Evaluating the Role of Parents in Understanding the Genetics of ASD

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ABSTRACT

Over the past decade huge technological progress has made it more affordable to analyze the complete genome, allowing researchers to confirm the role of numerous CNVs with minor effects in the hereditary aspects of ASD. Although analyzing a broad spectrum of genetic variations related to more than 100 identified risk genes seems daunting, such comprehensive genomics databases that encompass several developmental trajectories is gradually improving our understanding of the fundamental architecture of ASD pathology. And to continue in this direction, keeping in mind the vast heterogeneity of ASD, we need much larger cohorts combined with much longer studies to fully understand the genetics behind ASD. In this research I have tried to show that parents of children diagnosed with ASD are an important and untapped resource that should not be overlooked. Through an elaborate questionnaire I want to highlight the vast amount of useful data that parents and caregivers of ASD affected children can provide researchers with.

1 INTRODUCTION

Autism spectrum disorder (ASD) covers a wide spectrum of neuro-developmental conditions marked by an early onset of impairments in communication and social interactions along with certain stereotyped behavioral patterns. ASD related symptoms can develop as early as 1 to 1.5 years of age while diagnosis can generally not be made before the child turns 2. In 2010, more than 5 crore people worldwide had been diagnosed with ASD, at approximately 7.6 per 1000 [1]. Children under the age of ASD has often been cited as the leading cause of disability, and people on the spectrum may require a lot of support. This can be financially, emotionally and often times physically demanding for affected families. ASD can be linked to several complex and interlinked genetic as well as environmental risk factors. However, numerous family and twin based studies show that genetic factors are the most critical factors in ASD, so much so that association to ASD among monozygotic twins is as high as 60–90% compared with the 0–30% in dizygotic twins [1-3]. With an estimated heritability of around 50% [1] for ASD related conditions, genes definitely play a prominent role in its etiology. This review aims at identifying the most important genetic

variations along with their contributions to biological processes and molecular pathways involved in ASD. The pathophysiology of ASD is influenced by numerous genetic, developmental and environmental factors. Different genetic contributions can be associated with a variety of symptoms [4]. A wide range of symptoms across the autism spectrum must be explained by combinations of genetic factors [5]. Genetic contributors to Autism can influence behavior even in typically developing siblings as well as parents and that is why the spectrum of severity of symptoms need to be attributed to a wide range of genetic influences [5, 6]. In other words, people meeting the diagnostic criteria for ASD possibly have the most genetic factors for autism, but such factors are present in varying degrees in everyone. Every person lies somewhere in the spectrum.

Cutting edge bio-informatic innovations have enabled researchers to figure out functions of identified genetic variations at significantly less cost and time than examining the function of each and every gene variant one at a time in model organisms/cells [7]. A large number of genes that can be linked to ASD related symptoms have been identified and the list is rapidly growing [8]; the associated encoded proteins have helped focus on a small number of areas in biology, where advances in functional genomics and neurology have yielded path-breaking insights [8]. There now seem to be several paths forward toward therapeutic development by examining how genetic variants impact different types of brain cells, in different areas of the brain and at different stages of development [9]. While the specific mechanisms driving ASD are still unclear, the current understanding of the genetic variants involved in this condition point towards synaptic and neurotransmitter dysfunction along with chromatin modifications as the most important pieces of the puzzle [8, 10].

On the other hand, sequencing technology has shown that the causes of ASD involve several genes, with hardly any of the same gene variants in a significant percentage of patients complicating things [2]. And, if we include effects of other modifiers like environmental risks, epigenetics, sex linked factors etc. therapeutic directions will not be so straightforward. The diversity in genetic phenotype of ASD affected individuals, points to a more personalized treatment as a possible therapeutic direction. This could be helped by a series of genetic tests e.g., a microarray, to help figure out genetic etiology and, thereby, a personalized treatment plan. Therapies might also address convergent ASD phenotype encompassing several genetic etiologies, such as synaptic dysfunction and neuronal hyper-excitability [2].

Genome-wide association studies (GWAS) analyze numerous genetic variants across multiple genomes to identify statistically significant associations with specific ASD related traits [11-13]. This has yielded numerous strong associations with ASD traits, and as the sample sizes of GWAS increase, the number of associated variants will continue to grow. Such a utilization of "big data", in the form of large-scale studies of human genomes, has resulted in significant advancements in understanding the genetic architecture of ASD. Improvements in technology have enabled cost-effective analysis of the entire genome, confirming the involvement of multiple common gene variations with small effects in the inheritance of ASD. Analyzing such a wide range of genetic variation linked to over 100 identified risk genes does seem extremely challenging, however, extensive genomics databases covering numerous developmental paths is steadily enhancing our understanding of the underlying mechanisms of ASD pathology. Given the heterogeneity of ASD, this "big data" approach seems to be the only logical path forward. While several recent studies have employed large scale cohorts to understand the genetics of ASD, there is a drive to gather data both prenatally and deep into adolescence. This research wants to explore an important tool that seems to be missing in the arsenal of researchers exploring the genetics of ASD – "parents". In this research I have prepared an elaborate questionnaire surveying parents of children diagnosed with ASD. Through this questionnaire I have tried to understand the role parents can play in providing data covering immense variability/heterogeneity simply by spreading ASD awareness amongst the general public.

2 METHODOLOGY

This work started out as an elaborate literature review to understand the gaps in research on the genetic associations of ASD. However, it gradually evolved into a two-part research, with the first part, published here, evaluating the role parents play in diagnosis and intervention as well as how they can contribute to ongoing research efforts. The next part, published in a separate article, will deal with a scientometric analysis of existing literature to ascertain where research collaborations are lacking.

To evaluate the role of parents/caregivers a qualitative survey of 50 families who had a child diagnosed with autism was conducted. Considering that the autism spectrum is very vast, care was taken to introduce variation in the sample size, and include verbal and non-verbal children, those with dyspraxia, dyslexia, learning disability, and Asperger's syndrome. Parents in ***"Autism Parent's Forum"*** were contacted via messaging apps or personal interactions at therapy centers.

