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Prevalence of internet gaming disorder in German adolescents: diagnostic contribution of the nine DSM-5 criteria in a state-wide representative sample

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ABSTRACT

Background and aims Internet gaming disorder (IGD) is included as a condition for further study in Section 3 of the DSM-5. Nine criteria were proposed with a threshold of five or more criteria recommended for diagnosis. The aims of this study were to assess how the specific criteria contribute to diagnosis and to estimate prevalence rates of IGD based on DSM-5 recommendations. **Design** Large-scale, state-representative school survey using a standardized questionnaire. **Setting** Germany (Lower Saxony). **Participants** A total of 11 003 ninth-graders aged 13–18 years (mean = 14.88, 51.09% male). **Measurements** IGD was assessed with a DSM-5 adapted version of the Video Game Dependency Scale that covered all nine criteria of IGD. **Findings** In total, 1.16% [95% confidence interval (CI) = 0.96, 1.36] of respondents were classified with IGD according to DSM-5 recommendations. IGD students played games for longer periods, skipped school more often, had lower grades in school, reported more sleep problems and more often endorsed feeling 'addicted to gaming' than their non-IGD counterparts. The most frequently reported DSM-5 criteria overall were 'escape adverse moods' (5.30%) and 'preoccupation' (3.91%), but endorsement of these criteria rarely related to IGD diagnosis. Conditional inference trees showed that the criteria 'give up other activities', 'tolerance' and 'withdrawal' were of key importance for identifying IGD as defined by DSM-5. **Conclusions** Based on a state-wide representative school survey in Germany, endorsement of five or more criteria of DSM-5 internet gaming disorder (IGD) occurred in 1.16% of the students, and these students evidence greater impairment compared with non-IGD students. Symptoms related to 'give up other activities', 'tolerance' and 'withdrawal' are most relevant for IGD diagnosis in this age group.

Keywords Criteria, diagnostic validity, DSM-5, impairment, internet gaming disorder, prevalence.

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INTRODUCTION

Behavioural addiction refers to compulsive engagement in an activity that has rewarding properties initially, but results ultimately in long-term negative consequences [1]. The *Diagnostic and Statistical Manual for Mental Disorders* introduced the construct of behavioural addictions, for the first time, in its fifth revision (DSM-5) [2]. Gambling disorder is now included as a behavioural addiction alongside substance use disorders. Internet gaming disorder (IGD) refers to the problematic use of on-line or off-line video games. The DSM-5 introduced IGD in Section 3, 'Conditions for Further Study' [2], intending to stimulate further research. While bringing this condition to the attention of clinicians, the DSM-5 work-group [3], along with two independent reviews [4,5], noted that IGD has not been measured systematically and instruments to assess it vary considerably.

Although the DSM-5 proposes nine criteria for IGD, the text [2] notes explicitly that these criteria require validation. In particular, empirical data are required to ascertain the extent to which these criteria are endorsed in general populations and add to diagnosis.

In part because of differences in assessment, prevalence estimates of IGD diverge considerably across studies, especially in adolescents [4,6]. In representative studies, rates of IGD among adolescents range from 1.7 to 8.5% [7–9], although one review suggests that truly addictive use (versus not just excessive play patterns) appears to be present in 2–5% of youth [6]. For adults, fewer studies have been

conducted and, not surprisingly, they suggest a lower prevalence rate of IGD of 0.2–0.6% [10–12]. Although instruments used in previous studies show some overlap with the DSM-5 criteria for IGD, no study in the general population has evaluated all nine DSM-5 criteria.

Recently, Ko and colleagues [13] administered clinical interviews based on the DSM-5 IGD criteria to three subgroups: those with current gaming problems; those with past but not current gaming problems; and a control group. Criteria 6, 'continue despite problems' and 9, 'risk/lose relationships/opportunities', had high diagnostic accuracy in discriminating between control and gaming disorder groups, whereas criterion 7, 'deceive/cover up', had the lowest diagnostic accuracy [13]. They also assessed different cut-points and determined that meeting five or more DSM-5 criteria resulted in the best diagnostic accuracy in terms of distinguishing individuals with normal levels of play from those who had experienced clinically significant harms. That study represents the first attempt to apply the DSM-5 criteria in the context of a diagnostic interview in a clinical sample of adults.

