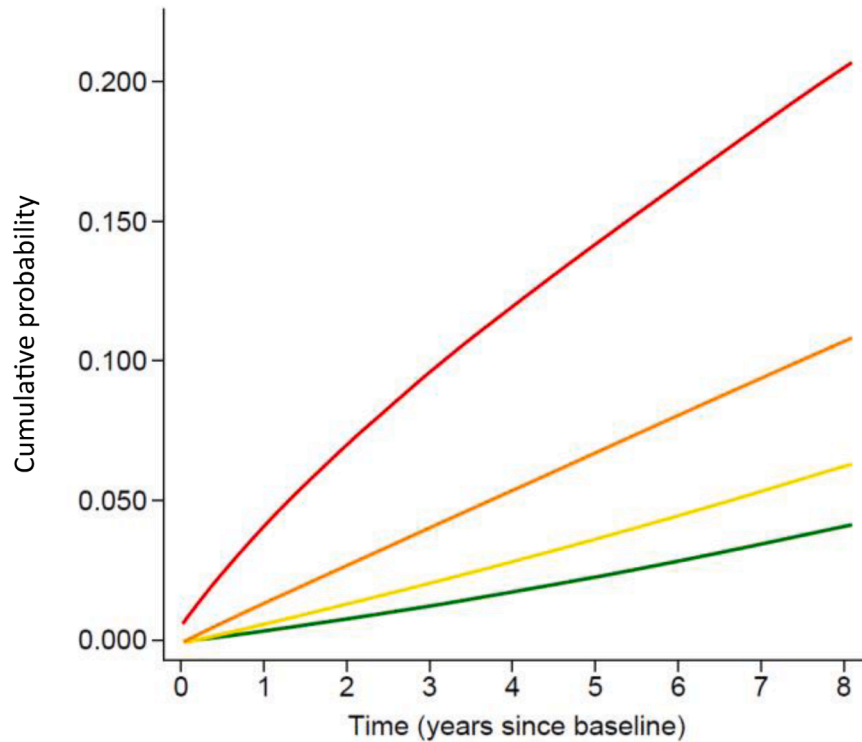


Males (n=27 265)



Mental Well-being Classes

Fig. 1: Bubble chart illustrating the distribution of mental wellbeing indicators in mental wellbeing subgroups in 15–19-year-old females and males of the Danish National Youth Cohort 2014 (n = 67,945).



Subgroup	Events	IR [†]	IRD [‡] (95% CI)	HR (95% CI)
Good	897	53.2	0.0 (ref.)	1.0 (ref.)
Moderate	1 510	80.4	27.2 (21.5, 32.8)	1.51 (1.39, 1.64)
Poor	1 433	139	85.5 (77.4, 93.5)	2.61 (2.41, 2.82)
Very Poor	1 793	283	230 (214, 246)	5.32 (4.92, 5.76)

Fig. 2: Cumulative probability of mental illness* by mental wellbeing subgroup over eight years of follow-up in 15–19-year-old participants of the Danish National Youth Cohort 2014 (n = 67,945). *Admission to psychiatric hospitals for any illness, excl. those related to alcohol, drug use, and suicidal behaviour. †IR: Incidence rate/10,000 person years. ‡IRD: Incidence rate difference/10,000 person years. HR: Hazard ratio. CI: Confidence interval. Adjusted for age, sex, self-perceived ethnicity, school year and type of education; standard errors were adjusted for clustering at the school level.

are from the combined analyses, as presented in Figs. 2 and 3.