Based on the willingness to participate and timing of availability, the survey had a sample size of 57, spread over 3 cities. Each respondent from the sample had to answer questions from the designed qualitative survey, responses of which were collected through a personal or telephonic interview. The questionnaire was fairly elaborate to analyze how well the parents are assessing their child's development. This could show how useful their inputs can be from a research perspective, especially research trying to understand the genetics behind phenotypic heterogeneity of ASD. One particular question in the survey gauged the willingness of respondents towards genetic testing of their ward, and the same were guided to undergo Chromosomal Microarray Testing. The analysis along with graphical representation of the responses was done on Excel.

3 RESULTS AND DISCUSSION

As mentioned earlier, the survey had a sample size of 50 respondents and was spread over the three metropolitan cities of Delhi-NCR, Pune and Bangalore. Figure (Figure 1a) represents the distribution of respondents from each of the three cities.

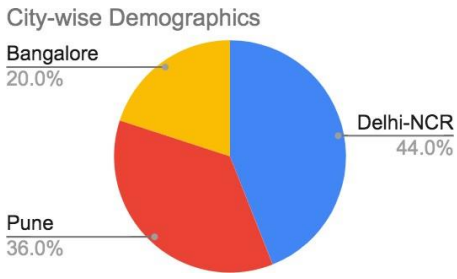

Figure 1a: City wise distribution of sample

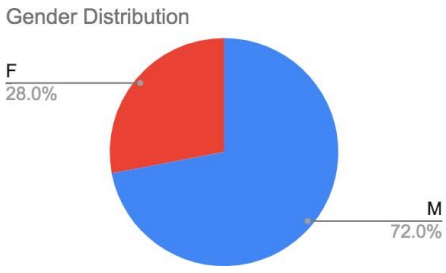

Figure 1b: Gender distribution of ASD in sample size

Figure (1b) reaffirms the common perception that the prevalence of autism is more widely found in boys over girls [14].

The qualitative survey was based on a whole family approach to understand the social, diagnostic, and therapeutic state of the impacted children and their families. The questionnaire was divided into the following four sections:

a) Understanding the family
b) Understanding the diagnosis
c) Understanding post-diagnostic interventions

3.1 Understanding the family.

ASD is highly genetically heterogeneous and may be caused by both inheritable and de novo gene

variations. In the past decade, hundreds of genes have been identified that contribute to the serious deficits in communication, social cognition, and behavior that patients often experience [2].

Out of the 50 respondents who participated in the study, only 30% of the respondents had siblings who were all neurotypical for this sample (Figure (Figure 2)). Among the 30% respondents, there was an equal distribution of siblings who are older than or younger to the autistic child.

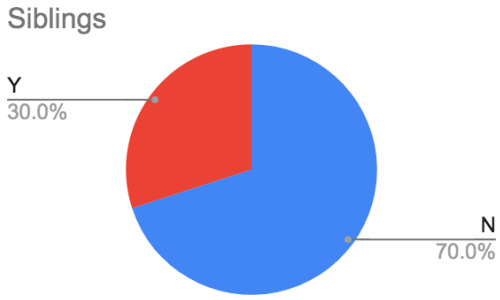

Figure 2: Percentage of autistic children in the study with siblings

Corroborating with the research in this aspect, the first twin study of autism conducted by Folstein and Rutter [3] was ground-breaking because it clearly showed a predominantly genetic contribution to autism. Another meta-analysis of all published twin studies of autism/autism spectrum disorder conducted by Tick and colleagues [15] also yielded a large heritability estimate of 64–91% and no significant shared environmental contribution.

Diving deeper into the families of the children with ASD whose families were surveyed, the findings indicated that 28% of the respondents had someone in the family 'diagnosed' with a neurodiverse condition which may not necessarily be autism. Some of those as indicated by respondents were ADHD (attention deficit hyperactivity disorder), Dyslexia, Asperger's Syndrome, Cerebral Palsy and Global Developmental Delay.

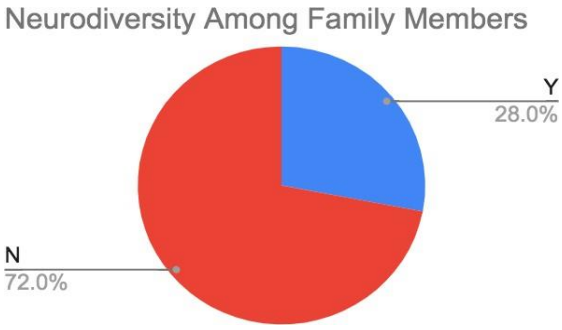

Figure 3: Percentage of neurodiversity in family of sample

Interestingly, as seen in Figure (Figure 4), the pregnancy of mothers whose children were later

diagnosed with ASD was largely uneventful. It is not surprising then that only 6% of parents opted for genetic testing for ASD during the pregnancy as shown by Figure (5). 100% of these parents had one child already diagnosed with ASD and therefore opted for genetic testing for the second born. Prenatal Genetic Testing is advised by some doctors, however there is limited research on factors associated with PGT utilization and relevant decision-making that may follow the results of the genetic tests [16], including the ethical decision of termination of pregnancy based only on risk assessment.

