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Annual Research Review: A meta-analysis of the worldwide prevalence of mental disorders in children and adolescents

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Background: The literature on the prevalence of mental disorders affecting children and adolescents has expanded significantly over the last three decades around the world. Despite the field having matured significantly, there has been no meta-analysis to calculate a worldwide-pooled prevalence and to empirically assess the sources of heterogeneity of estimates. **Methods:** We conducted a systematic review of the literature searching in PubMed, PsycINFO, and EMBASE for prevalence studies of mental disorders investigating probabilistic community samples of children and adolescents with standardized assessments methods that derive diagnoses according to the DSM or ICD. Meta-analytical techniques were used to estimate the prevalence rates of any mental disorder and individual diagnostic groups. A meta-regression analysis was performed to estimate the effect of population and sample characteristics, study methods, assessment procedures, and case definition in determining the heterogeneity of estimates. **Results:** We included 41 studies conducted in 27 countries from every world region. The worldwide-pooled prevalence of mental disorders was 13.4% (CI 95% 11.3–15.9). The worldwide prevalence of any anxiety disorder was 6.5% (CI 95% 4.7–9.1), any depressive disorder was 2.6% (CI 95% 1.7–3.9), attention-deficit hyperactivity disorder was 3.4% (CI 95% 2.6–4.5), and any disruptive disorder was 5.7% (CI 95% 4.0–8.1). Significant heterogeneity was detected for all pooled estimates. The multivariate metaregression analyses indicated that sample representativeness, sample frame, and diagnostic interview were significant moderators of prevalence estimates. Estimates did not vary as a function of geographic location of studies and year of data collection. The multivariate model explained 88.89% of prevalence heterogeneity, but residual heterogeneity was still significant. Additional meta-analysis detected significant pooled difference in prevalence rates according to requirement of funcional impairment for the diagnosis of mental disorders. **Conclusions:** Our findings suggest that mental disorders affect a significant number of children and adolescents worldwide. The pooled prevalence estimates and the identification of sources of heterogeneity have important implications to service, training, and research planning around the world.
Keywords: Mental disorders, anxiety disorders, depressive disorders, ADHD, disruptive behavior disorders, children, prevalence, epidemiology, meta-analysis, cross-cultural.

Introduction

The number of children and adolescents affected by mental disorders has been the focus of significant interest over recent decades (Achenbach, Rescorla, & Ivanova, 2012; Insel, 2014; Knudsen, Heckman, Cameron, & Shonkoff, 2006; Whiteford et al., 2013). Rates of diagnoses have increased substantially and a growing number of children and adolescents now requiring pharmacological and psychotherapeutic treatments, educational interventions, and a variety of special services and accommodations has prompted the interest of researchers, clinicians, and the community in general (Atladottir et al., 2014; Egan, 2008; Miller, 2010; Olfson, Blanco, Wang, Laje, & Correll, 2014; Sahakian & Morein-Zamir, 2007; Schwarz & Cohen, 2013). There is evidence to suggest that overdiagnosis and overtreatment exist to some extent (James et al., 2014; Visser et al., 2013). Nevertheless, a large body of evidence indicates that children currently in treatment do not exceed the number of children with mental disorders, and underdiagnosis and undertreatment are major public health problems around the world (Belfer, 2008; Merikangas, 2013; Morris et al., 2011). Accurate prevalence estimates are essential to inform service planning, resource allocation, training, and research priorities (Costello, Burns, Angold, & Leaf, 1993). Moreover, the identification of prevalence estimates variability can contribute to addressing questions about etiology and inform the design of future studies.

Community surveys measuring the frequency of children with emotional and behavioral problems have been conducted as early as the first half of the 20th century. These early surveys used

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nonstandardized methods with sampling strategies and measurement approaches that limited the internal and external validity of results. In the second half of the 20th century, the development of strong principles and methods in epidemiology reached child psychiatry, an emergent discipline at the time. In parallel, the introduction of explicit diagnostic criteria including childhood disorders in the DSM-III (1980) allowed the development of standardized psychiatric interviews and stimulated epidemiological research in the field. Community surveys employing sound epidemiological methods and following standardized diagnostic criteria were published in the 1980s and 1990s, providing reliable estimates of rates of mental disorders in children and adolescents in the community (Buka, Monuteaux, & Earls, 2002; Costello, 1989; Verhulst & Koot, 1991, 1995).

In the past three decades, the increasing number of community surveys provided unprecedented estimates in various regions of the world (Breton et al., 1999; Canino et al., 2004; Costello, Mustillo, Erkanli, Keeler, & Angold, 2003; Ford, Goodman, & Meltzer, 2003; Goodman, Slobodskaya, & Knyazev, 2005; Kessler et al., 2012). Systematic and narrative reviews have summarized the available literature, providing detailed methodological appraisals of studies. One important shared finding among reviews was the nonuniformity of methodological approaches, sampling strategies, and case definitions between original surveys, limiting the comparability of rates in different parts of the world (Bird, 1996; Brandenburg, Friedman, & Silver, 1990; Brauner & Stephens, 2006; Buka et al., 2002; Costello et al., 1993; Verhulst & Koot, 1995). To date, no international multisite study using strictly the same methodology and deriving formal categorical diagnoses of mental disorders in children and adolescents is found in the literature. In addition, there is no available meta-analysis calculating a worldwide-pooled prevalence estimate and testing the relative impact of each individual study method on the variability in estimates across the studies.

In this review, we first consider previous narrative and systematic reviews on the prevalence of mental disorders in children and adolescents in the community. Second, we address sources of prevalence variability identified in the literature. Third, we report an original comprehensive systematic review of the literature. Fourth, based on the studies included in our systematic review, we present the results of a meta-analysis calculating a worldwide-pooled prevalence of mental disorders in children and adolescents in the community. Fifth, we report the results of metaregression analyses conducted to test study-level covariates associated with the heterogeneity of prevalence estimates. Finally, we discuss and integrate the findings and their research, policy and clinical implications.

Prevalence estimates

A number of literature reviews have summarized community surveys and provided a comprehensive picture of the field (Angold & Costello, 1995; Bird, 1996; Brandenburg et al., 1990; Brauner & Stephens, 2006; Buka et al., 2002; Costello, Egger, & Angold, 2005; Duarte et al., 2003; Merikangas, Nakamura, & Kessler, 2009; Roberts, Attkisson, & Rosenblatt, 1998; Verhulst & Koot, 1991, 1995). An important limitation is that most of the reviews have not used a systematic methodology to identify relevant studies. Summary estimates have been usually calculated as the median of individual estimates, and none of them have implemented a meta-analytic approach. Verhulst & Koot (1991) identified 38 studies published between 1965 and 1990, with a median prevalence rate of mental disorders of 13%, ranging from 3% to 30%. Subsequently, 11 other studies were incorporated in the pool, resulting in a median rate of 12% (Verhulst & Koot, 1995). Another review identified 52 studies published between 1963 and 1996 with prevalence estimates ranging from 1% to 51%, and median rates of 8% for preschoolers, 12% for preadolescents, and 15% for adolescents (Roberts et al., 1998).

Cross-cultural differences

A large number of studies have used symptom scales such as the Child Behavior Checklist (CBCL) and Strengths and Difficulties Questionnaire (SDQ) to assess dimensional psychopathology in children and adolescents in a variety of countries (Achenbach et al., 2008). By using the same instrument and comparable study methods, differences that are detected across studies and countries can be interpreted as resulting from geographic, social, and/or cultural aspects. Culture in general may influence the identification and interpretation of symptoms and the meaning attributed to them, not only by parents and teachers, but also by health professionals (Bird, 1996; Egan, 2008; Miller, 2010; Olfson et al., 2014; Schwarz & Cohen, 2013). Moreover, culture and related factors that are more proximal to childhood development (e.g. parental style) influence the emergence of emotional and behavioral problems (Canino & Alegría, 2008; James et al., 2014; Visser et al., 2013). Nevertheless, studies assessing community samples around the world (most of them nonrepresentative of the populations) with dimensional measures found more similarities than differences in terms of the psychopathology and correlates between them, with slight differences in the rate of symptoms (Crijnen, Achenbach, & Verhulst, 1997; Ivanova et al., 2010; Rescorla et al., 2011, 2012; Verhulst & Achenbach, 1995; Verhulst et al., 2003).

Literature reviews have focused on surveys that used both diagnostic interviews and rating scales to assess prevalence rates of mental disorders in specific

countries and regions, such as Germany (Barkmann & Schulte-Markwort, 2012), Latin America (Duarte et al., 2003) and Asia (Srinath, Kandasamy, & Golhar, 2010). Bird (1996) conducted a narrative review of the literature and described studies in various countries employing different methodological approaches, but all of them using standardized diagnostic interviews to generate categorical diagnoses. Studies using ICD-9 diagnostic criteria detected rates of mental disorders of 12.4% in Chartres, France; 25.4% in Dublin, Ireland; and 51.3% in Mannheim, Germany. Studies following DSM-III or DSM-III-R detected rates of 19.4% in New York; 17.6% in Dunedin, New Zealand; 26% in Zuid-Hollands, The Netherlands; 18.1% in Ontario, Canada; 41.3% in Columbia, USA; 22% in Pittsburgh, USA; 49.5% in Puerto Rico; 27.3% in Christchurch, New Zealand. In general, these studies provided a heterogeneous picture of prevalence estimates in different countries. Nevertheless, because variation in cultural aspects cannot be disentangled from variation in study methods in this literature review, no conclusions can be drawn about the independent effect of culture and social aspects over prevalence estimates.

