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Article

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Abstract

Objective: To examine the prevalence of ADHD and the association of comorbid disorders, and multivariate disorder classes with role impairment in college students. **Method:** About 15,991 freshmen (24 colleges, 9 countries, WMH-ICS) (response rate = 45.6%) completed online WMH-CIDI-SC surveys for 6-month ADHD and six 12-month DSM-IV disorders. We examined multivariate disorder classes using latent class analysis (LCA) and simulated a population attributable risk proportions (PARPs) of ADHD-related impairment. **Results:** About 15.9% had ADHD, of which 58.4% had comorbidities. LCA classified ADHD respondents to pure (42.9%), internalizing (36.0%), bipolar comorbidities (11.3%), and externalizing disorder classes (9.8%). ADHD, comorbidities, and multivariate disorder classes independently predicted severe impairment. PARPs: eliminating ADHD hypothetically reduced severe impairment by 19.2%, 10.1% adjusted for comorbidities, 9.5% for multivariate disorder classes. **Conclusions:** ADHD and comorbid disorders are common and impairing in college students. Personalized transdiagnostic interventions guided by multivariate disorder classes should be explored. (*J. of Att. Dis. 2022; 26(8) 1078-1096*)

Keywords

ADHD, epidemiology, college students, mental disorder, role impairment

Introduction

ADHD is a common and heterogeneous neurodevelopmental disorder (Posner et al., 2020). Over half of individuals with childhood-diagnosed ADHD reported continued impairment in early adulthood, and a further half suffered psychiatric comorbidities (Faraone et al., 2006; Fayyad et al., 2017; Mak et al., 2020).

With increasing availability of tertiary education, more individuals with ADHD are entering college and in need of services (DuPaul et al., 2009; Stolzenberg et al., 2018). Surveys have reported a higher prevalence of ADHD (up to 11%) in college students (DuPaul et al., 2001; Lee et al., 2008; McKee, 2008; Norvilitis et al., 2008; Pope et al., 2007; Shen et al., 2018; Weyandt & DuPaul, 2006; Zhong et al., 2021) than population-based estimates (~3.6%) (Fayyad et al., 2017). This may have significant implications, as ADHD in college students predicted educational failure, study drop-outs (Advokat et al., 2011; Blase et al., 2009; DuPaul et al., 2021; Gormley et al., 2019) and

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impaired quality of life (Pinho et al., 2019). ADHD is commonly comorbid with other mental disorders: a recent multi-college survey of 443 students in the USA identified at least one comorbid psychiatric disorder in 55% of students with ADHD (Anastopoulos et al., 2018; Fayyad et al., 2017). Only a minority of college students with ADHD engage in treatment services and special academic accommodations (Chew et al., 2009), and in spite of known efficacy of various interventions, their effect on academic outcomes have been equivocal (Anastopoulos & King, 2015).

Large cross-national college survey data helps to delineate the complex needs of college students with ADHD worldwide and can form the basis for design and allocation of interventions and resources. There are several knowledge gaps however. Firstly, cross-national prevalence of ADHD in college students worldwide still needs verification (DuPaul et al., 2001; Lee et al., 2008; McKee, 2008; Norvilitis et al., 2008; Pope et al., 2007; Shen et al., 2018; Weyandt & DuPaul, 2006; Zhong et al., 2021). There is no data from Latin American or German-speaking countries. The two existing cross-national studies compared a limited number of countries (USA vs. China (Norvilitis et al., 2008); USA, New Zealand, and Italy (DuPaul et al., 2001)). There were other single-country studies in China (Shen et al., 2018; Zhong et al., 2021), USA (Lee et al., 2008; McKee, 2008), and UK (Pope et al., 2007), but the use of different screening instruments and sampling frames across different studies (e.g., recruitment of psychology course participants (DuPaul et al., 2001), a variety of course participants (Norvilitis et al., 2008), psychology majors (Pope et al., 2007), medical students (Shen et al., 2018), multiuniversity standardized sample (Lee et al., 2008)) made interpretation and comparison across different samples difficult. Secondly, the exact structure of ADHD comorbidities and their contribution to impairment on a college population level is unclear, related to the relatively small sample sizes and case/control designs in existing comorbidity studies of ADHD in college students (Anastopoulos et al., 2018; Shen et al., 2020). Information on distribution of these comorbid disorders and their respective independent contribution to impairment would have salient implications for service planning and delivery (Green & Rabiner, 2012).

The WHO World Mental Health Survey—International College Student Project (WMH-ICS) (Cuijpers et al., 2019) was established to obtain accurate epidemiological data on mental, substance, and behavioral disorders in college students worldwide (https://www.hcp.med.harvard.edu/wmh/college_student_survey.php) by online, confidential census surveys of college freshmen. The initial reports on 14,348 college freshmen in 19 colleges across 8 countries noted a high prevalence of mental disorders (Auerbach et al., 2018) and comorbidities that significantly predicted severe impairment (Alonso et al., 2018). We also identified multivariate patterns of comorbid disorders using latent class analysis that specifically predicted suicide risks (Auerbach et al., 2019) and functional impairment (Alonso et al., 2019).

In this paper, we report the cross-national prevalence of self-reported ADHD (using the Adult ADHD Self-Report Scale Screener [ASRS] (Kessler et al., 2007)) and six other mental disorders (major depression, bipolar disorder, panic disorder, generalized anxiety disorder, drug use disorder, and alcohol use disorder, using the Composite International Diagnostic Interview Screening Scales [CIDI-SC] (Kessler, Calabrese, et al., 2013; Kessler, Santiago, et al., 2013)) in 24 universities and colleges in 9 countries (Australia, Belgium, Germany, Hong Kong, Mexico, Northern Ireland, South Africa, Spain, and the United States) in the WMH-ICS project. To assess the structure of comorbid disorders, we examined population-based multivariate comorbid disorder profiles using latent class analysis (LCA). We assessed the independent impact of ADHD, comorbid disorders, and multivariate disorder profiles on impairment in college students using regression models. Lastly, population attributable risk proportions (PARPs) (Greenland & Drescher, 1993) were calculated for the best-fitting multivariable model for ADHD, comorbid disorders, and multivariate disorder profiles to simulate the potential effects of interventions of these respective conditions.