Based on the DSM-5 criteria of IGD and a recommended cut-off of five or more criteria, the aims of this study were to (1) assess rates of endorsement of the nine criteria in a representative community sample of adolescents, (2) estimate the 12-month prevalence rate of IGD, (3) analyse basic validators of impairment related to IGD classification and (4) evaluate the discriminative validity of the criteria. Additionally, this study examined differences in demographic characteristics of students based on IGD status.

METHODS

Participants and procedure

The sample was obtained from a ninth-grade school survey. A large sample was intended, as the study was designed as a criminological self-report study targeting low base-rate phenomena of deviant behaviour in youths. Thus, we selected approximately 12 000 students randomly in the state of Lower Saxony, Germany, which corresponds to an acquisition rate of one of eight 9th-graders residing in that region. School type in Germany is classified according to lower, middle and higher levels of academic achievement. Specific classes within each school type were selected randomly to approximate the distribution of school types that exist throughout Lower Saxony, Germany. Data collection occurred in Spring 2013.

Of 739 classes approached (n = 17273), 183 school principals (n = 4190) declined to participate, resulting in 556 classes comprising 13 083 students. On survey day, 955 students were absent due to illness or truancy, 439 did not have parental consent and 259 students were unwilling to participate. Another 336 students had other reasons for absence (special school event, or taking make-up examinations). Some questionnaires ($n = 91$) were excluded because they were clearly invalid (e.g. first response always checked), resulting in 11 003 valid data sets (1053 from lower, 6345 from middle and 3605 from higher secondary schools). This distribution closely matches the population (lower school students are 10.7% in the population and 9.6% in this sample; middle are 55.3 and 57.7%, respectively; and higher are 33.9 and 32.8%, respectively). Considering the 183 refused classes, plus the missing and excluded questionnaires, the overall response rate was 63.7% (without refused classes: 84.1%).

The questionnaire covered the DSM-5 IGD criteria, along with a range of other variables evaluating family and peer relationships, leisure-time and school activities, substance use, juvenile delinquency and victimization. The participants were told that the study was conducted to gain insight to life situations, leisure-time behaviours and experience of violence. After a trained interviewer provided instructions, students completed questionnaires on their own under the supervision of the interviewer in two school sessions (mean = 92 min in total). State school authorities approved the study. Respondents' parents provided written informed consent for their child's participation. Students could decline participation even if their parent consented, and they were informed about their right to refuse participation as well as to not answer specific questions.

Measures

Internet gaming disorder (IGD)

To assess DSM-5 IGD, the Video Game Dependency Scale (abbreviated as CSAS for the German version 'Computerspielabhängigkeitsskala') [14] was administered. This instrument was adapted from a previous instrument (KFN-CSAS-II) [7] to cover all nine DSM-5 criteria. Each DSM-5 criterion was reflected by two items, resulting in an 18-item scale (Table 1). Students were instructed to respond based on their gaming behaviour within the last 12 months and rated each item on a four-point scale: 1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree). For analyses presented in this paper, a criterion was considered endorsed if at least one of the two items was answered with 'strongly agree', ensuring that only full agreement of the construct was included (see on-line Supporting information for parallel analyses using a less conservative response threshold). Using DSM-5 recommendations, participants were classified with IGD if they

Table 1 Item parameters of the Computerspielabhängigkeitsskala/ Video Game Dependency Scale (CSAS), endorsement of single items, endorsement of criteria and agreement between single criterion endorsement and internet gaming disorder (n = 11 003).