Prevalence ratios were estimated by Poisson regression (Table 1).⁴¹ Prospective assessment of associations between mental well-being subgroup and outcomes were done by Cox regression, following individuals from time of survey participation until date of the outcome in question, death, or end of follow-up, whichever occurred first. Combining the survey data from 2014 with registers, we have prospective outcome information for each participant until January 1st, 2023, truncating follow-up at this time. We study first-time events only, meaning that individuals who had an events before baseline were excluded. The proportional hazards assumption was tested graphically as well as statistically, based on

Schoenfeld residuals. For hospitalisation for mental illness as the outcome, the test was statistically significant (p < 0.0001). However, visual inspection revealed no major deviances from proportionality (please also refer to time stratified results in Table 2). Dependency among students within the same school was taken into account by adjusting standard errors for clustering. All models were adjusted for age (continuous), sex (male, female), perceived ethnicity (Danish, Danish and other, other than Danish), school type (vocational school, upper secondary school leaving examination, higher preparatory examination course), school year (first, second, third). We produced an overall trend test for the significance of mental well-being groups by including the groups as a continuous variable (from 1 to 4).

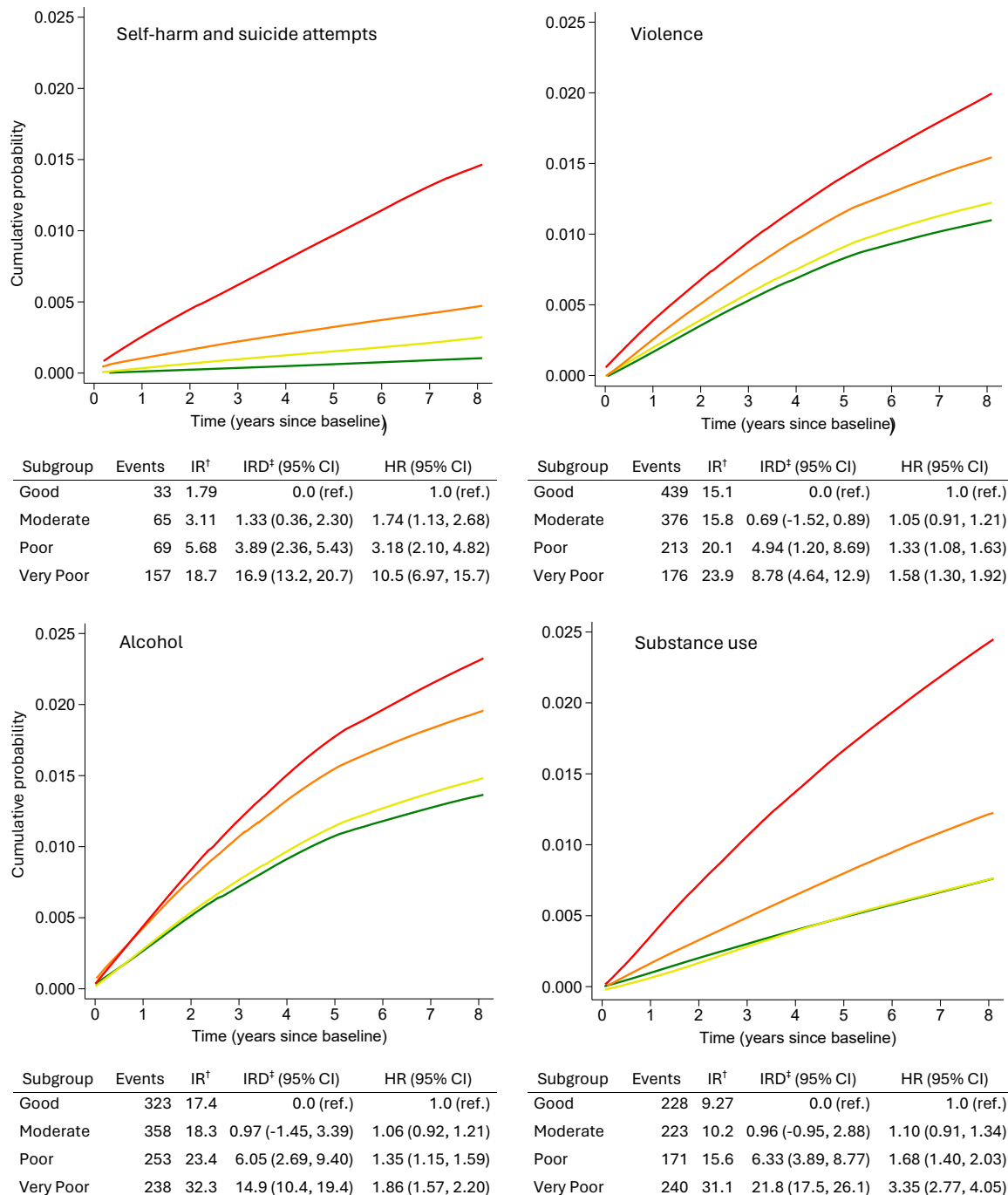


Fig. 3: Cumulative probability of self-harm and suicide attempts, violence, alcohol, and drug related contacts by mental wellbeing subgroup over eight years of follow-up, in 15–19-year-old participants of the Danish National Youth Cohort 2014 (n = 67,945). †IR: Incidence rate/10,000 person years. ‡IRD: Incidence rate difference/10,000 person years. HR: Hazard ratio. CI: Confidence interval. Adjusted for age, sex, self-perceived ethnicity, school year and type of education; standard errors were adjusted for clustering at the school level.

Sensitivity analysis and test for external validity

We conducted a number of analyses to test the robustness of our results. First, we repeated main analysis using the multiple pseudo-class draw method