Materials and Methods

Study Design

Results are based on WMH-ICS surveys conducted with freshmen in a census sample of 24 colleges and universities (8 private and 16 public) in 9 countries (Australia, Belgium, Germany, Hong Kong, Mexico, Northern Ireland, South Africa, Spain, and the United States) between September 2014 and February 2018 (Supplemental Table 1). The surveys used web-based self-report questionnaires and an attempt was made to assess all first-year students in each college. A total of 21,369 questionnaires were completed, with sample sizes ranging from 208 in Hong Kong to 8,053 in Mexico. The weighted (by achieved sample size) mean response rate across surveys was 45.6%. The current sample includes five additional colleges and one additional country (Hong Kong, China) compared to earlier WMH-ICS survey reports (Alonso et al., 2018, 2019; Auerbach et al., 2018, 2019; Bruffaerts et al., 2019; Ebert et al., 2019; Mortier et al., 2018a). Poststratification weights (Groves & Couper, 1998) were used to adjust for nonresponse bias based on socio-demographic information provided by officials from the participating schools.

The analyses reported here were restricted to 15,991 respondents who were assessed for ADHD, aged 18 or above and identifying as male or female and reporting full-time student status (Supplemental Table 1).

Data Collection Procedures

Data collection for this study was conducted using an online self-report survey that was distributed to all freshmen, who were invited to participate in various settings (i.e., during registration as a student, health screenings, or via a separate email invitation). The main strategies used to address the issue of low participation rates among students were repeated rounds of contact together with an offer of small tokens for completing the survey.

After initial contact, non-responders received follow-up personalized emails and 10 colleges provided low-cost incentives (e.g., movie passes, raffle for store coupons), while one survey team used an additional strategy of providing incentives to a random sample of non-responders. In Mexico, students were enrolled in the survey at a number of mandatory events (e.g., student health evaluations and tutoring sessions) where time was allocated specifically for completing the survey.

At all survey sites, the local ethics or institutional review committee reviewed and approved the protocol in line with appropriate international and local guidelines. All students signed an informed consent prior to participation. Participation was voluntary. Detailed information on the organizations responsible for ethics approval for each survey is available at this link: http://www.hcp.med.harvard.edu/wmh/ftpdir/IRB_EthicsApproval_WMH-ICS.pdf. On survey completion, all students were provided information regarding accessing mental health services at their institution, and additional in-depth information on services was provided to any student who reported recent and/or severe suicidal thoughts and behaviors (Mortier et al., 2018a).

Measures

Mental disorders: The WMH-ICS survey instrument was developed to assess six common mental disorders: major depressive disorder (MDD), broad bipolar spectrum disorder (BPD), generalized anxiety disorder (GAD), panic disorder (PD), ADHD, and drug use disorder (DUD), using the Composite International Diagnostic Interview Screening Scales (CIDI-SC) (Kessler, Calabrese, et al., 2013; Kessler, Santiago, et al., 2013).

The CIDI-SC scales are short validated self-report screening scales designed to screen for 12-month prevalence of disorders based on the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV). The CIDI-SC scales have good concordance with blinded clinical diagnoses (Area Under the Curve [AUC] of 0.70–0.78), and good concordance for all diagnoses in a college student sample (AUCs $>$ 0.8). ADHD was assessed with the Adult ADHD Self-report Scale (ASRS) screener. ASRS Screener consists of six items asking respondents how often a particular symptom of ADHD occurred to them in the past 6 months on a five-point response scale of never (0), rarely (1), sometimes (2), often (3), and very often (4). A total score was calculated by summing the points of each item to give a total score. A positive ADHD screen was defined by a total score of 14 or above (Kessler et al., 2007). The DSM-IV version of the ASRS was found to have good concordance with blinded clinical diagnoses based on a standard research diagnostic interview for adult ADHD in two separate clinical studies (Kessler et al., 2005, 2007). Population-based validation has also been done with Chinese (Yeh et al., 2008), Spanish (Ramos-Quiroga et al., 2007), Dutch (van de Glind et al., 2013), and German (Buchli-Kammermann et al., 2011) versions of the instrument. A seventh disorder, alcohol use disorder (AUD), was assessed with the Alcohol Use Disorders Identification Test (AUDIT) (Saunders et al., 1993). Alcohol use disorder is defined as either a total score of $\geq$16 or a score of 8 to 15 with $\geq$4 on the AUDIT dependence questions (Babor et al., 2001). AUDIT has good concordance with clinical diagnoses (AUC of 0.78–0.91) (Reinert & Allen, 2002).

Role impairment: Severity of health-related role impairment during the past 12 months was assessed using an adapted version of the Sheehan Disability Scale (SDS) (Leon et al., 1997; Ormel et al., 2008). SDS comprises four role domains including home management/chores, college-related and other work, close personal relationships, and social life. A 0 to 10 visual analog scale was used to rate the degree of impairment for each domain, which were labeled as no interference (0), mild (1–3), moderate (4–6), severe (7–9), and very severe (10) interference. Severe self-reported role impairment was defined as $\geq$7 rating (Kessler & Ustun, 2004; Wittchen et al., 1998). In our study Cronbach's alpha for the overall SDS scale was .88.

Socio-demographics and country factors: We controlled for socio-demographic variables including age (top-coded within country at two standard deviations above the mean and standardized), gender (male, female), and parental education (higher of two parents using the categories secondary school or less [low], some postsecondary education [medium], college graduate or more [high]), and country.

Analysis Methods

Weighting and imputation: Data were weighted within each college for discrepancies between college-wide and sample socio-demographic distributions. Standard post-stratification methods were used for weighting (Groves, 2006). Comparison of the distributions between respondents and populations found only one consistent difference prior to weighting: that females had a higher response rate than males. This was adjusted for in the weighting. Spain used an "end-game" strategy to increase recruitment. In other words, non-respondents at the end of the normal

recruitment period were more proactively followed-up. The "hard to reach" respondents who were eventually interviewed were assigned a weight equal to 1/*p*, where *p* represented the proportion of non-respondents at the end of normal recruitment that was included in the end game, to adjust for under-sampling of these hard-to-recruit respondents. The sum of weights of each country was set equal to the number of observations in the analysis.

Multiple imputation (MI) by chained equations (Buuren, 2012) was used to adjust for item-missing data, and missing data due to skip logic errors that occurred in a few countries. About 20 MI replicate datasets were used. Pre- and post-imputation statistics are listed in Supplemental Table 2. All standard errors (*SE*s) and degrees of freedom were adjusted using Rubin's rules for combining multiple imputed estimates (Rubin, 2004).

