REVIEW ARTICLE

Challenges and Opportunities in Attention Deficit Hyperactivity Disorder in Developing Countries.

Fourie PR[1*], Armstrong JC[2]

[1]Consultant to the Rustenvrede Optima Psychiatric Hospital, South Africa
[2]Research Assistant to Dr. Fourie. Bedford. UK

*pieter@stix.co.za

ABSTRACT

In the developing country a physician is faced with many challenges when seeing patients on the neurodiverse spectrum. Despite many well-known tools available, time restraints and lack of resources often results in sub-par diagnoses and continuation of care. Fortunately, with modern technology and the ever growing fields of machine learning and artificial intelligence, new developments have the possibility to ensure wider access to simplified and efficient tools with decreased need for specialist referral, helping to facilitate diagnosis, to reduce consultation time and costs and to simplify follow-up and monitoring.

Background:

The management of attention deficit hyperactivity disorder (ADHD) has come a long way since its formal identification as a neurological entity in 1902 by Sir George Frederic Still, who described it as an "abnormal defect of moral control in children"[1]. He discovered that, although these children are mostly intelligent, they find it difficult to sit still and control their emotions. What has now transpired into the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V) directive is a very specific and elaborative set of rules, distinguishing between the subsets of ADHD[2]. In addition to this directive, a number of fast rating scales have been added to the diagnostic armamentarium such as the Swan, Snap IV, Conner and Vanderbilt assessment and scales[3,4,5,6]. Although somewhat subjective, they aim to support the clinician, psychologist and educational expert to finally arrive at a formal diagnosis.

Nevertheless, making a diagnosis as a physician when confronted with a patient suffering from a specific ailment can often be quite daunting as it all depends on a number of factors: the willingness and ability of the patient, as well as his/her guardians, to relate the symptoms correctly, the signs of the underlying problem that presents at the time of the consultation and the expertise of the physician in the specific field of medicine involved[7,8]. Obviously, the diagnosis can be strengthened with a number of special investigations such as blood tests, an electrocardiogram, functional magnetic resonance imaging (fMRI), biomarkers and an electro-encephalogram (EEG) amongst others[9,10].

Nowhere is it more challenging than in the field of psychiatry as the diagnosis will often be made solely on the information received from the patient and his/her guardians during the first consultation[11]. Blood tests and additional special investigations are more often than not of no use and merely add to the cost incurred by the medical aid or patient themselves. In the pediatric arena, the diagnosis is usually made based on the information that a caretaker is willing to divest. Additional information such as school reports etc. are obviously of help. In the developed world, psychological assessments, reports from occupational, speech and play therapists are usually available. Unfortunately in developing countries they are seldom available due to multiple factors such as the costs incurred by the family or lack of access to these resources[12,13]

The information delivered by caretakers are also compromised due to a lack of understanding the psychological dynamics. They will usually be coaxed into making an appointment because of additional pressure outside the family circle such as complaints made by the school regarding concentration, behavior and communication issues. Delivering the complaints in a truthful manner can often be compounded by stigmata around certain psychological and psychiatric disorders in specific social and cultural circles. Language barriers, even in the developed world, pose an additional problem[14,15,16].

In the poor resource environment of the developing world, 70% of the world population will be constrained by the aforementioned. Given the limited time physicians have at their disposal per patient, they are rendered incapable of making a correct diagnosis such as ADHD as opposed to the autistic spectrum disorder (ASD), Tourette syndrome (TS) or some of the other

neuropsychiatric disorders[17,18,19]. To give an example, it is estimated that there are around 200,000 children in a very large suburb of Cape Town, South Africa called Khayelitsha, that suffers from ADHD[20]. In an ideal setting it will take a physician trained in the field of neuropsychiatry, not to mention specific to the pediatric population, minimally 30 minutes to come to a definitive diagnosis. Thus for one doctor to see this amount of patients it will take 6 hours a day, 250 days a year, totaling 66 years. This is a technical and absurd impossibility. In addition to this, if the physician were to charge $25 per patient, the average cost for a 15 min appointment at a general practitioner, it would require $5 million to fund the process in a single suburb. Reviews, referrals and yearly follow-up along with constant influx of new patients result in a never ending, unsolvable problem. Costs would also significantly increase if specialist fees were to be applied.

The financial burden of these psychiatric disorders on the GDP of any country is immense, even more so in a limited resource setting[21]. Neuropsychiatric illnesses account for more than 4% of the GDP in sub-Saharan countries and 8% in Northern America[21]. As an example, in South Africa the unemployment rate now sits at 32.59%, one of the major contributions being the lack of education[22]. Given the high prevalence of ADHD in developing countries sitting between 5.4% and 8.7%[23], it can be deduced that ADHD and other neurodiverse entities are a significant contributor to the lack of formal school education in South Africa[24.]