Methodological approaches

Methods in epidemiology evolved considerably in the second half on the 20th century and reached the field of child and adolescent psychiatry following the 1980s. Study designs have since become more sophisticated, as well as case definition and methods of ascertainment. New diagnostic interviews have been developed, information from different sources has been aggregated in a variety of new formats, and functional impairment has been conceptualized and operationalized differently. Thus, important variability in diverse aspects of study methods has characterized the surveys conducted to date (Breton et al., 1999; Buka et al., 2002; Canino et al., 2004; Costello et al., 2003; Ford et al., 2003; Goodman, Slobodskaya, & Knyazev, 2005; Kessler et al., 2012; Verhulst & Koot, 1991, 1995).

Variability in study methods introduces noise in the process of estimating a true global prevalence and of investigating the impact of social and cultural aspects on the estimates. Therefore, it has been understood as a barrier to the progress of the field (Brauner & Stephens, 2006; Buka et al., 2002; Merikangas et al., 2009; Verhulst & Koot, 1995). Nevertheless, fluctuations in the prevalence rates as a function of methodological approaches also contributed to the further refinement of epidemiological methods and principles (Bird, 1996; Brandenburg et al., 1990; Brauner & Stephens, 2006; Costello et al., 1993, 2005). In addition, it prompted the field's attention to the limitations of current nosological schemes in capturing mental disorders and the need to move beyond them (Angold & Costello, 1995, 2009; Bird, 1996; Brandenburg et al., 1990; Brauner & Stephens, 2006; Buka et al., 2002; Costello et al., 2005; Duarte et al., 2003; Hyman, 2010; Merikangas et al., 2009; Roberts et al., 1998; Verhulst & Koot, 1991, 1995). Described below are methodological strategies related to study design, case definition, and ascertainment that are identified in the literature as potentially relevant for variability on prevalence estimates.

Sampling strategy. Sampling is the process of selecting the specific study subjects. A study sample that accurately represents the target population is an essential characteristic of a prevalence study because it ensures that results are generalizable to all members of the population. To identify a representative sample of the population, a probabilistic sampling strategy must be adopted.That is, each eligible member of the population has a known chance to be identified and included in the sample by the principle of randomization. In practice, the population is defined through a sampling frame, which is a list of all of the units in the target population used to draw the sample. Examples of sampling frames include telephone directories, census data, and schools. Different sampling strategies can be adopted to select the units within the frame, such as simple random sampling, stratified random sampling, systematic sampling, and cluster sampling (Fleming & Hsieh, 2002; Rothman, Greenland, & Lash, 2008; Verhulst & Koot, 1991).

Community surveys of mental disorders in children and adolescents have commonly used schools as a sampling frame, which are selected within a defined area or randomly selected from a register of schools (Angold et al., 2002; Kroes et al., 2001; Leung et al., 2008; Verhulst & Koot, 1995). In countries where virtually all children are enrolled in schools, this is a robust strategy that is likely to have equivalent external validity to studies using population census or household frames (Ford et al., 2003; Roberts et al., 1998; Vicente et al., 2012), with practical and logistic advantages.

As the sampling frame and the individuals who are eligible for inclusion in the study are identified, it is possible to recognize those who in fact participated, and those who did not. The number of individuals eligible for participation who are included in the study, or the response rate of a study, is an important paremeter of the success of the sampling procedure. If a substantial proportion of the eligible participants does not take part in a survey or if nonparticipation occurrs nonrandomly (i.e. specific characteristics are associated to nonparticipation), results may not be generalized to the population or may be biased.

Study design. Community surveys using a one-stage design, in which diagnostic interviews are used to assess an entire representative sample of the population, provide strong methodological basis to generate prevalence rates. Nevertheless, these studies

are expensive and time-consuming for families, limiting their feasibility. The Isle of Wight (Rutter, Tizard, Yule, Graham, & Whitmore, 1976) study was the first to use a two-stage design to maximize resources and minimize burden to participants. This study design includes a screening instrument answered by the entire sample; subsequently, only individuals who screen positive (or a random sample of them) and a proportion of individuals who screen negative are further selected for the diagnostic phase. With the rates of diagnosis for both groups of individuals who screen positive and negative, it is possible to calculate the instrument's diagnostic properties and therefore to estimate the prevalence in the initial sample and the population. However, considerable work should be directed to identify the screening method, screening informant, and the most appropriate cut-off points. These are important elements that are frequently inconsistent across studies and may impact the resulting prevalence rates (Achenbach et al., 2008; Gómez-Beneyto, Bonet, Catalá, Puche, & Vila, 1994; Kroes et al., 2001).

Diagnostic criteria. The development of classification systems has provided the foundations for reliable assessment of mental disorders (Buka et al., 2002). Differences in the diagnostic criteria for the same disorder between the two most used systems in Psychiatry [the International Classification of Diseases – ICD and the Diagnostic and Statistical Manual of Mental Disorders – DSM] result in differences in prevalence rates (Anselmi, Fleitlich-Bilyk, Menezes, Araujo, & Rohde, 2010). In addition, as revised versions of ICD and DSM were published, and criteria of specific mental disorders changed, differences in prevalence rates are expected. Therefore, diagnostic criteria is a major issue to consider when comparing rates across studies.

Diagnostic assessment. Diagnostic assessment is the procedure employed by the investigators to determine the presence or absence of mental disorders following specific diagnostic criteria. The diagnostic interview is a major component of the assessment, as assessment standardization is a fundamental requirement to guarantee within and between studies consistency. Diagnostic interviews differ with regard to the way questions are formulated, to the presence of gate/skip questions, and to the emphasis on the respondent's understanding and interpretation of the questions (respondent-based), or the interviewer's interpretation of the answers given (interviewer-based). The former tend to be structured interviews, usually administered by lay-interviewers, and the latter, semistructured interviews usually administered by clinicians (Buka et al., 2002).

Informants. Community surveys commonly use parents as informants, adolescents, and less frequently teachers. The correlation between different informants is low, which may potentially be explained by the differential expression of symptoms according to the environment, and by the emphasis placed on different aspects of behavior by each informant (Breton et al., 1999). Thus, as in clinical practice, it is desirable to collect data from different sources. However, the challenge is how to integrate the data. A number of strategies have been developed, such as the 'best estimate procedure', 'and rule', and 'or rule'. Following the best estimate procedure, data from different sources and instruments are integrated by clinicians, who define the presence of a diagnosis based on their understanding of the available information (Leckman, Sholomskas, Thompson, Belanger, & Weissman, 1982). According to the 'and rule', a symptom is considered positive if both informants endorsed the symptom. According to the 'or rule', a symptom is considered positive if one of two informants endorsed the symptom. Evidence indicate that the 'or rule' approach results in higher rates than the 'and rule' approach (Verhulst, Van Der Ende, Ferdinand, & Kasius, 1997). Alternative strategies include the definition of specific rules for each diagnosis and the identification of optimal informants based on conditional agreement between informants (Bird, Gould, & Staghezza, 1992; Kraemer et al., 2003).

Functional impairment. The definition of functional impairment is an important parameter for case definition, as a significant number of children present with symptomatic criteria but have optimal functioning (Bird et al., 1988). On the other hand, a number of children do not met symptomatic criteria, but have functional impairment that justifies access to services (Angold, Costello, Farmer, Burns, & Erkanli, 1999). The presence of both symptomatic and impairment criteria is the most robust approach for case definition (Costello et al., 2005). Different definitions of functional impairment may be adopted, such as measures of impairment specifically related to the disorder or global measures of impairment (such as the Child Global Assessment Scale, CGAS). The former has the advantage to be related specifically to the identified disorder, and the latter, although not specifying the source of impairment, is a good predictor of adaptative functioning and need of service (Bird et al., 1990). Different studies have reported rates of mental disorders according to different impairment definitions and CGAS score thresholds. As expected, these diverse approaches result in variable estimates (Shaffer et al., 1996; Verhulst et al., 1997).

Methods

Literature search

We conducted a systematic review of the literature through electronic search in three separate databases and a review of

the references of all articles examined for inclusion as well as relevant review articles and textbooks. We followed the guidelines for conducting and reporting meta-analyses (Liberati et al., 2009; Stroup et al., 2000).

We searched PubMed, PsycINFO, and EMBASE using the following entry terms: 'mental disorders or psychiatric disorders AND epidemiology or prevalence or survey AND child or adolescent'. All abstracts were reviewed independently by two authors (L.S.S.and A.C.) supervised by the first author (G.V.P.) and selected based on consensus if they satisfied one of the two criteria: (a) reviews of the literature on the epidemiology of mental disorders in children and adolescents; (b) original prevalence studies of mental disorders assessing community samples of children and adolescents with standardized diagnostic procedures that derive diagnosis following DSM versions III, III-R, or IV, or ICD versions 9 or 10. If there was not enough information to determine eligibility, articles were selected for further review.

Study inclusion criteria

Two authors (L.S.S. and A.C.) reviewed the full text of selected articles and inclusion was discussed with the first author (G.V.P.). Inclusion criteria were (a) original prevalence studies assessing community samples; (b) probabilistic sampling strategy; (c) use of a standardized assessment procedure deriving diagnosis according to DSM-III, DSM-III-R, DSM-IV, ICD-9, or ICD-10); (d) assessment of a minimum of three diagnostic groups of disorders (e.g. anxiety disorders, mood disorders, disruptive behavior disorder); (e) inclusion of children or adolescents up to age 18. Twin samples and the first wave of longitudinal studies were eligible for inclusion. Studies without available data to estimate standard errors were excluded. Languages included Portuguese, English, Spanish, French, and German.

