Trajectories of healthcare utilization and costs of psychiatric and somatic multimorbidity in adults with childhood ADHD: a prospective register-based study

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Background: A better understanding of the trajectories and economic burden of psychiatric and somatic disorders (multimorbidity) in ADHD from childhood to adulthood is important for guiding more targeted areas for treatment of ADHD and prevention of multimorbidity, and for forecasting demands on the medical infrastructure. This study aimed to investigate patterns of healthcare utilization and costs of multimorbidity across young adulthood in individuals with a childhood ADHD diagnosis, and additionally in individuals who continue to have ADHD-related contact with health services (persisters) and those who do not (remitters). Methods: We prospectively followed a cohort (N = 445,790) born 1987–1990 from the ages of 18 to 26 years. Data on healthcare utilization were obtained from the Swedish National Patient Register (inpatient and outpatient care) and the Prescribed Drug Register (medication prescriptions). Results: Mean annual costs per capita from multimorbidity was €990 ($1,223) in individuals with a childhood ADHD diagnosis (persisters/remitters: €1,060 [$1,456]/€609 [$837]) and €304 ($418) in individuals without. Costs were largely driven by inpatient hospital admissions, mainly from drug abuse and injuries. Healthcare utilization and costs of psychiatric and somatic disorders at 18 years was significantly higher in individuals with childhood ADHD compared to those without. These group differences remained stable or increased across young adulthood for most outcomes and were generally larger in women than in men. ADHD remitters continued to show significantly greater healthcare utilization and costs compared to individuals without childhood ADHD, although their profiles were not as severe as ADHD persisters. Conclusions: Childhood ADHD has long-term associations with both psychiatric and somatic disorders. Findings demonstrate the individual and societal burden of ADHD in adulthood and highlight the importance of continued support from childhood–adolescent to adult health services and early prevention of multimorbidity. Findings also point to specific targets for intervention that may be effective, such as drug abuse and injuries. Keywords: ADHD; comorbidity; healthcare; epidemiology; cost.

Introduction

While attention-deficit/hyperactivity disorder (ADHD) is one of the most common childhood psychiatric disorders, with a prevalence of 3.4%–7.1% in childhood and adolescence (Polanczyk, de Lima, Horta, Biederman & Rohde, 2007; Polanczyk, Salum, Sugaya, Caye & Rohde, 2015), the disorder often persists into adulthood where the prevalence is 2.8%–3.4% (Fayyad et al., 2007; Fayyad et al., 2017; Willcutt, 2012). Individuals with ADHD often experience a range of behavioural (e.g. injuries) (Chang, Lichtenstein, D’Onofrio, Sjölander & Larsson, 2014), psychiatric (e.g. autism spectrum disorders [ASD], depression, drug abuse) (Kessler et al., 2006; Kessler, Chiu, Demler & Walters, 2005) and somatic (e.g. obesity and asthma) health problems (Cortese & Tessari, 2017; Instanes, Klungsoyr, Halmoy, Fasmer & Haavik, 2018). This increased risk of health problems in ADHD poses significant clinical and public health problems (Angold, Costello & Erkanli, 1999; Katzman, Bilkey, Chokka, Fallu & Klassen, 2017), but the patterns of healthcare utilization and economic burden from multimorbidity (multiple health problems) across early adulthood are not well documented. Investigating disease-specific healthcare utilization is crucial for forecasting demands on medical infrastructure and for guiding policy and health service planning. This is especially important during the critical transition from adolescence to adulthood, as there is little guidance for clinicians on how to best move ADHD patients into adult services and limited service provision in adults with ADHD (Hall et al., 2013; Libutzki et al., 2019).