Criterion	*Item*	*Mean*	*SD*	*% endorsing each rating*				*Overlap of rating 4 (%)*	*Criterion (%)*	*Cohen's kappa*
				1 (%)	*2* (%)	*3* (%)	*4* (%)			
Preoccupation	Games are on my mind, even at times when I'm not playing	1.61	0.83	57.26	27.67	11.54	3.54	19.02	3.91	0.33
	My thoughts constantly revolve around gaming, even at times when I'm not playing	1.24	0.57	81.59	13.59	3.78	1.05	64.35		
Withdrawal	I feel irritable and unhappy when I am unable to play games	1.30	0.63	78.14	15.57	4.76	1.53	30.95	1.85	0.51
	I start feeling restless and nervous when I'm not playing games for some time	1.18	0.50	86.50	10.10	2.60	0.80	59.09		
Tolerance	I feel that games are becoming more and more important to me	1.46	0.73	65.95	24.36	7.60	2.10	33.77	2.68	0.45
	I have to spend more and more time gaming in order to feel satisfied	1.28	0.60	78.71	16.30	3.71	1.29	54.93		
Reduce/stop	I feel that I can't control the amount of time I spend playing games	1.37	0.68	72.43	19.93	5.78	1.85	18.63	2.80	0.43
	I've tried to cut down how much I play games but failed	1.23	0.57	82.50	13.02	3.19	1.29	26.76		
Continue despite problems	Due to my frequent gaming, I sometimes get in trouble at school or work	1.26	0.58	80.21	14.67	4.09	1.04	19.30	1.72	0.50
	I often get into serious fights or arguments at home because I spend so much time playing games	1.20	0.53	84.99	10.90	3.24	0.88	22.68		
Give up other activities	Because of my gaming, I enjoy other activities less than I used to do	1.26	0.59	80.53	14.11	4.25	1.11	36.07	1.65	0.52
	I gave up other hobbies or cut down on them because gaming is more important to me	1.14	0.47	90.46	6.43	2.17	0.94	42.72		
Escape adverse moods	I often play games at times when other things in my life aren't going well	1.45	0.79	70.65	17.48	8.35	3.52	44.44	5.30	0.28
	Playing games is the best way for me to forget about my problems	1.39	0.77	74.88	14.47	7.31	3.34	46.74		
Deceive/cover up	I spend more time playing games than I admit to others	1.36	0.73	76.61	13.97	6.71	2.72	25.08	3.00	0.42

(*Continues*)

Table 1. (Continued)

Criterion	*Item*	*Mean*	*SD*	*% endorsing each rating*				*Overlap of rating 4 (%)*	*Criterion (%)*	*Cohen's kappa*
				1 (%)	*2 (%)*	*3 (%)*	*4 (%)*			
	I lie to others to hide how much time I spend playing games	1.16	0.50	88.41	7.91	2.72	0.96	70.75		
Risk/lose	I have already lost or risked an important relationship or friendship because of gaming	1.10	0.41	92.79	4.98	1.53	0.70	45.45	1.53	0.46
	Due to gaming, I have risked my opportunities at school or work	1.19	0.54	86.81	8.45	3.59	1.15	27.78		

Means are based on a four-point scale (1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree) SD = standard deviation. Cohens's kappa = agreement between single criterion endorsement and internet gaming disorder using DSM-5 recommendations (i.e. met five or more criteria). A criterion was considered endorsed if at least one of the two items was answered with 4 = strongly agree. WHO-conform forward–backward translation of all items from German to English.

endorsed five or more of the nine criteria. The CSAS was evaluated earlier in another sample of 3423 7–10th-graders from Hanover, Germany [14], demonstrating very good reliability in that sample (Cronbach's $\alpha = 0.94$) and the present sample (Cronbach's $\alpha = 0.93$) and very satisfactory model fit indices (see on-line Supporting information for further details).

Validation variables

Students estimated total on-line and off-line gaming time (hours and minutes) on school and weekend days separately. Total daily gaming time was calculated as (school day × 5) + (weekend day × 2)/7. For a simple self-evaluation of severe problems with video games, participants were asked on a four-point scale (1 = no to 4 = severely) if they felt 'addicted to video games'. Additionally, participants were asked whether they had difficulties in falling asleep in the past week (five-point scale: 1 = never to 5 = always). As an index of academic performance, participants self-reported their grades from the last school report in four subjects: German, mathematics, history and science (1 = very good to 6 = inadequate), which were averaged. Students were also asked whether they had skipped a class or a whole day of school in the past 6 months. Based on this information, the number of skipped classes was calculated (full school days × 5 + single lessons). Additionally, participants stated whether gaming (two-point scale: yes or no) was a reason for their truancy in the past 6 months, and the proportion reporting any gaming-related truancy is reported.

Statistical methods

Missing data

Of 11 003 respondents, 9904 (90.0%) students responded to all 18 CSAS items. Missing data for the CSAS (and other variables) were computed using non-parametric missing value imputation for mixed type-data (missForest [15]); for examples, see Kliem *et al.* [16] and Cohen *et al.* [17]). Unlike other techniques (e.g. multiple imputation or full information maximum likelihood), missForest does not require any distributional assumptions, and it outperforms other methods such as k-nearest neighbours imputation or multivariate imputation using chained equations [16].

