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Introduction

Nutrition is essential for optimal health, productivity, and overall functional effectiveness. Research provides evidence for the significance of nutrition by supporting sequential strength and abilities as well as assuring effective immune capabilities, behaviour development, and work capacity of an individual. The ability of a nation to be healthy, powerful, and productive depends on the health and nutritional quality of its children.

Children are more vulnerable to aberrations from the typical health and growth pattern throughout this period of accelerated growth in their lifespan. Any deficiency in the quality or amount of physical, cognitive, or emotional inputs impacts the child due to a biological predisposition, the child may not be in a good state of health. The children may have a broad range of common and uncommon physical/psychological problems and limitations.

Children with good nutrition in their life are keys to the sustainable development of any country and represents the human resource base for the future generations which is degraded by under-nutrition that undermines their survival, health, collective learning capacities and productivity in adulthood.

Children in general, even those with special needs, have similar feelings, emotions, motivations, and impulses. They have a few distinctive traits that call for unique services in their educational programmes. Individual differences, needs, and unique services must be addressed to meet those objectives. Some children have mild to moderate learning disabilities, hearing loss, mental retardation, emotional or behavioural issues, and visual or hearing impairment. Because of this, parents must play a variety of roles in accordance with the requirements of various special needs children in order to provide care that is more effective, foster positive relationships with others, and interact with peer groups.

A child with special needs is essentially a child who, due to his or her specific physical or developmental issues, has requirements in contrast to those of his or her peers,

for example, a child with behavioural problems will have distinct educational demands that most aged peers will not have. Special needs can range from modest to severe. The Indian government continues to integrate special needs children in a variety of educational initiatives, such as the Sarva Shiksha Abhiyan (SSA), which strives to provide quality primary education to all children. Several national and local NGOs, for example, offer specific resource centres to assist in the quality of education. The Spastic Society of India has a division dedicated to campaigning for the right of children with ADHD to receive inclusive therapy and intervention programmes.

Developmental disorders are characterised by a child's behaviour that takes into account their unique demands and characteristics. If children just had access to a conventional diet and therapy education, it is possible that this method would not be able to help children with special needs attain self - determination and academic and societal success. This strategy requires instead the individually designed and consistently observed, configuration of educational procedures, modified materials and tools, appropriate environments and other intervention.

Childhood developmental disorders have received increased attention in the previous decades. It is critical to understand that early detection and intervention are critical for allowing these children to have normal lives and providing a happy existence for their parents. A developmental problem arises when a child fails to develop normally for their age. This has an impact on their capacity to learn, act, and socialise. Despite the fact that a developmental issue may start at birth, it frequently doesn't show itself until a child is confronted with more difficult social and cognitive demands. Developmental problems range widely, but the most prevalent ones include Attention Deficit Hyperactivity Disorder (ADHD) and particular learning challenges including dyslexia and autism spectrum disorder.

Most people used to think that children's hyperactivity was just part of growing up, particularly in the Indian culture. Also well known is the fact that ADHD in children in India is not often well understood, and issues at school are frequently seen as negative behaviour and hence children with ADHD are punished. These factors cause majority of children with ADHD symptoms to leave school fairly young.

Attention Deficit Hyperactivity Disorder (ADHD), a neurobehavioural disorder that affects 5% of children globally, is one of the behavioural disorders. It is defined by excessive and detrimental impulsive, hyperactive, and inattentive behaviour (American Psychiatric Association, 2013). Its aetiology is influenced by genetic and environmental factors (Faraone and Larsson, 2018). The pathophysiology of ADHD is unknown, although research on children with ADHD has revealed an overall reduction in brain capacity, with a proportionally higher reduction in the volume of the left-sided prefrontal cortex (Curtin *et al.,* 2018)

The aetiology of Attention Deficit Hyperactivity Disorder cannot be identified to a single factor. It is multifactorial and the extent, to which each cause contributes to the severity of the condition, is not yet established. Genetics play a major role and literature has shown that genes involved in the production and metabolism of neurotransmitters are a likely factor to cause ADHD symptoms. Studies on families and twins have demonstrated the significance of genes in the emergence of ADHD. Genome-wide association studies are equivocal, although candidate gene analyses point to the involvement of genes involved in dopamine and serotonin receptors and transporters. (Larsson and Faraone, 2018).