ADHD was not assessed in the first round Australia or Belgium surveys, and those surveys were excluded from this analysis. We adopted a conservative approach to missing items in the self-reported six-item ASRS screener for adult ADHD, setting missing items to 0. About 0.4% ($n = 60$) of the sample had one or more missing items and their ADHD indicator set to 0.

Estimating prevalence: The prevalence estimate presented here report on positive 6-month *positive ADHD* screen (ASRS), as well as 12-month disorders (MDD, PD, GAD, BPD, AUD, DUD), based on weighted within-college proportions. Corresponding *SE*s are estimated using Rubin's rules to account for missing data imputation.

Analyzing multivariate disorder profiles: Latent class analysis (LCA) (Magidson & Vermunt, 2004) was used to examine multivariate profiles among the six 12-month DSM-IV disorders. Mplus software was used to estimate the models (Muthen & Muthen, 2012). LCA is a person-centered approach to defining associations among discrete variables. LCA assumes the existence of two or more distinct unobserved classes of individuals that differ in prevalence of disorders, where presence versus absence of individual disorders is independent across disorders within classes and each person has a probability of class membership that sums to 1.0 within individuals across classes. Analysis consists of simultaneously estimating the vector of class membership probabilities associated with each observed multivariate disorder profile and prevalence of each disorder in each latent class for a fixed number of classes. A standard measure of model fit, the Lo-Mendell-Rubin adjusted likelihood ratio test with *p*-value of .05, was used to select a best model from among those estimated with different assumed numbers of latent classes. Once a final model was selected, survey respondents with a given disorder profile were assigned to the class with the highest probability of membership for purposes of subsequent analysis.

Estimating associations: Logistic regression analyses were used to model 12-month mental disorders as predictors of any severe role impairment, and in each separate role domain. Regression coefficients and their MI-based standard errors were exponentiated to generate odds ratios (OR) and associated 95% confidence intervals (CI). Three models were evaluated: (M1) 6-month ADHD; (M2) M1 plus the six individual 12-month disorders; (M3) M2 plus the four multivariate disorder classes. All models adjusted for gender, age, parental education, and country membership. Akaike's information criterion was used to select the best model.

Simulating potential intervention effects: Population attributable risk proportions (PARPs) (Greenland & Drescher, 1993) were calculated for the best-fitting multivariable model for each disorder in order to estimate the upper bound of potential effects of interventions that reduced the impairment attributable to current ADHD. This interpretation of PARPs is based on the provisional assumptions that ADHD is causally related to impairment, that these causal effects are captured by the logistic regression coefficients, and a 100% success rate of interventions.

Simulations were used to calculate the PARPs. This began by estimating the expected prevalence of each impairment based on the best-fitting prediction model. Expected prevalence estimates were then recalculated after fixing the logits for the predictors across all disorders to 0. PARP was defined as the ratio of (i) the difference in the predicted prevalence of severe role impairment in the observed data versus if the logits of all mental disorder predictors were set to 0 and (ii) divided by the predicted prevalence of severe role impairment in the observed data. *SE*s of the PARP estimates were generated using the Jackknife Repeated Replication simulation method, where each college was treated as a stratum and two random half-samples per college were generated and treated as sampling error calculation units, with the whole Jackknife Repeated Replication estimation process embedded within the MI replicate design (Rust & Rao, 1996). All analyses were carried out using SAS Version 9.4 (SAS Institute Inc, 2013).

Results

The analyses reported here are based on 15,991 respondents. Weighted response rate was 45.6% than half respondents were aged 18 (52.9%), female (54.1%), and had a parent who graduated from college (54.6%).

About 15.9% screened positive for 6-month ADHD (Table 1). About 29.4% of the respondents were screened to have at least one 12-month mental disorder. About 15.7% reported severe role impairment in any domain (home, work, social, or relationship).

Table 1. Sample distribution of socio-demographics, disorders, latent class membership, and % ADHD prevalence by gender and parent education ($n = 15{,}991$).

Mean/% of respondents belonging to each category (*SE*)		
Sociodemographic	Female	54.1 (0.4)
	Age[a]	19.1 (0.0)
	Parental education,[b] high	54.6 (0.4)
	Parental education,[b] medium	25.5 (0.4)
	Parental education,[b] low	19.8 (0.3)
Disorders	ADHD	15.9 (0.3)
	MDD	14.1 (0.3)
	GAD	14.2 (0.3)
	PD	4.1 (0.2)
	BPD	3.7 (0.1)
	AUD	7.1 (0.2)
	DUD	2.1 (0.1)
Latent class membership	Internalizing disorders (C1)	10.9 (0.2)
	Bipolar comorbidities (C2)	2.9 (0.1)
	Externalizing disorders (C3)	2.1 (0.2)
	Pure disorders (C4)	20.2 (0.4)
	No disorders (C5)	64.0 (0.4)
Severe impairment[c]	Home	4.3 (0.2)
	Work	7.1 (0.2)
	Relationship	8.9 (0.2)
	Social	9.0 (0.2)
	Any	15.7 (0.2)

% ADHD prevalence by gender and parental education				
		Male	Female	Total
Parental education	Low	14.0 (1.2)	13.6 (0.8)	13.8 (0.7)
	Medium	15.7 (1.1)	16.2 (0.9)	15.9 (0.7)
	High	16.2 (0.7)	17.0 (0.6)	16.6 (0.5)
	Total	15.7 (0.5)	16.1 (0.4)	15.9 (0.3)

F-tests modeling ADHD prevalence with gender and parental education				
Parameters	Model controls	*F* statistic	Degrees of freedom	*p*-value
Parental education	Country	5.13	2	.0060*
Age[a]	Country	0.77	1	.3792
Female	Country	0.29	1	.5894
Parental education × gender	Country, parent education, age, gender	0.20	2	.8207

Note. ADHD = 6-month ADHD; AUD = 12-month alcohol use disorder; BPD = 12-month bipolar disorder; DUD = 12-month drug use disorder; GAD = 12-month generalized anxiety disorder; MDD = 12-month major depressive disorder; PD = 12-month panic disorder.
[a]Age was top-coded within country at +2 standard deviations above the mean and standardized.
[b]Parental education (high = university graduate or above; medium = some post-secondary education; low = secondary education or below).
[c]Severe impairment defined as 7+ out of 10 in each domain.
*$p < .05$.