Statistical procedures

The multi-level structure of the data (two-level binominal model with level 1: individual, level 2: class) was assessed using HLM version 7 [18]. The intraclass correlation (ICC) was 0.019 at level 2 so, at most, 1.9% of

the variance of IGD diagnosis could be explained by characteristics of the class context in this model (see Hox [19] and Snijders & Bosker [20]). Considering this small maximum variance explained at level 2, the multi-level structure was not introduced in prevalence estimates.

First, sample characteristics are described, and then proportions endorsing specific CSAS items, DSM-5 IGD criteria and at least five of the IGD criteria are detailed. To examine differences in impairment between respondents classified with IGD and those without, independent sample *t*-tests were performed with Stata SE version 12. To analyse associations between endorsement of particular criteria and a DSM-5 diagnosis of IGD, non-parametric conditional inference trees (C-Trees [21,22]), based on the principle of recursive partitioning, were applied (for examples see Kröger *et al.* [23] and Grocholewski *et al.* [24]). Recursive partitioning methods such as C-Trees are non-parametric modelling techniques that are able to deal with a large number of predictor variables, even in the presence of complex interactions. The C-Tree algorithm tests the global null hypothesis of independence between any of the input variables (nine IGD criteria, age, gender, gaming time) and the response variable (IGD) using a permutation test framework [23]. If this hypothesis is rejected, the input variable with the strongest association to the response variable is chosen and a binary split to this variable is implemented. Steps are repeated recursively until the hypothesis is rejected. The stop criterion was based on univariate $P < 0.001$. Permutation tests derive *P*-values from sample-specific permutation distributions of the test statistics.

RESULTS

Sample characteristics

Participants ranged from 13 to 18 years in age [mean = 14.88; standard deviation (SD) = 0.74], 51.09% are male. Table 2 provides demographic characteristics.

Endorsement of items

As displayed in Table 1, the item 'Games are on my mind, even at times when I'm not playing' was endorsed most often (3.54%) followed by both the 'escape adverse moods' items. The most rarely endorsed item was 'I have already lost or risked an important relationship or friendship because of gaming' (0.70%). The overlap of the two items associated with each criterion ranged from 18.63 to 70.75%. The highest overlap occurred for the deceive/cover up criterion; 70.75% of the students who endorsed 'I lie to others to hide how much time I spend playing games' also endorsed 'I spend more time playing games than I admit to others', but only 25.08% of those endorsing this latter item also endorsed the former. The mean score on all 18 items was 1.29 (SD = 0.42).

Endorsement of diagnostic criteria and prevalence of internet gaming disorder

The criterion 'escape adverse moods' was endorsed most frequently ($n = 583$, 5.30%), followed by 'preoccupation' ($n = 430$, 3.91%). The least often-endorsed criteria were 'risk/lose relationships/opportunities' ($n = 168$, 1.53%) and 'give up other activities' ($n = 181$, 1.65%). All criteria

Table 2 Sample characteristics.

	Total sample ($N = 11\,003$)	*Male students* ($n = 5621$)	*Female students* ($n = 5382$)
Age			
Mean (SD)	14.88 (0.74)	14.94 (0.75)	14.81 (0.71)
Median	15.00	15.00	15.00
Range	13–18	13–18	13–18
Respondent or parent(s) born outside Germany, *n* (%)			
All born in Germany	7903 (71.83)	4072 (72.44)	3831 (71.18)
One or more non-German-born	2898 (26.34)	1408 (25.05)	1490 (27.68)
Missing	202 (1.84)	141 (2.51)	61 (1.13)
School, *n* (%)			
Lower secondary	1053 (9.57)	585 (10.41)	468 (8.70)
Middle secondary	6345 (57.67)	3269 (58.16)	3076 (57.15)
Higher secondary	3605 (32.76)	1767 (31.44)	1838 (34.15)
Gaming			
Daily gaming (min)	95.99 (157.69)	161.71 (181.38)	27.36 (85.20)

Non-German background is defined as the student or at least one parent born outside Germany. This classification is based on birth location alone. SD = standard deviation.

were endorsed significantly more often by boys than girls [odds ratio (OR) range = 3.00–7.18; data not shown, available from the authors].

The mean number of criteria endorsed in the full sample was 0.24 [SD = 0.89; 95% confidence interval (CI) = 0.23, 0.26]. Most students (88.18%; 95% CI = 87.58, 88.78) fulfilled none of the IGD criteria (Table 3). A total of 1173 students (10.66%, 95% CI = 10.08, 11.24) endorsed one to four criteria, and 128 students (1.16%; 95% CI = 0.96, 1.36) met five or more criteria.

