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Incidence Rates and Cumulative Incidences of the Full Spectrum of Diagnosed Mental Disorders in Childhood and Adolescence

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+ Supplemental content

IMPORTANCE Knowledge about the epidemiology of mental disorders in children and adolescents is essential for research and planning of health services. Surveys can provide prevalence rates, whereas population-based registers are instrumental to obtain precise estimates of incidence rates and risks.

OBJECTIVE To estimate age- and sex-specific incidence rates and risks of being diagnosed with any mental disorder during childhood and adolescence.

DESIGN This cohort study included all individuals born in Denmark from January 1, 1995, through December 31, 2016 (1.3 million), and followed up from birth until December 31, 2016, or the date of death, emigration, disappearance, or diagnosis of 1 of the mental disorders examined (14.4 million person-years of follow-up). Data were analyzed from September 14, 2018, through June 11, 2019.

EXPOSURES Age and sex.

MAIN OUTCOMES AND MEASURES Incidence rates and cumulative incidences of all mental disorders according to the *ICD-10 Classification of Mental and Behavioral Disorders: Diagnostic Criteria for Research,* diagnosed before 18 years of age during the study period.

RESULTS A total of 99 926 individuals (15.01%; 95% CI, 14.98%-15.17%), including 41 350 girls (14.63%; 95% CI, 14.48%-14.77%) and 58 576 boys (15.51%; 95% CI, 15.18%-15.84%), were diagnosed with a mental disorder before 18 years of age. Anxiety disorder was the most common diagnosis in girls (7.85%; 95% CI, 7.74%-7.97%); attention-deficit/hyperactivity disorder (ADHD) was the most common in boys (5.90%; 95% CI, 5.76%-6.03%). Girls had a higher risk than boys of schizophrenia (0.76% [95% CI, 0.72%-0.80%] vs 0.48% [95% CI, 0.39%-0.59%]), obsessive-compulsive disorder (0.96% [95% CI, 0.92%-1.00%] vs 0.63% [95% CI, 0.56%-0.72%]), and mood disorders (2.54% [95% CI, 2.47%-2.61%] vs 1.10% [95% CI, 0.84%-1.21%]). Incidence peaked earlier in boys than girls in ADHD (8 vs 17 years of age), intellectual disability (5 vs 14 years of age), and other developmental disorders (5 vs 16 years of age). The overall risk of being diagnosed with a mental disorder before 6 years of age was 2.13 (95% CI, 2.11%-2.16%) and was higher in boys (2.78% [95% CI, 2.44%-3.15%]) than in girls (1.45% [95% CI, 1.42%-1.49%]).

CONCLUSIONS AND RELEVANCE This nationwide population-based cohort study provides a first comprehensive assessment of the incidence and risks of mental disorders in childhood and adolescence. By 18 years of age, 15.01% of children and adolescents in this study were diagnosed with a mental disorder. The incidence of several neurodevelopmental disorders peaked in late adolescence in girls, suggesting possible delayed detection. The distinct signatures of the different mental disorders with respect to sex and age may have important implications for service planning and etiological research.

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S ince 1990, studies on the global burden of disease have continuously ranked mental disorders as some of the most impairing conditions worldwide.[1,2] The Global Burden of Disease studies recently reported that in children and adolescents, mental disorders account for the most years lived with disability.[3] The World Health Organization emphasized in their *Mental Health Action Plan 2013-2020* the strong need for age- and sex-specific data on child mental health.[4] The United States and Australia have good survey data, but only 7% of all countries worldwide have such data,[5] and in 2013, none of 29 member states in the European Union could provide data on incidence of mental disorders in children or adolescents.[6]

Knowledge of the age-specific risks of mental disorders forms the backbone for public health decisions, prioritization of resources, evidence-based medicine, and research on risk factors and outcomes. Occurrence of a condition in a population is measured as prevalence (cases at a specific point) or incidence (new cases per unit of time). The cumulative incidence estimates the risk of developing the condition before a specified age, taking into consideration individual follow-up time.[7] Estimates of the prevalence of mental health disorders in childhood are often based on information from adolescents or parents and are thus prone to recall, information, and survival biases.

In adults, health registry data have made important contributions to our understanding of the incidence of the full spectrum of mental disorders[8] and their risk factors and outcomes.[9-13] In children and adolescents, similar methods have been informative about the frequency of a few certain mental disorders[14-16] and their comorbidities,[17] risk factors,[18-20] and outcomes.[21-24] These findings have been supplemented by prevalence estimates from surveys, most often at a single point[25-27] and sometimes with repeated assessments.[28,29] Hence, surveys estimating prevalence rates and registry studies estimating incidence rates of diagnoses complement each other and each have their own limitations.

Nevertheless, evidence on the incidence of the full spectrum of mental disorders in children and adolescents is lacking. The objective of this study was to estimate the incidence rates and cumulative incidences of any diagnosed mental disorder and 27 specific categories of diagnosed mental disorders during childhood and adolescence, with age- and sex-specific estimates, in a nationwide cohort in Denmark.