Studies have outlined the substantial economic burden in ADHD from healthcare utilization, with estimated incremental costs of $621–2,720 in children/adolescents and $1,137–4,100 in adults per year (Doshi et al., 2012). The economic burden of ADHD is similar to that of chronic somatic disorders (Chan, Zhan & Homer, 2002; Guevara, Mandell, Rostain, Zhao & Hadley, 2003; Hinnenthal, Perwien & Sterling, 2005), but comorbidities have been found to be the main cost drivers in ADHD (Guevara, Lozano, Wickizer, Mell & Gephart, 2001; Hodskins...
et al., 2011; Libutzki et al., 2019). A recent study of children and adults reported that the surplus comorbidity-related costs of depression, anxiety, obesity and substance use in ADHD amounted to €1,420–2,715 per year (Libutzki et al., 2019). This study found that overall costs were highest in the oldest age group (>30 years); however, an important limitation is that a cross-sectional design was used to compare age groups, and therefore, differences may be explained by other uncontrolled factors rather than age per se. It remains unclear how healthcare utilization and economic burden of multimorbidity in ADHD changes across age, which could be studied using robust longitudinal designs. With greater knowledge of the patterns of healthcare utilization and economic burden across adulthood, more targeted efforts could be made to prevent the development of multimorbidity with age, especially if the main drivers of utilization and cost are identified.

Despite a growing interest into the persistence and remittance of ADHD in adulthood (Franke et al., 2018), there is a lack of knowledge of the patterns of healthcare utilization and economic burden in ADHD persisters and remitters. A better understanding of how different developmental trajectories of ADHD from childhood to adulthood influence the individual and societal burden of the disease is a key challenge with important implications for ADHD treatment efforts and prevention of comorbidities. A recent population-based study showed that young adults who remitted from their childhood ADHD continued to show poor physical health and socioeconomic outcomes, while they normalized in most mental health outcomes (Agnew-Blais et al., 2018). The health outcomes were based on self-reports, which have questionable validity in young adults with ADHD (Barkley, 2002; Du Rietz et al., 2016); studies using more objective health measures, such as from electronic health records, are therefore needed to explore the validity of these initial findings.

Aims

We used comprehensive data from the Swedish National Registers, prospectively following young adults, from 18 to 26 years, with and without childhood ADHD diagnoses in their trajectories of multimorbidity. The main aim was to compare the patterns of healthcare utilization and economic burden of psychiatric and somatic disorders between young adults with and without childhood ADHD. The objective was also to examine if group differences were more pronounced in females than in males, which has been indicated by recent, although limited, research; studies have shown higher ADHD comorbidity rates (Solberg et al., 2018) and healthcare utilization costs (Libutzki et al., 2019) in females. We further aimed to examine if young adults that remit from their ADHD normalize in their levels of healthcare utilization and economic burden, in comparison to ADHD persisters.

Methods

Study population

We used a population cohort (N = 445,790; 48% female) born 1987–1990 identified in the Total Population Register and only included individuals who were alive and residents in Sweden during the follow-up (2001–2013). ADHD cases (N = 3,534) were identified using the National Patient Register (NPR) (National Board of Health & Welfare, 2019a) based on receiving an ADHD diagnosis (International Classification of Diseases [ICD-10] code F90) (World Health Organization, 1992) through inpatient or outpatient services before the age of 18 (10–17 years). Further categorization was made to identify those who also received an ADHD diagnosis or medication prescription in adulthood (ADHD persisters) and those who did not seek ADHD-related contact with healthcare services (ADHD remitters), using the NPR and Swedish Prescribed Drug Register.

The national personal identification number was used to link registers. The Regional Ethical Review Board in Stockholm, Sweden, approved this study. The use of Swedish register data does not require informed consent.

Measures

Demographics were obtained from Sweden’s Total Population Register and Longitudinal Integration database for Health Insurance and Labour Market Studies (LISA).

Healthcare utilization and expenditure. Primary ICD-10 diagnostic codes from inpatient admissions (99% coverage) and hospital-based outpatient visits (70%–96% coverage) (National Board of Health & Welfare, 2019b) were coded from the NPR when participants were between 18 and 26 years (2005–2013). All individuals were followed until 23 years, but only the oldest cohort born in 1987 was followed until 26 years. Cost information according to the primary ICD diagnosis was obtained from Sweden’s Cost Per Patient database (The Swedish Association of Local Authorities & Regions). ICD diagnoses were classified into psychiatric (excluding ADHD) and somatic. The total number of inpatient hospitalization days, outpatient visits and costs were calculated for psychiatric and somatic disorders per person and age (Watson et al., 2018).