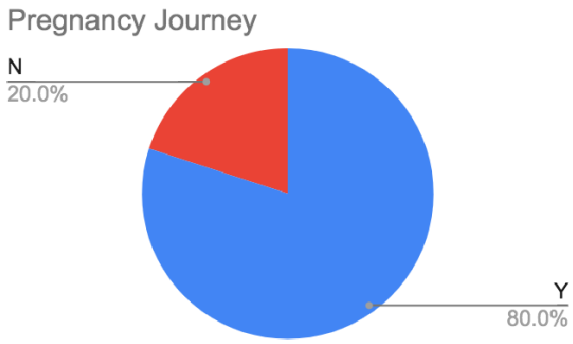

Figure 4: Normal vs eventful pregnancy

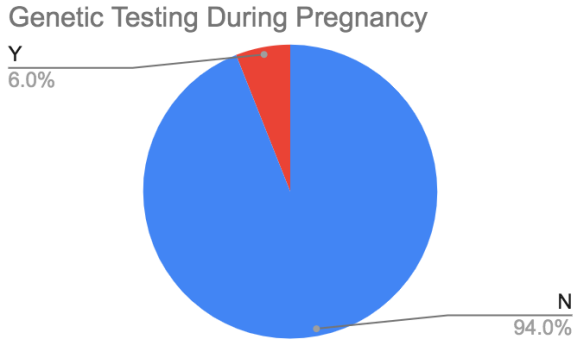

Figure 5: Opting for genetic testing during pregnancy

ASD is a heterogenous disorder with multifactorial etiologies [17]. Although the role of genetics in ASD etiology has been extensively studied, causative effects of many genetic variants remain unknown, and reduced/incomplete penetrance and variable expressivity are testing concerns [18]. Therefore, prenatal testing could definitely provide more answers if it were simply made part of the series of non ASD related prenatal tests.

3.2 Understanding the Diagnosis

Getting an accurate diagnosis for ASD has many benefits. From the parent's perspective, it helps them understand the underlying etiology of ASD, therapeutic management of sensory needs and other issues associated with ASD, medical management and helps them to understand behaviours and patterns of their child better. Sometimes, parents have lots of questions about certain behaviours of autistic children, and a diagnosis helps in getting the answers.

The average age at which parents started noticing unusual behaviours or delay in developmental milestones for this sample size was 2 years and 6 months. The average age at which the diagnosis was received was 3 years. Most parents noticed that their affected child missed certain milestones

and sought help from developmental pediatricians. Diagnosis was either provided by developmental pediatricians or neurodevelopmental pediatricians, both of which are specialists in the field of pediatrics.

DSM-5 (Diagnostic & Statistical Manual of Mental Disorders) is a standard manual used by mental health professionals in the United States. It offers an extensive list of conditions and symptoms that can aid mental health professionals in reaching accurate diagnoses. The latest version is the DSM-5-TR. The manual has come a long way since its first edition and now provides diagnostic criteria for 193 mental health conditions. Most healthcare professionals use the parameters in DSM-5 to diagnose ASD.

Some relevant parameters from DSM-5 were used in the questionnaire to understand the observations of parents that helped them receive a diagnosis for their child. The **five** criteria covered in the questionnaire were:

a) Social Emotional Reciprocity
b) Nonverbal communicative behaviors
c) Stereotyped/Repetitive Movements
d) Insistence on sameness/inflexible adherence to rules
e) Hyper/hypo reactivity to sensory input or sensory interests

Each of these are explained in detail as discussion points through the responses gathered through the questionnaire.

3.2.1 Social Emotional Reciprocity

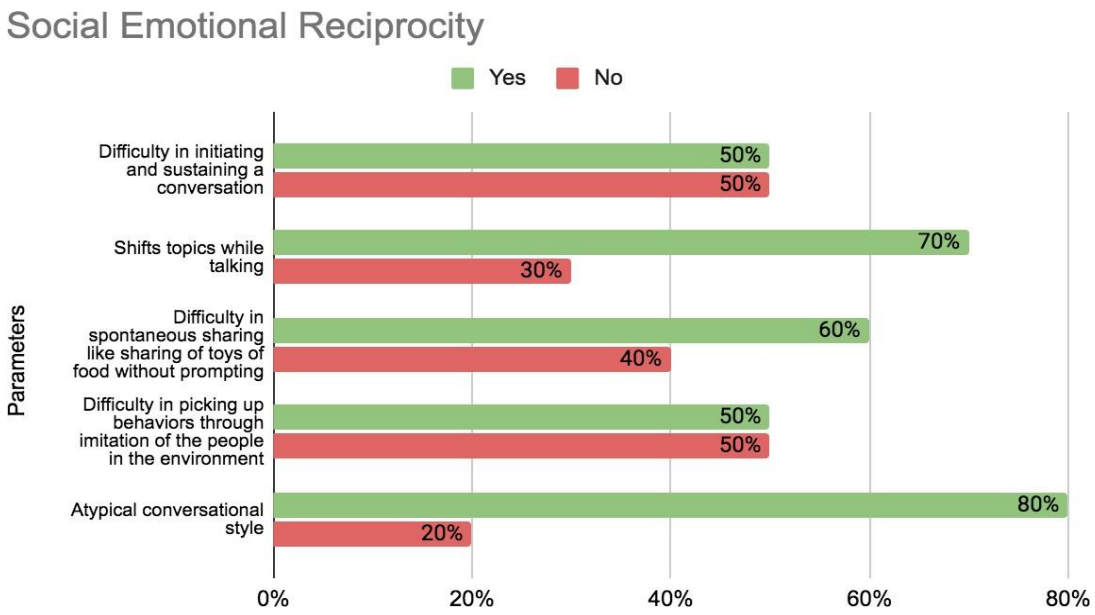

Figure 6: Social Emotional Reciprocity

- Difficulty in initiating and sustaining a conversation: 50% of individuals with ASD reported difficulty in initiating and sustaining a conversation. This can include difficulty starting a conversation, keeping a conversation going, or understanding the other person's point of view.
- Shifts topics while talking: 70% of individuals with ASD reported shifting topics while talking. This can include changing the subject abruptly, getting off topic, or having difficulty staying on topic.
- Difficulty in spontaneous sharing like sharing of toys of food without prompting: 60% of individuals with ASD reported difficulty in spontaneous sharing. This can include difficulty sharing toys, food, or other belongings without being prompted.
- Difficulty in picking up behaviors through imitation of the people in the environment: 50% of individuals with ASD reported difficulty in picking up behaviors through imitation of the people in the environment. This can include difficulty copying the actions of others, or difficulty learning new skills by watching others.
- Atypical conversational style: 80% of individuals with ASD reported an atypical conversational style. This can include using unusual words or phrases, speaking in a monotone voice, or having difficulty understanding the social rules of conversation.