The 12-month prevalence of IGD was higher in boys than in girls, and students from lower academic level schools experienced higher rates of IGD than students from more academically orientated schools (see Table 4). Students with IGD also rated themselves as more 'addicted' to games than those who were not classified with IGD, and the IGD students also reported more sleep disturbances, lower grades and more truancy, including that directly related to gaming. Additionally, they reported significantly elevated gaming times (Table 5).

Table 3 Number of students fulfilling different numbers of criteria (n = 11 003).

	n (%)		
Criteria fulfilled	*All*	*Male*	*Female*
0	9702 (88.18)	4564 (81.20)	5138 (95.47)
1	732 (6.65)	575 (10.23)	157 (2.92)
2	244 (2.22)	207 (3.68)	37 (0.69)
3	127 (1.15)	103 (1.83)	24 (0.45)
4	70 (0.64)	58 (1.03)	12 (0.22)
5	51 (0.46)	46 (0.82)	5 (0.09)
6	34 (0.31)	31 (0.55)	3 (0.06)
7	14 (0.13)	12 (0.21)	2 (0.04)
8	11 (0.10)	11 (0.20)	0 (0.00)
9	18 (0.16)	14 (0.25)	4 (0.07)

Table 4 Twelve-month prevalence estimates of DSM-5 internet gaming disorder (IGD) (five or more criteria endorsed).

	12-month prevalence estimate (%)	*95% CI*
All students	1.16	0.96, 1.36
Gender		
Male	2.02	1.65, 2.38
Female	0.26	0.12, 0.40
Respondent or parent(s) born outside Germany		
All born in Germany	1.01	0.79, 1.23
One or more non-German-born	1.55	1.10, 2.00
School		
Lower secondary	2.56	1.61, 3.52
Middle secondary	1.28	1.00, 1.55
Higher secondary	0.55	0.31, 0.80

Non-German background is defined as the student or at least one parent born outside Germany. This classification is based on birth location alone. CI = confidence interval.

Predictive power of the DSM-5 criteria for diagnosis

First, we evaluated how endorsement of single criteria corresponded with meeting five or more criteria of IGD (Table 1) using Cohen's kappa coefficient. The criterion 'give up other activities' corresponded best with full DSM-5 IGD classification (Cohen's $\kappa = 0.52$) In contrast, 'escape adverse moods' showed the lowest agreement with IGD (Cohen's $\kappa = 0.28$).

As a second step, associations between the nine criteria, age, gender, gaming time and classification with DSM-5 IGD, were tested using a conditional inference tree plot (Fig. 1). Again, the criterion 'give up other activities' showed the highest association with DSM-5 IGD. The right side of the model shows the diagnostic pathway for those who endorsed 'give up other activities'. Endorsement of this criterion alone was associated with a probability of IGD of 44.75% (95% CI = 37.51, 51.99), and if tolerance was also endorsed there was a very high probability of meeting the full DSM-5 IGD diagnosis, 89.23% (95% CI = 81.69, 96.77). Conversely, a positive response to 'give up other activities' and a negative response to 'tolerance' led to a considerably lower probability for IGD in only 19.83% of cases (95% CI = 12.57, 27.09). For students endorsing 'give up other activities' but denying 'tolerance', the probability of being classified with IGD increased to 42.31% (95% CI = 28.88, 55.74) if 'deceive/cover up' was endorsed.

The left side of Fig. 1 shows the diagnostic pathway for those who denied 'give up other activities'. A negative response to this criterion was associated with DSM-5 IGD in only 0.43% (95% CI = 0.31, 0.55) of the sample. However, students who did not endorse 'give up other activities' but reported both 'withdrawal' and 'preoccupation' had a high probability of IGD (57.89%; 95% CI = 45.07, 70.71). In contrast, students who denied both 'give up other activities' and 'withdrawal' were very unlikely to meet five or more other DSM-5 criteria; only 0.07% (95% CI = 0.02, 0.12) of students who failed to endorse both those criteria were classified with IGD.

The IGD criteria that are not shown in Fig. 1 ('continue despite problems', 'risk/lose relationships/opportunities', 'reduce/stop', 'escape adverse moods') and all the control variables (age, gender or gaming time) were not related significantly to IGD in these multivariate analyses.