Data extraction

Data were independently extracted by two authors (L.S.S. or A.C. and G.V.P.). For the meta-analyses of prevalence estimates and the metaregression analysis, each study contributed with a single estimate. Therefore, for studies that reported multiple estimates according to different case definitions, only one prevalence estimate was selected based on a priority criteria defined *a priori*. The following information was extracted and levels were created for each variable for purposes of analysis. Levels for each variable are presented in priority order for selection when multiple estimates were derived by the same study:

Population characteristics.

1. Study location, coded in seven levels: (a) North America; (b) Europe; (c) Asia; (d) Africa; (e) South America and the Caribbean; (f) Middle East; (g) Oceania.
2. Year of data collection, coded as a continuous variable.

Sample characteristics.

1. Age range, coded in three levels: (a) 6–18; (b) 6–11;(c) 12–18 years of age.

Study methods.

1. Representativeness and sampling strategy, coded in four levels: (a) country, weighted to represent the population; (b) large city or area, weighted to represent the population; (c) small-medium city or area, probably representative sample, complex sampling considered; and (d) small-medium city or area, probably nonrepresentative sample, complex sampling not considered.
2. Sample frame, coded in five levels: (a) schools; (b) households; (c) population census; (d) birth register; and (e) multiple frames.
3. Study design, coded in two levels: (a) one-stage and (b) two-stage.

Assessment procedures and case definition.

1. Time frame for assessment, coded in six levels: (a) 1 month; (b) 3 months; (c) 6 months; (d) 12 months; (e) current; and (f) lifetime.
2. Diagnostic criteria, coded in five levels: (a) DSM-IV; (b) DSM-III-R; (c) DSM-III; (d) ICD-10; and (e) ICD-9.
3. Diagnostic interview, coded in eight levels: (a) K-SADS; (b) CAPA; (c) DISC; (d) CIDI; (e) DAWBA; (f) DICA; (g) Isle of Wight interview; and (h) clinical interview.
4. Number of diagnostic groups assessed, coded as a continuous variable. (anxiety, mood, attention-deficit/hyperactivity disorders and developmental disorders, disruptive behavioral disorders, substance use disorders, impulse control disorders, elimination disorders, tic disorders, eating disorders, and psychotic disorders).
5. Informant, coded in five levels: (a) parent, child, and teacher; (b) parent and teacher; (c) parent and child; (d) parent; and (e) child;
6. Diagnostic algorithm to aggregate data from different informants, coded in seven levels: (a) best estimate procedure; (b) clinical assessment and decision;(c) and rule; (d) or rule; (e) parent only; (f) child only; and (g) different for each disorder.
7. Requirement of functional impairment for the diagnosis, coded in two levels: (a) yes; (b) no.
8. Definition of functional impairment, coded in five levels: (a) CGAS score below 69–71; (b) CGAS score below 59–61; (c) disorder-specific impairment, as defined by the diagnostic interview; (d) disorder-specific impairment, as defined by the diagnostic interview and CGAS score below 71; and (e) clinical judgment.

Data analysis

Initially, outlier and influential case diagnostics were performed using the externally standardized residuals, DFFITS values, Cook's distances, covariance ratios, leave-one-out estimates of the amount of heterogeneity, leave-one-out heterogeneity test statistics, and hat values and weights (Viechtbauer & Cheung, 2010). Studies identified as outliers were excluded from analysis.

The first set of analyses involved random effects meta-analysis of prevalence estimates of any mental disorders. It also included meta-analysis to estimate pooled prevalence rates of individual diagnostic groups that were commonly reported by the studies, i.e. any anxiety disorder, any depressive disorder, major depressive disorder, attention-deficit hyperactivity disorder, any disruptive disorder, oppositional defiant disorder, and conduct disorder. The second set of analysis included metaregression analysis, performed using linear mixed-effects models including study-level covariates identified in the literature as potentially implicated in heterogeneity (Raudenbush, 2009). Only studies that contributed to information on all covariates were included. Otherwise, results related to different covariates would not be comparable between them. For 12 studies, 'years of data collection' was not presented. Therefore, we performed data imputation from publication year using a linear regression model (Adjusted $R^2 = 0.89$; $F(1,34) = 280.9$, $p < 0.001$). For five studies, requirement of impairment for the diagnosis was not informed, and only five other studies reported estimates according to no

requirement of impairment, which would constrain variability for the analysis. Therefore, the effect of this covariate was not investigated in the context of metaregression. Time frame for assessment was not reported by 19 studies, and its effect was not evaluated in the metaregression analysis. The following covariates were tested in univariate models using the maximum likelihood estimator: geographic location, year of data collection, sample age range, sample representativeness, sample frame, study design, diagnostic criteria, diagnostic interview, number of diagnostic groups assessed, informants, and diagnostic algorithm. The '*Variance Accounted For (VAF)*', a pseudo-R^2 statistic, is given for each univariate model and indicates the proportion of the total heterogeneity in the true effects that is accounted for by each one of the covariates individually. Covariates associated with heterogeneity at a $p < 0.2$ were subsequently included in a multivariate model. The third set of analyses included random effects meta-analysis to estimate pooled difference in prevalence rates according to different definitions of funcional impairment for the diagnosis as presented by the same studies. This strategy provides a strong test of the effect of different case definitions, as other methodological variables were held constant within studies. All analyses were conducted with *R* using the 'metafor' package (Viechtbauer, 2010).

Results

Systematic review

The systematic review identified 23,191 abstracts, and 198 studies were selected for full-text review. Additional 82 studies were identified and reviewed. Figure 1 presents the detailed results of the review. Forty-eight original studies met inclusion criteria and are described in detail in Table 1.

Studies meeting inclusion criteria were published from 1985 to 2012, and conducted in 27 countries distributed in North America ($k = 14$) (Angold et al., 2002; Benjet, Borges, Medina-Mora, Zambrano, & Aguilar-Gaxiola, 2009; Breton et al., 1999; Canino et al., 2004; Carter et al., 2010; Costello et al., 1996; Kashani et al., 1987; Kessler et al., 2012; Merikangas et al., 2010; Offord et al., 1987; Roberts, Roberts, & Xing, 2007; Romano, Tremblay, Vitaro, Zoccolillo, & Pagani, 2001; Shaffer et al., 1996; Velez, Johnson, & Cohen, 1989), Europe ($k = 14$) (Almqvist et al., 1999; Fombonne, 1994; Ford et al., 2003; Frigerio et al., 2009; Gómez-Beneyto et al., 1994; Heiervang et al., 2007; Kroes et al., 2001; Lynch, Mills, Daly, & Fitzpatrick, 2006; McArdle, Prosser, & Kolvin, 2004; Petersen, Bilenberg, Hoerder, & Gillberg, 2006; Puura et al., 1998; Steinhausen, Metzke, Meier, & Kannenberg, 1998; Verhulst, Berden, & Sanders-Woudstra, 1985; Verhulst et al., 1997), Asia ($k = 8$) (Alyahri & Goodman, 2008; Goodman, Slobodskaya, & Knyazev, 2005; Hackett, Hackett, Bhakta, & Gowers, 1999; Leung et al., 2008; Malhotra, Kohli, & Arun, 2002; Mullick & Goodman, 2005; Pillai et al., 2008; Srinath et al., 2005), Africa ($k = 2$) (Ashenafi, Kebede, Desta, & Alem, 2001; Robertson, Ensink, Parry, & Chalton, 1999), South America and the Caribbean ($k = 5$) (Anselmi et al., 2010; Bird et al., 1988; Fleitlich-Bilyk & Goodman, 2004; Goodman, Neves dos Santos, et al., 2005; Vicente et al., 2012), Middle East ($k = 2$) (Eapen, Jakka, & Abou-Saleh, 2003; Farbstein et al., 2010), and Oceania ($k = 3$) (Anderson, Williams, McGee, & Silva, 1987; Fergusson, Horwood, & Lynskey, 1993; Sawyer et al., 2001). One study was identified as an influential outlier and was excluded from the analysis (see online Figure S1). Six studies did not report information on one or more relevant covariates (informants, algorithm for aggregating information from different sources). Forty-one studies reported data for all covariates and were therefore included in the meta-analyses and metaregression analysis.

Worldwide prevalence of mental disorders

Meta-analysis estimated a worldwide prevalence of mental disorders in children and adolescents of 13.4% (CI 95% 11.3–15.9; $k = 41$; pooled sample size 87,742). Heterogeneity was found to be substantial, I^2>99%, $Q(df = 40) = 5036747.2$, $p < 0.0001$. Random effects meta-analysis was also performed for every individual group of mental disorders. Prevalence rates were estimated as follow: any anxiety disorder, 6.5% (CI 95% 4.7–9.1); any depressive disorder, 2.6% (CI 95% 1.7–3.9); major depressive disorder, 1.3% (CI 95% 0.7–2.3); attention-deficit hyperactivity disorder, 3.4% (CI 95% 2.6–4.5); any disruptive disorder, 5.7% (CI 95% 4.0–8.1); oppositional defiant disorder, 3.6% (CI 95% 2.8–4.7); and conduct disorder, 2.1% (CI 1.6–2.9). Heterogeneity was found to be substantial for each individual outcome (I^2>99%). Results are presented in Figure 2.