3.2.2 Nonverbal Communicative Behaviors

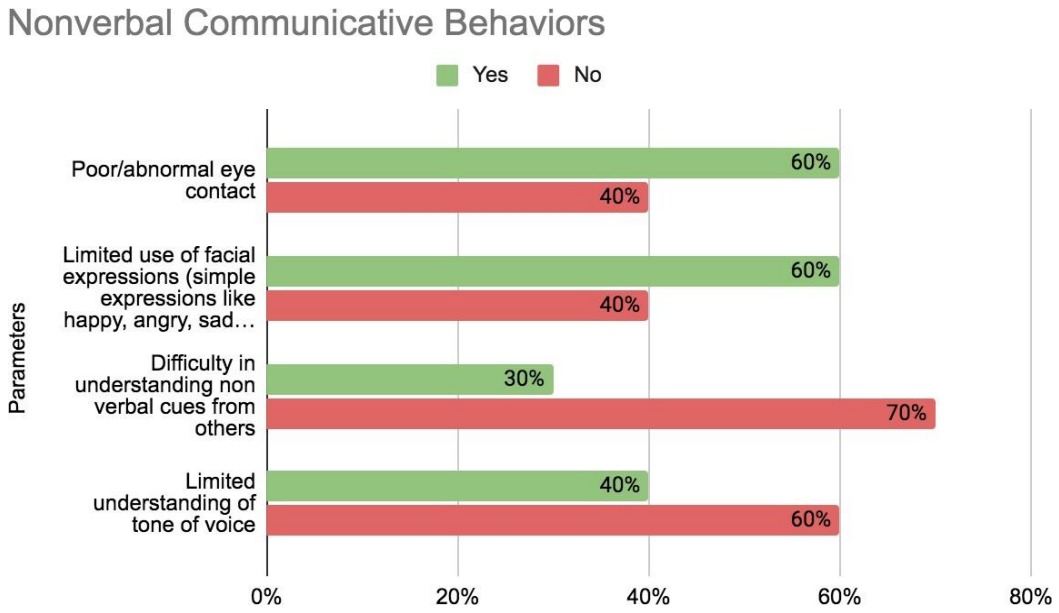

Figure 7: Nonverbal communicative behaviors

- Poor/abnormal eye contact: 60% of individuals with ASD reported poor or abnormal eye contact. This can include avoiding eye contact altogether or making excessive eye contact.
- Limited use of facial expressions: 60% of individuals with ASD reported limited use of facial expressions. This can include having a blank facial expression or using facial expressions in an unusual way.
- Difficulty in understanding nonverbal cues from others: 30% of individuals with ASD reported difficulty in understanding nonverbal cues from others. This can include difficulty understanding facial expressions, body language, or tone of voice.
- Limited understanding of tone of voice (cannot understand sarcasm): 40% of individuals with ASD reported limited understanding of tone of voice. This can include difficulty understanding the difference between sarcasm and seriousness, or difficulty understanding the emotional tone of a conversation.