Some cross-national variation in ADHD prevalence was observed (Table 2). Prevalence was lower in European sites (Germany [10.8%], Spain [12.4%], Belgium [18.4%]), highest in English-speaking countries (Australia [27.7%], followed by North Ireland [20.6%], South Africa [20.1%], and USA [18.8%]). The only Asian site was Hong Kong, which reported 15.6% prevalence, whereas Mexico reported 15.4%. All countries were high income countries except for Mexico and South Africa which were upper-middle income countries. ADHD prevalence was not observed to differ by country income levels.

Of the socio-demographic variables, ADHD was significantly more common in those with higher parental education (Table 1) after controlling for country effects.

Table 2. ADHD Prevalence, and % of ADHD Cases With Comorbid Disorders ($n = 15,991$).

Country name	Total (*N*)	Prevalence of ADHD—% (*SE*)	% (*SE*) of ADHD with ≥1 comorbid disorder	% (*SE*) of ADHD with ≥2 comorbid disorders
Australia	706	27.7 (1.8)	68.3 (3.6)	46.6 (3.8)
Belgium	1,194	18.4 (1.1)	57.4 (3.4)	27.0 (3.0)
Germany	1,707	10.8 (0.8)	63.9 (3.9)	36.7 (3.8)
Hong Kong	208	15.6 (3.0)	65.1 (10.5)	26.5 (9.7)
Mexico	8,053	15.4 (0.4)	52.8 (1.5)	25.2 (1.3)
Northern Ireland	711	20.6 (1.5)	68.4 (4.0)	47.4 (4.4)
South Africa	666	20.1 (1.6)	62.1 (4.6)	37.3 (4.4)
Spain	2,046	12.4 (1.2)	67.6 (4.4)	33.0 (4.5)
United States	700	18.8 (1.5)	57.5 (4.4)	29.1 (3.9)
Total	15,991	15.9 (0.3)	58.4 (1.1)	30.7 (1.0)

Note. 12m = 12-month; the comorbid disorders are 12m major depressive disorder, 12m bipolar disorder, 12m panic disorder, 12m generalized anxiety disorder, 12m drug use disorder, and 12m alcohol use disorder. ADHD = 6-month ADHD.

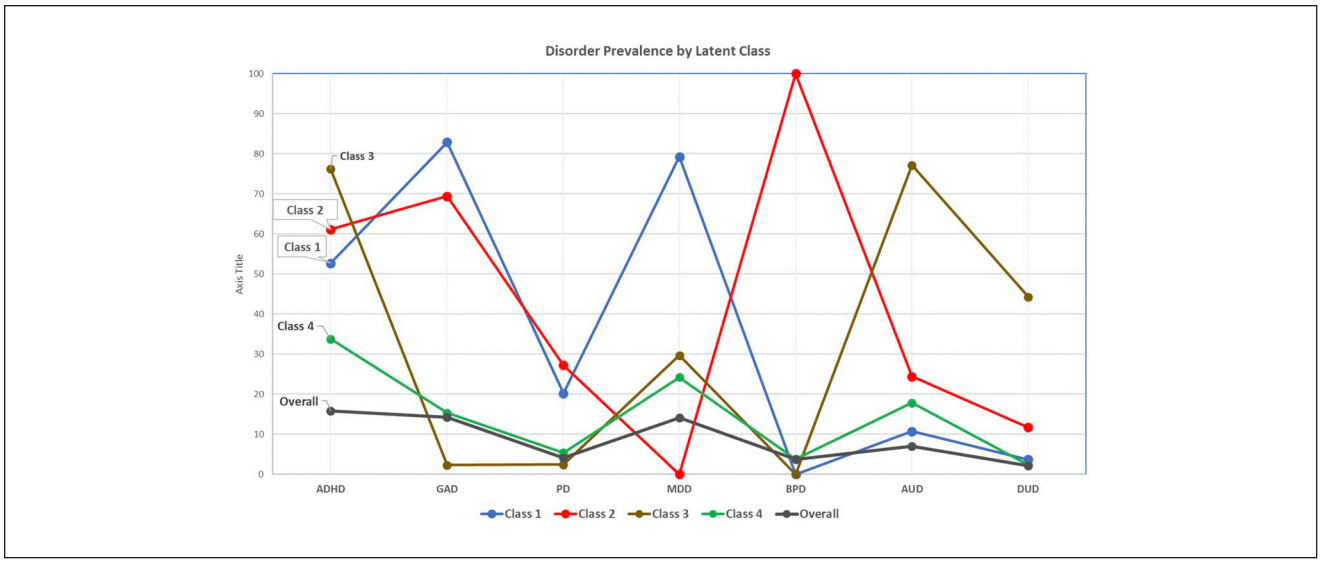

Figure 1. Prevalence of disorders within each latent class.
Note. ADHD = attention-deficit/hyperactivity disorder; GAD = generalized anxiety disorder; PD = panic disorder; MDD = major depressive disorder; BPD = bipolar disorder; AUD = alcohol use disorder; DUD = drug use disorder; Class 1 = internalizing disorders; Class 2 = bipolar comorbidities; Class 3 = externalizing disorders; Class 4 = pure disorders.

Prevalence of ADHD was similar in both genders, but numerically higher in the female (16.1% vs. male 15.7%) in those with higher parental education. After controlling for country effects, parental education was significantly associated with ADHD prevalence, but neither age, gender, nor interaction between gender and parental education were statistically significant.

Comorbidities

Psychiatric comorbidity was common. About 58.4% (52.8% in Mexico, to 68.4% in Northern Ireland) of those with ADHD had at least one comorbid disorder, 30.7% (25.2% in Mexico to 47.4% in North Ireland) with at least two comorbid disorders.

Multivariate Disorder Classes

LCA found that a four-class solution provided best fit to data (Figure 1; Supplemental Tables 3–5). The fourth class included both respondents with exactly one disorder, two or no 12-month disorders. We separated these two groups in our analysis and those with no disorders were removed to a fifth class.

About 36.0% of ADHD cases belonged to an *internalizing disorders class* (C1). ADHD was present in about half (52.7%) of those in this class, where a vast majority had MDD (79.3%) or GAD (82.9%). This was the second-most prevalent class in the sample (10.9%), and represented a large proportion of those with MDD (61.0%), GAD (63.6%), or PD (53.0%). None in this class had BPD. All in this class had comorbidities, with 38.4% having more than two disorders.