Methods

Study Population

The Danish Civil Registration System,[30] established in 1968, holds data on the personal identification number, sex, date of birth, and continuously updated information on vital status of all persons in Denmark. This enables accurate linkage of individual-level data across all registers and prevents duplication of prior events. Our study population included all liveborn singletons born in Denmark from January 1, 1995, through December 31, 2016. This study was approved by the Danish Data Protection Agency. By Danish law, informed consent is not re-

Key Points

Question What are the age- and sex-specific incidence rates and cumulative incidences of the full spectrum of diagnosed mental disorders during childhood and adolescence?

Findings In this nationwide cohort study of 1.3 million individuals in Denmark, the risk (cumulative incidence) of being diagnosed with a mental disorder before 18 years of age was 14.63% in girls and 15.51% in boys. Distinct age- and sex-specific patterns of occurrence were found across mental disorders in children and adolescents.

Meaning These findings suggest that precise estimates of rates and risks of all mental disorders during childhood and adolescence are essential for future planning of services and care and for etiological research.

quired for register-based studies. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Assessment of Mental Illness

The Danish Psychiatric Central Research Register and the Danish National Patient Register provided data on diagnosed mental disorders for all individuals within the study population.[31] These registers include nationwide data on all hospital contacts (inpatient, outpatient, and emergency ward visits) from 1995 onward. In Denmark, hospital treatment is free of charge, all visits are registered, and diagnoses of mental disorders are made according the *ICD-10 Classification of Mental and Behavioral Disorders: Diagnostic Criteria for Research* (*ICD-10-DCR*), since 1994.[32] The *ICD-10-DCR* codes of the categories of disorders are shown in **Table 1**, and observation time, stratified by sex, is presented in eTable 1 in the Supplement. Individuals with more than 1 disorder were included in the numerator for each specific disorder. Age at diagnosis was defined as the first day of the first contact, given the diagnosis of interest.

Study Design

In this nationwide cohort study, all included children were followed up from birth. Follow-up was terminated at the date of the first diagnosis of the disorder (for each disorder separately), death, emigration from Denmark, or December 31, 2016, whichever came first. Ignoring censoring from emigration and/or death would have biased the incidence rates toward underestimation and the cumulative incidences toward overestimation.[33] Competing risk is present when the failure event may be one of several distinct failure types, in this case date of onset, death, disappearance, or emigration.

Statistical Analysis

Data were analyzed from September 14, 2018, through June 11, 2019. We estimated sex- and age-specific incidence rates (incident cases per 10 000 person-years) and cumulative incidences (probability per 100 persons in the population diagnosed before a given age) of any psychiatric disorder (*ICD-10-DCR* codes F00-F99) and each of the separate mental disorders

before 6, 13, and 18 years of age. We refer to cumulative incidence as the risk of a disorder. In **Figures 1**, **2**, and **3**, incidence rates are shown in 1-year age intervals (or expanded intervals including >10 cases). In a sensitivity analysis, we estimated the cumulative incidences at 13 years of age, including only individuals born from 1995 through 2003 for whom complete follow-up data were available to examine possible cohort effects.[34]

We used the GENMOD procedure in SAS software, release 9.4 (SAS Institute, Inc),[35] to perform a Poisson regression analysis with the logarithm of person-years as an offset and to produce likelihood ratio–based incidence rates, 95% CIs, and 2-sided *P* values at a significance level of .05. This level is equivalent to a Cox proportional hazards regression under the assumption of piecewise constant incidence rates. The cumulative incidence was estimated in the presence of competing risk using the SAS-macro *comprisk*.[36]

Results

The study population consisted of 1.3 million children born in Denmark from 1995 through 2016 and was followed up until December 31, 2016, resulting in 14 million person-years of observation. In total, 99 926 individuals (41 350 girls and 58 576 boys) had a diagnosis of a mental disorder before 18 years of age. Among the overall study population, 2.7% were censored before the end of follow-up owing to death (n = 4962), disappearance (n = 515), and emigration from Denmark (n = 31 019).

Risks of Mental Disorders by 18 Years of Age

The risk of being diagnosed with any mental disorder before 18 years of age was 15.01% (95% CI, 14.98%-15.17%) in all individuals, 14.63% (95% CI, 14.48%-14.77%) in girls, and 15.51% (95% CI, 15.18%-15.84%) in boys (**Table 2**). The disorder with the highest cumulative incidence by 18 years of age in girls was anxiety disorder (7.85%; 95% CI, 7.74%-7.97%); in boys, attention-deficit/hyperactivity disorder (ADHD) (5.90%; 95% CI, 5.76%-6.03%). Figures 1 through 3 and eFigures 1 through 4 in the Supplement show the age-specific incidence rates and cumulative incidences for any mental disorder and each of the specific mental disorders investigated for boys and girls separately.