(20 draws) to account for uncertainty that may arise in assigning group membership by the maximum probability.⁴² We also adjusted for multiple testing using the false discovery rate, as described by Benjamini and

	N	Prevalence (%)	Prevalence ratio (95% CI)	
Parents receive social benefits				
Good mental wellbeing	21 697	3 104 (14.3)	1.0 (ref.)	
Moderate mental wellbeing	23 855	3 561 (14.9)	1.08 (1.04, 1.12)	
Poor mental wellbeing	13 224	2 081 (15.7)	1.14 (1.08, 1.20)	
Very Poor mental wellbeing	9 169	1 789 (19.5)	1.32 (1.25, 1.41)	
Financial problems in the family				
Good mental wellbeing	21 697	1 673 (7.8)	1.0 (ref.)	
Moderate mental wellbeing	23 855	3 488 (14.7)	1.87 (1.77, 1.97)	
Poor mental wellbeing	13 224	2 770 (21.0)	2.62 (2.46, 2.79)	
Very Poor mental wellbeing	9 169	2 716 (29.9)	3.63 (3.40, 3.87)	
Parents are separated				
Good mental wellbeing	21 697	5 686 (26.3)	1.0 (ref.)	
Moderate mental wellbeing	23 855	7 375 (31.1)	1.20 (1.17, 1.23)	
Poor mental wellbeing	13 224	4 735 (36.0)	1.39 (1.35, 1.43)	
Very Poor mental wellbeing	9 169	3 783 (41.5)	1.58 (1.53, 1.64)	
Parental Charlson score ≥4				
Good mental wellbeing	21 697	1 802 (8.3)	1.0 (ref.)	
Moderate mental wellbeing	23 855	2 136 (9.0)	1.10 (1.04, 1.16)	
Poor mental wellbeing	13 224	1 237 (9.4)	1.16 (1.08, 1.25)	
Very Poor mental wellbeing	9 169	918 (10.0)	1.23 (1.13, 1.34)	
Any parental mental illness				
Good mental wellbeing	21 697	1 337 (6.2)	1.0 (ref.)	
Moderate mental wellbeing	23 855	1 591 (6.7)	1.11 (1.04, 1.19)	
Poor mental wellbeing	13 224	926 (7.0)	1.17 (1.08, 1.27)	
Very Poor mental wellbeing	9 169	863 (9.4)	1.53 (1.40, 1.68)	
Alcohol problems in near family				
Good mental wellbeing	21 697	834 (3.8)	1.0 (ref.)	
Moderate mental wellbeing	23 855	1 490 (6.2)	1.60 (1.48, 1.73)	
Poor mental wellbeing	13 224	1 109 (8.4)	2.11 (1.93, 2.30)	
Very Poor mental wellbeing	9 169	1 136 (12.4)	3.04 (2.80, 3.30)	
Death of a parent or sibling				
Good mental wellbeing	21 697	1 087 (5.0)	1.0 (ref.)	
Moderate mental wellbeing	23 855	1 358 (5.7)	1.28 (1.18, 1.39)	
Poor mental wellbeing	13 224	781 (5.9)	1.36 (1.25, 1.49)	
Very Poor mental wellbeing	9 169	729 (8.0)	1.78 (1.61, 1.96)	

CI: Confidence interval. Adjusted for age, self-perceived ethnicity, school year and type of education; standard errors were adjusted for clustering at the school level.