Sources of variability on prevalence estimates

The metaregression analysis was performed to investigate the sources of heterogeneity of any mental disorder's pooled prevalence estimate. Results are presented in Table 2. Given the reduced number of studies reporting prevalence estimates for each specific group of disorders in relation to the combination of disorders, the metaregression was not performed for heterogeneity of specific outcomes. Initially, the proportion of the total heterogeneity in the true effects accounted for by each one of the covariates individually was investigated in univariate models. Also, a single test was performed for each specific covariate to estimate the prevalence difference (represented in percentage) and its significance between all levels and the contrast level. Covariates associated with heterogeneity at a $p < 0.2$ were subsequently included in a multivariate model. The following covariates were associated with estimates of heterogeneity at a $p < 0.2$ and were therefore included in the multivariate model: geographic location ($p = 0.1638$; VAF = 22.62%), sample age range ($p = 0.0521$; VAF = 14.94%), sample representativeness ($p = 0.1152$; VAF = 14.78%), sample frame

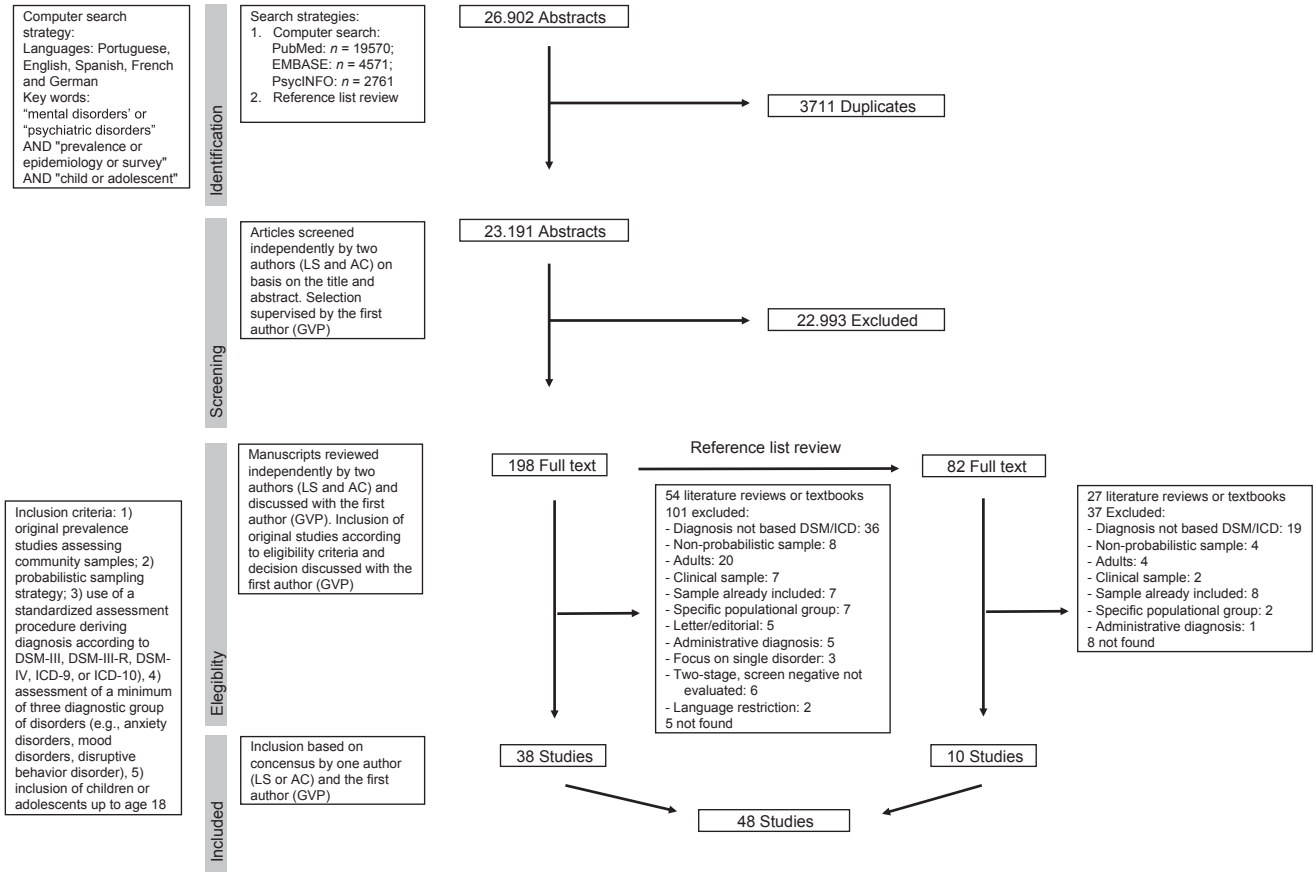

Figure 1 Flowchart of review process and study selection

($p = 0.0121$; VAF = 29.53%), diagnostic interview ($p < 0.0001$; VAF = 68.61%), and diagnostic algorithm ($p = 0.0519$; VAF = 26.66%).

The final multivariate model identified sample representativeness, sample frame, and diagnostic interview as significant moderators of prevalence estimates. Study geographic location and sample age range were not significant moderators. Studies conducted in single cities assessing probably representative samples generated a prevalence estimate of 11.46% (CI 95% −1.22–21.71) lower than studies assessing national representative samples. Studies that used schools as the sampling frame generated an estimate of 11.2% (CI 95% 2.17–20.23) higher than studies that used households as sampling frames. With regard to diagnostic interview, using studies that adopted K-SADS as the contrast, studies that adopted CIDI generated estimates 25,12% (CI 95% 6.59–43.64) higher, and studies that adopted Isle of Wight, DICA, and clinical interview generated estimates 22.91% (CI 95% −2.08–43.74), 13.17% (CI 95% −0.96–25.38), and 31.58% (CI 95% −10.98–52.18) lower. The multivariate model explained 88.89% of prevalence estimates variability, but residual heterogeneity was still significant at a $p < 0.001$. Results are presented in Table 2.

The effect of functional impairment on prevalence variability

Random effects meta-analysis estimated pooled difference in prevalence rates according to different requirements and definitions of funcional impairment for the diagnosis as presented by the same studies. Eleven studies reported prevalence rates following no requirement of impairment (pooled prevalence: 27.1%, CI 95% 20.2–34.0; $I^2 = 99\%$) and disorder-specific impairment defined by the diagnostic interview (pooled prevalence: 14.0%, CI 95% 11.1–16.9; $I^2 = 97.3\%$). Four studies reported prevalence rates following no requirement of impairment (pooled prevalence: 28.1%, CI 95% 14.1–42.1; $I^2 = 98.8\%$) and impairment defined as a CGAS score below 59–61 (pooled prevalence: 9.7%, CI 95% 4.5–14.8; $I^2 = 98.1$). Seven studies reported prevalence rates following no requirement of impairment (pooled prevalence: 20.2%, CI 95% 16.1–24.3; $I^2 = 97.2\%$) and impairment defined as a CGAS score below 69–71 (pooled prevalence: 9.6%, CI 95% 6.7–12.4; $I^2 = 97.2\%$). The pooled difference in prevalence rates following the possible comparisons within studies were all significant at a $p < 0.001$ and are presented in Table 3.

Table 1 Description of studies identified by the systematic review

First author (year)	Country	Years data collection	Representativeness	Frame	Time frame	Age range	% boys	Sample size – screening sample (if 2-step procedure)	Response rate screening sample (if 2-step procedure)	Sample size evaluated	Screening instrument (if 2-step procedure)
Almqvist (1999)	Finland	1989	National	Population	3 months	8–9	50.6	6017	96.6	5813	RA2. CDI. RB2
Alyahri (2008)	Yemen	2002–2003	City of Mukalla or the rural area of Tuban.	School		7–14					
Anderson (1987)	New Zealand	1983–1984	All children born in Dunedin, NZ in 1971-2	Birth registers	12 months	11	52.52				
Angold (2002)	United States		Catchment area in North Carolina. USA	Schools	3 months	9–17	52.7	3941	91.7	3613	CBCL
Anselmi (2010)	Brazil	2004–2006	City of Pelotas	Population		11–12	49.8	5249	87.5	4452	SDQ
Ashenafi (2001)	Ethiopia	1998	District of Butajira	Household		5–15	50.6				
Benjet (2009)	Mexico	2005	Representative sample of Mexico city	Household	12 months	12–17	49.9				
Bird (1988)	Puerto Rico	1985–1986	National. Multistage probability sample of 2036 households distributed across Puerto Rico in 210 clusters, weighted to complex sampling procedures	Household	6 months	4–16	50.4	843	92.7	777	CBCL
Breton (1999)	Canada	1992	Representative sample of Quebec	Household	6 months	6–14	51.6				
Canino (2004)	Puerto Rico	1999–2000	National, weighted to represent the general population	Household	12 months	4–17	53.1				
Carter (2010)	United States	2000–2004	Children born in New Haven–Meriden Standard Metropolitan Statistical Area from July 1995 to September 1997	Birth registers	12 months	5–6	53.4	1468	73.4	1078	ITSEA. CBCL. TRF. CDI
Costello (1996)	United States		All children from the southern Appalachian mountain region of North Carolina	Household	3 months	9. 11 and 13		4067	95.7	3896	CBCL
Eapen (2003)	United Arab Emirates		District of Al Ai, random sample	Household		6–18	50.15				
Farbstein (2010)	Israel	2004–2005	National	Population register		14–17	51.2				
Fergusson (1993)	New Zealand	1992	Children born in the Christchurch urban region during mid-1977	Birth register	Current	15					
Fleitlich-Bilyk (2004)	Brazil	2000–2001	City of Taubate, weighted to represent city	Schools		7–14	53				
Fombonne (1994)	France	1987	City of Chartres and the semirural county of Auneau	School	3 months	8–11		2441	88.4	2158	CBCL. RB2
Ford (2003)	United Kingdom	1999	National	Population register	Current	5–15	49.9				
Frigerio (2009)	Italy		Random sample of schools in 7 urban areas, random sample of students	Schools		10–14	46	5627	60.74	3418	CBCL
Gómez-Beneyto et al. (1994)	Spain		City of Valencia	Population		8. 11. 15	51.56	1200	93.91	1127	CBCL
Goodman (2001)	Brazil	2001	Ilha de Maré	Population		7–14	50	519	100		SDQ
Goodman (2005)	Russia		City of Novosibirsk	School		7–14	48.3	541	83	448	SDQ
Hackett (1999)	India	1992	Random sample of 2 local districts outside of Calicut, Kerala State	Household		8–12	59		100	1403	RA2. RB2
Heiervang (2007)	Norway	2002–2003	All children in the city of Bergen, Norway, attending primary school grades 2–4 in the fall of 2002	Schools		7–9	59.7	9430	66.7	6297	SDQ + specific to disorders
Kashani (1987)	United States		7% students in public schools in Columbia	School		14–16	50				
Kessler (2012)	United States	2001–2004	National	Household and school	1-month, 12-month	13–18	51.3				