The environmental causes include various prenatal and postnatal causes. When the foetus is exposed to certain substances, optimal brain development and maturation can be compromised in a child. In addition to this, maternal tobacco consumption, smoking, alcohol consumption, certain drugs, both recreational and a few antibiotics, duration of labour and type of delivery are offensive to the foetus. Postnatal causes include infections that might affect brain development, lead toxicity in the environment, lack of discipline in eating healthy foods and an inclination to the trend of snacking on processed foods.

Lead, mercury, organochlorine, organophosphates, phthalates are just a few of the chemicals and heavy metals which have been proposed as environmental triggers for ADHD. (Guney *et al.,* 2015.)

If a child with ADHD does not receive adequate early intervention, it might continue into adulthood and it has been reported in several studies that adults with ADHD resort to drug abuse and violate rules, have to be in trouble with the law and do not have the focus to pursue academic and career goals (Molina *et al.,*2014) Early diagnosis,

therefore, helps the child to cope with the physical, psychological and social expectations to live a healthy and productive life. Diagnosis of ADHD is not based on a single diagnostic test. The diagnosis is rather done by the presence of a cluster of syndromes. A psychologist or a certified health care provider must rule out a lot of other neurodevelopmental disorders, which present themselves similar to ADHD, but maybe anxiety disorders or some learning disorders (Drechsler *et al.*,2020).

Three subtypes of ADHD are typically recognised: the integrated type, the inattentive type, and the predominately hyperactive type. Diagnostic and Statistical Manual, Fifth Edition (DSM-V) of the American Psychiatric Association or the ICD-10 (International Statistical Classification of Diseases), released by the World Health Organization in 2013 are used as diagnostic tools following multiple updates in the criteria needed for the diagnosis of ADHD.

According to ICD-10, ADHD is classified as a hyperkinetic disorder and it requires meeting the criteria for both hyperactivity and inattention. The possibility of both existing in a child is less prevalent than the existence of either hyperactivity or inactivity, thus the prevalence rate of ADHD according to the ICD-10 classification is less. These two criteria are used by the psychologist in assessing the child but there are other diagnostic scales like Connor's scale, CBCL, NICHQ, SNAP IV, CBRS, ASRS, BADDS, ADHD-RS-IV, and ACDS, which are administered to the parents and/or teachers. These scales are in the form of questionnaires revolving around the DSM criteria to help the parents and teachers to observe and record the child's behaviour in an objective manner (Boyd *et al.*, 2021).

The prevalence of children with ADHD, therefore, varies according to the diagnostic method used, the geographical area, and the awareness among the parents and caregivers in a given population. The worldwide prevalence has not been studied in a single study but it has been estimated in meta-analyses of various studies across the world to be 5.3 per cent (E Azevêdo *et al.*,2020).

The incidence of ADHD among boys is more than girls and the prevalence varies according to the type of ADHD too (Slobodin, *et al.*,2019). It has also been observed that ADHD of the hyperactive type is more prevalent among lower socio-economic groups. This difference suggests the possibility of choosing different treatment plans. (Al-Balushi *et al.*, 2019)

Several research conducted in the United States has shown an onset of ADHD. The National Survey of Children's Health found a 42% increase in the number of diagnosed ADHD among adolescent and children aged (4 to 17 years) between 2003 and 2011. In India, the rate is estimated to be around 11.3 per cent (Venkata and Panicker, 2013).

ADHD has been recognized as a clinically diverse illness, with high rates of coexistence with other childhood-onset disorders as one of the causes. It is estimated that 60% to 100% of children with ADHD have one or more associated disorders that often continue into adolescence. (Beauchamp *et al.,* 2019) Worldwide research studies have revealed that the most common comorbidities associated with ADHD are autism spectrum disorder, depressive disorder, bipolar disorder, anxiety disorders, ODD, CD, and learning disability, and the researcher has focused on the prevalence of these in the study sample population.