Table 1: Number and prevalence ratios for family disadvantage in 15–19-year-old participants of the Danish National Youth Cohort 2014 (n = 67,945), by mental wellbeing group.

	Follow-up time				Interaction p-value [†]
	0 to <4 years		4 to 8.2 years		
	Events	HR (95% CI)	Events	HR (95% CI)	
Mental illness*	2 785		2 848		<0.001
Good mental wellbeing	361	1.0 (ref.)	536	1.0 (ref.)	
Moderate mental wellbeing	664	1.64 (1.43, 1.87)	846	1.43 (1.29, 1.58)	
Poor mental wellbeing	712	3.13 (2.75, 3.56)	721	2.25 (2.02, 2.51)	
Very Poor mental wellbeing	1 048	7.29 (6.46, 8.23)	745	3.92 (3.50, 4.38)	
Self-harm /suicide attempts	170		154		0.494
Good mental wellbeing	15	1.0 (ref.)	18	1.0 (ref.)	
Moderate mental wellbeing	32	1.87 (0.96, 3.62)	33	1.64 (0.92, 2.95)	
Poor mental wellbeing	41	4.03 (2.14, 7.59)	28	2.45 (1.36, 4.41)	
Very Poor mental wellbeing	82	11.5 (6.42, 20.7)	75	9.62 (5.65, 16.4)	
Alcohol-related contacts	803		369		0.358
Good mental wellbeing	223	1.0 (ref.)	100	1.0 (ref.)	
Moderate mental wellbeing	243	1.04 (0.89, 1.20)	115	1.10 (0.83, 1.47)	
Poor mental wellbeing	182	1.39 (1.14, 1.69)	71	1.25 (0.91, 1.72)	
Very Poor mental wellbeing	155	1.73 (1.41, 2.11)	83	2.16 (1.58, 2.95)	
Drug-related contacts	464		398		0.512
Good mental wellbeing	119	1.0 (ref.)	109	1.0 (ref.)	
Moderate mental wellbeing	120	1.14 (0.86, 1.51)	103	1.07 (0.83, 1.37)	
Poor mental wellbeing	87	1.65 (1.24, 2.19)	84	1.72 (1.31, 2.27)	
Very Poor mental wellbeing	138	3.69 (2.89, 4.72)	102	2.97 (2.27, 3.89)	
Violence	744		460		0.636
Good mental wellbeing	281	1.0 (ref.)	158	1.0 (ref.)	
Moderate mental wellbeing	228	1.02 (0.86, 1.20)	148	1.09 (0.87, 1.37)	
Poor mental wellbeing	130	1.33 (1.05, 1.69)	83	1.32 (0.98, 1.78)	
Very Poor mental wellbeing	105	1.54 (1.21, 1.96)	71	1.64 (1.25, 2.15)	
Mortality	29		59		0.276
Good mental wellbeing	7	1.0 (ref.)	15	1.0 (ref.)	
Moderate mental wellbeing	8	0.98 (0.33, 2.93)	19	1.38 (0.75, 2.55)	
Poor mental wellbeing	4	0.86 (0.29, 2.53)	15	2.21 (1.11, 4.41)	
Very Poor mental wellbeing	10	2.96 (1.09, 8.06)	10	2.15 (0.91, 5.08)	

Adjusted for age, self-perceived ethnicity, school year and type of education; standard errors were adjusted for clustering at the school level. HR: Hazard ratio. CI: Confidence interval. ^aAdmission to psychiatric hospitals for any illness, excl. those related to alcohol, drug use, self-harm, or suicide attempt. ^bAnalysis based only on data from females. [†]Test statistic for the interaction between follow-up time and the outcome.