About 11.3% of those with ADHD belonged to a *bipolar comorbidities class* (C2), where 79.3% of BPD respondents in the sample belonged, but takes up only 2.9% of the total sample. All individuals in Class 2 had BPD, 69.4% had GAD, and 61.1% had ADHD. Multiple comorbidities characterize this class: 39.7% had two disorders, while 34.9% had three disorders, and 25.4% had four disorders or more.

About 9.8% of those with ADHD and 2.1% of the total sample belonged to an *externalizing disorders class* (C3), to which the largest proportion (43.0%) of those with a DUD and 22.3% of those with AUD belonged. The majority of subjects in this class had ADHD (76.2%) or AUD (77.1%). About 44.2% had a DUD, while roughly 24.2% met criteria for MDD. About 70.9% had two disorders, with 28.2% having three or more disorders.

About 42.9% of the ADHD cases belonged to a *pure disorders class* (C4) where 97.3% had one disorder, and 2.7% had two disorders. This is also the most prevalent class (20.2%) in the sample. ADHD was the most common disorder in the class (33.8%), followed by MDD (24.2%) and AUD (17.8%). About 2.3% in this group reported DUD.

Severe Impairment: Logistic Regression Models

The results of the logistic regression models predicting severe impairment (any domain and individual domains) adjusted for sociodemographic variables, country (Models 1–3), 12-month comorbid mental disorders (Models 2, 3), and multivariate disorder class (Model 3) are presented in Table 3.

ADHD significantly and independently predicted any and all domains of severe impairment independent of age, gender, parental education, other comorbid 12-month disorders, or multivariate disorder classes, and country. Adjustment for other comorbid 12-month disorders reduced the ORs of ADHD predicting impairment by a range of 39.4% to 46.1% whereas further adjustment for disorder classes lowered the ORs by a range of 9.1% to 19.8%. The ORs for ADHD were on par with MDD and GAD in predicting work and home impairment, but lower than that of these disorders in predicting social, relationship, and any impairment. Independent of effects from individual disorders, age, gender, parental education, and country effects, multivariate disorder classes significantly predicted severe impairment in all but home domains. ORs for pure disorders (class 4) in predicting any severe impairment and relationship impairment were smaller than the higher comorbidity classes (C1–3). However, class 3 (externalizing disorders) only predicted impairment in the relationship domain, whereas class 4 (pure disorders) also predicted impairment in the social and work domains. Both classes 1 (internalizing disorders) and 2 (bipolar comorbidities) predicted impairment in social and relationship domains, whereas Class 2 also predicted impairment in the work domain. All classes predicted relationship impairment; none of the classes predicted home impairment.

Parental education showed no significant relationship with impairment in any model. Age significantly predicted having severe impairment in all four domains as well as any severe impairment. This effect was relatively constant across the three models. Female gender significantly predicted having any severe impairment when adjusted for ADHD, country and other demographic factors (Model 1), but lower risk of any severe role impairment and relationship impairment after adjustment for comorbid disorders (Model 2), and multivariate disorder profiles (Model 3).

PARPs

Population attributable risk proportion (PARP) of ADHD was estimated for severe impairment in each role domain in the three regression models (Table 4). The Model 1 PARPs from ADHD are broadly similar across role domains (19.9%–26.0%, 19.2% for any severe impairment) but highest in home and work domains. The PARPs for severe impairment from ADHD were reduced by a third in home (37.9%) and work (38.9%) domains to half in social (49.6%), relationship (48.9%), and any severe impairment (47.3%) when adjusted for the effect of comorbid disorders (Model 2), whereas adjustment for multivariate disorder profiles (Model 3) did not result in marked differences from adjusting for the disorders themselves.

Discussion

To our knowledge, this is the first study reporting on cross-national prevalence of ADHD, its comorbidity structure and respective multivariate contribution to functional impairment in college freshmen worldwide. The results are important in the following ways: a high prevalence of ADHD was found among college freshmen; ADHD was very frequently comorbid with other mental disorders; ADHD was distributed to pure, internalizing, bipolar, and externalizing multivariate comorbidity classes; and ADHD, comorbid disorders, and classes independently predicted functional impairment. These findings are discussed below in detail.

Firstly, the 15.9% ADHD prevalence was substantially higher than previous community (2.8%) (Fayyad et al., 2017) and college estimates (up to 11%) (DuPaul et al., 2001; Green & Rabiner, 2012; Zhong et al., 2021). As mentioned above, the self-reported six-item ASRS screener for adult ADHD (Kessler et al., 2005) and all the language versions WMH-ICS used (Buchli-Kammermann et al., 2011; Ramos-Quiroga et al., 2007; van de Glind et al., 2013; Yeh et al., 2008) were psychometrically robust. While self-report surveys may bias prevalence estimates upwards (Mortier et al., 2018b), and that population-based quantitative genetic studies showed self-reported, compared to

Table 3. Logistic Models: ADHD Predicting Sheehan Severe Role Impairment[a] ($n = 15{,}991$).