First author (year)	Screening informant (if 2-step procedure)	Method for screening selection	Sample size – diagnostic sample	Response rate diagnostic sample	Sample size evaluated	Diagnostic instrument	Diagnostic informants	Diagnostic algorithm	Diagnostic criteria	Requirement of functional impairment	Definition of functional impairment	Number of diagnostic groups considered for any disorder
Almqvist (1999)	P. C. T		435		435	Isle of Wight Interview	P		DSM-III-R	Yes	Clinical	
Alyahri (2008)				90	465	DAWBA	P.T	Clinical	DSM-IV	Yes	Interview items	4
Anderson (1987)			925	85.6	792	DISC-C.	C, supplemented by teacher and parent	Best estimate	DSM-III	No		4
Angold (2002)	P	Following screen distribution	1302	70.7	920	CAPA	C. P	Or rule	DSM-IV	Yes	Interview items	6
Anselmi (2010)	P. C	Or rule	280	94.64	265	DAWBA	P.C	Clinical rating	DSM-IV/ICD-10	Yes	Specific	5
Ashenafi (2001)				99.8	1477	DICA	P		DSM-III-R			6
Benjet (2009)				70.1	3005	WMH-CIDI-A	C		DSM-IV	Yes	Specific	6
Bird (1988)	P. T	Or rule	440	87.7	386	DISC	P, C	Best estimate	DSM-III	Yes/no	CGAS < 61	6
Breton (1999)			2400	83.5		DISC-2.25	C. P	C. P. Combined	DSM-III-R	Yes/no	Specific questions	4
Canino (2004)				90.1	1897	DISC-IV	C. P	Or rule	DSM-IV	Yes/no	Specific impairment, CGAS < 69, specific impairment + CGAS < 69	5
Carter (2010)	P. T	Or rule	567	78	541	DISC-IV	P		DSM-IV	Yes/no	DISC Impairment algorithm	5
Costello (1996)	P		1346	75.4	1015	CAPA	P, C	Or rule	DSM-III-R	Yes	Specific	10
Eapen (2003)			385	86	329	K-SADS	C. P	Best estimate	DSM-IV	Yes/no	CGAS < 60	5
Farbstein (2010)				68.2	957	DAWBA	C. P	Best estimate	DSM-IV			4
Fergusson (1993)			1265	78	986		C. P		DSM-III-R	No		5
Fleitlich-Bilyk (2004)			1504	83	1251	DAWBA	C. P. T	Best estimate	DSM-IV	Yes		4
Fombonne (1994)	P. T	Or rule	347	62.5	217	Isle of Wight Interview	P		ICD-9	Yes	Clinical, clinical + CGAS < 61	4
Ford (2003)			12529	83	10438	DAWBA	C. P. T	Clinical rating	DSM-IV	Yes	Clinical	7
Frigerio (2009)	P	Following screen distribution	972	64.9	631	DAWBA	P. C	Clinical rating	DSM-IV	Yes	Clinical	5
Gómez-Beneyto et al. (1994)	P	Following screen distribution	325	98.46	320	K-SADS-E	P. C. clinical	Best estimate procedure (excluded if low IQ)	DSM-III-R	Yes/no	No, CGAS < 60, GAF < 70	6
Goodman (2001)	P. T. C	Computer algorithm	100	100	100	DAWBA	C. P. T	Clinical rating	DSM-IV	Yes	Specific	4
Goodman (2005)	P. T. C	Computer algorithm	193	89.1	172	DAWBA	C. P. T	Clinical rating	ICD-10	Yes	Specific	4
Hackett (1999)	P. T	Or	426	100	426	Isle of Wight Interview	P	Clinical	ICD-10	No		5
Heiervang (2007)	P. T	Or rule	2180	46.32	1011	DAWBA	P, T (questionnaire)	Ratings by clinicians	DSM-IV/ICD-10	Yes	Specific	9
Kashani (1987)			150	72.4	115	DICA	P, C	Best estimate	DSM-III	Yes	Clinical	8
Kessler (2012)			10123	82.9	10123	CIDI	C. P	Or rule	DSM-IV	Yes	Specific impairment	6

Table 1 (continued)

First author (year)	Country	Years data collection	Representativeness	Frame	Time frame	Age range	% boys	Sample size – screening sample (if 2-step procedure)	Response rate screening sample (if 2-step procedure)	Sample size evaluated	Screening instrument if 2-step procedure)
Kroes (2001)	Netherlands		All children in the second grade of normal kindergartens in the south of the province of Limburg, weighted for the whole sample	School		6–8	57.8	2290	57.5	1317	CBCL
Leung, 2008	China		Random sample of schools from Hong Kong	Schools	12 months	Grades 7, 8 and 9 (mean age: 13.8 years; SD = 1.2).	48.2				
Lynch (2006)	Ireland		Catchment area in Dublin	Schools	Current and past	12–15	47	1412	51.2	723	CDI. SDQ. suicidal ideation question
Malhotra (2002)	India	1991–1994	City of Chandigarh			4–11	48.4	963			Rutter B scale, CPMS (indian adaptation of CBCL)
McArdle (2004)	England	1993–1994	City of Newcastle-upon-Tyne	Schools	Current	7–8		1051	99.3	1044	Rutter B (teacher). sociometric indices.YGRT. TRF
Merikangas (2010)	United States	2001–2004	National	Population	12 months	8–15	49	–	–	–	–
Mullick (2005)	Bangladesh	2004	Community samples of 5- to 10-year olds in each of the three areas (rural area, a moderately prosperous urban area, and an urban slum) were obtained by random sampling from the electoral registers	Population		5–10			75	922	SDQ
Offord (1987)	Canada	1983	Representative sample of province Ontario, weighted to represent the population	Household	6 months	4–16	49.7				
Petersen (2006)	Denmark	1999–2001	County of Funen	Schools	Current	8–9		751	49.7	373	CBCL
Pillai (2008)	India	2002–2003	Urban and rural catchment areas	Population		12–16	50.3				
Puura (1998)	Finland	1989	National	Population	12 months	8–9	58.6	3558	90.1	3206	Rutter A2 (parents). Rutter B2 (teacher). CDI
Roberts (2007)	United States	2000	Random sample weighted to represent metropolitan area of Houston	Household	12 months	11–17	51.14				
Robertson (1999)	South Africa		Settlement area in Cape Town	Household	6 months	6–16	45.5				
Romano (2001)	Canada	1995–1997	City of Quebec, weighted to represent the population	Community	6 months	14–17					
Sawyer (2001)	Australia		National	Household	12 months	6–17	49.8				
Shaffer (1996)	United States	1992	Representative sample of four areas in the country chosen by convenience	Community	6 months	9–17	53				
Srinath (2005)	India	1995–2000	Sample from Bangalore, selected by stratified random sampling from urban middle-class, urban slum and rural areas	Household		4–16	49.3				CBCL
Steinhausen (1998)	Switzerland	1994	Canton of Zurich	School	6 months	7–16	51.6	2780	70.6	1964	CBCL. YSR
Velez (1989)	United States	1983	Random sample of children from 2 counties in NY State	Household		9–12, 13–18	50				
Verhulst (1985)	Netherlands	1982–1984	National representative sample of Dutch children from the general population, not weighted	Municipal registers		8, 11					CBCL, TRF
Verhulst (1997)	Netherlands	1993	National	Community	6 months	13–18	50	2916	82.2	2227	CBCL. TRF. YSRF
Vicente (2012)	Chile	2007–2009	National	Household	12 months	4–11	50.9				