Table 2: Hazard ratios for outcomes by mental wellbeing subgroup in 15–19-year-old participants of the Danish National Youth Cohort 2014 (n = 67,945), in strata of follow-up time.

Hochberg.⁴³ The correction was applied to p-values for trend in the main results. Finally, we verified the external validity of our findings, by repeating the latent class analysis using an independent data set collected in 2019,²⁵ applying identical indicators and model specifications to re-evaluate the primary associations between mental well-being subgroups and outcomes. This dataset derived from the Danish National Youth Study 2019, a school-based survey targeting students in upper

secondary education, akin to the 2014 study. However, the 2019 version has a smaller sample size (n = 29,086). This analysis served to assess the external validity of our principal findings.

Ethics approval

The Danish Data Protection Agency approved data collection for the Danish National Youth Cohort 2014 (J. No. 2013-54-0526). At the beginning of the

questionnaire, participants had to read and accept an informed consent form that clearly expressed that participation was voluntary and that individual data would be kept confidential. The Danish Data Protection Agency also approved the linking of data to registers and all local confidentiality and privacy requirements were met including de-identification and aggregation of data.

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Results

We included 67,945 secondary school students, aged 15–19 years, at baseline in 2014 and eligible for the present study (Supplementary Fig. S1). Most were females (59.9%), at first year of school (40.0%), of Danish ethnicity (89.9%), living with both parents (68.8%), living in intermediate density areas (36.7%) and had parents with medium length of education (38.5%).

Latent class analysis-derived mental well-being classes

Four mental well-being groups were identified, named Good mental well-being, Moderate mental well-being, Poor mental well-being and Very Poor mental well-being, based on qualitative considerations of the class loadings (Supplementary S6). For graphical representation, the distribution of dichotomised indicators is shown in Fig. 1. As the names imply, mental well-being varied across groups, with very high levels of positive and very low levels of negative indicators in the Good, to more intermediate levels in the Moderate and Poor, to low levels of positive and high levels of negative indicators in the Very Poor mental well-being group (Fig. 1). As seen for females, 89% in the Good mental well-being group had high life satisfaction whereas this was the case for 2% only in those with Very Poor mental well-being. In the Good mental well-being group of males, feeling low and experiencing loneliness were virtually absent, whereas in the Very Poor mental well-being group, this was the case for 80% and 51%, respectively. A description of the groups can also be found in Supplementary Table S10. The mean age in the four subgroups was comparable (Supplementary Table S9).

The mental well-being groups appeared similar in females and males as the pattern of mental well-being indicators was similar; however, the relative sizes of groups differed, with Good mental well-being being much more prevalent in males than in females (48.1% vs. 21.1%) and Very Poor mental well-being being

much less prevalent in males than in females (7.1% vs. 17.8%).

Family disadvantage in mental well-being groups

Disadvantages were least prevalent in the Good mental well-being group, at intermediate levels in the Moderate and Poor mental well-being groups and most prevalent in the Very Poor mental well-being group (Table 1). For example, the prevalence ratios (adjusted for age, sex, school factors and ethnicity) of having alcohol problems in the near family were 1.60 (95% confidence interval [CI] = 1.48, 1.73), 2.11 (95% CI: 1.93, 2.30) and 3.04 (95% CI: 2.80, 3.30), in young persons in the Moderate, Poor and Very Poor mental well-being groups, as compared to the Good mental well-being group. Another example is the prevalence of financial problems in the family where prevalence ratios were 1.87 (95% CI: 1.77, 1.97), 2.62 (95% CI: 2.46, 2.79) and 3.63 (95% CI: 3.40, 3.87), in young persons in the Moderate, Poor and Very Poor mental well-being groups, as compared to the Good mental well-being group. These findings were comparable in females and males, as verified qualitatively as well as statistically (all p-values for interaction > 0.05), with the exception of financial problems in the family (p-value = 0.045) (Supplementary Table S7).