Medication, behavioural modification, and other intervention techniques such as diet modification and supplementation of key nutrients are used to treat ADHD. These nutrients play a crucial role in the creation of specific molecules that aid in the proper functioning of the brain. Linus Pauling proposed this in 1968, calling it an orthomolecular treatment (Carter *et al.*,2019).

Dr. Feingold developed the Feingold diet in the 1970s after noticing a link between certain food chemicals and hyperactivity. Foods to avoid on the Feingold diet include processed meats, grapes, apples, and drinks containing artificial flavours and colouring agents. Synthetic dyes coloured red and orange, and preservatives like butylated hydroxytoluene and butylated hydroxyanisole are not permitted. This diet gained popularity when it was originally introduced to doctors since it was thought to relieve symptoms in more than 50% of hyperactive children. (Tucker *et al.*,2017)

Several observational trials since then have failed to show the same efficacy; nonetheless, a small fraction of children who may be sensitive has been found. Only artificial food colouring and additives are urged to be removed in more recent diet versions (Madzhidova *et al.,* 2019).

Another prominent dietary treatment for children with ADHD is an oligoantigenic (hypoallergenic/elimination) diet which excludes a majority of known sensitising food

antigens or allergens, such as cheese, chocolate, wheat, cereals, egg, and citrus fruit, as well as buffalo milk, in order to uncover and regulate food allergies and intolerances that may be linked to neurologic dysfunction (Ly *et al.*,2017).

The brain is made up of millions of neurons, which are functional units. Emotions, memories, behaviours, and other actions are produced via cell interactions. Neurotransmitters are chemicals that facilitate cell communication. Neurotransmitters are made up of amino acids found in food, making nutrition and intellectual capacity the most essential link. Vitamin B, omega-3 fatty acids, other amino acids, and minerals are all precursors to neurotransmitters. These are the most common vitamin deficiencies found in children with cognitive impairment (Altomare *et al.,* 2017). During this early period, the brain has a strong dietary requirement, and nutritional inadequacies prevent optimal neurodevelopment, resulting in long-term cognitive impairments. As a result, understanding metabolic factors and specific nutrients is crucial for establishing successful nutrition intervention techniques (Spencer *et al.,* 2017).

Neurons are the functional units that make up the brain, and there are millions of them. Cells interact with one another to create feelings, memories, behaviours, and other actions. Molecules known as neurotransmitters facilitate cell-to-cell communication. The most significant connection between diet and intelligence is the amino acid content of neurotransmitters, which is a product of diet-related amino acids. Zinc, Magnesium, Iron, Omega-3 fatty acids, B vitamins, and various amino acids are examples of neurotransmitter precursors. The typical nutritional inadequacies found in children with cognitive impairment are due to these nutrients (Altomare *et al.,* 2017).

During the developing phase of a child, the brain requires a lot of nutrients. Nutritional inadequacies obstruct healthy neurodevelopment, which leads to long-term cognitive issues. To create effective nutrition intervention methods, it is essential to have a thorough grasp of metabolic factors and specific nutrients (Spencer *et al.,* 2017).

Children with ADHD have been reported to have deficiencies in copper, zinc, magnesium, iron, and omega-3 fatty acids, whereas sugar, artificial food colourings, and preservatives have been related to a higher risk of ADHD. Recent studies have examined the relationship between eating habits and ADHD. Studying dietary patterns can help us better understand the overall role of nutrition in ADHD since nutrients are ingested in combination and are intimately interrelated. (Woo *et al.,* 2014).

Iron, zinc, magnesium, vitamin B complex, omega-3 fatty acids, and omega-6 fatty acids have a major role in preserving good brain function in children. It is unknown whether micronutrient deficiency or ADHD contributed to a situation where these nutrients are inhibited or whether symptoms deteriorate due to poor nutrition.