3.2.3 Stereotyped/repetitive motor movements.

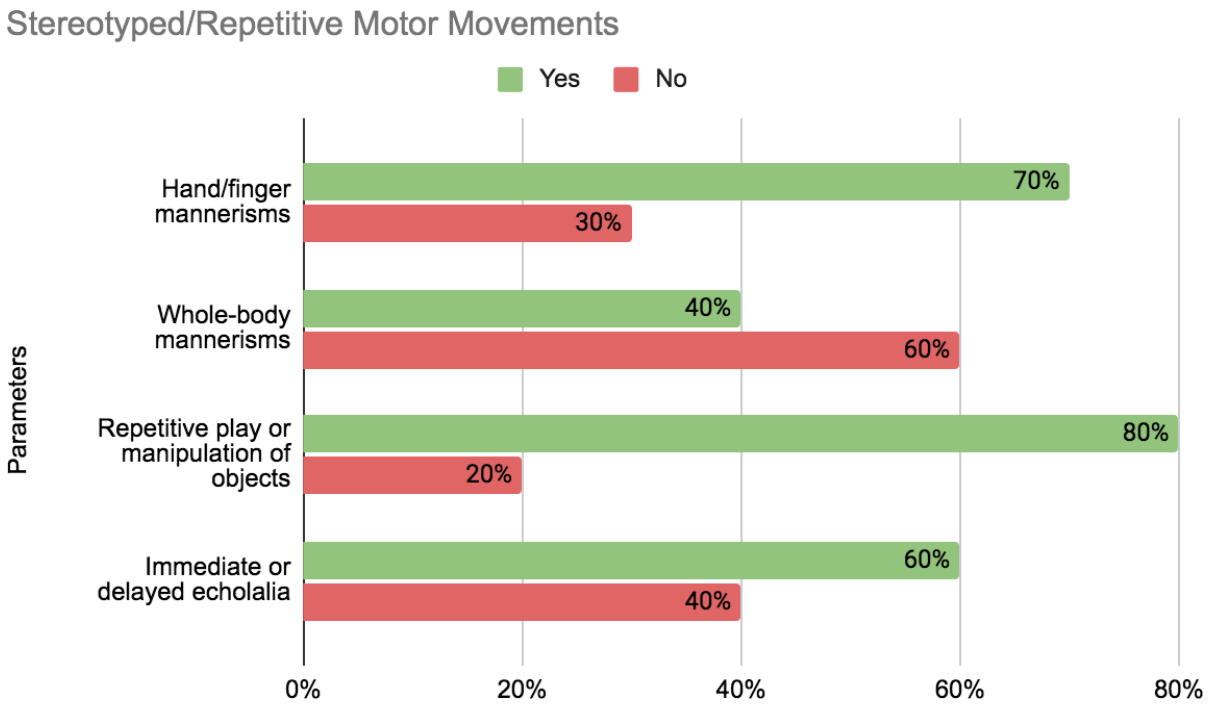

Figure 8: Stereotyped/repetitive motor movements

- Hand/finger mannerisms (e.g., hand flapping, finger flicking/twisting, posturing, clapping): 70% of individuals with ASD reported hand/finger mannerisms. This can include hand flapping, finger flicking/twisting, posturing, or clapping.
- Whole-body mannerisms (e.g., body rocking, tensing, pacing, foot-to-foot rocking, spinning): 40% of individuals with ASD reported whole-body mannerisms. This can include body rocking, tensing, pacing, foot-to-foot rocking, or spinning.
- Repetitive play or manipulation of objects (e.g., spinning wheels, tearing paper, lining up toys): 80% of individuals with ASD reported repetitive play or manipulation of objects. This can include spinning wheels, tearing paper, lining up toys, or playing with the same toy over and over again.
- Immediate or delayed echolalia (including more complex utterances such as TV show lines or portions of books): 60% of individuals with ASD reported immediate or delayed echolalia. This can include repeating phrases or words that have been heard recently, or repeating phrases or words that have been heard in the past.

3.2.4 Insistence on sameness/inflexible adherence to routines

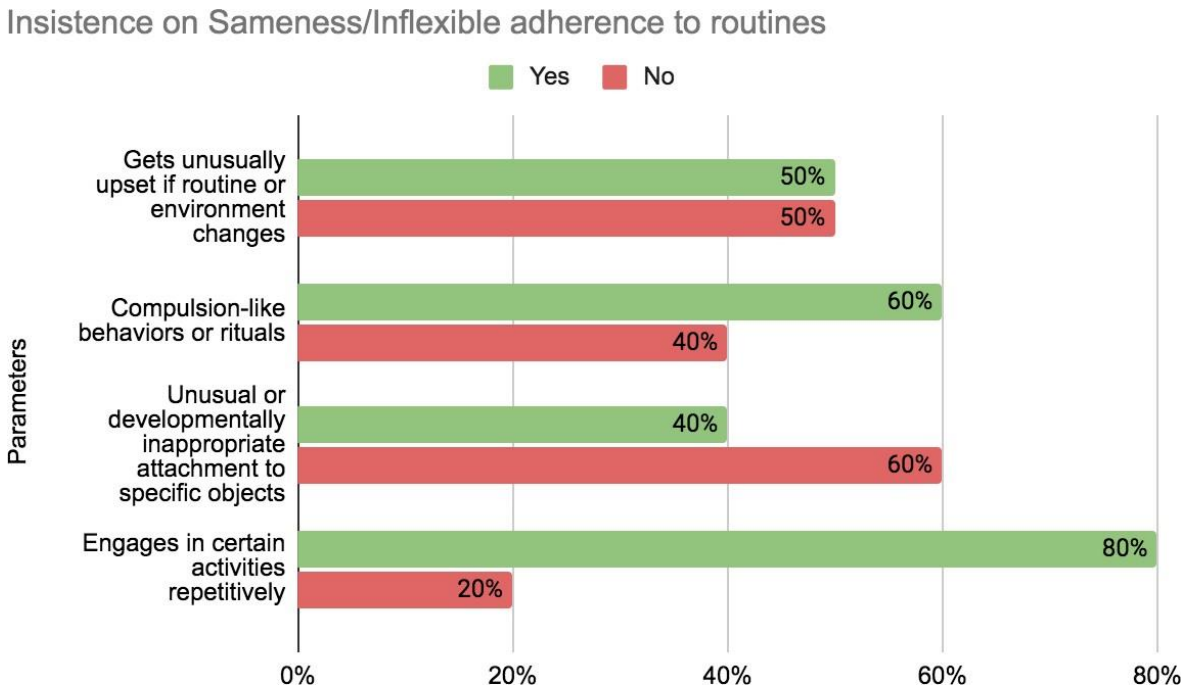

Figure 9: Insistence on sameness/inflexible adherence to routines

- Gets unusually upset if routine or environment changes: 50% of individuals with ASD reported getting unusually upset if routine or environment changes. This can include becoming upset if a routine is changed, or becoming upset if the environment is changed.
- Compulsion-like behaviors or rituals (e.g., arranges objects in a certain order/to maintain symmetry): 60% of individuals with ASD reported compulsion-like behaviors or rituals. This can include arranging objects in a certain order or engaging in other repetitive behaviors.
- Unusual or developmentally inappropriate attachment to specific objects: 40% of individuals with ASD reported unusual or developmentally inappropriate attachment to specific objects. This can include becoming attached to a specific object or refusing to let go of a specific object.
- Engages in certain activities repetitively (e.g., watches same movie repeatedly): 80% of individuals with ASD reported engaging in certain activities repetitively. This can include watching the same movie repeatedly or listening to the same song repeatedly.