The Swedish Prescribed Drug Register (>99% coverage) (Wettermark et al., 2007) was used to obtain data on utilization and expenditure for medication prescription fills (using the Anatomical Therapeutic Chemical classification). Medications were classified into psychiatric (excluding ADHD medications) and somatic (see Table S1). The total number of prescription fills and costs was calculated for psychiatric and somatic disorders per person and age (Watson et al., 2018). Costs were calculated as days x dose per day x corresponding unit total costs.

Expenditure was calculated in Swedish crowns (SEK) and inflated to 2017 Swedish prices. Costs are reported in Euro (€) and additionally reported in US dollars ($) in the text (2017). The purchasing power parity-based exchange rate in 2017 was $1.00 – 8.856 SEK and €1.00 – 12.165 SEK (The Organisation for Economic Co-operation & Development, 2019).

Statistical analysis

Generalized estimating equations (GEEs) (Liang & Zeger, 1986) were conducted to compare healthcare utilization and expenditure between the ADHD and non-ADHD groups at 18 years and the incremental difference between the ADHD and
non-ADHD groups over time (18 to 26 years). We further compared healthcare utilization and expenditure, averaged across young adulthood, between the ADHD persistent, remitter and non-ADHD groups. GEEs were run with the identity link function to model linear effects on the absolute scale (rather than the log-link function using a multiplicative scale) and yielded regression coefficients ($\beta$) of group differences with 95% confidence intervals [CIs]. The GEE model was suitable for our data due to the lenient distributional assumptions, and the use of a working correlation matrix, which adjusts for incorrect standard errors caused by dependent observations on the same subjects. Data management was conducted using the Statistical Analysis System (SAS Institute Inc [version 9.1], 2016) and analyses using STATA (version 15, 2017). We re-ran the main analyses in females and males separately to investigate sex differences in healthcare utilization and expenditure.

Socioeconomic status and sex were added as covariates in the statistical models, as these factors have been found to explain variability in healthcare utilization (Hughes, Martinez, Myon, Taeub & Wessely, 2006). Parental education and family income were obtained from LISA and used as proxies for socioeconomic status, for the year when participants turned 18. Parental education was indexed as the highest level attained by either parent. Income (standardized per year) was indexed as the disposable family income (Watson et al., 2018). We added year of birth as a covariate to adjust for birth cohort effects.

**Results**

**Sample descriptives**

Of the 3,534 individuals who received an ADHD diagnosis in childhood (0.8% of the cohort), 2,203 (62%) were categorized as ADHD persisters and 1,331 (38%) as ADHD remitters in young adulthood. About 75% ($N = 1,635$) of the ADHD persisters received both an ADHD diagnosis and ADHD medication in adulthood. See Figure S1 for the frequencies of clinical ADHD diagnoses per age group from 10 to 17 years in the ADHD persistent and remitter groups.

Descriptive statistics for annual expenditure are reported in Figure 1 (see Tables S2 and S3 for per-year values).

**What are the differences in healthcare utilization and expenditure from multimorbidity between adults with and without a childhood ADHD diagnosis?**

The overall mean annual expenditure of multimorbidity in young adulthood was $€890 ($1,223) for individuals with a childhood ADHD diagnosis and $€304 ($418) for those without. The mean annual expenditure was $€622 ($854) versus $€165 ($226) for inpatient care, $€152 ($209) versus $€76 ($104) for outpatient care and $€115 ($158) versus $€63 ($87) for medication prescriptions (Figure 1A).

Healthcare utilization and expenditure for psychiatric disorders at 18 years was significantly greater for individuals with a childhood diagnosis of ADHD compared to those without for all outcomes; inpatient days ($B = 0.20$), outpatient visits ($B = 0.18$) and medication prescriptions ($B = 0.90$), and their associated costs ($\epsilon$) ($B = 38.26$–$155.64$; Table 1). Healthcare utilization and expenditure for somatic disorders at 18 years was significantly greater for individuals with a childhood ADHD diagnosis for all outcomes except for medication costs; these include inpatient days ($B = 0.08$), outpatient visits ($B = 0.17$) and medication prescriptions ($B = 0.50$), and inpatient and outpatient costs ($\epsilon$) ($B = 37.77$–$88.40$; Table 1). Group differences in inpatient and outpatient care and costs at 18 years were similar in magnitude for psychiatric and somatic disorders (overlapping 95% CIs), while group differences in medication prescriptions and costs were larger for psychiatric disorders (nonoverlapping 95% CIs).