First author (year)	Screening informant (if 2-step procedure)	Method for screening selection	Sample size – diagnostic sample	Response rate diagnostic sample	Sample size evaluated	Diagnostic instrument	Diagnostic informants	Diagnostic algorithm	Diagnostic criteria	Requirement of functional impairment	Definition of functional impairment	Number of diagnostic groups considered for any disorder
Kroes (2001)	P	Following screen distribution		89	403	DICA	P	P	DSM-III-R	Yes/no	Clinical defined as in need of help	5
Leung, 2008					541	DISC-IV	P, C	Or rule	DSM-IV	Yes/no	Specific	5
Lynch (2006)	C	C. one or other instrument	314	62.1	195	K-SADS-PL	Best estimated procedure (C. P)	Best estimate	DSM-IV			6
Malhotra (2002)	P, T	Or rule (P, T)	228	97.3		Semistructured standard history	P, C	Best estimated procedure	ICD-10			
McArdle (2004)	C. child-peers. T	Or rule (C. C peers. T)	277	Sample replacement	277	CAPA	P	P	DSM-III-R	Yes/no	CGAS < 61, CGAS < 71,	4
Merikangas (2010)	–	–		79.2% to 92.3%	3024	DISC-IV	C. P	C (anxiety). P (ADHD. CD). C or P (eating. mood)	DSM-IV	Yes/no	Specific impairment for each disorders	5
Mullick (2005)	P, T				208	DAWBA	P, T		ICD-10	Yes	Specific	4
Offord (1987)				91.1	2674	Clinical	P, T, C	Best estimate	DSM-III	Yes	Clinical	
Petersen (2006)	P	P	208	90	188	K-SADS-PL	C. P		DSM-IV	Yes	CGAS ≤ 70	6
Pillai (2008)			2684	76.3	2048	DAWBA	C. P	Best estimate	DSM-IV	Yes		4
Puura (1998)	P. C. T	Or rule (C. P. T)	278	98.2	273	DISC, Isle of Wight interview	C. P	Best estimate	DSM-III-R	Yes	Clinical assessment	4
Roberts (2007)				66	4175	DISC-IV	C		DSM-IV	Yes/no	CGAS <70, DISC impairment	6
Robertson (1999)			500	98	500	DISC 2.3	C. P		DSM-III-R	Yes/no		6
Romano (2001)			2000	60.1	1201	DISC 2.25	C. P	C. P. or rule	DSM-III-R	Yes/no	Specific impairment	4
Sawyer (2001)				86	3597	DISC-IV	P		DSM-IV	No		3
Shaffer (1996)			1523	84.4	1285	DISC 2.3	C. P	C. P. or rule	DSM-III-R	Yes/no	CGAS ≤ 70	6
Srinath (2005)					1578	DISC	P, T	Best estimate	ICD-10	Yes/no	CGAS < 71	6
Steinhausen (1998)	P. C	Or rule (C. P)	705	56	399	DISC-P 2.3	P		DSM-III-R			6
Velez (1989)				79.5	320	DISC	P, T	Or rule	DSM-III-R	No		4
Verhulst (1985)	P, T		153	76	116	Clinical interview	P, C	Best estimate	DSM-III	Yes	Clinical	10
Verhulst (1997)	P. C. T	Combined	312	88		DISC 2.3	C. P	C. P. or rule. and rule	DSM-III-R	Yes/no	CGAS ≤ 71	8
Vicente (2012)				82.4	1558	DISC-IV	C. P	C. P. or rule	DSM-IV	Yes		7

P, parent; C, child; T, teacher.

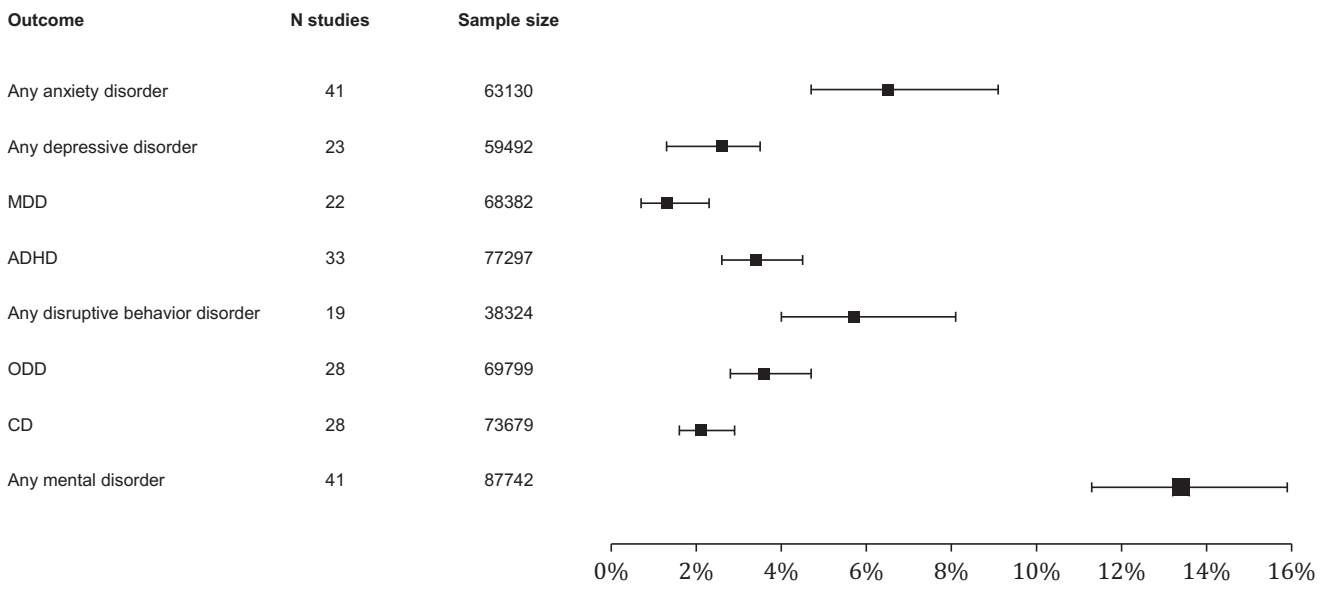

Figure 2 Worldwide-pooled prevalence estimates of any mental disorders and specific groups of disorders in children and adolescents. *Note:* MDD, Major Depressive Disorder; ADHD, Attention-Deficit/Hyperactivity Disorder; ODD, Oppositional Defiant Disorder; CD, Conduct Disorder

Discussion

We have identified community studies assessing the prevalence of mental disorders in children and adolescents from 27 countries and every world region. Meta-analysis indicated a pooled estimate of 13.4% (CI 95% 11.3–15.9) of children and adolescents affected by any mental disorder. Significant heterogeneity was detected and explained by sample representativeness, sample frame, and diagnostic interview. Although these variables explained approximately 89% of the variance, heterogeneity remained significant. Additional meta-analysis revealed that estimates with no requirement of impairment were identified to be up to 17.4% higher than estimates with requirement of impairment.

The worldwide-pooled prevalence of 13.4% for any mental disorder estimated by our meta-analysis is very similar to the median prevalence rates of 13% (Verhulst & Koot, 1991),12% (Verhulst & Koot, 1995), and 12% to 15% (Roberts et al., 1998) previously reported in the literature. The consistency of the estimate is a striking result considering that significant interstudy heterogeneity exists. In 2014, the US Census Bureau estimated a population of approximately 1.8 billions youth from 5 to 19 years around the world. Our estimates indicate that approximately 241 million youths around the world are affected by a mental disorder. The most common group of mental disorders are anxiety disorders, affecting 117 million; disruptive behavior disorder, affecting 113 million; ADHD, affecting 63 million; and depressive disorders, affecting 47 million. In comparison to the prevalence of other childhood chronic health conditions, such as obesity (16.8%) (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010) and asthma (8.5%) (Moorman et al., 2007), the high frequency of mental disorders and their associated negative consequences, render them major health priorities (Halfon, Houtrow, Larson, & Newacheck, 2012; Whiteford et al., 2013).

Pooled prevalence estimates, however, are heterogeneous and influenced by study methods, following results of metaregression analyses for childhood ADHD (Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007; Polanczyk, Willcutt, Salum, Kieling, & Rohde, 2014) and for common mental disorders in adults (Steel et al., 2014). Our study identified sample representativeness, sample frame, and diagnostic interview as significant moderators of prevalence variability. In addition, as several studies reported more than one prevalence rate according to different definitions of impairment, we could test its effect within studies, while other factors remain constant. This is a preferable approach to test the influence of study methods on estimates because unmeasured factors are also constant within studies. In this sense, requirement of functional impairment for the diagnosis, and definition of impairment were identified as major issues on prevalence estimates variability, as already documented in previous studies specifically addressing this issue (Bird et al., 1990; Leung et al., 2008; McArdle et al., 2004; Romano et al., 2001).