3.2.5 Hyper- or hypo-reactivity to sensory input or sensory interests

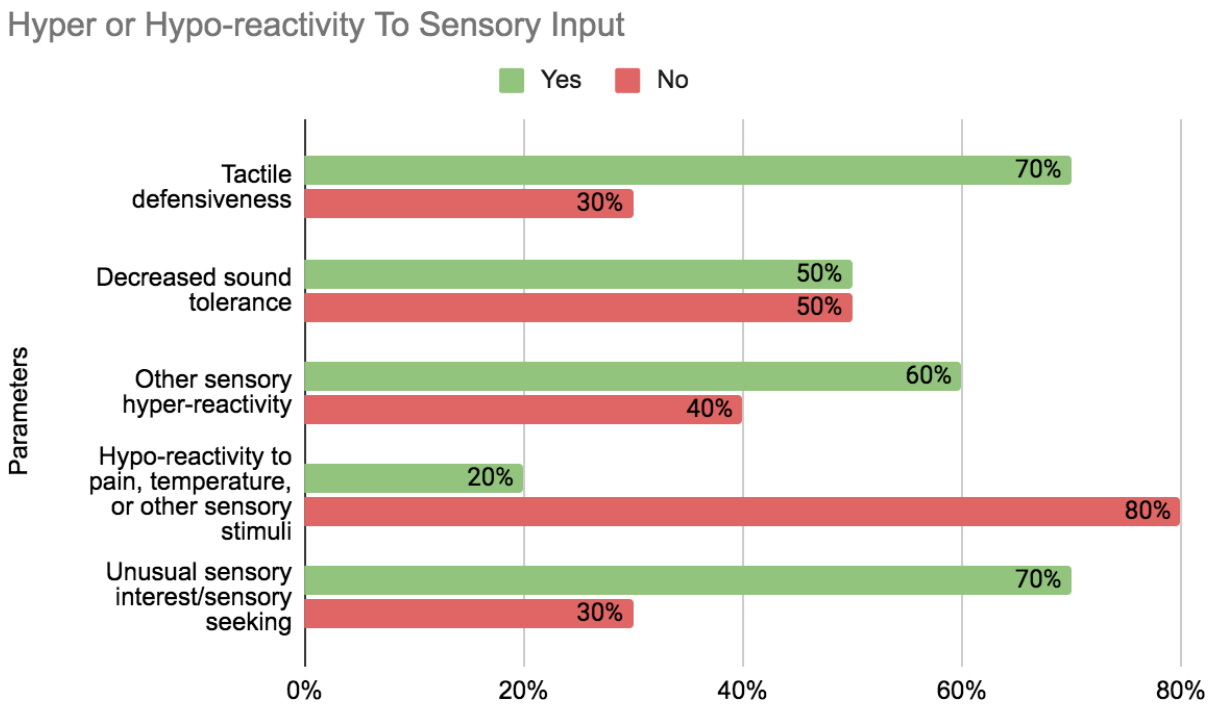

Figure 10: Hyper- or hypo-reactivity to sensory input or sensory interests

- Tactile defensiveness (e.g., excessively bothered by specific textures, difficulty being hugged/held): 70% of individuals with ASD reported tactile defensiveness.
- Decreased sound tolerance (e.g., difficulty tolerating loud noises): 50% of individuals with ASD reported decreased sound tolerance. This can include becoming upset by loud noises or avoiding loud noises.
- Other sensory hyper-reactivity (e.g., difficulty tolerating lights, colors, smells, tastes, foods, motion): 60% of individuals with ASD reported other sensory hyper-reactivity. This can include becoming upset by lights, colors, smells, tastes, foods, or motion.
- Hypo-reactivity to pain, temperature, or other sensory stimuli (e.g., indifferent to loud noise, strong smells, very spicy food, injury): 20% of individuals with ASD reported hypo-reactivity to pain, temperature, or other sensory stimuli. This can include not reacting to pain, not reacting to changes in temperature, or not reacting to other sensory stimuli.
- Unusual sensory interest/sensory seeking (e.g., seeks out textures, repetitive stroking, looking at objects from unusual angles): 70% of individuals with ASD reported unusual sensory interest/sensory seeking. This can include seeking out specific textures,

repetitively stroking objects, or looking at objects from unusual angles.

As complex as it is, there are a lot of manifestations of certain types of behaviors in certain individuals affected by ASD, however, these are also found to be unique to unique individuals, and one autistic individual may not show the same behaviors as the other autistic individual.

Drilling the diagnosis down further, the next part of the questionnaire dealt with genetic diagnosis. 70% of the parents surveyed did not go in for any kind of testing for their child. This is despite the fact that 92% of the respondents believed that autism has a strong genetic linkage. This is a huge potential source of genetic data that researchers are missing out on. There have been about 100 genes that can be linked with autism [19], however, it does not seem that there is one root causal gene that causes mutation every time it is mutated, unlike Fragile X or Rett syndrome. Eight of these genes were included as a part of the survey.

1. ARID1B is a gene that plays a role in the development of the brain. Mutations in this gene have been linked to autism spectrum disorder (ASD) [20].
2. ASH1L is a gene that is also involved in brain development. Mutations in this gene have also been linked to ASD [21].
3. CHD2 is a gene that helps to regulate gene expression. Mutations in this gene have been linked to a number of developmental disorders, including ASD [22].
4. CHD8 is another gene that helps to regulate gene expression. Mutations in this gene have also been linked to ASD [23].
5. DYRK1A is a gene that helps to control the activity of other genes. Mutations in this gene have been linked to a number of neurological disorders, including ASD [24].
6. POGZ is a gene that is involved in the development of the hippocampus, a part of the brain that is important for memory and learning. Mutations in this gene have been linked to ASD [25].
7. SHANK3 is a gene that is involved in the development of synapses, the connections between neurons. Mutations in this gene have been linked to ASD [26].
8. SYNGAP1 is a gene that is involved in the development of synapses. Mutations in this gene have also been linked to ASD [27].

However, out of the 30% of the respondents that did opt for genetic panel tests, none got any conclusive answer regarding any kind of genetic variations that might lead up to their child's symptoms.

3.3 Understanding Post Diagnosis Interventions

Three intervention areas after early diagnosis were covered in this research, based on the broad areas mentioned in [28]:

1. Etiological testing for associated medical conditions.
2. Assessment and management of co-morbid conditions.
3. Therapeutic interventions that address ASD-associated functional challenges.

3.3.1 Etiological testing for associated medical conditions.

An important aspect of post diagnostic intervention that comes much before therapeutic interventions is the diagnosis of associated medical conditions. 100% of the respondents of this survey were advised by their treating doctor to check for associated medical assessments. This included checking for hearing assessment using tests like BERA (Brainstem Evoked Response Audiometry) [29], simple vision tests or advanced vision tests like RMET (Reading Your Mind Eye Test) [30] or cycloplegic retinoscopy for understanding vision-related needs. These could be the use of corrective lens glasses for vision or prism lenses for enhancing visual/spatial awareness. Dental assessment for understanding sensory over or under responsivity also emerged as an intervention that pediatric or developmental pediatricians would suggest to some respondents of the sample. When it comes to metabolic testing, research has indicated that 30% ASD affected children exhibit metabolic abnormalities like elevations in plasma lactate or plasma lactate and/or the lactate-to-pyruvate ratio, and the levels of many other mitochondrial biomarkers (pyruvate, carnitine, and ubiquinone) are significantly different between ASD and controls [31]. Testing for metabolic indicators opens avenues of biomedical treatment of symptoms of ASD [32, 33].