DISCUSSION

This study found the 12-month prevalence rate of IGD was 1.16%, within the lower bound of estimates in other

Table 5 Validation variables of impairment for internet gaming disorder (IGD) classification.

	Non-IGD students ($n = 10\,875$)	*IGD-students* ($n = 128$)	*t-Test*
Self-evaluation of being 'addicted to gaming', mean (SD)	1.44 (0.41)	2.25 (1.11)	t[11 001] = 29.24, $P < 0.001$, d = 2.60
Gaming time per day in min, mean (SD)	92.71 (150.32)	375.36 (373.93)	t[11 001] = 20.54, $P < 0.001$, d = 1.83
Sleeping disturbance, mean (SD)	2.55 (1.32)	2.82 (1.56)	t[11 001] = 2.34, $P < 0.001$, d = 0.21
Grade point average, mean (SD)	3.02 (0.68)	3.38 (0.59)	t[11 001] = 5.94, $P < 0.001$, d = 0.53
Times skipped school classes in past 6 months, mean (SD)	4.70 (17.84)	19.34 (43.44)	t[11 001] = 8.98, $P < 0.001$, d = 0.80
Any gaming related truancy in past 6 months, % (SD)	3.92 (19.40)	65.63 (47.68)	t[11 001] = 34.78, $P < 0.001$, d = 3.09

Scores on the self-evaluation of being addicted to gaming scale range from 1 (no, not at all) to 4 (yes, severely), on the sleeping disturbance item from 1 (never) to 5 (always), with higher scores reflecting more sleep disturbances and on grade point average from 1 (very good) to 6 (insufficient). SD = standard deviation.

