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DEVELOPMENT OF A WEB-BASED SCREENING TOOL FOR IDENTIFYING NEUROPSYCHIATRIC SYMPTOMS IN CHILDREN AND ADOLESCENTS

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ABSTRACT

Assessing neuropsychiatric Patient Centred Outcome Measures (PCOMs) in routine child mental health and pediatric services is time-consuming and challenging due to the lack of a comprehensive single PCOM covering all psychopathology areas. To address these limitations, this study aims to develop a web-based scale tailored for screening and identifying young individuals exhibiting significant neuropsychiatric symptoms. Leveraging web-based software, the scale intends to streamline the assessment process and enhance the utilization of PCOMs in clinical practice. By facilitating early intervention through timely identification, the web-based scale seeks to improve outcomes for children and adolescents facing neuropsychiatric challenges.

Keywords: - Neuropsychiatric, Patient-Centered Outcome Measures (PCOMs), Web-based scale, Screening, Early intervention.

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INTRODUCTION

Mental disorders among children and adolescents pose a significant public health challenge, with a considerable portion experiencing functional impairment [1]. Despite this, many affected individuals do not have access to mental health specialists. Assessing the burden of psychiatric disorders in this population has improved over the past decade, with various structured interviews and self-report assessments available [2]. However, existing measures, such as neuropsychiatric Patient Centered Outcome Measures (PCOMs) [3], are often time-consuming and may not comprehensively cover all relevant areas. Children and adolescents receiving mental health services commonly exhibit symptoms of multiple emotional or behavioral disorders [4], including neurodevelopmental disorders like attention deficit hyperactivity disorder (ADHD) and autism spectrum disorders (ASD) [5]. Currently, disorder-specific rating scales lack child- and parent-rated versions, limiting their utility. Brief PCOMs that capture symptoms of multiple co-occurring disorders in a concise manner are urgently needed for efficient assessment and intervention planning [6]. This approach, combining genetics, neuroscience, and behavioral science, seeks to advance mental illness research beyond existing classification systems. Web-based platforms offer a promising solution to enhance the use of PCOMs in clinical practice, providing real-time data and accessibility for individuals with neurodisabilities. The HealthTrackerTM platform, designed for health monitoring, offers features like multi-modal questionnaire presentation and automatic assignment based on developmental level, catering to diverse user needs [7].

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The Profile of Neuropsychiatric Symptoms (PONS) was developed to address the shortcomings of existing assessment tools by comprehensively screening for symptoms across various disorders, including ADHD, ASD, and psychoses.

By adhering to FDA protocols and the NIH RDoC agenda, the PONS aims to capture changes in symptom frequency and impairment over time [8]. This project focuses on developing a web-based version of the PONS, following the Patient Reported Outcomes Measurement Information System (PROMIS) and FDA recommendations. The PONS includes versions tailored for different age groups and stakeholders, such as parents, teachers, and clinicians. The development and psychometric properties of the parent version of PONS are examined in both general population and neuropsychiatric disorder groups, aiming to provide a reliable and precise tool for assessing pediatric neuropsychiatric symptoms.

Methodology

Participants were recruited for the study, including children, adolescents, and parents, who provided written informed consent before participation. Control participants completed the study instruments after obtaining consent, while clinical data were collected anonymously during routine clinical care. The Profile of Neuropsychiatric Symptoms (PONS) scale was administered as part of routine clinical care during clinic visits. This unique scale employs domain-based descriptions of symptoms, providing a comprehensive understanding of each symptom's presentation rather than relying on specific items. Symptom domains were initially determined based on consensus among child and adolescent psychiatrists, neurodevelopmental pediatricians, and family members of neuropsychiatric patients, informed by a comprehensive literature review [9]. To develop the PONS scale, a panel of experts, including child psychiatrists, pediatricians, neurodevelopmental pediatricians, psychologists, and occupational therapists, reviewed the initial draft. Each participant rated the importance and relevance of different domains, resulting in unanimous endorsement of each domain's inclusion. Redundancies or overlaps among symptom domains were eliminated during this phase. A second draft of the PONS scale was then presented to young people and their parents for feedback on clarity, appropriateness, and relevance. Separate focus groups were conducted for young people and parents, allowing for discussion on various aspects of the scale, including question structure, response options, content clarity, frequency of administration [10], and recall period. Experts in child and adolescent neuropsychiatry and pediatric neurodisability reviewed summary reports from the focus groups to finalize the PONS scale. The scale encompassed various diagnoses, including attention deficit hyperactivity disorder, autism spectrum disorders, psychoses, bipolar disorder, anxiety, and depression. The final version of the PONS scale (parent version) consisted of 30 domains with seven response options on a seven-point Likert scale. This decision was based on feedback indicating that seven-point Likert scales allow for more accurate tracking of subtle changes over time. The PONS scales were integrated into the HealthTrackerTM platform and utilized in both clinical and research settings.