In addition to making a diagnosis of ADHD, the further management and treatment remains a significant challenge. Effective and regular feedback from the educator and the caretaker is virtually non-existent, depending on both educators and caretakers sounding an alarm when needed, or if fortunate, having regular scheduled visits at a unit specializing in ADHD[25]. Again, this is currently not feasible in the developing world setting. Furthermore, effective pharmaceutical interventions are exorbitantly expensive and outside the health budget of most developing countries and specifically that of the caretaker[26,27] These specialized treatments are mostly not available at public health facilities and the financial burden then lies on the parents/caretakers.

In order to find a suitable solution to the looming crisis of effective ADHD diagnosis and management, the challenges are to identify new solutions in making a definitive diagnosis, aiding clinicians in prescribing the correct pharmaceutical regimen, investigating non-pharmaceutical alternatives that will be cost-effective as well as managing the patient's progress frequently and effectively.

Discussion:

With the advent of artificial intelligence (AI), especially over the past 10 years, machine learning has brought to the table a very powerful statistical tool to support rapid diagnostic procedures whereby the time, cost and ease of making the diagnosis can be significantly reduced[28,29,30]. In addition, the subjectivity, i.e. the second hand information conveyed by the caretaker or the observations made by the educator prior to completing the assessment form, will be negated. One such diagnostic procedure would be a form of self-assessment whereby the patient alone is involved. Barriers such as language, mathematical

expertise as well as cultural differences should be reduced to the minimum. Ideally, the diagnostic tool must also include some form of cognitive assessment where it should be able to assess the level of intellectual capability in specific steps, e.g. 4-6, 7-9 and 11-13 years[31].

A number of solutions have come on to the market, some of them quite simple where the patient must follow a dot on the computer screen (MOXO) or an eye tracking method whilst playing a game[32,33] Apart from charging an exorbitant fee for each test, these tests require the patient to attend a clinic where the test rigs are installed making it logistically impractical as the time and costs to travel adds to the poor take up rate, thus only a limited amount of patients can access these resources[34].

Ideally a testing platform should be cloud based, easy to access by multiple (unlimited) users and either be free, charged (sponsored by a pharmaceutical company) or cost the minimum, around one two two USD per use. Information should be immediately made available to the caretaker or teacher. The platform program should be randomized so as to avoid inter-patient training. An additional advantage to aim for should be the way of assessing drug efficacy by comparing pre and post pharmaceutical intervention results as well and determining whether a patient, who has stopped using a specific drug, can continue without. Schools will be able to use the platform to determine entry readiness as well monitor performance.

Such a proof of concept was developed at the Stellenbosch University as part of a masters program in biomedical engineering. Panda as it was coined, is a gaming platform where the target (as a little panda) races through an underground mine trying to miss obstacles such as large rocks falling, ignoring explosions and to pick up diamonds and other jewels[35]. The machine learning algorithm was trained by presenting it with the results from both neurotypical and neurodiverse children. It takes around 5 minutes to play the game and, although a limited study, the concept game can statistically distinguish between neurotypical children and those with ADHD (inattentive type). Further development that is presently being pursued aims to include the ability to distinguish between the various neurodiverse entities.

Recently an AI powered monitoring platform called Tracto (www.augmentaltech.com) was developed to support the caretakers, educators and clinicians at effectively managing patients on a daily basis[36]. Timely identification of changes in behavior, concentration and mood allows appropriate and early therapeutic and appropriate management interventions. Attached educational programs renders additional information to caretakers concerning discipline, emotional and psychological support.

Managing patients with ADHD requires a combination of psychological, and therapeutic support, the latter that can be divided into pharmacological and non-pharmacological support[37,38]. In addition to the stimulant and non-stimulant interventions it is essential to consider pharmaceutical options in each patient that will support them, especially taking common associated comorbid conditions such as anxiety, depression, oppositional defiant disorder (ODD) and Tourette syndrome into

consideration[39]. The therapeutic guidelines as set out by Brentani are an excellent example of how one would approach the specific target domains and, although specifically designed to support children with autism, it nevertheless renders an effective guideline for all neurodiverse patients[40].

The single outstanding non-pharmacological support that has withstood the test of time is neurofeedback[41]. A number of commercially available products have demonstrated its efficacy in improving concentration. In addition to the latter, in combination with pharmaceutical options, it also improves confidence, self-esteem and anxiety[42]. The disadvantages of the neurofeedback options include; cost per session, having to visit the facility physically and the time it takes before the positive effect is established. Companies, such as Neeuro, offer home management options[43]. Future development will include mobile phone neurofeedback support which will enable children in underdeveloped communities to improve concentration on an ongoing and cost effective basis[44].

Conclusion:

In closing, the ADHD platform is set to experience a dramatic increase in AI supported tools to aid in the diagnosis, monitoring and treatment of children on a personal and continual basis[45]. This will bring effective management to the doorstep of the needy at minimal cost which should result in an improved clinical outcome and a significant increase in educational performance deliverables. With the overwhelming need to manage, treat and support children with neurodiverse issues, the move to early and simple diagnostic procedures, the introduction of inexpensive non-pharmacological daily treatment options and day to day monitoring of the progress as well as symptoms should lead to the effective outcome of these patients and thus to the decrease in long term emotional, social and educational sequelae.

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