**Do the patterns of healthcare utilization and expenditure change across young adulthood?**

Differences between the groups of individuals with and without a childhood ADHD diagnosis significantly increased over time from 18 to 26 years for inpatient days ($B = 0.06$) and medication prescriptions ($B = 0.29$) for psychiatric disorders and their associated costs ($\epsilon$) ($B = 3.32$–$59.08$), but were stable over time for psychiatric outpatient visits and costs (Table 1). For somatic disorders, the group differences significantly increased over time for medication prescriptions ($B = 0.05$) and showed no significant change over time for inpatient days ($B = -0.002$) and costs ($\epsilon$) of inpatient care and medication ($B = -0.32$ to $-0.18$). Group differences significantly decreased over time for somatic outpatient visits ($B = -0.01$) and costs ($\epsilon$) ($B = -2.57$; Table 1).

The increase over time in inpatient care and costs, and number of medication prescriptions in the ADHD group, relative to the non-ADHD group, were significantly greater for psychiatric disorders compared to somatic disorders (nonoverlapping 95% CIs of beta values) (Table 1). See Figure 2A-F for trajectories of healthcare utilization and expenditure over time after adjustment of covariates. The modelled change in the ADHD group relative to non-ADHD group is plotted at each age, when allowing the visits, prescriptions and costs to vary freely across age.

**What are the patterns of healthcare utilization and expenditure in ADHD persisters and remitters?**

The mean annual expenditure of multimorbidity was $€1,060 ($1,456) for ADHD persisters and $€609 ($837) for ADHD remitters. The mean expenditure for ADHD persisters and ADHD remitters was, respectively, $€738 ($1,014) and $€429 ($589) for inpatient care, $€179 ($246) and $€110 ($151) for outpatient care, and $€143 ($196) and $€70 ($96) for medication prescriptions (Figure 1B).

ADHD persisters showed significantly greater healthcare utilization ($B = 0.10$–$2.55$) and...
Figure 1  (A) Mean annual cost (€) per person in young adulthood (18–26 years) in individuals with and without a childhood diagnosis of ADHD. (B) Mean annual cost (€) per person in young adulthood in ADHD persisters, remitters and individuals with no childhood diagnosis of ADHD. The dark-coloured sections of the bars represent costs from psychiatric disorders and the light-coloured sections of the bars represent costs from somatic disorders.

Table 1 Differences between individuals with and without a childhood diagnosis of ADHD in healthcare utilization and expenditure from multimorbidity across young adulthood (18–26 years)

|                      | Psychiatric                          | Somatic                          |
|----------------------|--------------------------------------|----------------------------------|
|                      | ADHD/non-ADHD difference at 18 years (B) | Trend: Per year change between groups (B) | ADHD/non-ADHD difference at 18 years (B) | Trend: Per year change between groups (B) |
| Inpatient care (days) | 0.20 (0.07, 0.32)                    | 0.06 (0.02, 0.10)                | 0.08 (0.02, 0.14)                        | −0.002 (−0.02, 0.01)                     |
| Inpatient care costs  | 155.64 (52.35, 258.92)               | 59.08 (21.81, 96.35)             | 88.40 (23.25, 153.56)                    | −0.32 (−15.31, 14.68)                   |
| Outpatient care (visits) | 0.18 (0.15, 0.21)                   | −0.004 (−0.01, 0.004)            | 0.17 (0.13, 0.20)                        | −0.01 (−0.02, −0.006)                   |
| Outpatient care costs | 44.63 (37.95, 51.31)                 | 0.33 (−1.38, 2.04)               | 37.77 (29.89, 45.64)                     | −2.57 (−4.04, −1.11)                    |
| Medication (prescr.)  | 0.90 (0.70, 1.11)                    | 0.29 (0.22, 0.36)                | 0.50 (0.40, 0.59)                        | 0.05 (0.02, 0.09)                       |
| Medication costs      | 38.26 (29.81, 46.72)                 | 3.32 (1.18, 5.45)                | 8.11 (−3.02, 19.24)                      | −0.18 (−3.22, 2.86)                     |