STATISTICAL ANALYSES

The analyses were conducted using SPSS version 20.0. The data were analyzed using descriptive statistics. Based on Cronbach's alpha, alpha if deleted analysis, intraclass correlation, and factor analysis of the general population, the reliability of the study was evaluated. The rotation in ten interactions of the Promax rotation and Kaiser normalization were used for exploratory factor analysis. The factoring of principal axes was performed without fixing the number of factors. The maximum interaction for convergence was 0.25 (Kappa = 4) using Promax rotation. We set a threshold to determine the loading of factors. The factors' loading threshold was set at >0.25 given the explorative nature of the present study and the sample size. It was only considered the greater value when the cross-loading gap was greater than 0.2 between the loadings. Besides KMO's sampling adequacy measurement, Bartlett's test of sphericity and Kaiser-Meyer-Olikin's adequacy measuring method were used.

RESULTS

Phase 1: qualitative development of the PONS scale

Parental support for the PONS characterized by domains that describe specific areas of dysfunction was specifically expressed, as the traditional approach of having many items per domain would result in a longer scale and reduced uptake. This study developed the PONS scale (parent) with 30 symptom domains. Among the questions included in each domain are the name, its description, and two about frequency and impairment. As a result, HealthTracker only displays the impairment question if the frequency question is answered as present. In focus groups, this feature was strongly supported by all users. For baseline administration, all symptom domains were rated on a 7-point scale, and a 1 month recall period was used**.**

Phase 2: psychometric evaluation of the PONS scale Subjects

There were 147 children and adolescents with neuropsychiatric conditions, some of whom were comorbid. One in seventy-five percent of these students

had Attention Deficit Hyperactivity Disorder (ADHD) (n = 111), one in six were on the autism spectrum (n = 96), one in four had oppositional defiance disorder (ODD) or conduct disorder (n = 59), one in twenty one percent had bipolar disorder (BP), 51.4% had anxiety or depression (n = 80), 25.9 % had developmental coordination disorder (n = 38), and 24.4% had obsessive compulsive compulsive compulsive compulsive compulsive disorder.

Reliability

Factor analysis

A factor analysis was performed on the 30 symptom domains as shown in A 4-factor model was determined to best fit the data based on the screen plot. The four factors were classified into the following: (1) Neurodevelopmental Disability (predominant ADHD, ASD), (2) Behavioural and Emotional Dysregulation (ODD, CD), (3) Psychoses and Personality Dysfunction (Psychoses, blood pressure, emerging PD, spontaneous abnormal movements, (4) Anxiety and Depression (Anxiety and Depressive Disorders). Clinical and diagnostic clusters follow intuitively these factors for children and adolescents with mental health problems. In comparison with the KMO, there was a Bartlett's test of sphericity of 378, p = 0.001, while X2 was 20,507, 54.

Internal consistency

According to Cronbach's alpha, the 30 PONS symptoms domains (referred to as items here) have an alpha of 0.96. No item-item correlations were negative, and all item-total correlations exceeded 0.20. Also, the alpha if deleted analysis showed that no item should be dropped because the Cronbach's alpha value would be reduced.

Intra-class correlation

In addition to intraclass correlation coefficients for single measures, average measures showed intraclass correlation coefficients of 0.96 (0.95-0.96 95 % CI, F = 22.84, $p \leq 0.001$).

Validity

Receiver Operating Characteristic (ROC) analysis.

As shown in Table 2, the ROC area for the 4-factors was 0.96 (SE = 0.006; 0.95-0.97 95 % CI). ROC analysis results are shown in Table 2 for each factor**.**

T-test analysis

There was a significant difference in the Neurodevelopmental Disability score between patients with ASDs and ADHD ($p < 0.001$). There was a statistically significant difference in the Behavioural and Emotional Dysregulation scores between ODD and CD patients ($p < 0.001$). Additionally, individuals with psychoses and/or bipolar disturbance scored significantly higher on Psychoses and Personality Dysfunction ($p < .0022$). Last but not least, those with depression and/or anxiety had significantly higher scores for Anxiety and Depression.