	Home			Relationships		
	Model 1[b]	Model 2[c]	Model 3[d]	Model 1[b]	Model 2[c]	Model 3[d]
	OR [95% CI]					
6-Month ADHD	**3.45 [2.91–4.09]***	**2.09 [1.73–2.52]***	**1.90 [1.48–2.43]***	**3.00 [2.65–3.39]***	**1.62 [1.41–1.86]***	**1.30 [1.09–1.56]***
12-Month disorders						
MDD		**1.69 [1.35–2.11]***	**1.49 [1.08–2.05]***		**3.01 [2.59–3.49]***	**2.28 [1.84–2.83]***
GAD		**2.23 [1.80–2.77]***	**1.91 [1.39–2.63]***		**2.26 [1.94–2.63]***	**1.91 [1.52–2.40]***
PD		**1.63 [1.20–2.23]***	**1.57 [1.16–2.14]***		**1.71 [1.35–2.17]***	**1.62 [1.28–2.06]***
BPD		**1.87 [1.36–2.59]***	1.30 [0.47–3.61]		**2.93 [2.32–3.71]***	**2.02 [1.13–3.62]***
AUD		**1.62 [1.25–2.10]***	**1.56 [1.17–2.09]***		**1.39 [1.14–1.69]***	1.12 [0.89–1.39]
DUD		1.48 [1.00–2.19]	**1.55 [1.02–2.35]***		**1.76 [1.33–2.35]***	**1.55 [1.13–2.11]***
Latent classes						
Internalizing disorders (C1)			1.44 [0.81–2.55]			**1.88 [1.25–2.83]***
Bipolar comorbidities (C2)			1.88 [0.56–6.32]			**2.33 [1.11–4.88]***
Externalizing disorders (C3)			1.05 [0.53–2.05]			**2.18 [1.35–3.51]***
Pure disorders (C4)			1.25 [0.92–1.69]			**1.79 [1.44–2.21]***
No disorder (C5)						
	F-statistic (numDF) (*p*-value)[e]					
12-Month disorders		**37.49 (6) (<.0001)***	**6.10 (6) (<.0001)***		**122.41 (6) (<.0001)***	**13.93 (6) (<.0001)***
12-Month disorders and 6-month ADHD		**59.54 (7) (<.0001)***	**6.73 (7) (<.0001)***		**142.17 (7) (<.0001)***	**12.28 (7) (<.0001)***
Latent classes			0.74 (4) (0.5644)			**7.71 (4) (<.0001)***
Full model	**31.35 (13) (<.0001)***	**32.38 (19) (<.0001)***	**26.61 (23) (<.0001)***	**50.04 (13) (<.0001)***	**67.98 (19) (<.0001)***	**55.29 (23) (<.0001)***

(continued)

Table 3. (continued)

	Social			Work		
	Model 1[b]	Model 2[c]	Model 3[d]	Model 1[b]	Model 2[c]	Model 3[d]
	OR [95% CI]					
6-Month ADHD	**3.04 [2.69–3.44]***	**1.64 [1.42–1.88]***	**1.33 [1.11–1.59]***	**3.78 [3.31–4.32]***	**2.22 [1.91–2.57]***	**1.93 [1.59–2.34]***
12-Month disorders						
MDD		**2.99 [2.58–3.46]***	**2.23 [1.80–2.76]***		**2.20 [1.86–2.59]***	**1.94 [1.53–2.47]***
GAD		**2.56 [2.20–2.97]***	**1.99 [1.58–2.50]***		**2.25 [1.91–2.65]***	**2.07 [1.61–2.65]***
PD		**1.86 [1.47–2.36]***	**1.71 [1.35–2.18]***		**1.87 [1.47–2.39]***	**1.81 [1.42–2.32]***
BPD		**2.67 [2.11–3.39]***	1.75 [0.95–3.20]		**2.19 [1.70–2.83]***	1.10 [0.48–2.51]
AUD		1.15 [0.94–1.42]	1.02 [0.81–1.27]		**1.50 [1.21–1.85]***	**1.32 [1.04–1.68]***
DUD		1.34 [0.99–1.82]	**1.42 [1.02–1.97]***		**1.58 [1.16–2.16]***	**1.52 [1.09–2.12]***
Latent classes						
Internalizing disorders (C1)			**2.05 [1.35–3.10]***			1.40 [0.88–2.21]
Bipolar comorbidities (C2)			**2.51 [1.17–5.38]***			**2.81 [1.07–7.37]***
Externalizing disorders (C3)			1.31 [0.78–2.19]			1.47 [0.88–2.44]
Pure disorders (C4)			**1.78 [1.44–2.20]***			**1.51 [1.20–1.91]***
No disorder (C5)						
	F-statistic (numDF) (*p*-value)[e]					
12-Month disorders		**130.15 (6) (<.0001)***	**14.23 (6) (<.0001)***		**81.07 (6) (<.0001)***	**12.43 (6) (<.0001)***
12-Month disorders and 6-month ADHD		**150.02 (7) (<.0001)***	**12.42 (7) (<.0001)***		**117.72 (7) (<.0001)***	**12.42 (7) (<.0001)***
Latent classes			**7.73 (4) (<.0001)***			**3.90 (4) (0.0036)***
Full model	**57.33 (13) (<.0001)***	**73.95 (19) (<.0001)***	**60.55 (23) (<.0001)***	**51.90 (13) (<.0001)***	**57.56 (19) (<.0001)***	**46.74 (23) (<.0001)***

(continued)

Table 3. (continued)

	Any severe impairment from home, relationships, social, and work		
	Model 1[b]	Model 2[c]	Model 3[d]
		OR [95% CI]	
6-Month ADHD	**3.43 [3.09–3.81]***	**1.94 [1.73–2.19]***	**1.59 [1.35–1.88]***
12-Month disorders			
MDD		**2.84 [2.51–3.21]***	**2.29 [1.90–2.77]***
GAD		**2.68 [2.36–3.04]***	**2.32 [1.90–2.84]***
PD		**2.02 [1.60–2.55]***	**1.88 [1.49–2.36]***
BPD		**2.74 [2.23–3.38]***	**2.07 [1.27–3.37]***
AUD		**1.48 [1.25–1.76]***	1.22 [1.00–1.48]
DUD		**1.63 [1.24–2.14]***	**1.45 [1.07–1.96]***
Latent classes			
Internalizing disorders (C1)			**1.62 [1.12–2.35]***
Bipolar comorbidities (C2)			**1.93 [1.01–3.69]***
Externalizing disorders (C3)			**1.77 [1.15–2.74]***
Pure disorders (C4)			**1.60 [1.34–1.92]***
No disorder (C5)			
		F-statistic (numDF) (*p*-value)[e]	
12-Month disorders		**176.06 (6) (<.0001)***	**19.85 (6) (<.0001)***
12-Month disorders and 6-month ADHD		**208.30 (7) (<.0001)***	**17.20 (7) (<.0001)***
Latent classes			**7.30 (4) (<.0001)***
Full model	**87.34 (13) (<.0001)***	**100.48 (19) (<.0001)***	**83.75 (23) (<.0001)***

Note. OR = odds ratio; CI = confidence interval; ADHD = attention deficit/hyperactivity disorder; MDD = major depressive disorder; BPD = bipolar disorder; PD = panic disorder; GAD = generalized anxiety disorder; DUD = drug use disorder; AUD = alcohol use disorder.

[a]Severe impairment defined as 7+ out of 10 in each domain.