On the other hand, variability in prevalence estimates is not explained by geographic location of studies and year of data collection. This was tested by studies conducted in 27 countries and in every region of the world from 1985 to 2012, representing important differences with regard to socioeconomic characteristics, language, religion, and also attributions about mental disorders and the health system. The result is consistent with comparisons across multiple countries of self (Verhulst et al., 2003)

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Table 2 Univariate and Multivariate Metaregression Models for the diagnosis of any mental disorder

	Univariate Metaregression Models (k = 41)										Multiple Metaregression Model (k = 41)					
								Moderator analysis			F ($df1$ = 27, $df2$ = 13), p-value <0.0001, R^2 = 88.99%					
	Estimated Prev. (%)	Estimated Prev. Diff (%)	*SE*	*t*-value	*p*-value	Lower	Upper	*F*	*p*-value	VAF	Estimated Prev. Diff (%)	*SE*	*t*-value	*p*-value	Lower	Upper
Geographic location								$F(df1 = 6, df2 = 34) = 1,6497$	**0.1638**	22.62%						
North America [index]	19.9110	–	–	–	–	–	–				–	–	–	–	–	–
Europe	11.9664	−7.9446	3.2392	−2.4526	0.0195	−14.5275	−1.3618				−2.88	4.18	−0.6895	0.5026	−11.91	6.15
Asia	11.8599	−8.0511	3.5786	−2.2498	0.0310	−15.3237	−0.7785				5.38	4.63	1.1613	0.2664	−4.63	15.39
Africa	8.3423	−11.5687	5.7208	−2.0222	0.0511	−23.1947	0.0573				3.72	5.55	0.6695	0.5149	−8.28	15.72
South America and Caribbean	14.2938	−5.6172	4.0278	−1.3946	0.1722	−13.8028	2.5684				7.11	4.63	1.5351	0.1487	−2.89	17.11
Middle East	12.7758	−7.1352	6.1406	−1.1620	0.2533	−19.6144	5.3440				−1.78	5.0	−0.3567	0.7271	−12.59	9.02
Oceania	16.2802	−3.6308	5.7115	−0.6357	0.5292	−15.2380	7.9764				6.67	5.74	1.1622	0.266	−5.73	19.07
Year of data collection								$F(df1 = 1, df2 = 39) = 0,0311$	0.8609	0.12%						
1995 [mean]	14.8431	– 0.0353	– 0.2002	– 0.1764	– 0.8609	– −0.3696	– 0.4402									
Age range								$F(df1 = 2, df2 = 38) = 3,1957$	**0.0521**	14.94%						
6–11 [index]	12.3580	–	–	–	–	–	–				–	–	–	–	–	–
12–18	20.8717	8.5137	3.5526	2.3965	0.0216	1.3219	15.7054				−3.79	4.52	−0.8397	0.4162	−13.56	5.97
6–18	13.9663	1.6083	2.8056	0.5732	0.5699	−4.0714	7.2880				−5.72	3.42	−1.6753	0.1177	−13.10	1.66
Representativeness								$F(df1 = 3, df2 = 37) = 2,1126$	**0.1152**	14.78%						
Country [index]	16.6255	–	–	–	–	–	–				–	–	–	–	–	–
Large area	19.4807	2.8552	3.6031	0.7924	0.4332	−4.4454	10.1557				4.11	4.09	1.0058	0.3329	−4.72	12.95
City, probably representative	11.9750	−4.6505	3.2642	−1.4247	0.1626	−11.2644	1.9633				−11.46	4.74	−2.4182	**0.031**	−21.71	−1.22
City, probably not representative	12.7782	−3.8473	3.6574	−1.0519	0.2997	−11.2578	3.5632				−1.36	4.5	−0.3034	0.7664	−11.08	8.35
Sample frame								$F(df1 = 4, df2 = 36) = 3,7372$	**0.0121**	29.53%						
Household [index]	14.3885	–	–	–	–	–	–				–	–	–	–	–	–
Schools	13.2739	−1.1146	2.7040	−0.4122	0.6826	−6.5987	4.3694				11.2	4.18	2.6792	**0.0189**	2.17	20.23
Census register	14.0586	−0.3299	2.9312	−0.1126	0.9110	−6.2747	5.6149				3.81	3.68	1.0342	0.3199	−4.15	11.77
Birth register	19.5060	5.1175	5.4171	0.9447	0.3511	−5.8688	16.1039				8.91	4.95	1.8006	0.095	−1.78	19.61

Table 2 (continued)

	Univariate Metaregression Models (k = 41)										Multiple Metaregression Model (k = 41)					
								Moderator analysis			F ($df1$ = 27, $df2$ = 13), p-value <0.0001, R^2 = 88.99%					
	Estimated Prev. (%)	Estimated Prev. Diff (%)	*SE*	*t*-value	*p*-value	Lower	Upper	*F*	*p*-value	VAF	Estimated Prev. Diff (%)	*SE*	*t*-value	*p*-value	Lower	Upper
Household and school	40.30	25.9115	7.2383	3.5798	0.0010	11.2315	40.5915				−8.01	8.86	−0.9037	0.3826	−27.14	11.13
Study design								*F*(*df*1 = 1, *df*2 = 39) = 1,5579	0.2194	3.84%						
One-stage [index]	16.2199	–	–	–	–	–	–									
Two-stage	13.0877	−3.1322	2.5094	−1.2482	0.2194	−8.2080	1.9436									
Diagnostic criteria								*F*(*df*1 = 4, *df*2 = 36) = 0,5812	0.6782	6.00%						
DSM-IV [index]	15.6747	–	–	–	–	–	–									
DSM-III-R	14.8978	−0.7769	2.9851	−0.2603	0.7961	−6.8309	5.2771									
DSM-III	18.0192	2.3445	5.1763	0.4529	0.6533	−8.1536	12.8425									
ICD-10	10.2405	−5.4342	4.0682	−1.3358	0.1900	−13.6849	2.8164									
ICD-9	12.40	−3.2747	8.6823	−0.3772	0.7083	−20.8831	14.3338									
Diagnostic interview								*F*(*df*1 = 7, *df*2 = 33) = 9,4518	**<0.0001**	68.61%						
K-SADS [index]	15.3211	–	–	–	–	–	–				–	–	–	–	–	–
CAPA	17.5401	2.2190	4.5372	0.4891	0.6280	−7.0120	11.4501				−9.56	6.27	−1.5233	0.1516	−23.12	4.0
DISC	15.1797	−0.1414	3.6598	−0.0386	0.9694	−7.5874	7.3046				−8.97	5.58	−1.6079	0.1319	−21.02	3.08
CIDI	39.8405	24.5194	4.9117	4.9920	<0.0001	14.5263	34.5124				25.12	8.57	2.9295	**0.0117**	6.59	43.64
DAWBA	11.2495	−4.0716	3.8129	−1.0678	0.2933	−11.8290	3.6859				−8.43	4.84	−1.7434	0.1049	−18.89	2.02
Isle of Wight	10.6645	−4.6566	5.0700	−0.9185	0.3650	−14.9716	5.6583				−22.91	9.64	−2.3763	**0.0335**	−43.74	−2.08
DICA	7.5534	−7.7677	4.6067	−1.6862	0.1012	−17.1400	1.6046				−13.17	5.65	−2.3309	**0.0365**	−25.38	−0.96
Clinical Interview	6.30	−9.0211	6.3318	−1.4247	0.1636	−21.9033	3.8611				−31.58	9.53	−3.3123	**0.0056**	−52.18	−10.98
N diagnostic groups								*F*(*df*1 = 1, *df*2 = 39) = 0,6671	0.4190	1.50%						
5 [mean]	14.5793	–	–	–	–	–	–									
		0.7024	0.8599	0.8168	0.4190	−1.0370	2.4417									
Informant								*F*(*df*1 = 4, *df*2 = 36) = 1,3558	0.2685	13.74%						
Parent [index]	12.2141	–	–	–	–	–	–									
Child	20.7549	8.5408	5.0957	1.6761	0.1024	−1.7939	18.8754									
Parent and child	16.7838	4.5697	3.0808	1.4833	0.1467	−1.6784	10.8179									
Parent and teacher	12.3463	0.1322	4.2886	0.0308	0.9756	−8.5654	8.8298									
Parent, child, and teacher	11.1036	−1.1105	4.6613	−0.2382	0.8130	−10.5641	8.3430									

Table 2 (continued)

	Univariate Metaregression Models ($k = 41$)							Moderator analysis			Multiple Metaregression Model ($k = 41$)					
											F ($df1 = 27$, $df2 = 13$), p-value <0.0001, $R^2 = 88.99\%$					
	Estimated Prev. (%)	Estimated Prev. Diff (%)	*SE*	*t*-value	*p*-value	Lower	Upper	*F*	*p*-value	VAF	Estimated Prev. Diff (%)	*SE*	*t*-value	*p*-value	Lower	Upper
Diagnostic algorithm								$F(df1 = 5, df2 = 35) = 2{,}4606$	**0.0519**	26.66%						
Best estimate [index]	12.3165	–	–	–	–	–	–				–	–	–	–	–	–
Clinical decision	9.40	−2.9165	7.3936	−0.3945	0.6956	−17.9264	12.0934				15.87	9.5	1.6708	0.1186	−4.65	36.4
Or rule	20.7179	8.4014	2.9207	2.8765	0.0068	2.4720	14.3308				4.46	4.16	1.0703	0.3039	−4.54	13.45
Different for each disorder	11.30	−1.0165	7.4167	−0.1371	0.8918	−16.0732	14.0402				−0.34	8.97	−0.038	0.9703	−19.71	19.03
Parent only	12.4980	0.1815	3.0262	0.0600	0.9525	−5.9621	6.3250				0.37	3.83	0.0963	0.9248	−7.90	8.63
Child only	22.2778	9.9613	5.3676	1.8558	0.0719	−0.9354	20.8581				−8.57	6.85	−1.2507	0.2331	−23.36	6.23

Prevalence; Diff, difference; VAF, variance accounted for. *Note:* For this analysis, we used the crude prevalence rates (instead of prevalence transformed logits).
Bold values indicate covariates associated with heterogeneity at a p-value < 0.2 in univariate analysis that were subsequently included in a multivariate model and covariates associated with heterogeneity at a p-value < 0.05 in multivariate analysis.

and parental (Crijnen et al., 1997) ratings of dimensional measures that identified limited cross-cultural differences. With regard to assessment of time-trends, there are limited studies with directly comparable methods that repeatedly assessed succeeding generations (Maughan, Iervolino, & Collishaw, 2005). Thus, methodological variability between individual studies has been a major limitation to determining the effect of time over estimates. By controlling for the effect of study methods, the metaregression analysis conducted in our study did not detect a significant effect of time on rates of any mental disorders, for a period of approximately 30 years. It is important to highlight that the data included precluded the investigation of time-trends on individual rates of autism spectrum disorder, suicide, substance use, and eating disorders. Nevertheless, our results are important pieces of evidence supporting cross-cultural and temporal stability of prevalence rates of mental disorders.