Table 1: Factor Analyses of the Profile of Neuropsychiatric Symptoms (PONS) parent-version using database of general population

Domains	Neurodevelopmental Disability	Behaviour and Emotional Dysregulation	Psychoses and Personality Dysfunction	Anxiety and Depression
Language problems	0.680	0.076	0.063	0.059
Clumsiness	0.672	−0.131	121	133
Difficulties learning	0.671	0.013	−0.068	0.099
Social communication difficulties	0.627	0.020	0.051	0.105
Inattention	0.624	0.370	−0.187	−0.022
Mannerisms	0.576	−0.080	0.486	−0.146
Impulsivity	0.558	0.467	−0.084	−0.121
Hyperactivity	0.548	0.361	093	−0.208
Cognitive rigidity	0.534	0.173	−0.055	0.224
Sensory symptoms	0.511	−0.195	0.137	0.308
Circumscribed interests	0.408	0.056	0.202	137

Obsessions compulsions	395	−0.079	0.276	0.251
Body control	358	0.033	0.296	−0.101
Aggression	−0.045	872	0.028	021
Oppositionality	0.108	0.813	−0.093	−0.017
Explosive rage	0.210	0.744	0.036	0.093
Lack remorse	0.167	0.562	0.086	072
Labile mood	061	0.543	0.021	0.281
Eating problems	0.176	0.220	0.086	0.103
Hallucinations	0.033	−0.126	0.722	068
Spontaneous abnormal movements	0.246	−0.079	0.678	−0.143
SelfInjury	031	0.139	0.546	091
Antisocial behaviour	−0.142	433	0.534	−0.056
Paranoid thoughts	−0.070	0.168	0.365	0.347
Manic symptoms	0.200	0.139	0.357	127
Worries	187	042	−0.139	0.719
Low mood	−0.058	0.160	0.014	0.695
Fears	201	−0.099	−0.061	0.599
Depressive thoughts	−0.233	0.249	0.327	0.515
Sleep problems	0.265	.184	−0.053	0.295

Table 2: General population and clinical sample

	PONS cut off scores	Sensitivity	Specificity	ROC Area	SE	Asymptotic normal	
Total	≥77.60	91.90	90.20	0.970	0.007	0.950	0.971
Neurodevelopmental Disability	≥37.60	91.90	91.20	0.971	0.007	0.949	0.973
Behaviour and Emotional Dysregulation	≥19.60	87.20	87.50	0.946	0.010	0.918	0.954
Psychoses and Personality Dysfunction	≥4.64	84.50	83.40	0.901	0.015	0.873	0.929
Anxiety and Depression	≥11.78	83.10	82.60	0.909	012	0.887	0.931

DISCUSSION

It consists of 30 symptom domains that are rated for frequency and impairment on a 7-point scale, and takes approximately 10 minutes to complete. By using the PONS, child and parent ratings of neurodevelopmental disorders such as attention deficit hyperactivity disorder and autism spectrum disorders are combined with symptoms of schizophrenia [11], bipolar disorder [12], emerging personality disorders [13], anxiety [14], and depression on one brief and easy to use scale. The PONS scale can be used to screen for psychiatric disorders in children and adolescents with neuropsychiatric conditions with high reliability and validity. It was found that the symptom domains had an internal consistency value very close to 1.0, showing excellent reliability and providing evidence that the symptom domains are measuring the same underlying construct. Also, we found high correlations among the symptom domains but only medium correlations among the full instrument, suggesting that each domain is unique.

The PONS factor structure corresponds to the PROMIS domain framework. Four PONS factors are aligned to the PROMIS Peer Relationship, the PROMIS Anger domain, and the PROMIS Paediatric Anxiety and Depression domains to an extent: (1) Neurodevelopmental Disability, (2) Behavioural and Emotional Dysregulation, (3) Psychoses, and (4) Anxiety