[b]Model 1: 6-month ADHD;

[c]Model 2: 6-month ADHD, 12-month disorders;

[d]Model 3: 6m ADHD, 12m disorders, latent classes.

[e]All models controlled for gender, age, parental education, and country.

*[in bold] Significant at .05 level, two-sided MI-corrected test.

Table 4. Population Attributable Risk Proportions (PARP) for ADHD Reducing Impairments, for Models 1, 2, and 3.

	Model 1[a]		Model 2[a]		Model 3[a]	
Predictors	6-Month ADHD		6-Month ADHD, six 12-month mental disorders[b]		6-month ADHD, six 12-month mental disorders,[b] four classes of comorbidity[c]	
Impairment[d]	PARP (% change)	Difference	PARP (% change)	Difference	PARP (% change)	Difference
Home	13.4	0.174	8.3	0.108	8.5	0.110
Relationships	11.7	0.237	6.0	0.121	5.8	0.117
Social	11.3	0.236	5.7	0.119	5.4	0.113
Work	12.8	0.250	7.8	0.153	7.6	0.149
Total	12.2	0.897	6.8	0.501	6.6	0.489
Home, severe	26.0	0.011	17.8	0.008	17.2	0.007
Relationships, severe	19.9	0.018	9.5	0.008	8.4	0.007
Social, severe	20.3	0.018	9.7	0.009	8.6	0.008
Work, severe	25.7	0.018	17.1	0.012	16.3	0.012
Any severe	19.2	0.030	10.1	0.016	9.5	0.015

Note. Home = home management/chores; relationships = close personal relationships; social = social life; work = college-related and other work.
[a]Adjusted for gender, age, parental education, and country.
[b]12-Month mental disorders are major depressive disorder (MDD), bipolar disorder (BPD), generalized anxiety disorder (GAD), panic disorder (PD), alcohol use disorder (AUD), and drug use disorder (DUD).
[c]The fifth latent class, composed of respondents without any 12-month disorder, was the reference group.
[d]Range of home, relationships, social, and work impairment is 0 to 10; range of total impairment is 0 to 40; severe impairment is defined as score of 7 or above out of 10.

parent-reported ADHD, to have lower heritability (Merwood et al., 2013), persistence and association with cognitive measures (Cheung et al., 2016), previous college surveys yielding more conservative ADHD prevalence estimates were also self-reported (Green & Rabiner, 2012). Specificity is supported by multivariate analysis showing independent effect of ADHD and comorbid mental disorders in predicting functional impairment. The likelihood of feigning ADHD for educational benefits (Sullivan et al., 2007) was also low, as individual WMH-ICS survey results were kept confidential from school authorities and would not lead to certification for benefits. In fact, by adoption of user-friendly, confidential web-based surveys, the WMH-ICS surveys may have enabled access to an important subset of individuals with psychopathology who resist help-seeking and otherwise would not disclose their symptoms (Cuijpers et al., 2019).

We may therefore need to contend with the possibility that ADHD may be substantially more common in college students worldwide than the literature suggested. It is plausible because improving educational provisions across the world may have translated to improved support for adolescents with ADHD to increase their chances for university admission (DuPaul et al., 2009). Low self-awareness of ADHD symptoms, which is common in adults (Manor et al., 2012), may have reduced participation in previous ADHD-specific surveys (Green & Rabiner, 2012). ADHD in the general population may also be less common than in colleges, as older participants in population-based studies may more likely under-report childhood symptoms or no longer suffer impairment (Fayyad et al., 2017). Self-awareness of ADHD-related impairment and cognitive challenges may be higher in college students who are required to cope with structured tasks and environment, compared to school leavers who may already have chosen a job and lifestyle suiting their cognitive attributes, leading to under-report, or reduced impairment from the ADHD symptoms. In fact, despite slightly higher rates in English-speaking countries similar to multi-national population-based findings, ADHD prevalence was high in all country sites, suggesting ADHD in college freshmen to be a global phenomenon (Fayyad et al., 2017; Polanczyk et al., 2007), demanding attention from college health services around the world.

Secondly, consistent with previous college (Anastopoulos et al., 2018) and community data (Fayyad et al., 2017), we found that roughly half of the students with ADHD had comorbid mental disorders. Previous studies had adopted latent class analysis to validate the clinical subtypes of adult ADHD (Marcus et al., 2012) and comorbidity pattern of ADHD, oppositional defiant disorder, anxiety, and depression in female adolescent twins (Neuman et al., 2001) but our data showed the distribution of a broader range of disorders in the college population. The presently reported multivariate disorder profiles were broadly like our earlier report based on the first round of WMH-ICS surveys but yielded different results likely attributable to a larger sample size and exclusive categorization of bipolar disorder for individuals with 12-month depressive episodes and hypo/manic episodes (Auerbach et al., 2019). The current analysis found "pure" ADHD to be the commonest disorder profile, followed by internalizing disorders, and then a significant minority with complex comorbidities related to externalizing disorders or bipolar disorders. Examination of

multivariate disorder profiles in adult community samples would be important to see if a different pattern of comorbidity may be yielded, such as a higher rate of substance-related disorders compared to the 1.9% prevalence of DUD found in this college sample.

One important observation was that ADHD was uniquely ubiquitous in all disorder classes (Figure 1), which is not observed for any other disorder examined. Our analysis showed that ADHD and comorbid disorders all independently predicted impairment, suggesting these comorbid conditions to be separate entities. In fact, the broad range of comorbid conditions associated with ADHD may reflect the vast overlaps of genetic profiles of ADHD with a large range of externalizing and internalizing disorders (Faraone & Larsson, 2019; Lahey et al., 2021; Pettersson et al., 2016). Other mental disorders such as anxiety, depression, or substance use disorders have also been known to develop as a complication of ADHD in mechanisms that are not entirely known (Asherson et al., 2016). The transdiagnostic ubiquity of ADHD may also be explained by its propensity for perpetuating symptom severity and impairment from other anxiety and depressive disorders (Posner et al., 2020).

Fourth, the current analyses suggested that both ADHD, type of comorbid disorders and multivariate disorder classes independently predicted severe functional impairment, and like our earlier report, the relationship between impairment and complexity of disorders followed a monotonic pattern (Alonso et al., 2019). Furthermore, whereas we previously reported that removing all disorders would reduce a third of all severe impairment in the students (Alonso et al., 2019), the current analysis showed that removal of all ADHD cases would hypothetically lead to removal of one-fifth of severe impairment in all college students, assuming causality in the observed associations, and that interventions were 100% effective in removing impairment (Krysinska & Martin, 2009). This effect was reduced by a third to half after controlling for comorbid disorders.