Sex Differences

The incidence rate of schizophrenia spectrum disorders (Figure 1B) was low before 13 years of age, after which it increased in girls and boys. By 18 years of age, the cumulative incidence was higher in girls (0.76%; 95% CI, 0.72%-0.80%) than in boys (0.48%; 95% CI, 0.39%-0.59%). Similar patterns showing higher risks in girls were found for mood disorders (2.54% [95% CI, 2.47%-2.61%] vs 1.10% [95% CI, 0.84%-1.21%]) (Figure 1C), depression (2.41% [95% CI, 2.34%-2.48%] vs 0.92% [95% CI, 0.76%-1.12%]) (Table 2), anxiety disorders (7.85% [95% CI, 7.74%-7.97%] vs 4.58% [95% CI, 4.33%-4.84%]) (Figure 1D), obsessive-compulsive disorder (OCD) (0.96% [95% CI, 0.92%-1.00%] vs 0.63% [95% CI, 0.56%-

Table 1. Diagnostic Classification of Mental Disorders According to the *ICD-10-DCR* and the Number of New Cases During Follow-up of the Cohort[a]

Diagnostic Group	*ICD-10-DCR* Code	No. of Incident Cases With Mental Disorders During Follow-up[b]
Any mental disorder	F00-99	99 926
Organic mental disorders	F00-09	413
Substance use disorders	F10-19	6122
Alcohol abuse	F10	3951
Cannabis use	F12	1323
Schizophrenia spectrum disorder	F20-29	2678
Schizophrenia	F20	610
Acute psychoses	F23	620
Mood disorders	F30-39	7396
Bipolar disorder	F30-31	314
Depressive episode	F32-33	6940
Anxiety disorders	F40-48 plus F93	33 541
OCD	F42	4359
Eating disorders	F50	5429
Anorexia nervosa	F50.0	1649
Bulimia	F50.2	291
Personality disorders	F60-69	2631
Intellectual disability	F7	9236
Other developmental disorders	F80-83	15 493
Autism spectrum disorders	F84.x excluding F84.2-F84.4	21 602
Childhood autism	F84.0	7844
Asperger syndrome	F84.5	5074
ADHD	F90.0 plus F98.8	30 776
Combined type	F90	26 285
Inattentive type	F98.8	5973
ODD/CD	F91 plus F90.1	6094
Attachment disorders	F94.x excluding F94.0	4518
Tic disorders	F95	6793

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; *ICD-10-DCR*, *ICD-10 Classification of Mental and Behavioral Disorders: Diagnostic Criteria for Research*; OCD, obsessive-compulsive disorder; ODD/CD, oppositional defiant disorder/conduct disorder.

[a] Participants were born in Denmark from January 1, 1995, through December 31, 2016, and followed up until 18 years of age or date of death, emigration, or December 31, 2016, whichever came first.

[b] Individuals with more than 1 disorder were included in the numerator for each of the separate disorders.

0.72%]) (Figure 2A), eating disorders (1.80% [95% CI, 1.74%-1.86%] vs 0.28% [95% CI, 0.19%-0.41%]) (Figure 2B), and personality disorders (1.05% [95% CI, 1.00%-1.10%] vs 0.30% [95% CI, 0.18%-0.49%]) (eFigure 3C in the Supplement). In most of these individuals, incidence peaked in late adolescence (approximately at 17-18 years of age).

Compared with girls, boys had higher risks of intellectual disability (1.52% [95% CI, 1.46%-1.59%] vs 0.88% [95% CI, 0.85%-0.92%]), autism spectrum disorders (ASD) (4.26% [95% CI, 4.16%-4.36%] vs 1.77% [95% CI, 1.72%-1.82%]), other developmental disorders (2.74% [95% CI, 2.67%-2.81%] vs 1.41% [95% CI, 1.37%-1.46%]), ADHD (5.90% [95% CI, 5.76%-