Regression coefficients (B) with 95% confidence intervals. Per year change: Average change in group difference per year (18–26 years).
expenditure ($) ($B = 11.80 – 393.02) in adulthood compared to individuals with no childhood ADHD on all outcomes. ADHD remitters showed significantly greater healthcare utilization ($B = 0.05 – 0.50$) and expenditure ($B = 13.29 – 243.41$) compared to individuals with no childhood ADHD on all outcomes except medication costs for somatic disorders (Table 2).

ADHD remitters showed significantly lower levels of healthcare utilization and expenditure on outpatient visits and medication prescriptions compared to ADHD persisters, whereas levels of inpatient care days and costs were not significantly different between ADHD remitters and persisters (Table 2).

Inpatient care was the main driver of costs in individuals with childhood ADHD (Figure 1) and was similarly high in ADHD remitters and persisters (Table 2). To further investigate if the inpatient care costs were driven by specific disease categories (ICD categories; Table S4), we calculated the extent to which each disease category explained the overall inpatient costs in individuals with childhood ADHD (Figure 3). The top drivers of costs were drug abuse (28%), injuries (15%) and ASD (12%); see

Figure 2 (A–F) Predicted average change in ADHD group (childhood diagnosis of ADHD) compared to non-ADHD group across age (18–26 years) after adjustment of covariates.
interpretation in Appendix S1), followed by schizophrenia (7%), depression (7%) and anxiety (5%). See Figure S2 for results stratified by sex; drivers of inpatient costs in females were drug abuse (34%), injuries (17%) and ASD (9%) and in males were ASD (19%), nervous system disorders (15%) and schizophrenia (14%).

Sensitivity analyses

We ran sex-stratified analyses by conducting the main ADHD/non-ADHD group analyses on females and males separately (Tables S5 and S6). Greater group differences at 18 years were observed in females compared to males (nonoverlapping 95% CIs) for outpatient visits and costs and for the number of medication prescriptions (somatic conditions only), while similar group differences were found for the remaining outcomes. The incremental ADHD/non-ADHD group difference over time was similar across sexes for all outcomes except for medication prescriptions for psychiatric disorders, which increased significantly more per year in females ($B = 0.49$ [95% CI: 0.31, 0.67] vs. $B = 0.24$ [95% CI: 0.16, 0.31]).

We re-ran the analyses on differences in healthcare utilization and expenditure between the ADHD persistent, remittent and non-ADHD groups using a stricter criterion for ADHD persistence. ADHD persistence was defined as receiving an adult ADHD diagnosis or medication prescription after the age of 19 to examine if our results would hold if we excluded ‘persisters’ who only received an ADHD diagnosis or medication prescription just after turning 18 years. While the overall patterns of findings remained, significant differences emerged between the ADHD persistent and remittent groups for inpatient care for psychiatric disorders and inpatient care costs for somatic disorders (Table S7).

Discussion

In this large-scale and prospective register-based study, we found that healthcare utilization and economic burden of both psychiatric and somatic disorders across young adulthood was persistently higher in individuals with a childhood diagnosis of ADHD compared to those without. While somatic disorders have been highlighted as prevalent in older adults with ADHD (Cortese & Tessari, 2017; Instanes et al., 2018), the current study demonstrated that somatic disorders are highly evident already in younger adulthood. The greater healthcare utilization and costs of multimorbidity in the ADHD group remained stable or increased over time for most outcomes, and the largest increase was found for inpatient care of psychiatric disorders, with a modelled annual increase of €59 per person relative to those without ADHD. Costs in individuals with childhood ADHD were largely driven by inpatient care, mainly due to drug abuse, injuries and ASD. For the first time, we
also showed that young adults who no longer seek ADHD-related contact with healthcare services continue to show greater healthcare utilization and economic burden in adulthood compared to individuals with no childhood ADHD.