Risk of adverse outcomes including mortality in mental well-being groups

Next, we studied how the mental well-being groups associated with the risk of five adverse outcomes (Figs. 2 and 3) and all-cause mortality (Supplementary Table S11) during the 8.2 years following baseline.

Hospitalisation for mental illness was the most common outcome. During the follow-up period, 5633 of 67,945 adolescents had at least one hospital contact due to mental illness, corresponding to 8.3%. This number was much higher in adolescents in the Very Poor mental well-being group (19.6%) compared to adolescents in the Good mental well-being group (4.1%).

For all outcomes the risk was highest in the Very Poor mental well-being group and lowest in the Good mental well-being group, with risk in the Moderate and Poor mental well-being groups being in-between. For example, the hazard ratios (HR) for having had a hospital contact due to mental illness were 1.51 (95% CI = 1.39, 1.64), 2.61 (95% CI = 2.41, 2.82), and 5.32 (95% CI = 4.92, 5.76) in the Moderate, Poor, and Very Poor mental well-being groups, respectively, compared to the Good mental well-being group (Fig. 2).

The most pronounced relative risk was observed for self-harm and suicide attempts, where the HR for the Very Poor mental well-being group compared to the Good mental well-being group was 10.5 (95% CI = 6.97, 15.7) (Fig. 3). The mortality rate was low as expected in this young age group (88 deaths in total; 47 in females

and 41 in males). The HR for all-cause mortality was 2.54 (95% CI = 1.37, 4.71) in the Very Poor compared to the Good mental well-being group. Of the 88 total deaths, the manner of death was known in 69 cases: 23 (33%) died from natural causes, 22 (32%) died from suicide and 24 (35%) died from accidents or homicide.

Despite the quite large difference in the relative size of the groups in females and males, the HRs for adverse outcomes as well as mortality appeared similar (Supplementary Table S8). This was confirmed by a statistical test for interaction (all p-values > 0.05), except for any mental illness (p = 0.042) and drug-related contacts (p = 0.035).

Adjustment for covariates had little impact on the size and precision of HRs (Supplementary Table S11).

Risk of adverse outcomes and mortality in mental well-being groups in four-year strata of follow-up time

We reanalysed all outcomes, separating up to four years of follow-up from four years to end of follow-up. Although this procedure naturally reduced the statistical power, HRs for the first period (0–4 years) were remarkably similar to HRs in the latter period (4–8.2 years) (Table 2). For example, HRs for drug-related hospital contacts were 1.14 (95% CI = 0.86, 1.51), 1.65 (95% CI = 1.24, 2.19), and 3.69 (95% CI = 2.89, 4.72) for the Moderate, Poor, and Very Poor mental well-being groups, respectively, compared to the Good mental well-being group during the first four years of follow-up. During the follow-up period from four to 8.2 years after baseline, the HRs were 1.07 (95% CI = 0.83, 1.37), 1.72 (95% CI = 1.31, 2.27), and 2.97 (95% CI = 2.27, 3.89), respectively, compared to the Good mental well-being group (Table 2).

Sensitivity analyses

The sensitivity analysis using the multiple pseudo-class draw method⁴² to examine the effect of uncertainty that may arise from assigning group membership also showed similar results (Supplementary Table S11) when compared to the maximum probability assignment rule. Application of the Benjamini-Hochberg correction for multiple comparisons did not alter the p-values for trend in mental well-being groups (Supplementary Table S11).

We employed the exact same procedure on an independent dataset (The Danish National Youth Profile 2019, n = 26,934). Thus, a four-class model with the nine mental well-being indicators was used to derive groups, HRs were assessed (Supplementary Table S12). The four resulting mental well-being groups appeared qualitatively similar to the Good, Moderate, Poor, and Very Poor groups (data not shown). Individuals were followed for an average of 3.7 years. Results confirmed that the classification of adolescents into four mental well-being groups predicted the outcomes, with the

lowest and highest risk consistently being observed in the Good and Very Poor mental well-being groups, and risk in the Moderate and Poor mental well-being groups being in-between. For mortality, a total of 14 cases were observed and, while confidence intervals were broad, the HRs in the Moderate, Poor, and Very Poor mental well-being groups were significantly higher compared to the Good mental well-being group.