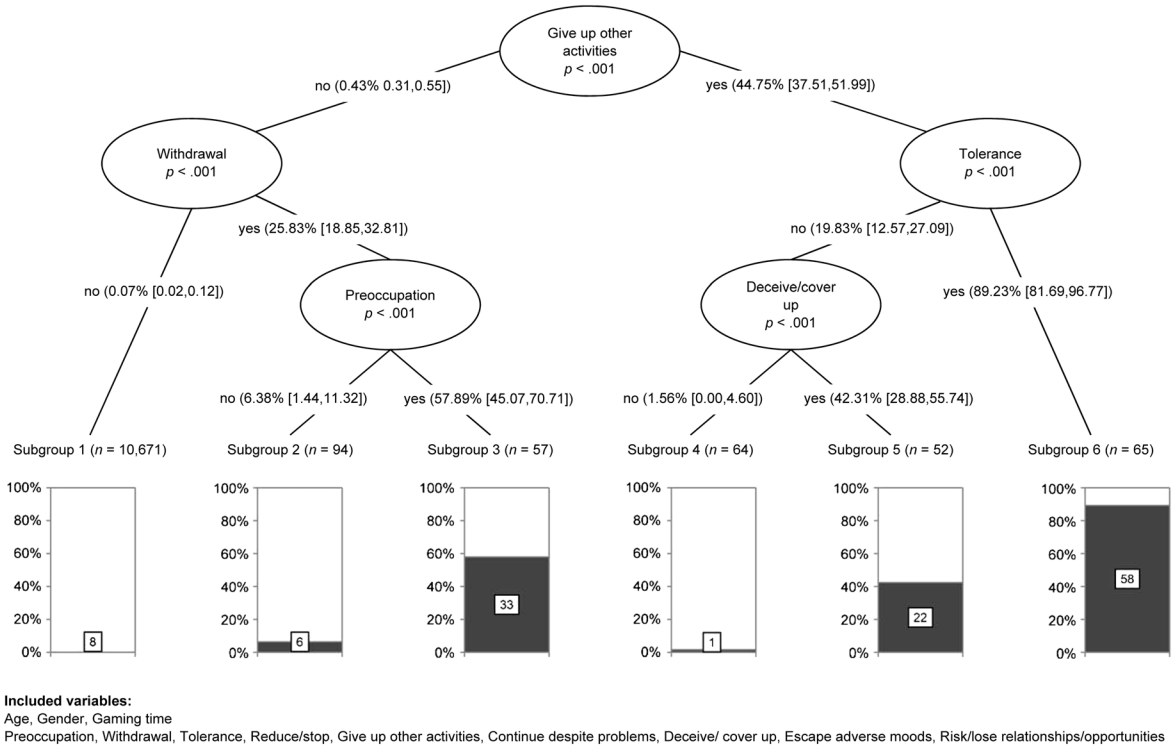

Figure 1 Conditional inference tree plot predicting DSM-5 IGD by diagnostic criteria, age, gender and gaming time ($n = 11\,003$). The circle on the top represents the DSM-5 criterion 'give up other activities', which is the single input variable with the highest predictive value for internet gaming disorder (IGD). Endorsement of this criterion (yes) leads to 'tolerance', giving the most subsequent information. If 'give up other activities' is not endorsed (no), this leads to 'withdrawal', giving the most subsequent information. Paths are labelled with the probability of suspected IGD in the respective diagnostic step including confidence intervals. The rectangles on the bottom represent the six subgroups of students computed by C-Tree (the share of IGD students is marked in black). Summarizing the IGD students in the six subgroups results in the total number of IGD students ($n = 128$) in the sample. Subgroup 1 are students basically screened out by the model after negating the two criteria 'give up other activities' and 'withdrawal', with a remaining probability for IGD of 0.07%. Subgroups 2 to 5 are groups of students with varying probabilities of IGD. Subgroup 6 represents the main group of IGD students having a 89.23% probability for IGD after 'give up other activities' and 'tolerance' are endorsed.

adolescent samples [4,7–9,25]. To the best of our knowledge, the present study is the first to encompass fully all nine DSM-5 IGD criteria in a large-scale survey. This prevalence rate may reflect a conservative approach of the DSM-5, recommending IGD diagnosis only for individuals fulfilling five or more criteria. As shown in Table 3, if four or more criteria related to diagnosis, our prevalence estimate would be 1.80%. These prevalence rates are derived by considering a criterion endorsed only if the respondent rated an item as 'strongly agree'. Using ratings of 'somewhat agree' or higher for endorsement, the percentage of students classified with IGD rises considerably to 6.27% (95% CI = 5.82, 6.72) (see on-line Supporting information). Although a possible prevalence estimate of IGD,

instruments generally do not consider subthreshold endorsement as fulfilling criteria [26]. Thus, the approach we focus upon (endorsing one or both items related to a criterion as 'strongly agree' and requiring five or more criteria for diagnosis) ensures that only clinically relevant symptoms apply towards diagnosis and may be best viewed as a minimal prevalence estimate.

In this study, each criterion was represented by two items, attempting to balance length of assessment with comprehensiveness by utilizing two items per criterion, tapping independent aspects of each criterion when appropriate. As discussed previously [3], diagnostic criteria are complex in nature and capturing their full meaning is critical for valid assessment. By breaking down each criterion into two items, the reading level of this instrument was within an appropriate range for adolescents, and assessment burden was minimized. The moderate response overlap between some of the item pairs was expected, because some items addressed distinct aspects of a criterion while other criteria were captured by two items that were conceptually similar but of different intensity in nature. For example, the criterion related to continuation despite problems refers to both problems at home as well as at school, which tap distinctly different problems, and endorsement of both was relatively modest (Table 1). In contrast, the deception criterion was assessed by two items of increasing severity, i.e. cover up versus lie directly, and more than 70% of students who lied directly about gaming also covered it up, but only 25% of those who covered up gaming lied directly. More items per criterion will enhance endorsement rates, yet many of these criteria are too complex conceptually to be captured within a single item, especially at a middle-school reading level. Utilizing two items per criterion appears to balance these concerns. Although different items or wordings may better or more succinctly capture criteria for IGD, this study and these analyses represent an important step in classifying this condition.

Using this assessment approach, these data confirm a significantly higher prevalence of IGD in males than females [7,8,10]. Further, those classified with DSM-5 IGD reported longer daily gaming times, more truancy including gaming-related truancy, poorer grades and more sleeping problems than those not classified with IGD, consistent with other studies [7,8,25,27–29], and demonstrating construct validity.

The criteria 'escape adverse moods' and 'preoccupation' were endorsed at high rates, but weak in predicting IGD. Other reports have similarly raised concerns about 'preoccupation' with gaming [30,31]. Charlton & Danforth [31] distinguished core and peripheral criteria and found preoccupation loaded onto a non-pathological engagement factor. Thus, thinking about gaming when not playing may relate to high engagement, but not necessarily pathology.