These findings highlight the need for improved actions to prevent the development of multimorbidity in ADHD, even in adults who no longer have ADHD-related contact with healthcare services, with more targeted efforts towards psychiatric disorders and a focus on drug abuse and injuries. Such preventative actions would be important during the transition from adolescence to adulthood as there is little guidance for clinicians on how to best transition ADHD patients from child to adult services, and as service provision in adults is still limited (Hall et al., 2013; Libutzki et al., 2019). There is evidence of potential beneficial effects of stimulant medications in individuals with ADHD on a number of serious health-related problems (Chang et al., 2019; Chang et al., 2014; Chen et al., 2014; Ruiz-Goikoetxea et al., 2018), including subsequent drug abuse and injuries (Chang et al., 2019; Dalsgaard, Preben, Frydenberg & Thomsen, 2014; Wilens, Faraone, Biederman & Gunawardene, 2003). If more targeted healthcare efforts would be implemented to support young individuals with ADHD, with evidence-based continued care from childhood into adulthood, it may lead to reduced rates of multimorbidity, which would have a positive impact on both an individual and societal level.

A novel finding in this study was that individuals with childhood ADHD who no longer had ADHD-related contact with healthcare services in adulthood (remitters) continued to show severe psychiatric and somatic health problems, often leading to hospitalization. This group of individuals showed intermediate profiles on outcomes, with values lower than the ADHD persistent group but higher than the non-ADHD group. These continued health problems may reflect that their childhood ADHD develops into other health disorders in adulthood or that the individuals continue to show ADHD-associated problems even though they do not receive a formal adult ADHD diagnosis. The individuals that we refer to as ‘remitters’ may also include those who, despite not receiving a diagnosis in adulthood, have not fully remitted from their ADHD; thus, the increased burden of other psychiatric and somatic health problems may in part also be a result of untreated adult ADHD. A recent population-based study using self-report measures of health showed that young adult ADHD remitters continued to show adverse physical health, while they normalized in mental health outcomes (Agnew-Blais et al., 2018). We extend these findings to show that when using more objective measures, and a comprehensive selection of comorbid disorders, ADHD remitters also show continued mental health problems. These findings highlight the need for using cross-informant approaches, rather than solely relying on self-reports, when investigating mental health problems in young adults.

We further found that group differences in healthcare utilization and economic burden between individuals with and without childhood ADHD were generally larger in women than in men. These findings replicate and extend other research findings (Libutzki et al., 2019; Solberg et al., 2018) and highlight the large potential for introducing preventive measures in women with ADHD. We also found that the main cost drivers differed between females (drug abuse, injuries, ASD) and males (ASD, nervous system disorders, schizophrenia), suggesting that preventative efforts in ADHD should be sex-specific.

**Strengths and limitations**

This large-scale study has several strengths, including the use of comprehensive and objective assessments of...
healthcare utilization across young adulthood. We also used a representative population-based cohort, rather than insurance health claims databases which may not represent the whole population.

However, we need to consider our findings in light of some limitations. Firstly, we report a prevalence rate of ADHD at 0.8%, which is lower than what is generally reported in the literature (Polanczyk et al., 2007, 2015), suggesting that there are individuals in our non-ADHD group who had childhood ADHD that was not identified in the patient register. Due to the limited time window of linkage to patient registers (2001–2013), childhood ADHD was based on individuals receiving ADHD diagnoses from the age of 10 years, which may have contributed to an underestimated prevalence rate. However, ADHD was not commonly diagnosed in Sweden before and during the 1990s, and the rates of clinically diagnosed ADHD have greatly increased over time since 2001 (Atladottir et al., 2015; Rydell, Lundström, Gillberg, Lichtenstein, & Larsson, 2018). This suggests that our childhood ADHD sample would not have increased by a considerable amount if we had incorporated diagnostic data before year 2001. Our prospective study design may also have led to an underestimation of childhood ADHD cases as some individuals may not receive their first ADHD diagnosis until adulthood; this was however a conservative approach as bias would lead to underestimated ADHD/non-ADHD group differences. Nevertheless, it would be important to replicate our findings using a complementary study design, for example a population-based cohort study, with detailed ADHD assessments over time and linkage to healthcare records. One should note, however, that the ADHD persistence rate of 62% in our study is largely in line with prior estimates from clinical follow-up studies (Caye et al., 2016; Cheung et al., 2016; van Lieshout et al., 2017), which lends support for the representativeness of our clinical ADHD sample. Considerably lower ADHD persistence rates are reported in population-based cohort studies, which is likely due to the different use of source informants (informant ratings vs. clinicians) as well as the severity of the ADHD cases identified, as cases in cohort studies may not necessarily seek help for their ADHD symptoms, unlike clinically referred cases (Agnew-Blais et al., 2016; Moffitt et al., 2015).