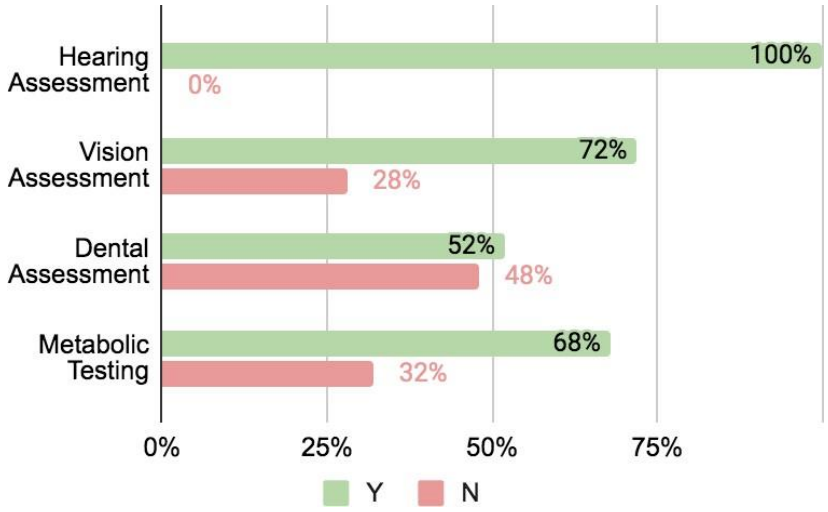

Figure 11: Percentage of respondents that underwent assessments for ASD associated conditions

Figure (Figure 11) demonstrates the percentage of individuals from the sample size who were advised on assessments for ASD associated conditions; Hearing assessment (100%), Vision assessment (72%), dental assessment (52%) and metabolic testing (68%). The results of the assessments varied, and appropriate action was taken by the respondents to manage the results of the assessments for their wards.

3.3.2 Assessment and management of co-morbid conditions

Presence of co-morbid conditions was the next parameter that was checked through this qualitative survey. Research has indicated that 80% individuals suffer from sleep disorders while GI disorders are in the range of 46-84% [34]. Survey through our respondents also revealed that 80% children on the spectrum displayed some comorbid condition (Figure (Figure 12))

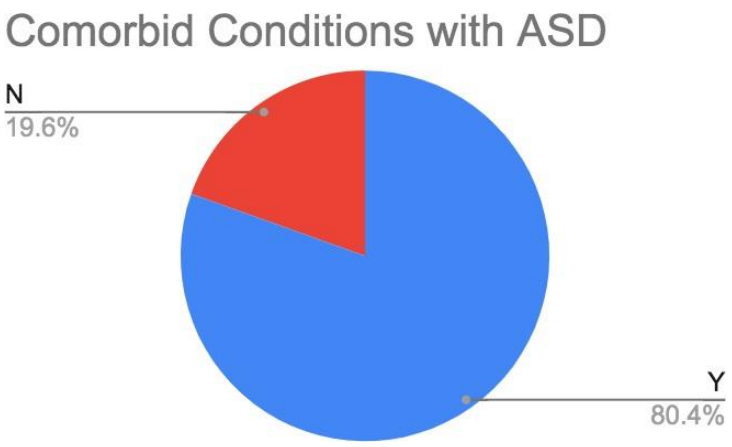

Figure 12: Percentage of respondents showing comorbid conditions with ASD

Detailed understanding of the comorbid conditions with ASD revealed the following statistics (Figure (Figure 13)):

- 58% of children suffered from gastrointestinal disturbances, most common of which were chronic constipation, chronic diarrhea, gastroesophageal reflux, nausea and/or vomiting, flatulence, chronic bloating, abdominal discomfort, inflammatory bowel disease and food intolerance.
- 64% of children had sleep related issues like photosensitivity of eyes, fewer than normal hours of sleep, crying at night, poor sleep environment, and sleep apnea.
- 78% of children exhibited attention deficit while doing activities, especially focus based activities like reading, sorting, writing and other academic activities.
- Only 4% of children in the sample size of those affirmative with comorbid conditions displayed anxiety. As gathered through the qualitative survey, this was mostly social anxiety or stranger anxiety. None of the respondents were taking any medication to manage any symptoms of anxiety or depression.
- 8% of children in the sample size showed nutritional disturbances. This was gauged through reduced levels of Hemoglobin, or deficiency of some sort.

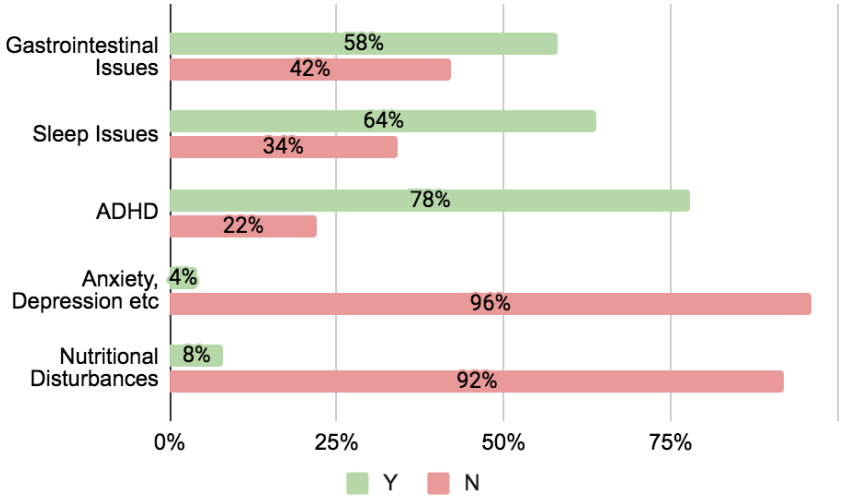

Figure 13: Comorbid conditions

3.3.3 Therapeutic interventions that address ASD-associated functional challenges

Our qualitative survey result indicated that 100% of the respondents were undergoing some therapeutic intervention. Considering, the Indian context, the most popular therapies were surveyed, and the results can be seen in Figure 14)