Figure 1. Sex- and Age-Specific Incidence Rates and Cumulative Incidences for Any Mental Disorder, Schizophrenia Spectrum Disorder, Mood Disorders, and Anxiety Disorder
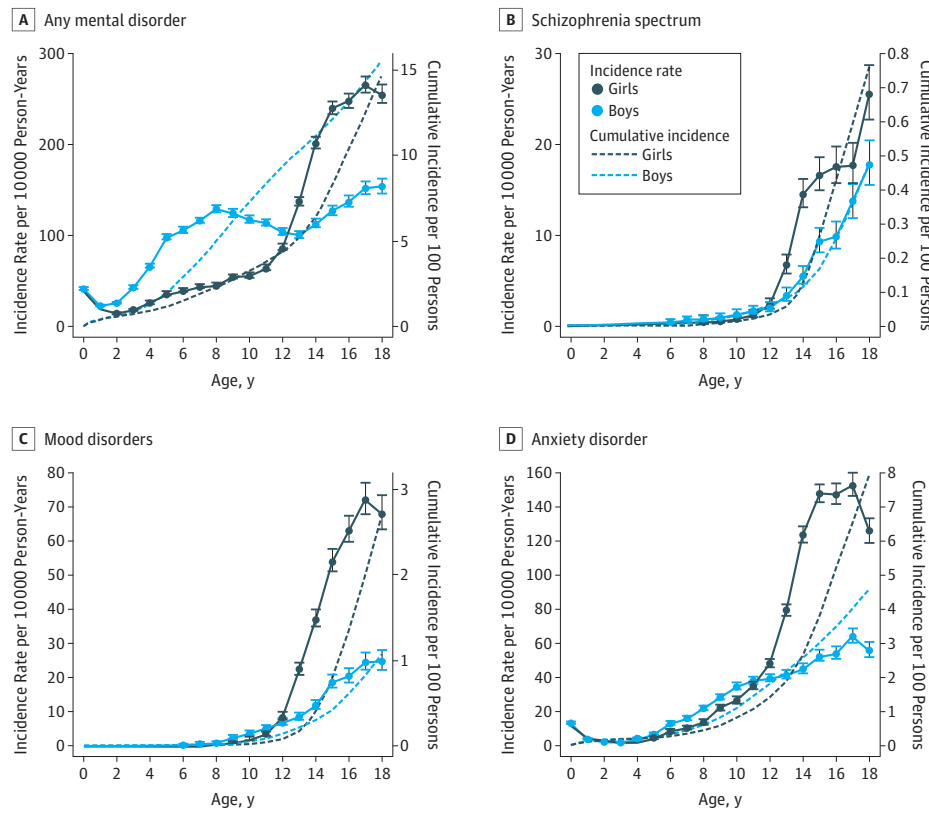
Any mental disorder was identified as *ICD-10 Classification of Mental and Behavioral Disorders: Diagnostic Criteria for Research* (*ICD-10-DCR*), codes F00 to F99; schizophrenia spectrum disorder, as *ICD-10-DCR* codes F20 to F29; mood disorders, as *ICD-10-DCR* codes F30 to F39; and anxiety disorder, as *ICD-10-DCR* codes F40 to F48 and F93. Error bars show the 95% CIs in designated age ranges. Owing to the large sample size, the 95% CIs for the cumulative incidences are very close to the estimates and are therefore not shown. Because the cumulative incidences are estimated continuously with respect to age and the incidence rates are estimated in 1-year age intervals, the abscissa for the cumulative incidence measures the exact age, whereas the abscissa for the incidence rates measures the lowest cutoff point for the age interval. The y-axis scales differ by disorder to correspond to the range of observed outcomes.

6.03%] vs 3.04% [95% CI, 2.97%-3.11%]), oppositional defiant disorder/conduct disorder (ODD/CD) (1.28% [95% CI, 1.23%-1.33%] vs 0.46% [95% CI, 0.44%-0.49%]), attachment disorders (0.71% [95% CI, 0.66%-0.75%] vs 0.52% [95% CI, 0.49%-0.54%]), and tic disorders (1.36% [95% CI, 1.32%-1.41%] vs 0.42% [95% CI, 0.40%-0.45%]) (Table 2). For boys, the ASD incidence sharply increased from birth to peak at 4 years of age, after which it was almost constant until 15 years of age, when it declined (Figure 2D). For girls, the ASD incidence was low until 10 years of age, then increased and peaked in early adolescence. In ADHD (Figure 3A), the incidence in boys increased steadily until it peaked at 8 years of age, then steadily declined, whereas the incidence in girls was almost constant from 7 to 12 years of age, after which it increased to peak at 17 years of age, where the incidence of ADHD in girls was higher than in boys. Similar patterns with a late adolescent peak in girls (but not in boys) were seen in ODD/CD (Figure 3C), other developmental disorders (eFigure 3D in the Supplement), and attachment disorders (eFigure 4D in the Supplement).

Risks of Mental Disorders by 6 and 13 Years of Age

The cumulative incidence of any mental disorder before 6 and 13 years of age was higher in boys (2.78% [95% CI, 2.44%-3.15%] and 10.23% [95% CI, 9.90%-10.57%], respectively) than in girls (1.45% [95% CI, 1.42%-1.49%] and 5.17% [95% CI, 5.10%-5.24%], respectively) (eTables 2 and 3 in the Supplement). Risk in total of being diagnosed before 6 years of age was 2.13% (95%

CI, 2.11%-2.16%) (eTable 3 in the Supplement). The risk of anxiety disorders by 6 and 13 years of age was higher in boys (0.31% [95% CI, 0.13%-0.67%] and 2.17% [95% CI, 1.93%-2.44%], respectively) than in girls (0.27% [95% CI, 0.26%-0.29%] and 1.88% [95% CI, 1.83%-1.92%], respectively). However, by 18 years of age, the pattern was reversed, with a higher risk of anxiety disorders in girls (7.85%; 95% CI, 7.74%-7.97%) than in boys (4.58%; 95% CI, 4.33%-4.84%).

Sensitivity Analyses

When including only individuals with complete follow-up data available, the estimated cumulative incidence of mental disorders tended to be lower than in our main analyses (eTable 4 in the Supplement). In girls, risks were lower for 8 of the 27 mental disorders investigated; in boys, risks were lower for 5 of the disorders. For girls and boys, the largest difference from our main analyses was seen in the cumulative incidence of childhood autism (sensitivity analysis, 0.20% [95% CI, 0.19%-0.22%] in girls and 0.85% [95% CI, 0.80%-0.89%] in boys; main analysis, 0.44% [95% CI, 0.42-0.46] in girls and 1.48% [95% CI, 1.43%-1.53%] in boys).