Given the size of the population that are likely affected and the range of complexities in service need, a transdiagnostic approach appears ideally suited, and should be explored as a cost-effective means to limit impairment from ADHD in college students, who may be allocated to services of differing intensity and modality according to multivariate disorder profiles. At present, evidence on effective treatment for ADHD with comorbidities in adults have been confined to individual comorbidities such as bipolar disorder, depression, or anxiety (Bond et al., 2012; CADDRA, 2018; Katzman et al., 2017). There appears to be a lack of evidence on effective intervention approaches and service models for adults with ADHD with comorbidity profiles of differing complexities (Coghill, 2015; Katzman et al., 2017). It is plausible that more resource-intensive multidisciplinary interventions may be reserved for the most severe, high-risk cases. For other students, the effectiveness of inexpensive online intervention programs for ADHD have been supported by meta-analytic evidence (Khan et al., 2019). These programs may be integrated with evidence-based transdiagnostic online interventions for comorbid internalizing and externalizing disorders for large-scale, personalized deployment (Cuijpers et al., 2017; Ebert et al., 2018).

Lastly, the lack of gender difference in ADHD prevalence was similar to previous college findings (DuPaul et al., 2001), attributable to higher symptom awareness and ADHD persistence ADHD in females (Cortese et al., 2016). Increased severe impairment in females was shown in multivariate analysis to be explained largely by comorbid disorders instead of ADHD, similar to previous population findings (Cortese et al., 2016). The positive relationship of parental education with ADHD prevalence contradicted previous cohort findings (Torvik et al., 2020), but had been reported in previous college samples (DuPaul et al., 2001). High parental education may be over-represented in college students with ADHD by its protective effect, via IQ and quality of education, toward promoting college enrollment in individuals with ADHD (DuPaul et al., 2001).

Limitations

There are several limitations to consider in interpreting the results.

Firstly, although WMH-ICS are census surveys, variable response rates may limit representativeness of the cross-national prevalence of ADHD reported here. In spite of weighting, a previous meta-analysis from our group suggested a risk of over-estimating prevalence rates in samples with lower response rates to self-report surveys (Mortier et al., 2018b). Secondly, the self-report format in the ASRS screener and lack of parental corroboration in developmental history may specifically produce bias in ADHD prevalence estimate. The six-item ASRS screener with a cut-off score of 14 has been shown on a sample of USA health plan subscribers to yield a sensitivity of 64.9% and specificity of 93.9% against blinded ACDS-based clinical diagnosis (Kessler et al., 2007). However, psychometric performance of the screener may differ in this multinational college sample. Clinical re-appraisal and calibration studies are now under way in several countries to address this.

Third, the self-report format of ASRS, especially without specification of age-of-onset, may produce positive ADHD screen that conflates with other mental disorders with overlapping clinical features. The ADHD prevalence estimate should therefore be interpreted with caution, although our analysis showed that ADHD and comorbid disorders all independently predicted impairment, suggesting these comorbid conditions and a positive ADHD screen to be separate entities.

Fourth, survey length limitations prevented accommodating more diagnoses, such as post-traumatic stress disorder, social phobia, and somatic symptoms disorder, which were associated with ADHD (D'Agati et al., 2019). To accommodate more disorders without increasing respondent burden, matrix sampling may be used in future versions of the WMH-ICS survey, where subsets of screening scales may be rotated at random to provide partial information about prevalence and correlates of a broader range of disorders (Hughes et al., 2015; Merkouris, 2015; Thomas et al., 2006).

Fifth, in surveying college freshmen, this dataset did not include grade point average (GPA), that is, the average of the students' grades, and other indices of college functioning and academic outcomes, which will be addressed in future waves of the WMH-ICS cohorts, in relation to the baseline predictors.

The sixth limitation is that the three assumptions for PARPs analyses do not hold well in our context, but we also considered that: (i) ADHD does cause impairment, and the lack of exclusivity in this relationship is assessed with multivariate analysis and latent class analysis; (ii) logistic regression coefficients do not reveal causal relationships, but disentanglement of correlations is still relevant if we interpret PARPs in full knowledge of its limitations; and (iii) while interventions cannot be 100% successful, the same applies to interventions for all disorders. PARPs represent the upper hound on potential intervention effects, which gives us a picture of the relative impacts in delivering interventions for various comorbid disorders and multivariate disorder classes.

Lastly, latent class analysis assumed the existence of true underlying classes that lead the disorders to be conditionally independent within classes. Future analysis in the WMH-ICS may investigate if other methods might give more valid characterizations of multivariate disorder classes should this assumption not hold.

Conclusion

While further efforts may help substantiate these findings, the high prevalence of ADHD and its comorbidities in this multinational sample of college students calls for the adoption of comprehensive, confidential online screening of these conditions in all college freshmen around the world. Recapitulating on the aforementioned problems in a lack of real-world effectiveness in intervention and support services for college students with ADHD, our multinational cross-sectional data suggested the potential role in intervention of comorbidities enhancing effectiveness in supporting college students with ADHD. Multivariate disorder classes could be effectively deployed to allocate students with ADHD to services of different complexities and intensities, which would be important in a cost-effective and personalized service delivery.

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Author Contributions

All authors have approved the final article. RK and AM conceived and designed the work. RK and all coauthors contributed to the acquisition, analysis or interpretation of data for the work. AM, SL, NS, and RK were responsible for drafting the work. All coauthors helped revise the work critically for important intellectual content. All coauthors provided approval for publication of the content. AM agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Supplemental Material

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Data Availability

The datasets analyzed are available from the corresponding author on reasonable request.

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Harald Baumeister, PhD is Head of the Department of Clinical Psychology and Psychotherapy at Ulm University, Germany. Dr. Baumeister's research focuses on e-mental and e-behavioral health.

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Coral Lapsley, PhD was a researcher, at Ulster University, UK, specialising in personalised medicine, while contributing to this publication.

Christine Lochner, PhD is a clinical psychologist, Professor in Psychiatry, and Co-Director of the SA MRC Unit on Risk and Resilience in Mental Disorders, at Stellenbosch University, South Africa.

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