Discussion

Mental health and well-being among young people is a significant public health concern.³ Our data reveals that using relatively simple indicators of mental well-being among youth can categorize young individuals into distinct and meaningful subgroups. We found that socioeconomic and familial disadvantage, such as financial issues and parental alcohol problems, were much more common in certain mental well-being groups, particularly affecting young females and males with Very Poor mental well-being (17.4% and 7.8% of the population, respectively). Mental well-being subgroups predicted future adverse outcomes, and the risk of any mental illness, self-harm and suicide attempts, alcohol and substance abuse, interpersonal violence and all-cause mortality, varied significantly among the mental well-being groups. Individuals with Very Poor mental well-being had the worst prospects, followed by those with Poor and Moderate mental well-being, while those with Good mental well-being consistently had the lowest risk. These outcomes were chosen based on their substantial contribution to overall disease burden among young people in high-income countries²² underscoring the importance of our findings.

Contrary to our initial hypothesis, poor mental wellbeing was consistently and strongly associated with adverse outcomes not only in the immediate period after baseline but also across the entire 8.2-year follow-up period: We anticipated that mental wellbeing would be most strongly linked to detrimental outcomes in the period immediately following baseline, based on prior literature suggesting substantial intra-individual fluctuations in mental wellbeing in similar age groups. Specifically, the phenotype with the poorest mental wellbeing has been shown to exhibit the least temporal stability,²³ implying that such states may be transient and therefore less likely to predict long-term consequences. This unexpected stability in predictive strength raises important questions about the persistence and impact of poor mental wellbeing during adolescence. This discrepancy may reflect methodological differences, such as the operationalization of wellbeing categories, the timing and frequency of assessments, or the analytic approach used to model change. Further research is needed to investigate the stability of adolescent wellbeing and to clarify the

mechanisms through which poor mental wellbeing may exert long-term effects.

Our study has strengths as well as limitations. Limitations include that the true incidence of outcomes were not identified as we captured the most severe cases by relying on hospital data. Cases that were not acutely treatment demanding are lacking or at least underrepresented. Naturally, this limitation does not apply for mortality. Another limitation is that our cohort consisted of young people in secondary education, so we did not include those outside the school system well-known to have worse mental and physical health. Therefore, the distribution of mental well-being subgroups in our study likely underrepresents the Poor and Very Poor groups compared to the general population. On a similar note, Denmark is a high-income country with social welfare and universal health care, and our findings may not apply to other countries. Another limitation is that we did not account for the fact that approximately nine percent of participants had full siblings in the data. While we acknowledge that our analysis does not adjust for the interdependence between these individuals, we believe that its impact is likely negligible. Lastly, the entropy, which is a measure of how well the latent class analysis separates individuals into distinct classes, was lower than 0.80, often suggested to be the lower threshold for good class separation, although no specific cutoff is agreed upon.^{35,44} However, the prospective analysis showed a differentiation regarding risk of adverse outcomes, implying that the mental well-being subgroups had distinct properties.

Strengths include the study size which was unusually large for this age group with a high participation rate in combination with the prospective design. Our study was unique in terms of the variety of outcomes included, which demonstrated the breadth of the burden associated with poor mental well-being. We were able to follow each participant in nation-wide registers thus minimising bias due to loss of follow-up. Another strength was the ability to link to parents' social and health register data, allowing us to include independent information on the adolescents' social and family backgrounds. This conveyed a deep understanding of background factors of the adolescents in the mental well-being groups.