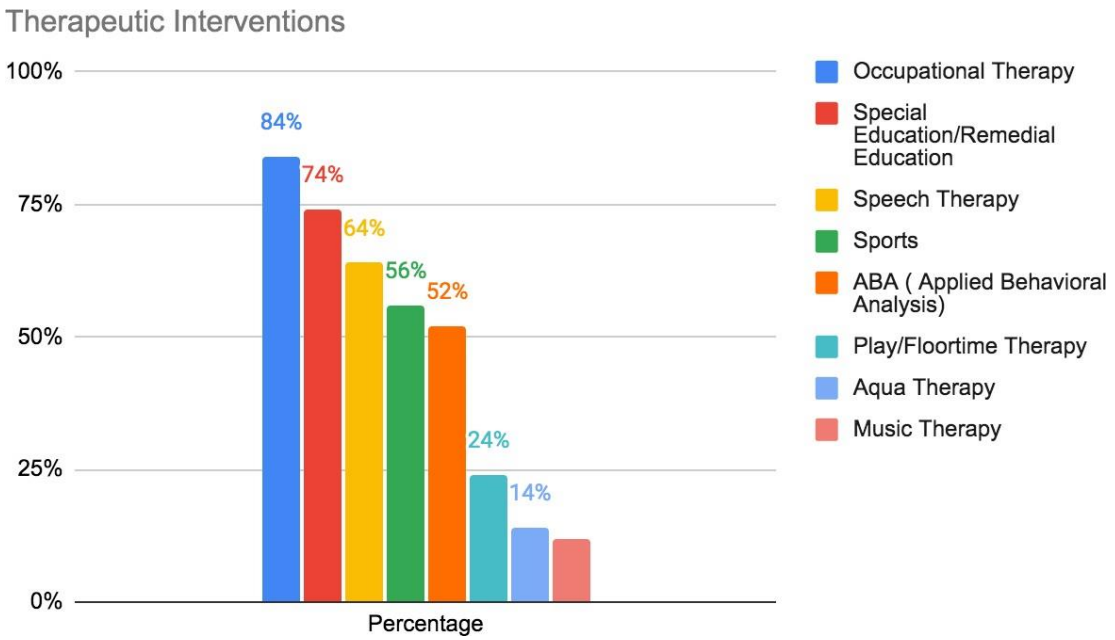

Figure 14: Therapeutic interventions for autistic individuals by parents/caregivers

These percentages are based on the sample survey of parents of children with autism. The actual

percentage of children who receive each type of therapy may vary depending on the child's individual needs and the availability of services in their area. For our sample, occupational therapy was the most popular therapeutic intervention. It is interesting to note that there is no particular time duration for which a particular therapy is provided to the child, and it solely depends on the needs of the individual. Thus, there is no one-size-fits-all treatment for autism. As is the case with syndromes and conditions that are yet to have a definitive cure, there are a lot of alternate therapies and treatments that parents and caregivers opt for. While the effort to improve the behaviors of autism are many pronged, no parent or caregiver believes in any exclusive therapy. 100% of parents are exploring alternate treatments along with therapeutic interventions. An important inference from this is how deeply involved parents are in following their child's progress, keeping track of the minutest improvements and managing therapies accordingly. This is yet another instance of how much potential data parents/caregiver can provide to researchers, especially for longitudinal studies.

4 CONCLUSION

As mentioned in the previous section, I wanted to show the plethora of information that can be obtained from parents of children diagnosed with ASD. The survey, while covering only 57 of the many thousands of parents spread all over the world, followed expected trends in heritability, co-morbidities, sex, age of diagnosis and post diagnostic interventions. This shows that even without expert researchers to guide them, caregivers of neuro-divergent children have taken a lot of initiative to keep track of their child's progress from a very early age. With a little bit of intervention from scientists involved in genetic research of ASD, extremely valuable data can be obtained directly from clinics for a wide range of symptoms. The survey clearly shows that all parents who took the survey have keenly observed the complex diagnostic measures used in DSM-5. This is evident from their responses seen in Figure 6) –Figure 10). Parents were also willing to undergo etiological testing using standardized tests like BERA and RMET. In addition to etiological data there is also a lot of data on comorbid conditions just waiting to be tapped. The survey reveals that 80% of the respondents answered positively for some associated comorbidity for their wards, ranging from GI issues to ADHD. A more elaborate questionnaire designed by researchers working in the relevant field could easily look for environmental and genetic associations with behavior patterns, etiological and comorbid conditions. However, the most

obvious area, in context of this research, where parent participation is lacking is genetic testing. While it is heartening to see that 92% of the respondents believed that autism has a strong genetic linkage, it is equally disappointing to find out that 70% of the respondents were unwilling to get their child tested for genetic variations. Another area where clinical participation can help is prenatal testing. Only 6% got a genetic test prenatally. This is one aspect of ASD research where parent participation is immensely important. Genetic tests both prenatal as well as post diagnosis in addition to all the above mentioned etiological and comorbid conditions can provide invaluable data to current researchers. All that is required is a little better dissemination of information by researchers to clinicians and parents, thereby encouraging all expectant parents coming their way to get all relevant tests as well as frequent assessments starting prenatally. Once an ASD diagnosis has been made, parents should be encouraged to provide frequent feedback on all the points mentioned in section 3, as well as get tested for genetic variations in line with current research. This type of three-pronged collaborative effort is what is required to understand the nature of ASD and develop new and more effective therapeutic and management measures.

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