'Give up other activities' predicted the greatest likelihood of meeting five or more DSM-5 IGD criteria, and provided the most initial information for diagnosis. This criterion reflects behavioural salience and is an essential feature of substance use disorders [2], implying narrowing of activities [3]. Of students classified with IGD in this sample, the probability of IGD rose from 1 to 45% if this criterion was endorsed relative to if it was not. 'Tolerance' provided the next most additional information for diagnosis. Tolerance is a central feature of substance use and gambling disorders; it develops over time and, in IGD, reflects long-lasting increasing involvement with games [3]. Among students who endorsed both 'give up other activities' and 'tolerance', 89.23% also endorsed at least three other DSM-5 IGD criteria.

Two other criteria played an important role in IGD diagnosis. The criterion 'preoccupation' gave the most relevant information if 'give up other activities' was denied but 'withdrawal' was endorsed. 'Preoccupation' and 'withdrawal' refer to symptoms that can appear when one is unable to play or is attempting to reduce or stop playing. Thus, endorsement of both criteria might reflect a subgroup of individuals who are trying to control their gaming behaviour.

The criterion 'deceive/cover up' provided important diagnostic information if 'give up other activities' was endorsed and 'tolerance' denied. This criterion may be most relevant to adolescents, who may deceive or lie to their parents about gaming [3]. In a clinical sample of adults [13], this criterion had the lowest diagnostic accuracy. Thus, different pathways and classification trees may result depending on age and living situation.

Finally, although 'continue despite problems' and 'risk/lose relationships/opportunities' had fairly high predictive power of IGD independently (Table 1), they did not provide unique information in the multivariate analysis. This pattern may have resulted because few adolescents who remained in school and were surveyed in this study have experienced severe consequences from gaming; those who did generally reported multiple other criteria as well. Similarly, in the diagnosis of gambling disorder, a criterion representing risking or losing relationships or educational/career opportunities represents a severe symptom [32,33].

Although this study provides unique information about the DSM-5 criteria for IGD, limitations should be considered. First, the sample was restricted to adolescent students in Germany aged 13–18 years, and different patterns of item endorsement may occur in other groups. Secondly, as in most epidemiological studies, we used a self-report questionnaire. No gold standard exists for IGD, but this study provides some evidence of internal consistency and validity of the diagnosis as described in the DSM-5. However, a different threshold may reflect more accurately

individuals with clinically significant harm associated with gaming, and different patterns of endorsement may arise if a lower threshold (e.g. four or more criteria) or ratings of 'somewhat agree' rather than 'strongly agree' are applied (see on-line Supporting information). Further research should address optimal cut-points and evaluate the psychometric properties of this instrument in other populations, age groups and cultures, as well as the common and unique aspects of IGD relative to other behavioural and substance use addictions [34,35]. These data, nevertheless, provide an initial attempt to evaluate the DSM-5 IGD criteria in the context of a condition of growing public health concern throughout the world.

Declaration of interests

None.

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Table S1 Model-fit indices.
Table S2 Item parameters of the Computerspielabhängigkeitsskala / Video Game Dependency Scale (CSAS), endorsement of single items, endorsement of criteria and agreement between single criterion endorsement and Internet Gaming Disorder (n = 11 003).
Table S3 Number of students fulfilling different numbers of criteria (n = 11 003).
Table S4 12-month prevalence estimates DSM-5 internet gaming disorder (IGD) (five or more criteria endorsed).
Table S5 Validation variables of impairment for internet gaming disorder (IGD) classification.
Figure S1 Conditional inference tree plot predicting DSM-5 IGD by diagnostic criteria, age, gender and gaming time (n = 11 003). Estimates derived from alternatively using 3=somewhat agree and 4=strongly agree and thus subclinical (sc) endorsement of symptom and criterion. The circle on the top represents the DSM-5 criterion "continue despite problems (sc)", which is the single input variable with the highest predictive value for IGD. Endorsement of this criterion (yes) leads to "reduce/stop (sc)", giving the most subsequent information. If "continue despite problems (sc)" is not endorsed (no), this leads to "give up other activities (sc)", giving the most subsequent information. Paths are labelled with the probability of suspected IGD in the respective diagnostic step including confidence intervals. The rectangles on the bottom represent the eight subgroups of students computed by C-Tree (the share of IGD-students is marked in black). Summarizing the IGD-students in the eight subgroups results in the total number of IGD-students (n = 690) in the sample.