Discussion

Worldwide, this nationwide study is the first, to our knowledge, of the incidence of the full spectrum of diagnosed men-

Figure 2. Sex- and Age-Specific Incidence Rates and Cumulative Incidences for Obsessive-Compulsive Disorder, Eating Disorders, Intellectual Disability, and Autism Spectrum Disorders
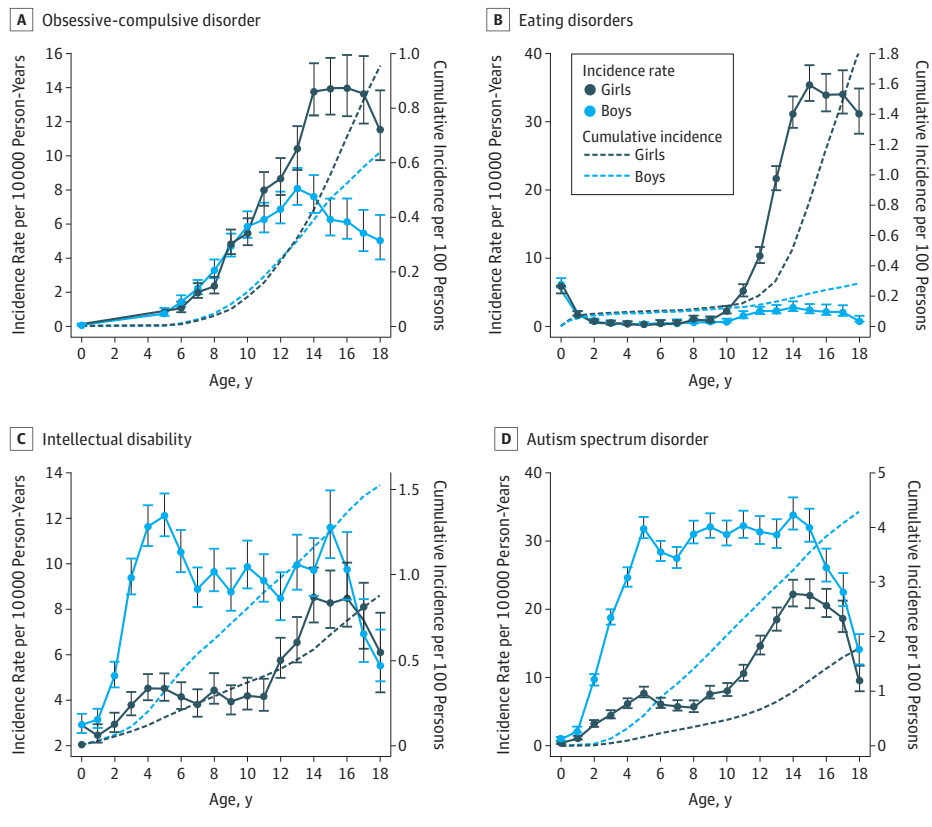
Obsessive-compulsive disorder was identified as *ICD-10 Classification of Mental and Behavioral Disorders: Diagnostic Criteria for Research* (*ICD-10-DCR*), code F42; eating disorders, as *ICD-10-DCR* code F50; intellectual disability, as *ICD-10-DCR* codes F70 to F79; and autism spectrum disorders, as *ICD-10-DCR* codes F84.x, excluding F84.2 to F84.4. Error bars show the 95% CIs in designated age ranges. Owing to the large sample size, the 95% CIs for the cumulative incidences are very close to the estimates and are therefore not shown. Because the cumulative incidences are estimated continuously with respect to age and the incidence rates are estimated in 1-year age intervals, the abscissa for the cumulative incidence measures the exact age, whereas the abscissa for the incidence rates measures the lowest cutoff point for the age interval. The y-axis scales differ by disorder to correspond to the range of observed outcomes.

tal disorders in childhood and adolescence. Herein, we will discuss 4 key findings.

Risk of Mental Disorders

We found that 15.01% of all children and adolescents were diagnosed with a mental disorder before reaching 18 years of age, which is consistent with the overall prevalence of 13% to 20% in US surveys[26,37-40] and the estimated worldwide prevalence of mental disorders in young people of 13.4%.[41] The prevalence of anxiety disorders in US surveys was 4.4% in girls and 5.0% in boys (7.85% and 4.58%, respectively, in our study).[40] Depression was more prevalent in the United States (3.7% in girls and 4.1% in boys)[40] compared with our sample (2.41% and 0.92%, respectively), especially in boys. Our study is likely biased toward capture of the more severe cases with depression, whereas surveys in the US studies are often based on retrospective information from the participating parents (potentially leading to misclassification and recall and selection bias), and the methodological aspects may explain some of these differences.