The goal of nutrition education and communication programmes has changed from simply disseminating information to convince target populations to alter their food beliefs, attitudes, and behaviours to a two-way sharing process where participants in a nutrition programme can freely exchange knowledge, values, and practises on nutrition, food, and related topics. This viewpoint on nutrition education as an interaction mechanism ensures that those who can and should engage in decision-making do so actively, as well as motivating and facilitating users' access to nutrition-related information (Gavaravarapu *et al.*,2019).

The ultimate aim of nutrition education is to produce decision-makers who are knowledgeable about nutrition and who are eager, talented, and motivated to choose the best nutrition options. Nutrition education must deliver precise knowledge with a focused behaviour aim for target audiences if it is to be effective.

Smartphone technology has opened up new avenues for Nutrition Research, including dietary management and intervention techniques. (Pendergast *et al.,* 2017)

Mobile app for mobile devices or as a web application for computers/handheld devices are the recent technologies for Communication. In the application, chatbots and FAQs for rapid appraisals can be made available. It enables the user to gain access to information and communication (BMI calculator, calorie counter, tailored and generic diet suggestions) from any location in the world. The proposed method employs technology to bring Dietitians' services to their intended audience. By developing the website and adding AI, evidence-based, individualised nutrition web pages may be delivered authentically.

Increased usage of cell phones and the internet over the past ten years suggested that these are more accessible technological tools may be useful in educating caregivers about the value of food and the potential effects of a disrupted eating pattern on children's physical and mental development. Digital Health Intervention is the most modern initiative to shift the responsibility of health care outside of medical institutions and better therapeutic treatments through the concept of an optimistic healthier lifestyle.

It included telemedicine, Web-based methods, e-mail, cell phones, smartphone apps, text messaging, and monitoring sensor systems.

With this in view, the current study aimed to assess the aetiology, nutritional intake, physical activity pattern, and its effect on behaviour functions in children with ADHD symptoms, as well as to provide a sustainable intervention to maintain cognitive development and neurotransmitter levels through diet modification and digital health intervention in web applications and one-on-one telephonic counselling with nutrition education, and to evaluate the effectiveness of the intervention.

1.2. Need for the study

Nutritionally deficient diets are becoming the primary risk factor for global disease loads. Improving children's nutritional status necessitates food systems that provide safe, nutritious, cheap, and feasible diets for all children (UNICEF, 2019).

Several international researchers have found a link between poor growth features and poor academic achievement. Children with ADHD symptoms in their early years may have reduced cognitive impairment and poor attention in school years than children with appropriate nutrition (O'Neill *et al.,* 2017). Over the last four decades, India has implemented numerous intervention measures to improve children's health care. However, the prevalence and consequences of ADHD symptoms persist.

It is vital for a child's growth and development to consume safe, sufficient, and healthy food. Children who do not develop adequately during this vital growth period may be unable to compensate for the growth loss even with an adequate diet later in life (WHO, 2018).

The eating habits of today's children reflect the global "nutrition shift," which sees the younger generation abandoning traditional diets that are frequently healthier and richer in fruits, nuts and seeds, whole grains, veggies, and omega-3 fatty acids (FAO, 2019). Foods that are functionally beneficial, nutrient-balanced, high in energy, and simple to digest must be designed and the general public must be made aware of their importance.

In particular, the diets of low-income people in developing nations play a significant role in human nutrition regarding cereals, millet, and legumes. Nutritional supplements may be the underlying fundamental component in preventing deficits in

children with ADHD symptoms who are at threat of developing impaired behaviour functions as good nutritional support is essential for proper neurodevelopment (Halperin *et al.*,2012).

Nutrition is the foundation of human development. Awareness, understanding, and proper feeding practices for ADHD children can play an important role in reducing symptoms such as hyperactivity or inattention. World Bank highlights the importance of community and school-based nutrition education programmes.