Our approach was person-centred, meaning that we aimed to categorise adolescents based on their similarities regarding the pattern of well-being indicators. This contrasts with a variable-centred approach, where individuals are categorised based on specific cut points of a variable of interest. We adjusted results for basic socioeconomic variables (age, sex, ethnicity, school type and school year), not including etiological factors (potential confounders) such as social determinants or family disadvantage. We were not interested in mechanistically explaining differences between the mental

well-being groups but rather, we sought to answer the question *what is the face value of having answered the questionnaire in a certain way?*

Other studies have also adopted a person-centred approach to operationalize mental health and well-being as multidimensional, often guided by the dual-factor model.^{45–49} This model is based on the idea that mental well-being should be understood through two distinct dimensions: one representing mental illness and the other reflecting mental well-being. In contrast, we took a slightly different approach,^{18,19} defining mental well-being through a framework focused on emotional and functional aspects, without incorporating mental illness or symptomatology. This perspective aligns to some extent with the World Health Organization's definition of mental health as "a state of mental well-being that enables people to cope with the stresses of life, realize their abilities, learn and work well, and contribute to their communities," and which is "not defined by the presence or absence of mental disorder".^{50,51}

The Good mental well-being group manifests these definitions in practice; the young females and males in the Good mental well-being group feel good about and believe in themselves; they have supportive friends and family and are not weighed down by emotional symptoms or loneliness - in stark contrast to the mental well-being of those with Poor and Very Poor mental well-being.

In our literature review, we focused on studies that aimed to define mental well-being as a multidimensional construct using person-centred statistical approaches. Specifically, we included studies employing Latent Class Analysis (LCA), Latent Profile Analysis (LPA), and Latent Growth Mixture Models (LGMM), as these methods are particularly suited for identifying subgroups based on patterns of mental well-being indicators. We acknowledge that this approach did not systematically include studies using other methodologies, such as factor analysis, cluster analysis, or network analysis.

Our findings have a number of implications. First, they show that combining relatively simple questions related to mental well-being, available in many surveys, can create subgroups that are predictive of future outcomes. This classification can serve as a target for intervention and is important for policymakers who may consider directing such efforts. Adolescent years are formative in human neurophysiological development, as key periods of brain development and maturation. This period is sometimes referred to as a "window of vulnerability" due to the increased risk of emotional problems,⁵² is also a period of opportunity,⁵³ with the identification of and intervention for mental health difficulties at this age having the potential to significantly impact on the young person's long-term outcomes.

Second, we identified a pronounced difference in socioeconomic and familial indicators of disadvantage

in the mental well-being groups. This supports a growing body of research on the importance of social determinants for mental health and well-being in young people²⁰ and shows how the environment and actual situation of the young individuals influences their current situation as well as their immediate future. Thus, findings demonstrate that mental health complaints in adolescents should be taken seriously.

Third, from a policy perspective, the strong association between mental well-being and long-term adverse outcomes is remarkable. For those in the Very Poor mental well-being group, almost 20% had a mental illness diagnosis within the study period of 8.2 years, calling for further investigation to test if the classification can be used for screening and tailored interventions, integrated into the school setting. This approach has obvious advantages especially in cases where the home situation is unstable and simply because school is where the young individual can be reached. Preventing school-dropout in these young individuals should be of paramount priority as not completing a secondary education is associated with a range of adverse outcomes and poorer socioeconomic situation, tracking through lifetime.³⁴

In summary, our study shows that poor adolescent mental well-being, as defined through multidimensional self-reported information, strongly predicts adverse outcomes in young adulthood. These findings highlight the importance of identifying and addressing mental health complaints in adolescents.

Contributors

JT conceived the study idea, performed data analysis and wrote the manuscript. JT and SR designed the tables and figures. All authors contributed to designing the study, interpretation of the data and critically reviewing the manuscript. JT is the co-corresponding author. All authors approved the manuscript. JT and SR accessed and verified the underlying data. JT was responsible for the decision to submit.

Data sharing statement

Data from the Danish National Youth Study are available upon reasonable request from the corresponding author.

Declaration of interests

IK was supported by grants (awarded to his institutions) from the Health Research Board (ECSA-2020-005), the Academy of Medical Sciences (APR8\1005), and the UK Department for Business, Energy and Industrial Strategy. The other authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.lanepe.2025.101435>.

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