Sex Differences in Peaks in Incidence Rates

Although we obtained statistically significantly different estimates of the risk of any mental disorder in girls and boys, these rates were conceptually identical. Our study is the first, to our knowledge, to report girls having later peaks in the incidence of ASD, ADHD, ODD/CD, other developmental disorders, and

attachment disorders compared with boys. Indeed, most girls with neurodevelopmental disorders were diagnosed during late adolescence despite these disorders having an early age of onset. Cumulative incidence of any mental disorders by 13 years of age was also higher in boys than in girls but equal between sexes by 18 years of age. These findings suggest a delayed detection of mental disorders in girls. In support of this possibility, studies of time trends[42,43] have found larger increases in the number of girls being diagnosed with ASD and ADHD compared with the increase in the number of boys being diagnosed. Further, compared with boys, girls have been found to be more likely to have undiagnosed ADHD.[44]

Previous studies on the incidence rates of OCD in children and adolescents have found no differences or mixed sex differences in occurrence[45] or higher rates in boys.[46,47] We found equal incidence rates before 10 years of age, after which the incidence rate increased more in girls than in boys; by 18 years of age, the risk of OCD was higher in girls than boys. The incidence of OCD peaked in both sexes in early adolescence rather than in late adolescence, contrary to previous reports.[45] For eating disorders[48-50] and mood disorders,[51] our findings on age at peak of incidences were consistent with previous studies.

Sex Differences in the Risk of Selected Mental Disorders

We found that girls were more likely to be diagnosed with schizophrenia spectrum disorder (ie, early-onset), mood dis-

Figure 3. Sex- and Age-Specific Incidence Rates and Cumulative Incidences for Attention-Deficit/Hyperactivity Disorder (ADHD), ADHD-Inattentive Type, Oppositional Defiant Disorder/Conduct Disorder, and Tic Disorders
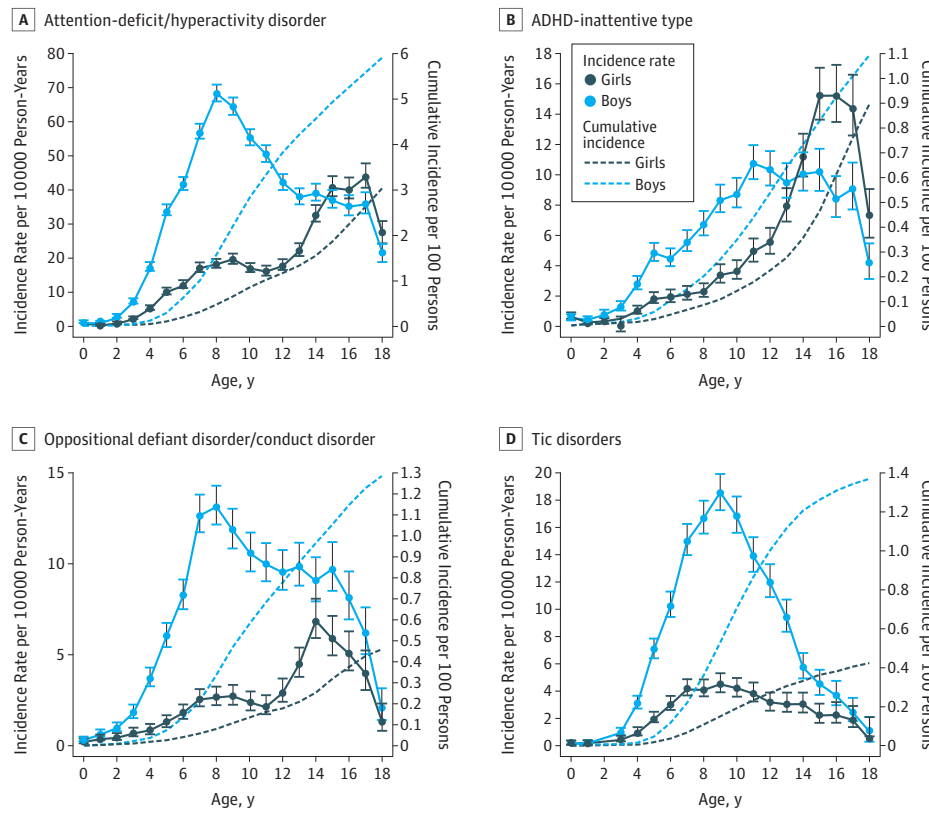
ADHD was identified as *ICD-10 Classification of Mental and Behavioral Disorders: Diagnostic Criteria for Research* (*ICD-10-DCR*), codes F90 and F98.8; ADHD-inattentive type, as *ICD-10-DCR* code F98.8; oppositional defiant disorder/conduct disorder, as *ICD-10-DCR* codes F91 plus F90.1; and tic disorders, as *ICD-10-DCR* code F95. Error bars show the 95% CIs in designated age ranges. Owing to the large sample size, the 95% CIs for the cumulative incidences are very close to the estimates and are therefore not shown. Because the cumulative incidences are estimated continuously with respect to age and the incidence rates are estimated in 1-year age intervals, the abscissa for the cumulative incidence measures the exact age, whereas the abscissa for the incidence rates measures the lowest cutoff point for the age interval. The y-axis scales differ by disorder to correspond to the range of observed outcomes.

orders, anxiety disorders, OCD, eating disorders, and personality disorders, and boys were more likely to be diagnosed with intellectual disability, ASD, other developmental disorders, ADHD, ODD/CD, attachment disorders, and tic disorders. Despite girls having a higher risk of anxiety disorder by 18 years of age, boys had a higher risk of anxiety disorders by 13 years of age compared with girls, which has also, to our knowledge, not previously been reported.