Few studies in India examine the efficacy of existing treatment options, mainly focusing on the efficacy of nutrition therapy for ADHD. This is partially due to the diverse cuisine culture that exists in India. Although food habits and cultures vary from place to place, identifying the dietary variances that reflect the nutritional health of children with ADHD in each Indian state is critical. Diet therapy should indeed be investigated to supplement other treatment choices for effective treatment and enhance the overall quality of life.

When combined with a nutrition-based programme in special schools, several known intervention options and awareness of causative variables can assist those affected in dealing with this prevalent but unfamiliar learning condition. In children with ADHD, this thought approach is not yet common in India. Educating parents on the importance of diet and the potential consequences of a poor food pattern on children's physical and mental development must be stressed by using all available communication media. ADHD and other linked diseases have received little attention in the Indian government's health and nutrition policy thus far. The expense of managing the ailment includes not only money but also the parents' and caregivers' health and mental state. Newspapers and television can be utilised to advertise the various relationships one can research for different health concerns about the meals ingested.

This study is unique in that it attempts to investigate the aetiology, nutritional intake, and behavioural assessment of ADHD symptoms in ADHD children from special schools in Chennai.

1.3. Significance of the study

Each child with ADHD should be handled individually, rather than using a "one diet fits all" approach. The diet emphasises nutritious foods while avoiding triggering items and treating macro and micronutrient deficiencies.

This study on ADHD children would help us understand the aetiology, nutritional intake, and its impact on the behavioural functions of ADHD symptoms. This would aid in identifying the issues that might affect their nutritional condition. Parents might identify with symptoms that may have gone overlooked or were assumed to be "normal" for a child. This, in turn, would encourage early intervention and prompt treatment of children, as well as the importance of nutrition, so that they may function as productive and healthy persons.

An effort has been made to ascertain the advantages of a nutrition intervention programme. The findings would help educators and parents recognise nutrition as a significant tool for ADHD symptoms while expanding mainstreaming options for children. Finally, the project will attempt to provide parents with an idea of nutrition for ADHD via a web-based portal regarding the Indian scenario.

Nutrition intervention through caregivers is a critical approach for children with ADHD Socioeconomic and educational level, family size and type, birth weight, missing breakfast, and breastfeeding all have an impact on nutritional status and behaviour. The impact of these factors on children's health, nutrition, and ADHD symptoms remained unclear.

In India, very few researchers have studied the relationship between these variables and children with special needs. As a result, the current study will encourage policymakers to develop intervention programmes to combat the impact of ADHD symptoms on behavioural function. Intervention measures of the present study, which included nutritional supplementation with tailored micronutrient health snacks produced from selected possible components and nutrition and health education for caregivers, will bring fresh insights for future research.

1.4. Operational Definitions

ADHD: Attention Deficit Hyperactivity Disorder is one of the most common neurodevelopmental disorders of childhood.

DSM -V : The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, is the 2013 update to the Diagnostic and Statistical Manual of Mental Disorders, the taxonomic and diagnostic tool published by the American Psychiatric Association

Comorbidity: Comorbidity is defined as the co-occurence of more than one disorder in the same individual.

Special school: A school for children who are unable to benefit from ordinary schooling because they have learning or physical disabilities.

Nutrition education : Nutrition education is a set of learning experiences designed to assist in healthy eating choices and other nutrition-related behavior.

Digital Health Interventions : Digital health interventions (DHIs) are defined as health services delivered electronically through formal or informal care. DHIs can range from electronic medical records used by providers to mobile health apps used by consumers.

Research Hypothesis

- Dietary modification and digital health technology has a greater impact on improving the nutritional status and behavioural function of children with ADHD symptoms.

Objectives of the present study

Primary Objectives:

To

- ❖ Provide digital technology assisted nutritional support to children with ADHD symptoms.

Secondary Objectives:

To

- ❖ Study the health and nutritional status of children with ADHD symptoms.
- ❖ Formulate micronutrient-rich snacks.
- ❖ Evaluate the impact of digital health intervention and dietary modification in reducing the symptomatology of ADHD.