and Depression. The PROMIS does not currently include psychological disorders and personality dysfunction in children, nor does it capture all symptoms. As well as ADHD, autism spectrum disorders, obsessive compulsive disorders, motor coordination disorders, disruptive disorders such as ODD and Conduct Disorder, the PONS uniquely captures the symptoms of mental health disorders such as depression, anxiety, and bipolar disorders. No existing scale is capable of capturing all of these symptoms in around 10 minutes. Even though the Strengths and Difficulties Questionnaire (SDQ) [15] is a brief, valid and widely used questionnaire, it does not cover psychoses, personality dysfunctions, bipolar disorders, etc., and has not been used to track changes between clinic appointments. CBCL [16] is a much longer and more time consuming PCOM that cannot be completed in around 10 minutes. It lacks available online optimization capabilities for the child versions of PONS, such as audio recordings or animations. A unique characteristic of PONS is that there is a clear validation for web-based use. A unique feature of the PONS is the capture of domain-specific, dimensional frequency and impairment ratings that allow use across diagnostic categories, as required by the NIH Research Domain Criteria (RDoC) . In addition, the parents were very pleased with the PONS format and that it is a PCOM developed with the full input of the users. It was more likely that the PCOM will be used if it is optimized, Web-based, uses intelligent branching, provides audio-assistance for those with reading difficulties, provides adaptations for visual impairment (with large font-size adaptations), and is available in multiple languages. All of these have been achieved specifically through the PONS on the HealthTrackerTM. [17] By using it, questionnaires will be used and completed more frequently, geographically isolated populations will have better access to care, automated triaging could be developed, and automated, real-time scoring will be available to clinicians during clinic visits, even if the PONS was completed while waiting for the clinician in the waiting room. Parents' feedback from the focus group was very positive. Using HealthTrackerTM's online delivery system, intelligent branching minimises completion time. Furthermore, HealthTrackerTM randomly orders the symptom domains, significantly reducing practice effects.[18]

A special test has been conducted on the HealthTrackerTM system, which has been optimised for children, adolescents, and parents to use in a simple and effortless manner. It is also possible to listen to the scale with a recorded voice, which is especially helpful for people with dyslexia. A PONS version is automatically allocated based on developmental age, rather than chronological age, which is extremely important for those with neurological disabilities. A HealthTrackerTM system can also be used for neuropsychiatric screenings in busy clinics and automated triaging. With HealthTrackerTM, PONS scores can be calculated automatically and displayed in a graphical format. By sharing feedback in real-time, clinical time can be used most effectively, both in face-to-face and non-face-to-face settings.

A potential limitation of this study is that PONS was primarily designed as a screening tool and for triaging purposes. Afterwards, we used the instrument in epidemiological studies and compared its effectiveness with other measures. [19] Since this instrument is designed for online use, normative data must also be collected online. This means, however, that we were not able to practically supervise every online entry, and Receiver operating characteristics of the factor analyses using the Profile of Neuropsychiatric Symptoms (PONS) between general population and clinical sample PONS cut off scores Sensitivity Specificity ROC Area SE Asymptotic normal (%) (%) (95 % CI) Total ≥77.50 91.80 90.10 .960 .006 .950 .971 Neurodevelopmental Disability ≥37.50 91.80 91.10 .961 .006 .949 .973 Behaviour and Emotional Dysregulation ≥19.50 87.10 87.40 .936 .009 .918 .954 Psychoses and Personality Dysfunction ≥4.54 84.40 83.30 .901 .014 .873 .929 Anxiety and Depression ≥11.68 83.00 82.50 .909 .011 .887 .931 ROC: Receiver Operating Characteristics; SE: Standard Error; CI: Confidential Interval . As a result of the large number of participants recruited, we expect such errors to be small, and the advantages of administering tests in their intended environment will outweigh any disadvantages. The clinical sample size is modest, it is from a national CAMHS setting, and may not be representative of symptom profiles seen at community CAMHS for less severely ill children.

Despite this, this neuropsychiatric sample indicates that PONS successfully screened for psychiatric conditions and identified them. Psychiatric and neurodisability services in communities need to test the diagnostic accuracy of empirically derived PONS diagnoses for children and adolescents. The PONS will be used in future longitudinal studies to evaluate the ability to capture changes in symptom severity and impairment

CONCLUSION

This HealthTrackerTM system-based fast, engaging PCOM offers excellent psychometric properties and reports on neuropsychiatric symptoms and neurodisabilities along with their frequency and impairment. A total of 30 symptoms are examined in the PONS-parent version, rated for frequency and impairment on a 7-point scale. This tool is ideal for treating ADHD, Autism Spectrum Disorder, ODD, OCD, Anxiety Disorder, Depression, Psychoses, and Bipolar

Disorder. In clinical trials and epidemiological studies, this tool can be used to screen and triage children and adolescents with emotional and behavioral problems. Clinical decision-making is assisted by its automated scoring and immediate feedback of statistically significant cut-off points as it is available online and optimises the use of clinician time. Future research will need to examine PONS as a change measure.

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