Our finding of the female preponderance of early-onset schizophrenia spectrum disorder is novel. A meta-analysis of incident cases of schizophrenia[52] found male preponderance in all age groups, including those with the first diagnosis before 20 years of age. Three other studies examining changes in the incidence of schizophrenia[53,54] and early-onset schizophrenia[55] over time have pointed toward sex differences similar to those found in our study, with higher incidence rates in girls than in boys in the youngest group. Another study[56] has also found the mean age of onset of schizophrenia to be lower in girls compared with boys. Still, the sex difference in risk of early-onset schizophrenia spectrum disorder to date has not previously been estimated as accurately as in our sample.

To our knowledge, the incidences and risks of attachment disorders and personality disorders in children and adolescents have not been previously reported. As in adults,[57] we found female preponderance in personality disorders. Very few individuals were diagnosed with personality disorder before

13 years of age, which is in accordance with diagnostic classifications and international clinical guidelines.[32,58,59] Finally, we found no sex difference in the risk of substance use disorders before 18 years of age, which contrasts with findings from studies of adults.[8]

Risk of Mental Disorders in Preschool Children
In preschool children, the overall risk of being diagnosed with a mental disorder was 2.78% in boys and 1.45% in girls (2.13% in total). Apart from a handful of studies related to tic disorders[14] and ASD,[14,42] our study, to our knowledge, provides the most detailed estimates for the risk of being diagnosed with a broader range of mental disorder in children younger than 6 years of age.

Relevance
We believe the novelty of this report is the comprehensive estimates of risks of diagnosed mental disorders throughout childhood and adolescence in a total nationwide population, and this adds new knowledge to the field of mental health. The existing literature mainly reports prevalence rates in a population alive at a certain point, only obtaining data on surviving individuals, thereby potentially missing data on those with the most severe psychopathologic diagnoses who did not survive until start of the study. Surveys estimating lifetime prevalence rates retrospectively are also prone to recall bias and selection bias, and the occurrence of episodic or remitting

Table 2. Cumulative Incidences of Diagnosed Mental Disorders in Childhood and Adolescence in a Nationwide Cohort[a]

Diagnostic Group	No. of Incident Cases		Cumulative Incidence, % (95% CI)[b]	
	Girls	Boys	Girls	Boys
Any mental disorder[c]	41 350	58 576	14.63 (14.48-14.77)	15.51 (15.18-15.84)
Organic mental disorders	179	234	0.07 (0.06-0.08)	0.07 (0.05-0.11)
Substance use disorders	2897	3225	1.53 (1.47-1.59)	1.63 (1.46-1.82)
Alcohol abuse	1874	2077	1.01 (0.96-1.06)	1.07 (0.94-1.22)
Cannabis use	558	765	0.31 (0.28-0.33)	0.42 (0.35-0.49)
Schizophrenia spectrum disorder[d]	1569	1109	0.76 (0.72-0.80)	0.48 (0.39-0.59)
Schizophrenia	360	250	0.19 (0.17-0.21)	0.12 (0.07-0.21)
Acute psychoses	346	274	0.16 (0.14-0.18)	0.12 (0.08-0.16)
Mood disorders[d]	5047	2349	2.54 (2.47-2.61)	1.01 (0.84-1.21)
Bipolar disorder	185	129	0.10 (0.09-0.12)	0.06 (0.02-0.15)
Depressive episode[d]	4793	2147	2.41 (2.34-2.48)	0.92 (0.76-1.12)
Anxiety disorders[d]	19 259	14 282	7.85 (7.74-7.97)	4.58 (4.33-4.84)
OCD[d]	2432	1927	0.96 (0.92-1.00)	0.63 (0.56-0.72)
Eating disorders[d]	4297	1132	1.80 (1.74-1.86)	0.28 (0.19-0.41)
Anorexia nervosa[d]	1506	143	0.68 (0.64-0.71)	0.05 (0.02-0.13)
Bulimia[d]	282	9	0.16 (0.14-0.18)	0.00 (0.00-1.67)
Personality disorders[d]	1982	649	1.05 (1.00-1.10)	0.30 (0.18-0.49)
Intellectual disability[c]	3091	6145	0.88 (0.85-0.92)	1.52 (1.46-1.59)
Other developmental disorders[c]	4545	10 948	1.41 (1.37-1.46)	2.74 (2.67-2.81)
Autism spectrum disorders[c]	5354	16 248	1.77 (1.72-1.82)	4.26 (4.16-4.36)
Childhood autism	1600	6244	0.44 (0.42-0.46)	1.48 (1.43-1.53)
Asperger syndrome	1260	3814	0.50 (0.47-0.53)	1.14 (1.07-1.21)
ADHD[c]	8815	21 961	3.04 (2.97-3.11)	5.90 (5.76-6.03)
Combined type[c]	6995	19 290	2.35 (2.29-2.41)	5.13 (5.00-5.25)
Inattentive type[c]	2311	3662	0.89 (0.85-0.93)	1.09 (1.02-1.15)
ODD/CD[c]	1393	4701	0.46 (0.44-0.49)	1.28 (1.23-1.33)
Attachment disorders[c]	1705	2813	0.52 (0.49-0.54)	0.71 (0.66-0.75)
Tic disorders[c]	1486	5307	0.42 (0.40-0.45)	1.36 (1.32-1.41)