Our results have important implications for the administrative and the scientific fields. In terms of administrative implications, a worldwide-pooled prevalence rate contributes to estimating the economic burden of disorders, planning services, and the allocation of resources. Also, it is a relevant parameter to evaluate the health care coverage within a given area. It is important to emphasize that the resulting prevalence rate of 13.4% was calculated by preferentially selecting estimates associated with the presence of functional impairment as defined by a CGAS score below 69–71. Therefore, these are youths who are most likely to be in need of treatment. In comparison to prevalence rates following the impairment criteria defined as CGAS scores below 69–71 and 59–61, prevalence rates following no requirement of impairment are 10.7% and 17.4% higher, respectively. Resulting prevalence rates of mental disorders with no impairment are 10.7% (in comparison to a CGAS score below 69–71) and 17.4% (in comparison to a CGAS score below 59–61) higher. In this sense, services should be prepared to assess up to approximately 30% of children and adolescents from the community who present with a diagnosis and may be clinically impaired. Furthermore, it is important to consider that the number of youths with subthreshold symptoms and funcional impairment who need to be observed or even treated is considerable, and has not been included in these estimates (Angold et al., 1999). Youth with subthreshold symptoms are understudied and there are limited estimates of their numbers in representative samples of the population. A large European study assessing approximately 12,000 adolescents from 11 countries estimated the prevalence of anxiety disorder in 5.8% of youths, subthreshold anxiety in 32%, depression in 10.5%, and subthreshold depression in 29.2%. Rates of comorbidity were approximately 50% and subthreshold symptoms were significant predictors of functional impairment and suicidality (Balázs et al., 2013). Therefore, it is possible to anticipate that an

Table 3 Pooled difference on prevalence rates according to different requirements and definitions of funcional impairment for the diagnosis presented within studies

Requirement and definition of funcional impairment contrast	*k*	Estimated prevalence difference (%)	95% Confidence Interval		Heterogeneity		
			Lower	Upper	Q Test	*p*-value	I^2
No impairment versus CGAS <69–71	7	10.7	6.8	14.5	Q(6) = 57.2	<0.001	91.15
No impairment versus CGAS <59–61	4	17.4	1.2	33.6	Q(3) = 60.7	<0.001	95.50
No impairment versus Disorder-specific impairment	11	12.8	5.2	20.4	Q(10) = 572.6	<0.001	98.42

additional substantial number of children and adolescents from the community present with subthreshold symptoms and may need to be monitored or even treated. These figures indicate the significance of mental disorders for the health of populations, and the urgent need for consistent policies for mental healthcare globally (Belfer, 2007).

In terms of scientific implications, our results contribute to the process of designing future community surveys. Study methods, assessment procedures, and case definition are essential elements in a prevalence study affecting significantly its estimates. Studies that differ in these elements provide results that are not directly comparable and therefore broad conclusions about distribution of the disorder and risk factors cannot be drawn. It is urgent that researchers in the field aim for consistency between surveys, otherwise they will impair the informative potential of the future generation of studies. Our results also contribute by showing no evidence of cross-cultural and temporal variability in the prevalence of mental disorders in children and adolescents. This is relevant for etiological research, which should not expect risk factors with large magnitude of effect varying across cultures and time. Nevertheless, results suggest that consistency of methods is a major requirement to test the effect of culture and time on rates of disorders. Multicountry studies assessing proximal cultural aspects with identical methodological approaches and repeated studies over time in the sample population with consistent methodologies are necessary to establish solid conclusions.

Results should be interpreted in the context of limitations. First, results are limited by the studies included, which were constrained by the inclusion criteria imposed, such as probabilistic samples, use of standardized diagnostic criteria, and assessment of at least three diagnostic groups. These criteria were established to identify surveys with sound methodology. The fact that these are well-designed studies might have indirect effects over the covariates, or may be related to other methodological aspects not measured. For example, these studies may have included more trained interviewers, may have had a lower number of missing variables and less errors in data registration, and more consistent strategies of data analysis may have been used. Also, by including studies with a sound methodological design, we have likely restricted the variability in other ascertainment variables and case definitions variables. All these aspects may have restricted the impact of methodology on the results of metaregression analysis. A number of available studies have used nonprobabilistic strategies in selecting the sample frame or the units for the sample, or presented other important caveats in the sampling strategies. These limitations do not guarantee a random sample of the population, and consequently their representativeness. We therefore chose to exclude these studies. By including the studies with the best designs, we aimed to estimate a pooled prevalence of mental disorders that might be as representative as possible of the worldwide population of children and adolescents.

Second, results are also limited by the information provided by original studies for the covariates. There were reduced studies in various levels of different covariates, and poor reporting for others. For example, for geographic location, a small number of surveys were conducted in Africa ($k = 2$), the Middle East ($k = 2$), and Oceania ($k = 3$). Although national representative studies were conducted in the Middle East (Farbstein et al., 2010) and Oceania (Sawyer et al., 2001), studies identified in Africa assessed samples that were likely not representative of the population (Ashenafi et al., 2001; Robertson et al., 1999). As identified by the 2010 Global Burden of Disease Study, nationally representative studies estimating prevalence of mental disorders and other epidemiological parameters are absent in most parts of the world (Baxter, Patton, Scott, Degenhardt, & Whiteford, 2013). For diagnostic algorithm as a covariate, no study using the 'and rule' was included in the analysis. For variables such as response rate and time frame, reports were poor for several studies, which precluded the investigation of its effect. This is significant as it has been demonstrated that these methodological characteristics are important sources of variability. Nevertheless, we chose to adopt a conservative approach by including in the analysis only studies that were informative for all covariates of interest to ensure that results for different covariates are comparable. This resulted in the exclusion of six studies, and would have resulted in the exclusion of a number of other studies if we had decided to include additional covariates in the model. Also, it precluded the test of functional impairment for diagnosis in the context of multivariate metaregression analysis.

Third, by including only studies that assessed multiple diagnoses we have restricted the number of prevalence estimates included for specific disorders

and the resulting pooled estimate. For example, the estimate of 3.4% (CI 95% 2.6–4.5) for ADHD prevalence based on 33 studies is significantly lower than a previous pooled estimate of 5.29% (95% CI 5.01–5.56) based on 102 studies that investigated only this disorder (Polanczyk et al., 2007).

Finally, most of the studies did not report prevalence estimates for less frequent disorders, such as eating disorders, obsessive–compulsive disorder, psychotic disorders, and autism spectrum disorders. Studies were inconsistent in the assessment of substance use disorders in adolescents and in reporting rates of comorbidity. Although metaregression analysis did not identify the number of diagnostic groups assessed in the individual studies as significant moderators of variability – which is consistent with a previous metaregression (Steel et al., 2014) – the pooled prevalence estimate is likely to be an underestimate.

To the best of our knowledge, this is the first meta-analysis to estimate the worldwide-pooled prevalence of mental disorders in children and adolescents. Results indicate that mental disorders are frequent across 27 countries in all continents, and that variability in estimates is largely explained by study methods, assessment procedures, and case definition. These results are essential to service, training, and research planning around the world.

Supporting information

Additional Supporting Information may be found in the online version of this article:

Figure S1. Plot of the externally standardized residuals, DFFITS values, Cook's distances, covariance ratios, estimates of τ^2, and test statistics for (residual) heterogeneity when each study is removed in turn, hat values, and weights.

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Key points

- Prevalence estimates of mental disorders in children and adolescents vary significantly across studies, and there has been no meta-analysis to calculate a worldwide-pooled prevalence and a metaregression to determine sources of variability.
- A meta-analysis of 41 studies conducted between 1985 and 2012 in 27 countries estimates a worldwide prevalence of any mental disorder of 13.4%; any anxiety disorder, 6.5%; any depressive disorder, 2.6%; major depressive disorder, 1.3%; attention-deficit/hyperactivity disorder, 3.4%; any disruptive disorder, 5.7%; oppositional defiant disorder, 3.6%; and conduct disorder, 2.1%.
- Sample representativeness, sample frame, diagnostic interview, and definition of functional impairment are associated with significant variability across estimates.
- Variability in prevalence estimates is not explained by geographic location of studies and year of data collection.
- Future surveys should be conducted in areas with very restricted or no data on prevalence rates and should follow methodological strategies that guarantee comparability across studies.
- The worldwide-pooled prevalence rate contributes to estimating the economic burden of disorders, planning, and evaluating services, and allocation of resources.

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