Furthermore, we did not have access to data on all healthcare services, such as emergency admission, outpatient primary care and over-the-counter medications (e.g. sumatriptan, omeprazole), and somatic disorders (e.g. not cancers); thus, our cost estimates are expected to be underestimated. Finally, it would have been useful to stratify ADHD persisters into subgroups based on ADHD medication prescriptions and to study the potential effects of stimulants. However, only a limited number of individuals with an adult diagnosis were not prescribed ADHD medication ($N = 273$, 14%). The effects of ADHD medication on healthcare utilization and economic burden should therefore be investigated in separate, well-powered studies with detailed assessment of ADHD symptomology.

**Conclusion**

Our research findings suggest that ADHD in childhood has long-term associations with psychiatric and somatic disorders with large financial costs. These findings highlight the importance of early preventative efforts of multimorbidity in ADHD and point towards specific targets for intervention, such as drug abuse and injuries. Continued treatment and support for individuals with childhood ADHD throughout the transition from adolescence to adulthood may be beneficial at both an individual and societal level.

**Supporting information**

Additional supporting information may be found online in the Supporting Information section at the end of the article:

**Appendix S1.** Interpretation of autism spectrum disorder as driver for inpatient hospital admission costs.

**Figure S1.** Frequency of clinical ADHD diagnoses (in- or out-patient) for each age from 10 to 17 years in the ADHD persistent and remittent groups.

**Figure S2.** Percentage of total costs of inpatient care explained by each disease category in the group of individuals with a childhood ADHD diagnosis (for males and females separately).

**Table S1.** Anatomical Therapeutic Classification (ATC) codes.

**Table S2.** Means and standard deviations of health care utilization and costs across the ADHD (childhood ADHD diagnosis) and control groups per year of age (18–26 years).

**Table S3.** Annual means and standard deviations of health care utilization and costs across ADHD persistent and remittent groups per year of age (18–26 years).

**Table S4.** Disease categories based on ICD coding.

**Table S5.** MALES ONLY: ADHD-control differences in healthcare use and costs across early adulthood (18–26 years).

**Table S6.** FEMALES ONLY: ADHD-control differences in healthcare use and costs across early adulthood (18–26 years).

**Table S7.** Differences between ADHD persisters ($N = 1,920$), remitters ($N = 1,614$) and individuals with no childhood ADHD diagnosis ($N = 442,256$) in healthcare utilization and expenditure from multimorbidity; ADHD persistence based on ADHD diagnoses or medication prescriptions after 19 years of age.

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**Key points**

- It remains unclear how healthcare utilization and economic burden of multimorbidity in ADHD changes across age, especially during the critical transition from adolescence to adulthood.
- This study showed that healthcare utilization and costs of psychiatric and somatic disorders across young adulthood was persistently greater in individuals with childhood ADHD than in those without (annual cost per capita €890 [S1,223]/€304 [S418]).
- These costs were largely driven by inpatient hospital admissions, mainly from drug abuse and injuries.
- Even young adults who no longer had ADHD-related contact with healthcare services continued to show significantly greater healthcare utilization and costs from multimorbidity compared to individuals with no childhood ADHD.
- Findings demonstrate the individual and societal burden of ADHD in adulthood and highlight the importance of preventing the development of multimorbidity. Findings also point to specific targets for intervention.

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