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; *ICD-10-DCR*, *ICD-10 Classification of Mental and Behavioral Disorders: Diagnostic Criteria for Research*; OCD, obsessive-compulsive disorder; ODD/CD, oppositional defiant disorder/conduct disorder.

[a] Participants were born in Denmark from January 1, 1995, through December 31, 2016, and followed up until 18 years of age or date of death, emigration, or December 31, 2016, whichever came first.

[b] Measures the probability of being treated for the disorder before 18 years of age. Individuals with more than 1 disorder were included in the numerator for each of the separate disorders.

[c] Boys had a higher probability of being diagnosed with the disorder by 18 years of age than girls.

[d] Girls had higher probability of being diagnosed with the disorder by 18 years of age than boys.

disorders may be underestimated in prevalence studies. However, to fully understand the epidemiology of mental disorders in children and adolescents, surveys on prevalence rates and register-based studies on incidence rates are both required.

As such, with unprecedented comprehensiveness (covering an entire nation) examining the broad diagnostic spectrum and reporting detailed sex- and age-specific patterns, our study offers additional new knowledge on the occurrence of mental disorders in children and adolescents. Our estimates of incidence and risks would likely be broadly representative of many high-income nations. Many of the presented findings, including our main finding of 15.01% being diagnosed with a mental disorder at younger than 18 years, concurs with estimates of prevalence rates obtained in the previous surveys using the most rigorous methods. Our findings may also be thought of as important comparisons for studies evaluating prevalence rates of mental disorders in children in low-income countries or living in situations of extreme circumstances, such as war, natural disasters, or other humanitarian emergencies, all of which may influence the occurrence of mental disorders in children.[60-62]

According to the World Health Organization's most recent *Mental Health Atlas* from 2017, only 18% of the member states had a plan or strategy for child and adolescent mental health.[63] We believe the evidence presented in this study of the patterns of distribution and probabilities of all diagnosed mental disorders across ages and sexes during childhood and adolescence may strengthen advocacy and governance for child and adolescent mental health and form an important platform to guide future policies on access to mental health care, planning of services, prioritizing of resources in public health care, the promotion of human rights of young people with mental disorders, and future research on preventive measures, risk factors, course, and outcome of mental disorders in this age group.

Strengths and Limitations

This study has some strengths. The applied design has previously been used in a study of adults,[8] and its main strength lies in the complete and nationwide data coverage during several decades and in the high quality of the diagnostic data, which is based on comprehensive clinical assessments of all mental disorders by cross-disciplinary clinical teams, includ-

ing child and adolescent psychiatrists. Public health care in Denmark is free of charge, and monetary factors are thus less likely to affect the likelihood of receiving treatment in our study compared with studies performed in other countries.

However, the applied methods also have limitations. Our study was not aimed at examining time trends, and, as in other observational studies, our estimates may be biased by cohort effects.[34] Our sensitivity analyses suggest slight overestimation of the risk of a few mental disorders in the main analysis. This overestimation may be related to higher incidence rates in younger cohorts and changes over time in thresholds for referral, attitudes toward mental illness, available resources, and/or environmental risk factors. The risks may also be underestimated because register-based studies are unable to detect mental disorders for which the patients or their families do not seek help (eg, "wait and see"). Further, we did not include individuals with mental disorders diagnosed outside hospital departments (by psychiatrists in private practices). However, in Denmark, most children and adolescents assessed and treated for mental disorders receive such care within public hospital departments. For instance, for ADHD, more than 86% of all cases are assessed in a hospital setting;[64] for anxiety and depression, this fraction may be lower. In Denmark, only licensed child and adolescent psychiatrists (not general practitioners) are authorized to initiate pharmacological treatment of mental disorders in individuals younger than 18 years, as stipulated by the Danish health authorities.[65-67] Finally, although some diagnoses have been validated in Danish registers (eg, schizophrenia, depression, mood disorder, ADHD, and childhood autism),[68-75] not all of the diagnostic categories have been validated, especially not in preschool children.

Conclusions

This population-based study provides, to our knowledge, a first comprehensive nationwide assessment of the incidence and risks of all mental disorders in childhood and adolescence. For many mental disorders, we believe we have identified age- and sex-specific patterns of occurrence that, to our knowledge, have not been previously reported. The distinct signatures of the different mental disorders with respect to sex and age may have important implications for service planning and etiological research.

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